NOAA FORM 76-35A

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

DATA ACQUISITON AND PROCESSING REPORT

NOAA Ship FAIRWEATHER

2004 Season

For survey OPR-O167-FA-04 & OPR-O193-FA-04

LOCALITY

State Alaska

General Locality Decision Pass & Behm Canal

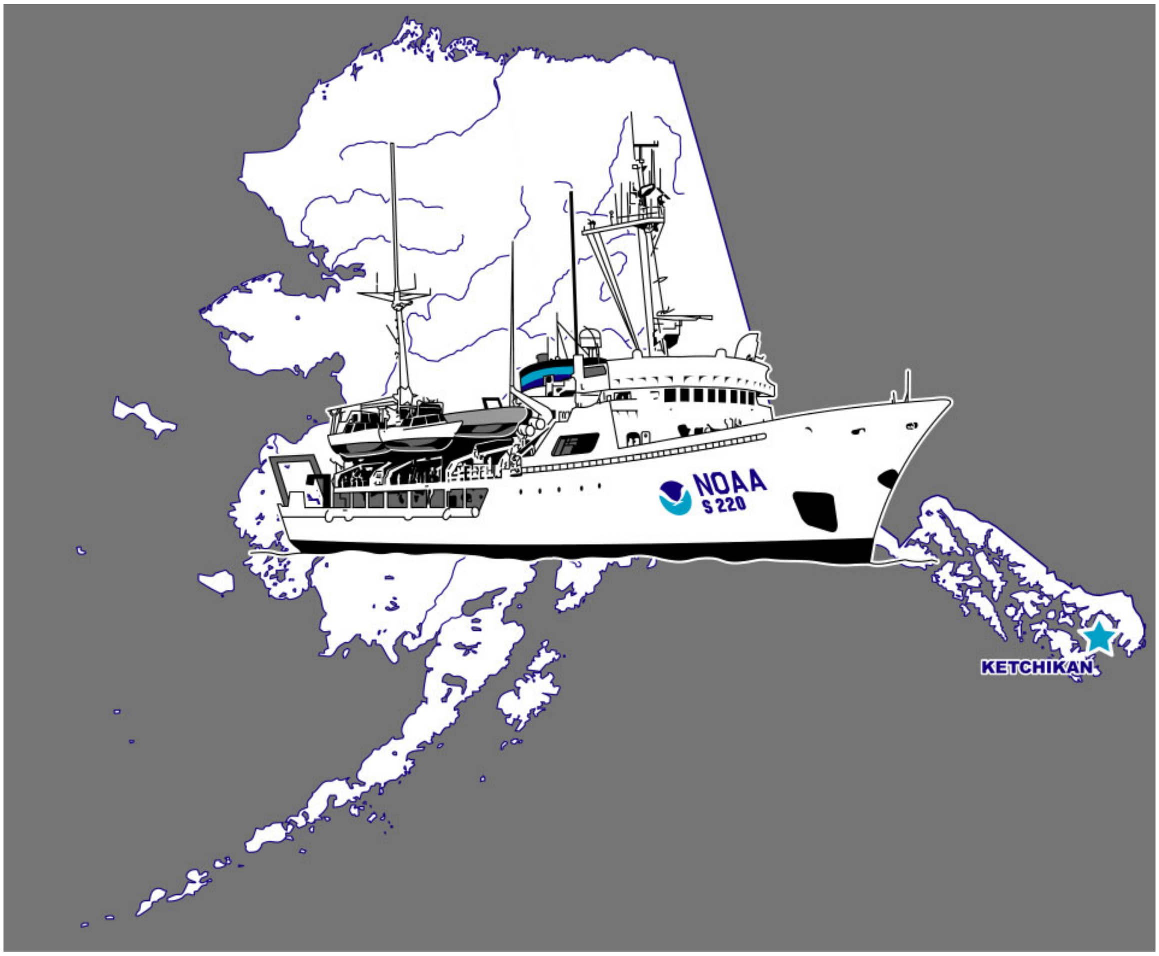
CHIEF OF PARTY

CDR John E. Lowell, Jr

LIBRARY & ARCHIVES

DATE____________________

FAIRWEATHER
Data Acquisition and Processing Report
2004



FAIRWEATHER DAPR 2004

TABLE OF CONTENTS:

1. INVENTORY

1.1. Hydrographic Vessels

The NOAA Ship FAIRWEATHER (HRN S220) and her survey launches (HRN 1010 and HRN 1018) are equipped to acquire multibeam echosounder (MBES) and sound velocity profile (SVP) data. The AMBAR (HRN 2302) and MonArk (HRN not assigned) are used during shoreline, dive, horizontal control, and vertical control operations. See Table 1 below for a list of vessels and vessel information. Any unusual vessel configurations or problems will be addressed in the Descriptive Reports of individual surveys.

	FAIRWEATHER	Launch 1010	Launch 1018	MonArk	Ambar 700	Fast Rescue Boat
Hull Registration Number	S220	1010	1018	Not assigned	2302	2301
Call Letters	WTEB	WTEB 1010	WTEB 1018		WTEB 2302	WTEB 2301
Builder	Aerojet-General Shipyard	The Boat Yard, Inc	The Boat Yard, Inc	MonArk	Marine Silverships, Inc	Zodiac of N. America
Year built	1967	1974 / 2004	1982 / 2004		2004	2004
Delivered to NOAA	January 1968	1974	1982		2004	2004
Commissioned	October 1968					
Re-activated	August 2004	2004	2004			
Length Overall	231 feet	28' 10"	28' 10"	17'	23'	23'
Beam	42 feet	10' 8"	10' 8"	7'	9' 4"	8' 6"
Draft, Maximum	15' 6"	4' 0" DWL	4' 0" DWL	1' 3"	1' 4"	1' 5"
Cruising Speed	12.5 knots	24 knots	24 knots	20 knots	22 knots	20 knots
Max Survey Speed	10 knots	10 knots	10 knots			
Capacity	58	13	13	7	7	5
Crew	31 Authorized	2	2	2	2	
MBES Launches	2					
Primary Echosounder	RESON 8111 & RESON 8160	RESON 8101	RESON 8101			
Secondary Echosounder						
Imagery System						
Sound Velocity Equipment	SBE 19plus & 45, MVP 200	SBE 19plus	SBE19plus			

Table 4: Vessel Inventory

1.2.Hardware

1.2.1. Sounding Equipment

RESON 8111ER Multibeam Echosounder (MBES)
FAIRWEATHER is equipped with a RESON SeaBat 8111 MBES with the Extended Range (ER) and snippet options. The 8111ER is a 100 kHz multibeam system with a swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. The typical operational depth range of the 8111ER on the FAIRWEATHER in 2004 was 20 to 400 meters. No calibration information was provided by the manufacture for the system.

The 8111ER is hull-mounted within a reinforced projection that extends 27 inches below the keel. It is located 39.5" starboard of the centerline at approximately frame 29. It has a specified depth range of 3 to 1200 meters. See Appendix I-1 for system specifications.

RESON 8160 Multibeam Echosounder (MBES)
FAIRWEATHER is equipped with a RESON SeaBat 8160 MBES with the snippet option. The 8160 is a 50 kHz multibeam system with a swath coverage of 4x water depth. Each swath is made up of 126 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of 10 to 3000 meters. No calibration information was provided by the manufacture for the system.

The 8160 is hull-mounted within a reinforced projection that extends 13.6 inches below the keel. It is located 54 inches port the centerline at approximately frame 29. See Appendix I-1 for system specifications. The 8160 was not used during the 2004 field season.

RESON 8101 Multibeam Echosounder (MBES)
Survey Launches 1010 and 1018 are each equipped with a RESON SeaBat 8101 MBES with the Extended Range and snippet option. The 8101ER is a 240 kHz multibeam system with a swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of up to 500 meters. The typical operational depth range of the 8101 on launches 1010 and 1018 in 2004 was 3 to 120 meters. Under optimal conditions with a hard bottom, high power and high gain, the depth range of the 8101 ER was observed to be as deep as 350 m producing a swath of ±45º from nadir. No calibration information was provided by the manufacture for the system.

Each system is attached to a launch using a swing mount which is to the starboard of the keel and approximately centered fore and aft. See Appendix I-1 for system specifications.

Leadlines
Vessels 1010, 1018, MonArk, and 2302 are each equipped with a lead line. Lead lines are used for depth measurements usually near shore and for echosounder depth comparison.

Lead lines were created, measured and calibrated according to Section AF.1, pages AF1-3 in the 1976 NOS Hydro Manual, see Appendix VI-2. Calibration was performed on September 22 , 2004. Calibration reports for the lead lines are included in Appendix V.

1.2.2. Positioning, Heading, and Attitude Equipment

TSS Positioning and Orientation System for Marine Vehicles (POS/MV)
FAIRWEATHER, 1010 and 1018, are each equipped with a TSS POS/MV 320 v.3, configured with TrueHeave™ and Precise Timing. The POS/MV calculates the position, heading, attitude, and vertical

displacement (heave) of a vessel. It consists of a rack mounted version 2.12 POS Computer System (PCS), a strap down IMU-200 Inertial Measurement Unit (IMU), and two NovAtel GPS antennas corresponding to GPS receivers in the PCS. The port side antenna is designated as the primary receiver, and the starboard side antenna is the secondary receiver. Differential correctors are supplied to the POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver.

For all multibeam systems aboard FAIRWEATHER and her launches timing between the sonar swath, position, heading and attitude information was synchronized by utilizing the TSS POS/MV 320 v.3's aboard each vessel. A timing string was sent from the POS/MV to the RESON topside unit and to the ISIS computer recording the incoming data. See Appendix I-2 for system specifications.

MBX-3S DGPS Receiver
FAIRWEATHER, launch 1010, and launch 1018 are each equipped with commercial grade CSI Wireless MBX-3S DGPS Receivers that are used in conjunction with TSS POS/MV to provide vessel positioning during data acquisition. The DGPS receivers are configured in manual mode to allow reception of only one U.S. Coast Guard (USCG) differential GPS beacon station. Beacons used for a given survey will be reported in individual descriptive reports. Vessel wiring diagrams are in Appendix III-(vssl)-6.

Trimble Backpack
FAIRWEATHER uses two GPS Pathfinder® Pro XRS receivers in conjunction with either a handheld data collector TSCe or a field computer to acquire detached and generic positions during shoreline verification in the field. FAIRWEATHER's field computers consist of three Panasonic CF-18 Toughbooks and one Dell Pentium 4 laptop. The receivers have integrated beacon/satellite differential antennas which allow access to digital real-time sub-meter accuracy solutions. Data quality assurance testing was conducted by FAIRWEATHER personnel. See Appendix I-4 for Trimble system specifications.

Impluse LR Hand-Held Laser
The Impluse Laser Rangefinder was used in conjunction with the Trimble Backpack GPS unit to acquire distances and heights during shoreline verification. These data were entered directly into the TerraSync shoreline acquisition software and annotated on the detached position forms. The Impulse LR does not function properly in lowlight, when a feature is not distinguishable from surroundings, or in choppy seas. The specification document Impulse200LRSpec.pdf is located in Appendix I-4.

1.2.3. Sound Velocity Equipment

SBE 19plus SEACAT Profiler
FAIRWEATHER is equipped with three SBE 19*plus* SEACAT sound velocity profilers used to acquire conductivity, temperature, and depth (CTD) data in the water column to determine the speed of sound through water. Two of the SBE 19*plus* profilers have pressure sensors rated to 1000 meters. The third has a pressure sensor rated to 3,500 meters.

Calibration files and testing information of the SBE 19*plus* SEACAT sound velocity profilers were included with the manuals provided by the manufacturer. Periodic quality assurance checks include comparison casts between CTD instruments. See Appendix I-5 for system specifications.

SBE 45 Micro Thermosalinograph (TSG)
FAIRWEATHER is equipped with one SBE 45 MicroTSG. The SBE 45 uses continuously pumped sea water to measure conductivity and temperature near the ship's hull mounted transducers. The intake is located 9 feet below the DWL (13 ft) between frames 11 and 12.

The conductivity and temperature information is converted to sound velocity and output to the RESON 8160's and 8111's processing units. The 8160 requires sound velocity information for beam forming and pitch stabilization while the 8111 only requires it for pitch stabilization. The 8111, when not receiving sound velocity information, can be used to acquire data but not in the pitch stabilization mode. The 8160 cannot be used to acquire data without real time sound velocity information.

Current calibration files are not available for the SBE 45. The unit will be calibrated yearly. At this time, FAIRWEATHER personnel have not developed data quality assurance testing procedures because the unit is newly installed. FAIRWEATHER personnel are investigating techniques and processes for future testing.

The SBE 45 MicroTSG was not utilized during the 2004 field season.

1.2.4. Vertical Control Equipment

Water Level Gauges
Four Sutron 8210 tide gauges are provided to FAIRWEATHER by the Center for Operational Oceanographic Products and Services (CO-OPS). These gauges are equipped with Paros Scientific Sensors (SDI-12) for pressure measurements. The tide gauges are checked annually by CO-OPS Field Operations Division personnel to ensure that their accuracy standards are being met.

CO-OPS does not provide calibration or quality assurance documentation to the FAIRWEATHER. FAIRWEATHER personnel are responsible for installation and removal of the water level gauges. CO-OPS is responsible for delivering final approved vertical correctors to the processing branch for application to the hydrographic data set.

Leveling Equipment
FAIRWEATHER is equipped with two Zeiss NI2 333 stadia levels and two Leica NA2 100 stadia levels used to level tide gauges. Meter staffs are also used in the leveling process. Specifications for the levels are in Appendix I-6.

1.2.5. Horizontal Control Equipment

FAIRWEATHER is equipped with three Ashtech Z-Xtreme dual-frequency GPS receivers for the positioning of tidal benchmarks, aids to navigation and portable DGPS reference stations (Fly-Aways). The Ashtech Z-Xtreme receivers are 12 channel, L1/L2 receivers that are connected to Ashtech Geodetic 4 GPS antennas. The Ashtech Geodetic 4 GPS antennas can be equipped with an optional ground plane and mounted on fixed height Seco GPS tripods.

FAIRWEATHER also carries equipment for a portable DGPS reference station (Fly-Away). This station is to be used when USCG DGPS corrector beacon reception is not available in an area. The portable DGPS reference station consists of an Ashtech Z-Xtreme receiver, 1 Ashtech Geodetic 4 GPS antenna with ground plane, 1 Pacific Crest Position Data Link High Powered Base Unit, 1 VHF antenna, 3 Pacific Crest Position Data Link Rovers, 10 marine deep cycle batteries and 8 solar panels. In addition, an Ashtech Z-Xtreme receiver, an Ashtech Geodetic 4 GPS antenna with ground plane, and a ruggedized laptop configured with Ashtech Evaluate v6.25 are necessary equipment to produce an analysis check.

Horizontal control equipment specifications, *ZXtreme Ashtech GPS* and *PDL Flyaway Specs*, are located in Appendix I-6.

1.3. Software

Hydrographic acquisition, processing and quality control software applications utilized aboard FAIRWEATHER and her launches were updated throughout the field season. A list of software applications, versions and dates of patch applications, called *Survey Software*, is located in Appendix II.

1.3.1. Data Acquisition Software

Isis Sonar/BathyPro/DelphMap/DelphNav
The FAIRWEATHER uses the Triton Imaging Inc. software packages Isis Sonar and Sonar Suite to acquire multibeam echo sounder and side scan sonar data on all of its' multibeam platforms. Sonar Suite has two software packages; DelphNav and DelphMap which work together along with Isis Sonar to produce real time data planning, acquisition, and execution.

Triton Imaging BathyPro is an add-on package for Isis Sonar which processes XTF data real-time to produce DTMs supported by DelphMap. Triton Imaging DelphNav is an add-on package to DelphMap used for line planning and vessel navigation. Triton Imaging DelphMap is a stand-alone GIS program which combines georeferenced bathymetric digital terrain models and reference files such as raster charts and vector shoreline files to display real-time bathymetric bottom coverage.

See Appendices VI-1 & 3 for the Standard Operating Procedures, *Configuring Real Time Bathy* and *TEI Real Time Bathy SOP* respectively, and Appendices III-(vssl)-6 for vessel wiring diagrams.

TerraSync/PathFinder Office
For GPS positioning and shoreline verification FAIRWEATHER primarily used two Trimble Navigation Limited software programs: GPS Pathfinder 3.00 and TerraSync 2.4.1.

GPS Pathfinder is run on a Microsoft Windows operating system and is used to manage and process Trimble GPS data, transfer files to and from GPS receivers and handheld data collectors, and export processed data.

Trimble TerraSync 2.4.1. supports data dictionaries and georeferenced TIFF images. The georeferenced TIFF images are used for reference and navigation purposes as well as for immediate S-57 attribution of positions in the field. TerraSync is installed and configured for data collection on the TSCe handheld computer as well as the Dell Pentium 4, both Toughbook field computers, and the ToughTab.

GPS precision masks in TerraSync using the following parameters:

- Horizontal Dilution of Precision (HDOP) ≤ 2.5
- Signal-to-Noise Ratio (SNR) ≥ 4
- Elevation Mask ≥ ~8°-15° (varies by location)

Differential GPS correction is applied real-time, using the unit's integrated beacon as the first choice corrector, and specifying "wait for real-time" as the secondary option. Positions are filtered so that only those with a minimum of 4 satellites (3D position), and HDOP ≤ 2.5, and Positional Dilution of Precision (PDOP) ≤ 6 will be exported into shapefile format.

1.3.2. Data Processing Software

Velocwin
Sound velocity data is processed with Velocwin, in-house software produced and maintained by NOAA's Hydrographic Systems and Technology Programs (HSTP) division. Velocwin creates and archives water column profiles, performs quality assurance, and processes pressure based depth data. Velocwin creates a standard file format across NOAA's hydrographic fleet for sound velocity profiles applied to shallow water multibeam and single beam data.

CARIS HIPS & SIPS
CARIS HIPS™ (Hydrographic Information Processing System) is used to process all shallow water multibeam data including data conversion, filtering, sound velocity, tide correcting, merging and cleaning. CARIS HIPS also calculates the Total Propagated Error (TPE) used to produce Bathymetry Associated with Statistical Error (BASE) surfaces which assist the Hydrographer in data cleaning and analysis.

CARIS SIPS™ (Side-scan Information Processing System) is not currently used by the FAIRWEATHER as there is no side-scan sonar equipment.

CARIS Notebook
CARIS Notebook™ is utilized to stream line the data pipeline from the field to the processing branch. Notebook was used to compile and display source shoreline, shoreline updates and S-57 features imported from Pydro for cartographic review. The .hob files created in Notebook are the initial components for H-cell creation.

Pydro
Pydro, another NOAA program produced and maintained by HSTP, is used to process features such as detached positions(DP), generic positions(GP), and Automated Wreck and Obstruction Information System(AWOIS) contacts. PYDRO also converts and attributes features according to S-57 standards for insertion in to CARIS Notebook.

Fledermaus
Fledermaus is third-party, licensed software for which the FAIRWEATHER has two licenses. Fledermaus ™, an Interactive Visualization Systems 3D™ (IVS 3D) program, is used for data visualizations and creation of public relations material, data quality control, and comparisons.

As a data quality assurance check Fledermaus ™ is used to examine the CARIS HDCS multibeam data before submission. The procedure is to convert the HDCS data using PFMDirect using a 2 to 5 meter grid size. Because of the algorithms used to grid the data within Fledermaus ™ any data errors or flyers tend to be highly visible. The entire PFMDirect generated surface for a sheet is completely examined in a stepwise fashion. If artifacts or fliers are visible in the grid then the soundings are examined in the 3D Editor. Line numbers and soundings are then noted and given to the survey manager for investigation in CARIS.

MapInfo
MapInfo™ is utilized to review tables and workspaces associated with assigned projects received from Hydrographic Survey Division (HSD). MapInfo may also be used to produce scaled plots produced for public relation purposes. HydroMI, a HSTP produced and maintained MapBasic program, is used through MapInfo to convert tide and tidal zoning files into a format that is useable in CARIS HIPS, and obtain latitude/longitude coordinates for pre-survey planning.

1.4. Personnel

The following personnel were involved with hydrographic systems and operations this field season: CDR Lowell (CO), LCDR Baird (XO), LT Wetzler (FOO), LTjg Van Waes, ENS Higgins, CST Morgan, SST Abrams, SST Froelich, ST Keene, AST Kellner, AST Castle, PS Sampadian and ECO Eipert.

2. DATA ACQUISITION

2.1. Multibeam Echosounder

Methods of acquisition took into consideration system performance limitations, the bottom topography, water depth, and the ability of the vessel to safely navigate the area.

All multibeam data were acquired in Triton Elic's extended transfer format (XTF) and monitored in real-time using the 2-D and 3-D data display windows and the on-screen displays for the RESON SeaBat 8101 and 8111ER sonar processors. Adjustable parameters that were used to control the RESON from the ISIS software include range scale, power, gain, and pulse width. These parameters were adjusted as necessary to ensure best data quality. Additionally, vessel speed was adjusted as necessary to ensure the required along-track coverage for object detection in accordance with the NOS Specifications and Deliverables and Standing Project Instructions.

Mainscheme multibeam sounding lines using the RESON Seabat 8101ER and 8111ER were generally run parallel to the contours at a line spacing approximately three to four times the water depth. For discrete item developments, line spacing was reduced to two-times water depth to ensure least-depth determination by multibeam near-nadir beams. Triton Elic's DelphMap Real Time Bathy was utilized in lieu of planned line files. The Real Time Bathy displayed the acquired multibeam swath, filtered to ±60˚, during acquisition and was monitored to ensure full bottom coverage. If coverage was not adequate, additional lines were run while still in the area.

For all multibeam systems aboard FAIRWEATHER and her launches, timing between the sonar swath, position, heading and attitude information was synchronized by utilizing the POS/MV version 3's aboard each vessel. A timing string was sent from the POS/MV to the RESON topside unit and to the ISIS computer recording the incoming data. For further information see *Upgrading to Precise Timing* located in Appendix VI-1. In addition, vessel wiring diagrams are included in Appendix III-(vssl)-6.

2.2. Shoreline

FAIRWEATHER personnel conducted field shoreline verification at times near predicted low water, in accordance with the Standing Project Instructions and Field Procedures Manual, section 6.1 and 6.2. Pertinent standard operating procedures, *S57 Shoreline Presurvey*, *S57 Shoreline Acquisition, and SHP File to Ntbk Edit Layer* are included in Appendix VI-3.

MapInfo was used to translate the source shoreline files to shape files for editing. The shape files were then translated to .hob file format in CARIS Notebook 2.2 Beta. Charted shoreline, when used for reference purposes or when source data were not available, was digitized with S57 attribution into the Notebook H#####_CHD_Shoreline.hob file.

Detached positions (DPs) and generic positions (GPs) acquired during shoreline verification indicate revisions to features, or features not found in the field. They were recorded in the shoreline acquisition software TerraSync and on DP forms, then processed through GPS Pathfinder. Scanned copies of the DP forms are included in the digital Separates folder and hard copies are submitted with the Separates to be included with Survey Data. In addition, annotations describing shoreline were recorded on hard copy plots of the digital shoreline, or boat sheets which are also submitted with the Separates.

3. DATA PROCESSING AND QUALITY CONTROL

3.1. Processing

3.1.1. Multibeam Echosounder Data

Raw XTF multibeam data were converted to HDCS format in Caris HIPS & SIPS 5.4. After conversion, the Total Propagated Error (TPE) was calculated in HIPS to determine the quality of the multibeam data. Error estimates were entered into the HIPS Vessel File (HVF) file for each vessel. A report was produced in the CARIS Vessel Editor for each vessel, which contain the values entered into the HVFs.

The *HVF Reports* are included in Appendix III-(vssl)-1. An *HVF Database* was utilized to track changes and the copying of the HVFs to specific projects, it is located in Appendix II. The *TPE values* used on the FAIRWEATHER for the 2004 field season are provided in Appendix IV.

Vessel heading, attitude, and navigation data were only reviewed and/or edited in navigation editor and attitude editor as deemed necessary by the Hydrographer. When necessary, fliers or gaps in heading, attitude, or navigation data were manually rejected or interpolated for small periods of time.

Sound velocity correction was applied in HIPS. Tide corrections, dynamic draft correctors, sensor lever arm information, bias information and timing errors, and attitude correctors were applied to the data during the "Merge" process.

The TPE takes into account uncertainties in the measurements coming from each sensor (Heave, Pitch, Roll, Position, Heading, Sound Velocity, and Tide) and uncertainties in static measurements (Draft and Latency) to calculate the total uncertainty associated with each sounding. Caris HIPS & SIPS 5.4 uses the vertical uncertainty from TPE to produce a Bathymetry Associated with Statistical Error (BASE) surface. These BASE surfaces and child layers (Depth,Uncertainty, Density, Standard Deviation, Mean, Shoal, Deep) were used for directed data editing, to demonstrate coverage, and to check for systematic errors such as tide, sound velocity, or attitude and timing errors. The data were reviewed and edited in swath editor as needed. All multibeam data were edited and reviewed in HIPS subset mode. Located in Appendix VI-4, are the *Hydrographic Surveys Technical Directives (HSTD)* granting permission to process data using CARIS HIPS 5.4 BASE surfaces along with details on the processing procedures utilized, outlined in the *Bathymetric Processing*.

3.1.2. Trimble Detached Positions and Generic Positions

During shoreline verification, detached positions were acquired with TerraSync 2.4.1. Data were reviewed, edited and exported as ESRI shape files(shp) in GPS Pathfinder 3.00. The exported shape files included the S-57 field attributed positions organized by object type.

3.1.3. Field Products

In an effort to streamline the data pipeline from the field to the processing branch, MapInfo tables and workspaces were not used for shoreline processing by FAIRWEATHER personnel. Instead, Pydro and CARIS Notebook were used exclusively.

Positions acquired during shoreline verification operations are in shape file format from GPS Pathfinder. The Generic GPs/DPs Import tool in Pydro is utilized to retain the S-57 attribution during import into Pydro. Once the features are in Pydro, short descriptive comments along with investigation or survey methods are listed under the Remarks tab in Pydro. Features were flagged as Primary, unless there were multiple detached (DPs) or generic (GPs) position taken on the same feature. In that case, the most important DP was marked Primary and the associated DPs/GPs were flagged Secondary. A Carto Action of Add, Modify or Delete was assigned to each item in Pydro, and all features were S57 attributed. Items for particular surveys that were associated with a DP or GP that needed further discussion were flagged Report in Pydro. Along with the investigation methods provided in the Remarks tab, the hydrographer included recommendations to the cartographer in the Recommendations tab when warranted. All features were flagged according to *Pydro Logic* located in Appendix VI-4.

Terminology used during shoreline verification is as follows. The term “Noted” indicates that the feature is correctly located within the scale of the chart or source, as confirmed from a distance. The term “Verified” was used when the existence of the feature was confirmed in close proximity and the feature is correctly located within the scale of the survey.

The HDCS_DATA line associated with DPs require further processing in CARIS HIPS & SIPS to correct for tide and sound velocity when necessary. GPs do not have heights associated with them and require no additional processing.

All primary and accepted DPs and GPs were imported from Pydro as an .xml to CARIS Notebook 2.2 Beta. Three separate stand alone .hob files were created for the features, based on the Carto Action assigned in Pydro. The separated files were named H#####_Add_Features.hob, H#####_Modify_Features.hob, H#####_Delete_Features.hob. Remarks and recommendations from Pydro were imported to the “remrks” and “recomd” fields associated with each feature in CARIS Notebook.

New HW/MLLW features and any changes to the source shoreline, such as ledges or reefs, were digitized with S57 attribution to the H#####_Shoreline_Updates.hob file. Any comments or annotations made on the boat sheets from observations made in the field, including field notes made by the Hydrographer regarding verification of features, were added to the associated features in CARIS Notebook. Remarks pertaining to point features were added directly to the “remrks” field of the feature in the .hob file. Marker layers were used to add comments to line features that did not have an associated DP or GP. Markers were also used for carto-symbols, because the text from the “remrks” field currently does not display in CARIS Notebook.

Additional standard operating procedures used in field product creation were *S57 Shoreline Processing, Pydro Editor Notebook,* and *Survey PIC Shoreline Duties*, are included in Appendix VI-4.

3.2. Quality Control

3.2.1. Standard Operating Procedures

The standard operating procedures (SOPs) followed by FAIRWEATHER survey personnel to ensure consistent and quality data and products are located in Appendix VI. Procedures outlining Offsets and Configurations can be viewed in Appendix VI-2, and the pertinent Calibration and Testing procedures are included in Appendix VI-2. The procedures pertaining to Acquisition are located in Appendix VI-3. Processing SOPs, Hydrographic Surveys Technical Directives pertinent to the 2004 field season, the data processing flowchart and the *Survey Mangement* SOP detailing specific steps in running a survey are all included in Appendix VI-4.

3.2.2. Data Review

Specific procedures were used on the FAIRWEATHER to ensure quality control of data throughout acquisition, processing, and submission. These procedures are outlined in the *FA QC Checksheets* located in Appendix VI-5. The QC Check is preformed by the survey manager. The QC Review is completed by an outside reviewer of the survey data and deliverables (can be FOO, CST or a qualified SST). The Data Submission and Analog Submission checklists are used to ensure that all data and deliverables are complete and included upon submission.

4. CALIBRATIONS AND CORRECTORS

In collaboration with Office of Coast Survey personnel, the FAIRWEATHER personnel determined appropriate methods for testing and calibration of systems used to acquire hydrographic data for 2004 projects. Methods were in accordance with the Standing Letter Instructions (April, 2003), the Specifications and Deliverables (March, 2003), and the Field Procedures Manual (March, 1998).

4.1. Vessels

Sensor offsets were measured with respect to each vessel's reference point. Specific offset values were entered into the POS/MV. All offsets and their associated error estimates were used to create a HIPS Vessel File (HVF). For each vessel in CARIS HIPS & SIPS, an *HVF Report* was produced that contains all HVF entries. These reports are included with the individual vessel reports in Appendix III-(vssl)-1.

4.1.1. Ship Offsets

A ship survey was done for the FAIRWEATHER by Westlake Consultants, Inc. A report of the results from that survey, dated September 23, 2003, was used to define the ship offset values. The Westlake document and detailed spreadsheet, which includes derivations, a description of methodology used, diagrams, and coordinate system references are located in Appendix III-S220-2.

4.1.2. Launch Offsets

Permanent control points were established on launches 1010 and 1018, in July of 2004. Sensor offsets were measured according to the procedures listed in *Measuring Launch Offsets & Installation of Benchmarks* included in Appendix VI-1. Total stations were utilized for positioning the permanent control points. The total station specifications are located in Appendix I-7, the calibration certificates for the *Nikon DTM 310* and the *Sokkia SET 5F* are included in Appendix V. A summary of measurements, derivations, descriptions of methodology used, diagrams, and coordinate system references are included in the respective vessel's Offsets section in Appendix III-(vssl)-2.

4.1.3. POS/MV Correctors and Calibration

POS/MV Position Computation
On all FAIRWEATHER vessels the POS/MV is used for positioning multibeam data. The POS/MV controller software was used to monitor position accuracy and quality during data acquisition. This ensured that positioning accuracy requirements were met, as outlined in the NOS Hydrographic Surveys Specifications and Deliverables. The POS/MV controller software provides clear visual indications whenever accuracy thresholds are exceeded.

Due to the high latitude and rough Alaskan topography, the Horizontal Dilution of Position (HDOP) would occasionally exceed 2.5, which is the maximum threshold allowed in Specifications and Deliverables section 3.2.1. In order to obtain 100% coverage in survey areas, FAIRWEATHER vessels would continue to acquire data up to a maximum HDOP of 4.0. These data were examined during post-processing and positions were interpolated or rejected when necessary.

POS/MV Heading Computation
On all vessels, the heading computed by the POS/MV, was used as a corrector for multibeam data.

POS/MV Pitch and Roll Computation
On all vessels, the POS/MV was used for pitch and roll values.

POS/MV Heave Computation
The POS/MV's on FAIRWEATHER and her launches are equipped with the TrueHeave™ option. Stored TrueHeave™ data contains time stamps with attitude, position, acceleration and rotation information. TrueHeave™ data were acquired in accordance with section 6.0 of the *POS/MV Version 3 Installation and Operation Manual,* dated October 2003. These data were post processed in CARIS HIPS & SIPS 5.4 in order to determine the vessel heave correctors associated with simultaneously collected multibeam data. FAIRWEATHER personnel compared Applanix's TrueHeave™ solution to the real time heave solution and found that induced heave artifacts were minimal or non-existent. Previous work by Thales GeoSolutions (formally Fugro) show an increased heave corrector data quality in large swell (Earth Imaging Journal). Due to unresolved issues with recording and processing TrueHeave™ only 70% of the multibeam data acquired by FAIRWEATHER had TrueHeave™ correctors applied.

In cases where post processed heave information could not be applied, real time heave correctors were used. Real time heave is computed in the POS/MV by performing a double integration of the IMU-sensed vertical accelerations. This information is then run through a high pass filter which limits the appearance of noise in the solution. The high pass filter is characterized by the heave bandwidth and dampening ratio. For FAIRWEATHER and her launches, these constants were set at 20 s and 0.707 respectively. Real time heave data were recorded in Triton Elic's Isis software, stored in the .XTF format and applied as the heave corrector for multibeam data in CARIS HIPS & SIPS 5.4.

POS/MV GAMS Calibration
GAMS calibrations were performed on each of the three POS/MV units. The GAMS calibration procedure is located in the POS/MV 320 manual, section 4-25 to 4-34, located in Appendix VI-2. Results of the GAMS calibrations are included in the individual vessel reports and spreadsheets, with calibration details located in Appendix III-(vssl)-5.

4.1.4. Dynamic Draft

Dynamic draft tests were conducted for launches 1010 and 1018. The Dynamic Draft Settlement & Squat Method, *DDSSM Procedure* is located in Appendix VI-2. Results of the DDSSM for each vessel are included in the individual vessel reports located in Appendix III-(vssl). Detailed processing spreadsheets from the DDSSM are also included in Appendix III-(vssl)-4. In addition, optical settlement and squat testing was conducted on Launch 1010, results are included in Appendix III-1010-4.

Dynamic draft tests were conducted for FAIRWEATHER in Port Angeles in August 2004. Due to configuration issues, the results could not be applied to the HVF files. The dynamic draft portion of the S220_8111.hvf was left blank.

4.1.5. Patch Tests

Patch tests were conducted for FAIRWEATHER, 1010 and 1018. The *Patch Test Procedure* is located in Appendix VI-2. The results of the patch tests are included in the individual vessel reports located in Appendix III-(vssl). Acquisition and Processing Logs utilized during testing are included in Appendix III-(vssl)-3.

4.2. Uncertainty Modeling

An understanding of the errors inherent in the multibeam systems and ancillary equipment is required for the proper use of CARIS HIPS & SIPS 5.4. These values are used to generate an uncertainty model needed to compute the Total Propagated Error (TPE) estimation and for the creation of Bathymetry Associated with Statistical Error (BASE) surface. Uncertainty information for FAIRWEATHER has been entered into the HIPS Vessel File (HVF). The uncertainty information entered reflects the statistical accuracy to which equipment can measure a value or to which a value was measured in the case of offsets.

Error estimates for FAIRWEATHER and associated survey launches were compiled from manufacturer specification sheets for each sensor (Heave, Pitch, Roll, Position, and Heading) and calculated for instrument reading uncertainty for static measurements (Draft and Offset measurements).

In instances where uncertainty information was unavailable or unknown the best estimation of the uncertainty was used.

The TPE values for FAIRWEATHER and her launches, referencing original source information, are entered into an Excel spreadsheet and included in Appendix IV.

4.3. Static Draft and Loading

The static draft value in the FAIRWEATHER HVF (Waterline Height in HVF) remained constant throughout the 2004 field season. Its value and calculation are listed in the Offset spreadsheet located in Appendix III-S220-2.

Static drafts (Waterline Height in HFV) for launch 1010 and 1018 were calculated using measurements from a known reference mark to the waterline made with a steel tape. The launch static drafts remained constant throughout the 2004 field season.

Loading measurements were taken on both launches throughout the field season when weather conditions allowed. The procedure was to measure from a known mark to the waterline to calculate the draft. These values were collected and inserted into the *Vessel Loading* worksheet located in Appendix IV-1. The standard deviations of the draft changes were used to generate the loading values for the TPE model which are listed in the *FA_TPE_Values_2004* spreadsheet in Appendix IV. These values were not used for vertical corrections to multibeam data.

4.4. Sound Velocity Equipment

The SBE 19*plus* SEACAT profilers were purchased in 2004 from Seabird Electronics. Calibration files and testing information were included with the manuals provided by the manufacturer. Simultaneous casts were taken with multiple instruments and compared to each other in Velocwin to ensure that the instruments met calibration specifications.

The calibration files were loaded into Velocwin and used during processing of casts. See Appendix V-CTD's for calibration and testing reports.

SVP casts from the SBE 19*plus* were processed with Velocwin and the correctors were applied to echosounder data during post processing.

4.5. Water Level

Predicted and unverified observed water level correctors can be downloaded from the CO-OPS website. When internet was unavailable, the ship enabled the automated Tidebot program, which would send daily observed water level correctors for selected tide stations to the ship via email. The daily water level correctors arrived in .txt file format. The files for the relevant days were collated into a tide station master file which was converted to .tid file format in HydroMI. The .tid files were applied to data along with the .zdf file in CARIS HIPS & SIPS. The Pacific Hydrographic Branch applies final approved (smooth) tides to the survey data during final processing.

4.5.1. Tide Gauges

The Sutron 8210 tide gauges are equipped with factory calibrated Paros Scientific Sensors. The Sutron 8120 tide gauges are checked yearly by CO-OPS Field Operations Division personnel to ensure that accuracy standards are being met.

4.5.2. Leveling Equipment

FAIRWEATHER is equipped with two Zeiss NI2 333 levels and two Leica NA2 100 universal automatic levels. A Kukkamaki procedure was performed on Zeiss NI2 333 level S/N 100056 to verify the collimation. The results of the *Kukkamaki 100056* calibration are located in Appendix V-Control. The results of the Kukkamaki calibrations for the remaining tides leveling equipment are not available.

4.6. Horizontal Control

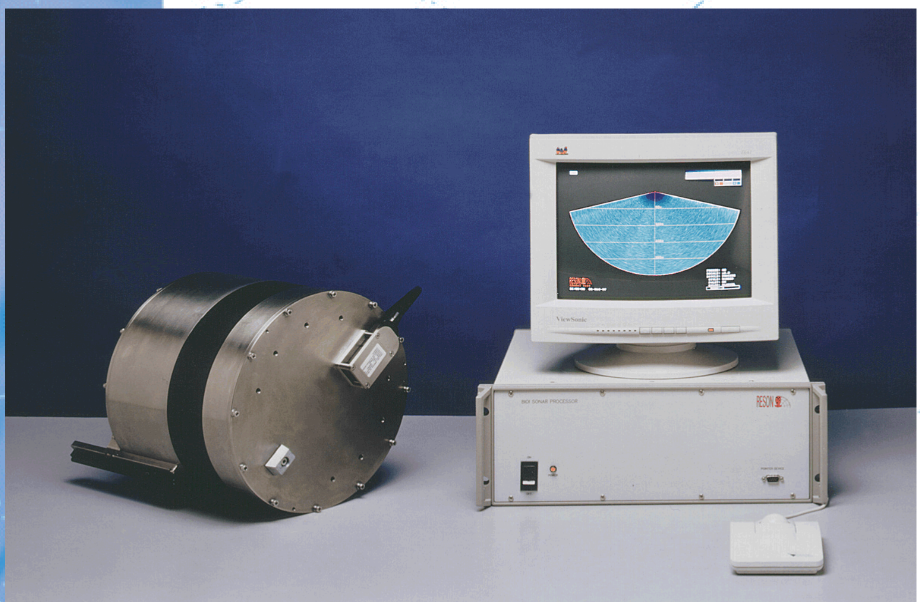
The Ashtech Z-Xtreme GPS receiver is capable of 0.5cm horizontal and 1cm vertical accuracies. Data is downloaded and converted to Rinex format using Ashtech Solutions v2.60. Rinex files are uploaded to NGS Online Positioning User Service (OPUS) for processing.

The FAIRWEATHER portable DGPS reference station (Fly-Away) is set up in conjunction with an Ashtech Z-Xtreme receiver, an Ashtech Geodetic 4 GPS antenna with ground plane, and a ruggedized laptop configured with Ashtech Evaluate v6.25, in order to produce a 24 hour scatter plot for quality analysis check.

Appendix I

Equipment Specifications

SeaBat 8101
PRODUCT SPECIFICATION
240kHz MULTIBEAM ECHO SOUNDER



- **Phase and Amplitude Bottom Detection**
- **150◦ Wide Swath Coverage**
- **240 kHz Frequency**
- **Up to 500m Range Capability**
- **Portable Configuration**
- **Meets USACE Class 1 Standards**
- **Meets IHO Standards**

The SeaBat 8101 Multibeam Echo Sounder measures discrete depths, enabling complex underwater features to be mapped with precision. Dense coverage is achieved utilizing up to 3,000 soundings per second for a swath that can be over 500 meters wide, even as the survey vessel travels at speeds of over 18 knots.

With high accuracy and a measurement rate up to 30 profiles per second, the SeaBat 8101 enables surveys to be completed faster and in greater detail than previously realized. The SeaBat is an integral part of the new, integrated bathymetry surveying systems.

The SeaBat transducer is available pressurized for depths from 100 to over 3,000 meters. Small and lightweight, it can be can be mounted on small un vehicles (ROV, AUV or towed) and taken to where accurate measure required.

RESON A/S
Denmark
Tel : +45 47 38 00 22
Fax : + 45 47 38 00 66
E-mail: reson@reson.dk

RESON INC.
USA
Tel :+1 805 964-6260
Fax :+1 805 964-7537
sales@reson.com

RESON OFFSHORE LTD.
United Kingdom
Tel : +44 1224 727 427
Fax : +44 1224 727 428
sales@reson.infotrade.co.uk

http://www.reson.com

SeaBat 8101 Built-In Test Environment ("BITE") Screen

SYSTEM SPECIFICATIONS

Operating Frequency:	240kHz
Range Scales:	5, 10, 15, 20, 25, 35, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500m.
Range Resolution:	1.25 cm
Number of Beams:	101
Horizontal Beamwidth:	1.5°
Horizontal Coverage:	150°
Vertical Beamwidth:	1.5°
Update Rate:	Range-variable up to 30 times per second

SONAR HEAD SPECIFICATIONS

Power Requirement:	24VDC, 2 Amps max. (Power available from surface processor.)
Uplink:	Digital, 76.8 Mbaud
Down Link Control:	RS-232 or RS-422, 19,200 baud
Operating Depth:	100 meters (300m, 1500m, 3000m & 6000m avbl.)
Dimensions:	266x320mm W/Diam (does not include projector)
Temperature:	Operating: -5° to +40°C Storage: -30° to +55°C
Weight (aluminum):	Dry: 26.8 kg (59 lbs) Wet: 4.8 kg (10.6 lbs)
Weight (titanium):	Dry: 40 kg (88 lbs) Wet: 18 kg (39.6 lbs)

DISPLAY SPECIFICATIONS

Screen Size:	14 inch Diagonal
Input:	SVGA (800x600, 72 Hz)
Display:	High Resolution Color
Power Consumption:	62 W

PROCESSOR SPECIFICATIONS

Power Requirements:	115/230VAC, 50/60Hz, 100W max.
Data Output:	Selectable, 300-155.2 Kbaud or Ethernet 10 base T or 10 base 2
Video Output:	SVGA (800x600, 72 Hz) or NTSC or PAL video.
Graphics Colors:	256 colors (8-bit)
Display Mode:	Sector Format
Display Arc:	150°
Input Device:	3-Button Trackball
Dimensions:	19" rack, 4U high (266x483x434mm HWD)
Temperature:	Operating: 0° to +40°C Storage: -30° to +55°C
Weight:	20 kg (44 lbs)

SeaBat 8101 Head with Optional Fairings

OPTIONS

Option 033:	Side Scan Upgrade
Option 034:	Mounting Plate Assembly
Option 035:	Fairings (pictured above)
Option 036:	Spares Kit
Option 037:	Titanium Housing
Option 038:	210° Swath
Option 040:	Extended-Range Projector
Option 049:	Increase Transducer Depth Rating

Version 4.0
032399

RESON

Due to our policy of continuous product improvement, specifications are subject to change without notice.

SeaBat 8111

PRODUCT SPECIFICATION

MULTIBEAM ECHOSOUNDER

- **Phase and amplitude bottom detection**
- **100 kHz frequency**
- **150° swath coverage**
- **Real-time quality control**
- **Sidescan upgradeable**
- **Modular and portable**
- **Pitch stabilization**

The SeaBat 8111 is a modular multibeam echosounder system operating at 100 kHz. When installed on a vessel, it produces high-density, high-accuracy soundings on the seafloor over a 150° swath. Major system components include a transducer array, a transceiver unit, and a processor unit.

The SeaBat 8111 transducer array is comprised of a cylindrical receive array and a linear transmitter array, mounted together on a support cradle that provides mounting points to the vessel. Lightweight and portable, the array can be installed temporarily over the side of a vessel of opportunity—a first for a system in this frequency range.

The SeaBat 8111 transceiver features plug-in cards for easy maintenance and is controlled from the sonar processor.

The Seabat 8111 processor is compatible with other SeaBat sonar heads, can be updated in minutes to accommodate future requirements, and features a user-friendly point-and-click interface.

RESON
www.reson.com

RESON A/S
Denmark
Ph: + 45 47 38 00 22
Fax: + 45 47 38 00 66
email: reson@reson.dk

RESON Inc.
USA
Ph: + 1 805 964 6260
Fax: + 1 805 964 7537
email: sales@reson.com

RESON Offshore Ltd.
UK
Ph: + 44 1224 709 900
Fax: + 44 1224 709 910
email: sales@reson.co.uk

RESON GmbH
Germany
Ph: + 49 431 720 7180
Fax: +49 431 720 7181
email: reson@reson-gmbh.de

RESON SA (PTY) LTD
South Africa
Ph: + 27 21 786 3420
Fax: +27 21 786 3462
email: reson@reson.co.za

RESON-Telenav
Singapore
Ph: + 65 6 872 0863
Fax: +65 6 872 1334
email: telenav@mbox2.singnet.com.sg

SeaBat 8111 SYSTEM SPECIFICATIONS

SYSTEM PERFORMANCE

Frequency:	100 kHz
Range Resolution:	3.7 cm
Swath Coverage:	150º
Range:	3m to 1200m (with Option 040)
Number of Beams:	101
Along-Track Beamwidth:	1.5º 3.0º 4.5º 6.0º*
Across-Track Beamwidth:	1.5º
Stabilization:	Pitch stabilization within +/-15º
Projector Beam Control:	External motion sensor required
Accuracy:	IHO Compliant
Operational Speed:	Up to 20 knots
Max. Update Rate:	35 Hz
Transducer Pressure Rating:	100m

*operator selectable

INTERFACE

System Supply:	90 to 260VAC, 50/60 Hz, 200W max.
Video Display:	SVGA, 800 x 600, 72 Hz
System Control:	Trackball or from Ethernet
Data Output:	10 MB Ethernet or serial RS232C
Data Uplink:	High-speed digital coax with fiber-optic option
Temperature:	Operating: 0° to +40° C Storage: -30° to +55° C

RELATED PRODUCTS

- Option 040 Extended range capabilities
- Option 033 Sidescan upgrade
- Option 051 24DC power supply for SeaBat 81-P Processor

MECHANICAL INTERFACE

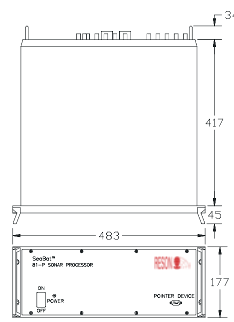
Dimensions (in mm):

Transducer Array:	
Hydrophone:	636 x 118 (Dia./Length)
Projector:	113 x 650 (Dia./Length)
Processor:	177 x 483 x 417
Transceiver:	267 x 483 x 489

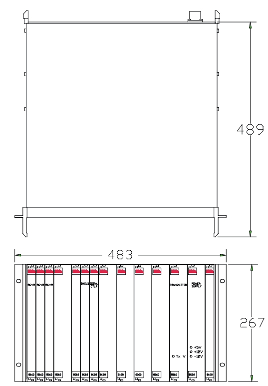
Weight:

Transducer Array:	72 kg (dry) / 59 kg (wet) with cables
Processor:	20 kg
Transceiver:	13.6 kg

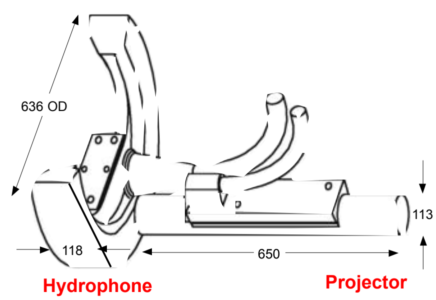
Cable Length: 15m



Processor



Transceiver



Transducer Array

SEAFLOOR COVERAGE

(with Extended Range option)

Bottom Depth (meters)	Swath Width (meters)
5 to 150	Up to 1110 (7.4 x water depth)
300	960 (3.2 x water depth)
450	810 (1.8 x water depth)
600	600 (1.0 x water depth)
750	450 (0.6 x water depth)
900	360 (0.4 x water depth)

RESON

Version: B006 030205

SeaBat 8160

PRODUCT SPECIFICATION

MULTIBEAM ECHOSOUNDER SYSTEM

- **Swath coverage greater than 4x water depth**
- **Operational depth: 10m to 3000m**
- **50 kHz frequency**
- **126 beams**
- **Hull-mount or portable**
- **Meets IHO accuracy**
- **Sidescan upgradable**

The SeaBat 8160 is a new addition to the 8100 series of multibeam echosounders. Operating at 50 kHz, the system ensonifies the whole swath in a single ping, generating 126 simultaneous high-resolution receive beams.

The SeaBat 8160 transducer array is comprised of a linear receive and transmit array mounted together on a support base. The T-shaped array geometry provides the basis for a compact, high-resolution sonar which is easily installed for portable or hull mounts—a first for a high-resolution system in this frequency range.

The system features a pitch-stabilized transmitter and an active roll-compensated receiver.

The SeaBat 8160 processor is compatible with other SeaBat sonar heads. It can be updated in minutes to accommodate future requirements, and features a user-friendly point-and-click interface.

RESON

RESON A/S • DENMARK
Tel +45 47 38 00 22
Fax +45 47 38 00 66
Email: reson@reson.dk

RESON OFFSHORE • UK
Tel +44 1224 709 900
Fax +44 1224 709 910
Email: sales@reson.co.uk

RESON, INC. • USA
Tel +1 805 964 6260
Fax +1 805 964 7537
Email: sales@reson.com

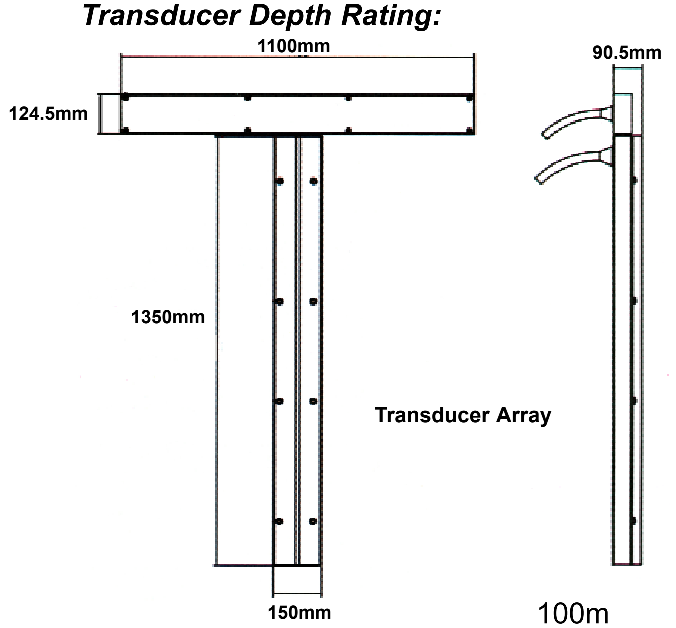
RESON, GmbH • GERMANY
Tel +49 431 720 7180
Fax +49 431 720 7181
Email: reson@reson-gmbh.de

www.reson.com

SeaBat 8160 SYSTEM SPECIFICATIONS

SYSTEM PERFORMANCE

Frequency:	50 kHz
Depth Resolution:	2.4 cm / 9.6 cm
Swath Coverage:	Greater than 4x water depth
Max Operational Depth:	3000 m
Number of Beams:	126
Along-Track Beamwidth:	1.5º
Across-Track Beamwidth:	1.5º
Pitch Stabilization:	±10º
Accuracy:	IHO Special Order
Operational Speed:	Up to 20 knots
Max. Update Rate:	15
Transducer Depth Rating:	100m



Mounting Frame
Option 034H

INTERFACE

System Supply:	115V/230V 50/60 Hz, 350W
Video Display:	SVGA, 800 x 600, 72 Hz
System Control:	Trackball or from Ethernet
Data Output:	10 MB Ethernet or serial RS232C
Data Uplink:	High-speed digital coax with fiber-optic option
Temperature:	Operating: 0° to +40° C Storage: -30° to +55° C

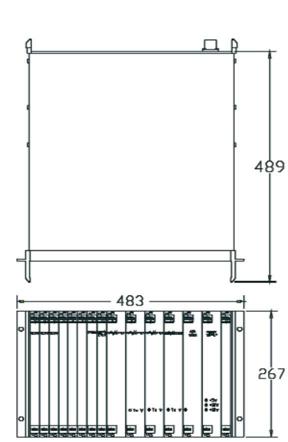
MECHANICAL INTERFACE

Dimensions (HWD in mm):

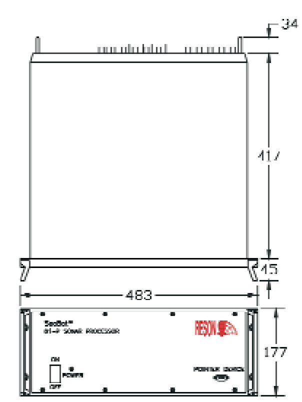
Transducer Array:	1474.5 x 1100 x 90.5
Processor:	177 x 483 x 417
Transceiver:	265 x 483 x 492

Weight:

Transducer Array:	50 kg (dry) / 30 kg (wet)
Processor:	20 kg
Transceiver:	13.6 kg



Transceiver



Processor

Version: B34-PDF-011009

Due to our policy of continuous product improvement,
RESON reserves the right change specifications without notice.

POS MV™ 320

Performance

	RTK	DGPS
Position (m)	0.02 - 0.10	0.5 - 4.0
Velocity (m/s)	0.03	0.03
Roll and Pitch	0.01û	0.02û
True Heading	4m baseline: 0.01, 2m baseline: 0.02û	
Heave	5% of heave amplitude or 5cm	

Physical Specifications

Size	IMU	204 x 204 x 168mm
	PCS	441 x 111 x 346mm, 2.5U 19" rack mount
	Antenna	178 ∅ x 77mm (2x)
	Choke Ring	360 ∅ x 61mm (2x)
Weight	IMU	3.5 Kg
	PCS	7 Kg
Power		110/220 VAC, 60/50 Hz, 60W
Operating Temperature	IMU & Antennas	-40û to +60ûC
	PCS	0û to +60ûC
Humidity	IMU & Antennas	0 to 100%
	PCS	5 to 95% RH non-condensing
Cables	IMU	8m standard
	Antennas	15m standard (2x)

Interfaces

Ethernet Interface (10base-T)	Function	Operate POS MV™ & record data
	Data	Position, attitude, heading, velocity, track and speed, acceleration, status and performance, raw data. All data has time and distance tags
	UDP Ports	Display port - low rate (1Hz) data
		Data port - high rate (1-200Hz) data
	IP Ports	Control port - used by POS™ controller
RS232 Interface (DB9 males)	NMEA Port	GGA, HDT, VTG, GST, ZDA, PASHR, PRDID (1-50Hz), GGK
	High rate attitude data port	Roll, pitch, true heading and heave in all multibeam proprietary formats (1-200 Hz)
	Auxillary GPS input	GGA, GST, GSA, GSV from Auxilliary DGPS, P-code or RTK reciever
Options	Internal RTK GPS receiver; analog interface (roll, pitch & heave); field support kit	

All performance figures are RMS, unless otherwise noted. Specifications subject to change without notice.

APPLANIX™ MARINE

Applanix LLC 17461 Village Green Drive, Houston, TX, 77040
tel: 713-896-9900 fax: 713-896-9919 email: info@applanix.com

MBX-3S

The most popular commercial-grade Coast Guard Beacon Receiver

- Dual-channel Coast Guard beacon receiver
- Supplements GPS systems with free differential corrections, enhancing accuracy
- Fast signal acquisition
- Wide input voltage range for a variety of power sources
- Low power consumption extends battery life
- Automatic tuning mode for hands-free operation
- Integrated signal splitter outputs GPS signal from combined GPS /differential antennas
- Front-panel interface for easy configuration and status monitoring

ESRI Technology
AUTHORIZED BUSINESS PARTNER

csi wireless™
www.csi-wireless.com

MBX-3S

The most popular commercial-grade DGPS Beacon Receiver

Receiver Specifications

Channels:	2 independent channels
Channel Spacing:	500 Hz
Frequency Range:	283.5 to 325.0 Hz
MSK Bit Rates:	50, 100, 200 bps
Cold Start Time:	<1 min
Warm Start Time:	<2 seconds
Demodulation:	Minimum shift keying
Sensitivity:	2.5 µV/m for 6 dB SNR
Dynamic Range:	100 dB
Frequency Offset:	±8 Hz (27 ppm)
Adjacent Channel Rejection:	61 dB f_o ± 400 Hz
Correction Output Protocol:	RTCM SC-104
Input Status Protocol:	NMEA 0183

Communications

Interface:	RS-232C or RS-422
Baud Rates:	2400, 4800, 9600

Environmental Specifications

Operating Temperature:	-30°C to +70°C
Storage Temperature:	-40°C to +80°C
Humidity:	95% non-condensing
EMC:	EN 60945 EN 50081-1 EN 50082-1 FCC: Part 15, sub-part J, class A digital device

Power Specifications

Input Voltage Range:	9 to 40 VDC
Nominal Power:	2.5 W
Nominal Current:	210 mA
Antenna Voltage Output:	10 VDC (5 VDC optional)
Antenna Input Impedance:	50 Ω

Mechanical Specifications

Dimensions:	150 mm L x 125 mm W x 51 mm H (5.9" L x 4.9" W x 2.0" H)
Weight:	0.64 kg (1.4 lb)
Display:	2-line x 16-character LCD
Keypad:	3-key switch membrane
Power Connector:	2-pin circular locking
Data Connector:	DB9-S
Antenna Connector:	BNC-S
Optional GPS Output Port:	TNC-S

Operating Modes

MBX-3 Mode (Default):	RTCM SC-104 correction and NMEA status message output (Default Mode)
MBX-E Mode:	RTCM SC-104 correction and NMEA status message output and GPS NMEA message input for position and satellite status display

NMEA 0183 I/O

- Receiver Automatic and Manual tune command
- Frequency and data rate query
- Receiver performance and operating status queries
- Automatic search almanac queries (proprietary)
- Baud rate selection command
- Receiver tune command
- Force cold start command (proprietary)
- Software upgrade command (proprietary)
- Configuration up-load command (proprietary)

Accessories

Antenna:	Various
Power Cables:	Various
Antenna Cables:	Various
Data Cables:	Various
CSI Beacon Command Center:	MS Windows 95® beacon control software

Pin-out

RS, 232C (DB9 PIN#)

Pin 2	TXD, RTCM SC-104/Status Output
Pin 3	RXD, configuration input
Pin 5	Signal return

RS-422 (DB9 PIN#)

Pin 1	TXD +, RTCM SC-104 / Status Output
Pin 2	TXD -, RTCM SC-104 / Status Output
Pin 4	RXD -, configuration input
Pin 5	Signal return
Pin 7	RXD +, configuration input

Warranty: Each CSI Wireless product is covered by a limited one-year warranty on parts and labor.

CSI Wireless Dealer

Avery label #05260 (laser print)

Printed in Canada.

csi wireless™
4110 - 9th Street SE • Calgary • AB • Canada • T2G 3C4
Phone (403) 259•3311 • Fax (403) 259•8866

CEEDUCER™ Hydrographic Survey System

The CEEDUCER hydrographic survey system comprises of three basic modules, integrated with appropriate firmware into one neat composite package to give a system that is unsurpassed for portability, accuracy, ease of use and installation. Various options, such as tracking display, tide gauge, GPS Base station, and radio telemetry are easily added with minimum fuss at additional cost.

Display and processor unit (DPU):
The DPU unit has been designed for easy of operation, with very simple controls. Provision is made for entry of speed of sound, draft setting and calibration gate for bar checking the echo sounder. Where appropriate, sounding velocity can be set automatically based on water temperature and salt/fresh water selection by User. The unit provides a RS232 output in NMEA or ODOM emulation formats. All soundings, plus position every two seconds, are logged internally. Special 'event' markers can be entered manually from the keyboard. Full geodetic setup facilities for change of spheroid and grid are available. Where appropriate, positions can be averaged automatically. The LCD display is a high contrast type for use in bright light conditions and includes a backlit panel for night use, the LCD can be turned off after a selected interval when using the power save option.

Echo sounder unit:
The CEEDUCER echo sounder uses the latest technology in transducer manufacture. The sound source and the power driver/receiver electronics are moulded as an integral unit. The result is that cable noise is totally eliminated, with the echo returns being sent to the display unit in digital form rather than analogue. The CEEDUCER produces a bottom trace that is remarkably free from noise. This design also allows the CEEDUCER to work accurately in very shallow water, to a minimum depth of 30cm. No other echo sounder can produce such noise-free signals to do this. Bruttour International has worked closely with the manufacturer in design and testing, to produce a Bruttour proprietary survey standard, high-accuracy instrument. Two 200kHz-transducer types are available with beam widths of either 8° or 2.75°. Depth range is 0.3 to 99.99 metres with 0.01 metre accuracy. If preferred user can input Digital depth data (single or dual channel) from external echosounder.

GPS Receiver:
The display unit can be fitted with an 8 or 12 channel GPS receiver using a dual Marine Beacon / GPS antenna. The display unit's micro-controller integrates the GPS data and provides Grid conversions and display / logging options. GPS position data can be averaged over a period of time. If preferred user can input position from external GPS receiver. The CEEDUCER System can be also supplied with internally installed RTK receiver and associated telemetry, plus remote RTK Base Station.

Differential input (DGPS):
For differential operation, a Marine Radio Beacon receiver is included to provide RTCM differential input to the GPS receiver. Alternatively, differential corrections can be entered from an external source.

Track Guidance:
The companion program, CEEDUCER2, provides track guidance, graphical data editing, preparation of plot files, and computation of quantities. Alternatively, for track guidance use MiniCEE™ and the Psion Workabout™ Handheld computer, especially suitable for bright sunlight conditions.

Units: The CEEDUCER™ can operate in either metric or imperial units, User selects as required.

Impulse 200 LR Laser

Our Impulse lasers are specifically designed for optimal performance under whatever conditions you might encounter in the field. They are lightweight, extremely rugged, completely waterproof and versatile. Use them as a handheld unit or mount them on a tripod for added stability.

Hardware Specifications:

Typical Target Accuracy & Range	IMPULSE 200 LR	
	(Imperial)	(Metric)
Accuracy (Typical)	0.1 - 0.2 ft	3 - 5 cm
Accuracy (Max)	0.5 ft	15 cm
Overhead cable / Stake	330 ft	100 m
Phone pole / Stockpile	655 ft	200 m
Tree / Tower	985 ft	300 m
Rock Face / Building	1640 ft	500 m
Max Distance	1885 ft	575 m
Range Resolution	.01 ft	0.01 m
Inclination Limits	+/- 90 deg	+/- 90 deg
Inclination Accuracy	+/- 0.1 deg	+/- 0.1 deg
Weight	2.2 lbs.	1 kg
Size	6 x 2.5 x 5 in.	15.2 x 6.4 x 12.7 cm
Power Supply	(2) AA batteries (20 hours of use)	
Environment	Waterproof to IP 67 and NEMA 6	
Temperature	- 22 to + 140 F	-30 to + 60 C

(Max distances are approximate)

Impulse Laser w/
1.5 to 4 X Zoom Scope
and Mounting Bracket

For 3-D data collection, integrate the Impulse with a MapStar System.

MapStar
Angle
Encoder

MapStar
Compass
Module

Key Features:

- Custom backlit LCD display
- Audible and visual indicators
- RS232 serial output for electronic data storage
- Selective range gating for positive target acquisition
- Built-in tilt sensor
- Filter system to discriminate reflective targets
- Cumulative distance capability
- Determines the distance between two in-line objects
- Integrates with GPS

Package Includes:

- Impulse laser
- Red-dot scope
- Hand strap
- Tripod / monopod mounting bracket
- (2) AA batteries
- Operator's manual
- Padded carrying case

Optional Accessories:

- 1.5 to 4 X zoom scope
- Yoke and staff
- Remote trigger data cable

Impulse Laser w/
Red-dot Scope
and Hand Strap

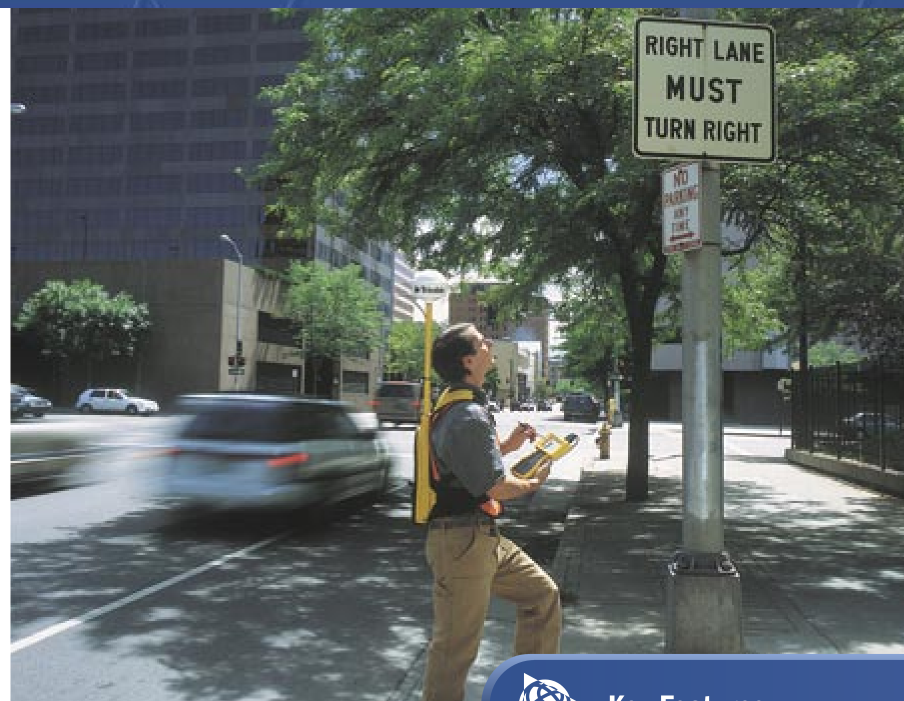
LASER TECHNOLOGY INC
Redefining Measurement

7070 S. Tucson Way, Centennial, CO 80112 USA
Toll Free: 1 (800) 280-6113 | Local: 1 (303) 649-1000
Web Page: www.lasertech.com | E-mail: info@lasertech.com

* All specifications are subject to change without notice.
(Rev. 11/15/03)

GPS Pathfinder Pro XRS

High-performance GPS with a world of real-time options



The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

Built to meet your demands

With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

You're spoiled for real-time choice

If you're navigating in the field, or finding your way back to a previously recorded feature, you've got all the real-time options covered. Corrections from a radiobeacon, a satellite differential service such as OmniSTAR, or a satellite-based augmentation system (SBAS) like WAAS[1] or EGNOS[2] are not just built in, they're seamlessly integrated into the receiver. Want the freedom to connect to an external correction source like a virtual reference station (VRS)? You've got it. This array of real-time sources makes the Pro XRS the most adaptable real-time GPS receiver around.

High quality, accurate data for your GIS

With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.

Get the results you want

The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

Flexible data collection options

Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

All you need

You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

Introduction

The GPS Pathfinder Systems receivers calculate very accurate GPS positions on a second-by-second basis. After postprocessed differential correction, the horizontal accuracy of each position for the GPS Pathfinder Pro XR and Pro XRS receivers is better than 50 cm (RMS) + 1 part per million (ppm) times the distance between the base and the rover. For the GPS Pathfinder Power receiver, the horizontal accuracy is submeter (RMS) + 1 ppm. Using real-time corrections, each position can be as accurate as submeter with the GPS Pathfinder Systems, but is subject to a number of operational conditions.

Note – *RMS means that approximately 63% of the positions are within the specified value.*

Differential GPS Positioning Techniques

Differential GPS (DGPS) requires two or more receivers. One receiver, called the reference station, is located at a known point to determine the GPS measurement errors and compute corrections to these errors. An unlimited number of mobile GPS Pathfinder Systems receivers, commonly called *rovers*, collect GPS data at unknown locations within the vicinity of the reference station. Errors common at both the reference and rover receivers are corrected with DGPS either in real time or during postprocessing.

Note – *For more information about GPS and DGPS, review the All About GPS tutorial on the Trimble website at www.trimble.com.*

The GPS Pathfinder Systems receivers, in combination with Trimble controlling software and the GPS Pathfinder Office software, provide three ways of obtaining submeter positions:

- Real-time DGPS
- Postprocessed DGPS
- Postprocessed real-time DGPS

The accuracy figures given in the sections below are obtained under the following conditions:

- Number of satellites used: ≥ 4
- PDOP: ≤ 6
- Signal-to-noise ratio: ≥ 4
- Satellite elevation mask: ≥ 15°
- Reference station receiver is a Trimble GPS Pathfinder Pro XL, Pro XR, Pro XRS, 4700, 4800, 5700, 5800, 4600 LS™, Series 4000 GPS receiver, DSM™, Reference Station, or equivalent.
- Synchronized measurements are logged at the reference station.
- The logging interval for the roving receiver is the same as, or a multiple of, the logging interval at the reference station.
- The reference station uses the correct antenna.

Real-Time DGPS

When using real-time DGPS, the reference station broadcasts the correction values to the rovers within coverage range, through a transmitter such as a radiobeacon (beacon DGPS) or a satellite (satellite DGPS). The rover applies the corrections to its position in real time.

The positions calculated by the GPS Pathfinder Systems receivers using real-time DGPS are of submeter accuracy + 1 ppm. If you use a provider of real-time DGPS that uses VRS/VBS techniques, there is no degradation associated with distance from the reference station, and the accuracy always stays at the submeter level (RMS).

GPS Pathfinder Systems also supports corrections from satellite-based augmentation systems (SBAS) such as WAAS and EGNOS.

For information on postprocessing GPS data collected with real-time DGPS, see Postprocessed real-time DGPS, page 20.

Postprocessed DGPS

When real-time DGPS is not available, or is available only part of the time, you have to postprocess the autonomous GPS data in your rover file to obtain the stated accuracy. When using postprocessed DGPS, the reference station stores the correction values in base data files on a computer.

Many reference station owners provide their base data to the community through the Internet or other means of communication. Often this means that you do not have to set up your own reference station for postprocessed DGPS, but can use an existing one. For a list of available reference stations, visit the Trimble website www.trimble.com/trs/findtrs.asp.

Postprocessed real-time DGPS

Postprocessed DGPS positions are generally more accurate than DGPS positions obtained in real time. If you collect SuperCorrect records as well as GPS positions using Trimble TerraSync or GPScorrect™ software, or applications developed using the GPS Pathfinder Tools SDK, you can use the SuperCorrect option in the GPS Pathfinder Office software to process the data if the accuracy of the real-time DGPS positions is not sufficient, provided that you have access to suitable reference station base files.

The accuracy using postprocessed real-time DGPS is the same as for postprocessed DGPS (see the previous section).

Factors Affecting Postprocessed DGPS Accuracy

The accuracy that you obtain after data collection depends on several factors, including:

- Number of visible satellites
- Multipath
- Distance between reference station and rover receivers

- Position Dilution of Precision (PDOP)
- Signal-to-noise ratio (SNR)
- Satellite elevations
- Occupation time at a point
- Receiver type at reference station
- Accuracy of the reference station position
- Synchronized measurements are logged at the reference station.
- The logging interval for the roving receiver is the same as, or a multiple of, the logging interval at the reference station.
- The reference station uses the correct antenna.

Number of visible satellites

Generally, you need a minimum of four satellites to get a good position. If you have five or more satellites, accuracy increases by a small amount. You can obtain positions from only three satellites by supplying a height value manually. However, Trimble recommends that you do not use this method, as an inaccurate height can significantly reduce horizontal accuracy.

Note – *The TerraSync software always uses a minimum of four satellites. You cannot configure this setting.*

When the number of visible satellites drops below the required number, the controlling software stops logging positions and displays the message Too few satellites.

Multipath

GPS signals are sometimes reflected off nearby objects, particularly metallic objects, creating false or erroneous results. This phenomenon is known as *multipath*. Severe multipath may cause position errors of many meters, while mild multipath may cause small, undetectable errors. For optimal accuracy, collect data in an environment that is free of large reflective surfaces, such as buildings and trees. EVEREST multipath reduction technology in the receiver helps reduce the effects of multipath.

Distance between reference station and rover

When you postprocess GPS Pathfinder Pro XR and Pro XRS data using the GPS Pathfinder Office software Differential Correction utility, the horizontal accuracy of the positions received is 50 cm (RMS) at a 1 km base line (distance from reference station). For the GPS Power receiver, the horizontal accuracy of the positions received is submeter (RMS) at a 1 km base line.

Accuracy degrades by 1 ppm as the distance between the reference station and the rover increases. This means that 1 mm of degradation occurs for every kilometer between the reference station and the rover. For example, you must collect data within 500 km (310 miles) of your reference station to obtain submeter accuracy for the GPS Pathfinder Pro XR and Pro XRS receiver.

PDOP

PDOP (Position Dilution of Precision) is a unitless measure of the current satellite geometry. It indicates when the most accurate results are provided. When satellites are spread around the sky, the PDOP value is low, and the computed position is more accurate. When the satellites are grouped closely together, the PDOP value is high, and the computed position is less accurate. The lower the PDOP value, the more accurate the GPS positions.

You can configure the PDOP mask so that if the PDOP exceeds the mask value, the controlling software stops logging positions. A PDOP mask of 6 is required for submeter accuracy.

SNR

SNR (signal-to-noise ratio) is a measure of the satellite signal strength relative to the background noise. A strong signal with low noise provides better accuracy. You can raise the SNR mask so that weak signals with an SNR below the mask are excluded from the position computation. In areas of dense canopy, the SNR mask can be lowered so that you can collect GPS positions, although you may not achieve submeter accuracy. For best results, the recommended setting for the SNR mask is 4.

Elevation mask

When a satellite is low on the horizon, the GPS signals must travel further through the atmosphere, delaying reception by the receiver. To minimize noisy data, adjust the elevation mask. Satellites below the mask are excluded from the position computation. For best results, the recommended setting is 15°.

Occupation period

The GPS Pathfinder Systems receivers achieve the specified horizontal accuracy with a one-second occupation time.

***Note** – To achieve higher levels of accuracy using a GPS Pathfinder Systems receiver, collect carrier-phase data and postprocess using the GPS Pathfinder Office software.*

Receiver type

The following Trimble receiver models use Maxwell™ technology and, when used as the reference station, yield submeter accuracy with GPS Pathfinder Systems receivers:

- GPS Pathfinder Pro XRS
- GPS Pathfinder Pro XR
- GPS Pathfinder Pro XL

- 5800 GPS receiver
- 5700 GPS receiver
- 4800 GPS receiver
- 4700 GPS receiver
- 4600 LS Surveyor
- 4000 series receiver
- DSM Reference Station

Warning – If the GPS receiver at the reference station has fewer than 12 channels, you may be unable to differentially correct some of your data. If the reference station is not capable of logging data from all of the satellites the rover is using, the data collected by the rover cannot be differentially corrected using postprocessing.

Accuracy of the reference station position

Any inaccuracy in the reference station position is reflected in your rover position accuracy. For information on the accuracy of your local DGPS reference station coordinates, contact the provider of that service, and check the Integrity Index in the GPS Pathfinder Office version 3.00 Differential Correction utility when selecting a new base station provider.

The Integrity Index provides you with an indication as to the quality of available base data in comparison to other available sources. Poor base data can result from a number of factors, such as an incorrect reference position, bad environmental location, or a large distance between the base and rover receivers. Base data downloaded from each station is analyzed to formulate the quality indicator values and three key measures are taken into account:

- Bias (the measure of distance between an averaged GPS position and a specified reference position)
- Precision (the measure of the spread of actual GPS positions)
- The distance between the base and rover receivers

Use the Integrity Index to avoid selecting base data that may provide an inferior differential correction result. The quality indicator has a range of 0 to 100, where 0 represents low quality base data and 100 represents high quality base data. For more information, refer to the GPS Pathfinder Office 3.00 Differential Correction Help.

Synchronized measurements

To obtain optimal accuracy from differential correction, the reference station must record reference data (or output differential corrections) from synchronized measurements. Synchronized measurements occur when the reference station receiver and rover receivers simultaneously make measurements to all the satellites they are tracking.

When you use one of the receivers listed in Receiver type, page 23, as a reference station receiver, the data is always synchronized. When measurements are not synchronized, there is no equivalent reference station position measured at exactly the same time as the rover position. A simultaneous reference station position must be interpolated, which reduces accuracy.

Logging intervals

Ideally, the logging interval at the reference station should be the same as the logging interval at the rover. For example, if the reference station is using a 5-second logging interval, the rover logging interval should be 5 seconds. The rover logging interval can also be a direct integer multiple of the interval at the reference station. For example, if the reference station is logging every 5 seconds, the rover can log every 10 seconds.

If the rover logging interval is not synchronized with the reference station, the accuracy of the GPS positions logged by the rover may not be submeter. This is because the reference station measurements must be interpolated to correct the roving receiver's measurements. For more information, see Synchronized measurements, page 25.

If the synchronized measurement logging interval at the reference is 1 second, you can use any logging interval at the rover. However, this generates a large file at the reference station. If the computer or data collector at the reference station runs out of space, you cannot differentially correct any rover data collected after the base file ends.

When disk space is at a premium, the best option is a 5-second logging interval for synchronized measurement data at the reference station and a 5-second logging interval for positions at the rover. This is frequent enough to be practical at the rover and uses the default reference station logging interval, which results in base files that are not too large.

Table 3.1 gives examples of various reference station and rover intervals and their effect on accuracy. They are valid for both postprocessed and real-time corrections.

Table 3.1 Logging Interval Accuracy

Reference station interval (seconds)	Rover interval (seconds)	Base data interpolated?	Notes
1	1	No	Recommended for best accuracy.
5	5	No	Recommended if reference station disk space is at a premium.
1	3, or 5, or 6, etc.	No	The rover interval is a direct integer multiple of the reference station interval.
5	10	No	The rover interval is a direct integer multiple of the reference station interval.
5	1	Yes	Base data is interpolated at seconds 1, 2, 3, and 4. A slight degradation of accuracy occurs with interpolation. One in five of the rover positions is not interpolated.

Factors Affecting Real-Time DGPS Accuracy

Real-time DGPS offers similar accuracies to postprocessed GPS. However, in addition to the factors discussed in Factors Affecting Postprocessed DGPS Accuracy, page 20, there are other factors that affect the accuracy of real-time DGPS positions. These factors include:

- Update rate of the corrections
- Corrections based on a different datum

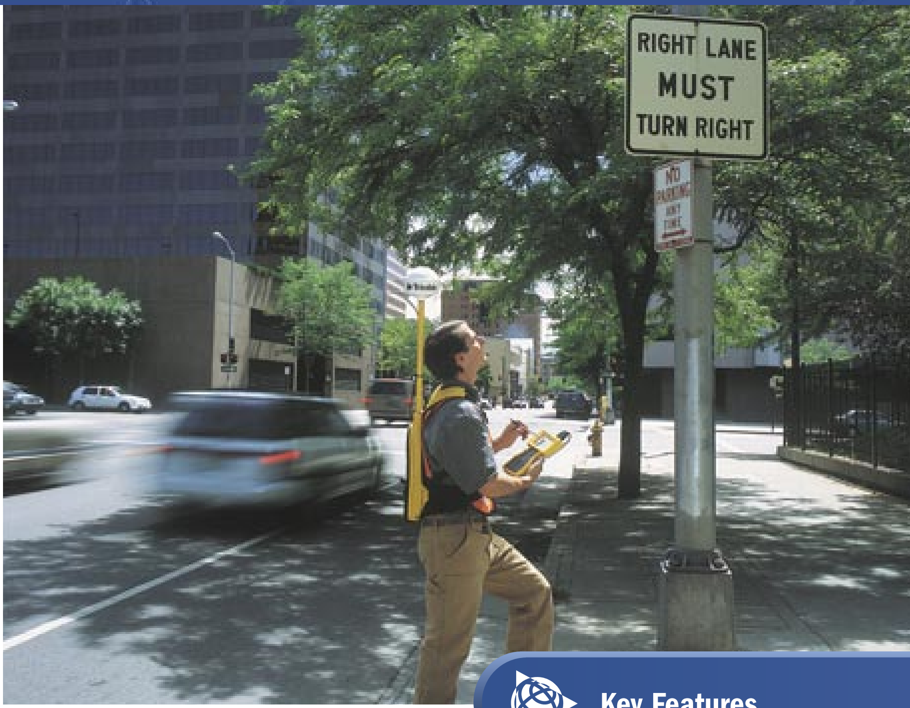
Update rate of the corrections

The frequency, or rate, at which the RTCM differential correction messages are output from the reference station affects the accuracy of the GPS positions recorded by the roving receiver. The latency of the corrections (that is, the time it takes for up-to-date information to get from the reference station to the rover) also affects the rover position accuracy.

Datum of corrections

Errors can occur if the reference stations use a datum other than WGS-84 as the basis for the DGPS corrections. The error introduced by using a reference station that transmits coordinates using a different datum is generally quite small. However, in some places the margin of error can be 5–10 meters. To avoid this type of error, set Trimble controlling software to collect SuperCorrect data. You can then postprocess the real-time DGPS positions if required.

GPS Pathfinder Pro XRS



High-performance GPS with a world of real-time options

The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

Built to meet your demands

With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

You're spoiled for real-time choice

If you're navigating in the field, or finding your way back to a previously recorded feature, you've got all the real-time options covered. Corrections from a radiobeacon, a satellite differential service such as OmniSTAR, or a satellite-based augmentation system (SBAS) like WAAS[1] or EGNOS[2] are not just built in, they're seamlessly integrated into the receiver. Want the freedom to connect to an external correction source like a virtual reference station (VRS)? You've got it. This array of real-time sources makes the Pro XRS the most adaptable real-time GPS receiver around.

High quality, accurate data for your GIS

With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.

Get the results you want

The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

Flexible data collection options

Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

All you need

You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

What Can the GPS Pathfinder Systems Receivers Do?

The GPS Pathfinder Systems receivers, with Trimble controlling software, make an ideal system for all GIS data collection and maintenance projects. The system allows you to collect precise data for utility, urban, and natural resource databases. As the demand for accurate and up-to-date position and attribute information increases, the system allows you to update existing GIS data, ensuring that decisions made with the GIS are based upon the most accurate, current, and reliable data available.

The foundation of the GPS Pathfinder Systems receivers is precise GPS positioning technology. The GPS receivers feature 12 parallel channels for continuous satellite tracking. Using differential GPS, the GPS Pathfinder Systems receivers deliver differentially corrected C/A code positions to submeter accuracy on a second-by-second basis under the most challenging operating conditions.

Integrated Satellite Based Augmentation System (SBAS) receiver

Satellite Based Augmentation System (SBAS) support is integrated into the GPS Pathfinder Pro XR, Pro XRS, and Power receiver. It allows you free access to real-time solutions transmitted from geostationary SBAS satellites, such as the Wide Area Augmentation System (WAAS) in the United States and the European Geostationary Navigation Overlay Service (EGNOS) in Europe.

Integrated beacon receiver

The MSK beacon receiver is included in the GPS Pathfinder Pro XR and Pro XRS receivers. It allows you free access to real-time solutions transmitted from DGPS radiobeacons operating in the MF (medium frequency) band from 283.5 kHz to 325 kHz. The integrated MSK beacon receiver is an advanced dual-channel radiobeacon receiver. It tracks broadcasts from DGPS radiobeacons conforming to the IALA Standard. The beacon receiver uses its *all-digital signal processing* techniques to track and demodulate signals from DGPS radiobeacons.

For an up-to-date list of beacon stations, visit the following Web page:

- www.trimble.com/findbeacon.asp

Integrated satellite differential receiver

The integrated satellite differential capability of the GPS Pathfinder Pro XRS and Power receivers decodes and uses satellite differential corrections to provide submeter position accuracy. To receive and decode these satellite signals, you must subscribe to a satellite differential correction service. The GPS Pathfinder Pro XRS and Power receivers support the OmniSTAR satellite differential correction services. For information on obtaining a subscription, subscription rates, and satellite coverage maps, visit www.omnistar.com

Once you have a subscription, you activate the service through an on-the-air signal or an encrypted activation message entered into the controlling software.

Satellite differential signals provide valid corrections over a large area. Integrated virtual reference/base station (VRS/VBS) technology permits the satellite corrections to be uniformly accurate over the entire satellite coverage area, without the degradation in accuracy associated with increasing distance from fixed reference stations.

Satellite differential signals are line-of-sight and can be blocked by mountains, buildings, or tree canopy. Wet canopy, from a heavy rain, reduces the signals even more. The same environmental factors that affect the GPS signal, such as radar and microwave transmitters, can interfere with the satellite signal. Power lines usually have no effect.

External differential correction receiver

The GPS Pathfinder Systems receivers can also receive differential corrections from any external differential correction receiver that communicates in the standard RTCM SC-104 data format.

Standard GPS Pathfinder Pro XR and Pro XRS Features

The GPS Pathfinder Pro XR and Pro XRS receivers offer the following:

- 12-channel DGPS receiver with EVEREST™ multipath rejection technology, L1 C/A code tracking with carrier-phase smoothing, and instantaneous full-wavelength carrier-phase measurements.
- Submeter accuracy – Typically horizontal accuracy less than 50 cm RMS with GPS Pathfinder Office software postprocessing. This requires data to be collected with a minimum of 4 satellites, maximum PDOP of 6, minimum SNR of 4, minimum elevation of 15 degrees, and reasonable multipath conditions.
- Integrated WAAS/EGNOS differential corrections
- 1 Hz position and velocity update rate.
- Velocity computations incorporate carrier-phase data.
- Time to First Fix typically less than 30 seconds.
- Two RS-232 serial ports.
- NMEA-0183 output to external NMEA devices (supported messages are ALM, GGA, GLL, GSA, GSV, VTG, and ZDA).
- RTCM-SC 104 input from an external differential correction receiver.
- TSIP protocol to/from the field device.
- Fully automatic and manual beacon operating modes, fast acquisition of differential beacon signals.

- Immunity to MSK jamming signals, advanced techniques for combating atmospheric noise in the beacon receiver.
- Integrated GPS/MSK beacon antenna.
- User-upgradeable receiver firmware.
- Receiver manual.
- CE Mark compliance.

Additional GPS Pathfinder Pro XRS receiver features

The GPS Pathfinder Pro XRS GPS/MSK/beacon/satellite differential receiver offers the items previously listed, and also:

- Integrated L-band satellite differential correction receiver
- Combined L1 GPS/beacon/satellite differential antenna

Combined L1 GPS/beacon/satellite differential antenna

The GPS Pathfinder Pro XRS receiver integrated L1 GPS/beacon/satellite differential antenna (P/N 33580-50) features two antenna components:

- L1 GPS/satellite differential antenna

  This active antenna is designed to filter out unwanted signals and amplify the L1 GPS and satellite differential signals for transmission over the antenna cable to the receiver.

- MSK H-field loop beacon antenna

  This antenna features a pre-amplifier for filtering out signal interference such as AM radio broadcasts and noise from switching power supplies. After filtering, the pre-amplifier amplifies the MF signal for transmission over the same antenna cable to the beacon receiver.

The coaxial antenna cable also carries DC power to the pre-amplifier of both the L1 GPS/satellite differential and beacon antennas over the center conductor of the cable.

The antenna assembly integrates the L1 GPS/satellite differential antenna and a beacon antenna into a single antenna assembly, as shown in Figure 2.2. The antenna assembly is completely weatherproof and is designed to withstand harsh environmental conditions.

Figure 2.2 Combined L1 GPS/beacon/satellite differential antenna (for the GPS Pathfinder Pro XRS receiver)

Introduction

This appendix lists specifications for GPS Pathfinder Systems receivers and antennas, and pinouts for cables that are supplied with the receivers.

Specifications

Table B.1 lists specifications for the GPS Pathfinder Pro XR and Pro XRS receiver.

Table B.1 GPS Pathfinder Pro XR and Pro XRS receiver specifications

Parameter	Specification
General	12 channel, L1/CA code tracking with carrier phase filtered measurements and multibit digitizer
Update Rate	1 Hz
Time to First Fix	< 30 seconds, typical
Size	11.1 cm × 5.1 cm × 19.5 cm (4.4" × 2.0" × 7.7")
Weight	0.76 kg (1.68 lb)
Power	XR 6 W (maximum) XRS 7 W (maximum) both 10 to 32 VDC
Temperature	–20 °C to 65 °C (–4 °F to 149 °F) operating –30 °C to 85 °C (–22 °F to 185 °F) storage
Humidity	100% non-condensing
Casing	Dustproof, splashproof, shock-resistant, sealed to 5psi

Table B.3 lists specifications for the GPS Pathfinder Pro XRS antenna.

Table B.3 Combined L1 GPS/beacon/satellite differential antenna specifications

Parameter	Specification
General	Right-hand, circular polarized; omnidirectional; hemispherical coverage
Size	15.5 cm diameter × 14 cm high (6.1" × 5.5")
Weight	0.55 kg (1.2 lb)
Temperature	–20 °C to 65 °C (–4 °F to 149 °F) operating –40 °C to 85 °C (–40 °F to 185 °F) storage
Humidity	100% fully sealed
Casing	Dustproof, waterproof, shock resistant

Pinouts

Table B.5 lists the pinouts for the GPS Pathfinder Pro XR and Pro XRS receiver's data/power cable.

Table B.5 Data/power cable pinout (P/N 30231-00)

To GPS Pathfinder Pro XR and Pro XRS receiver				Field Device		Input Power		
Conn P1			**7 Cond Cbl #1**	**Conn P2 DE9-F**		**2 Conn Cbl #2**	**Conn P3 TA3-M**	
Event In	1	in	—	—		—	—	
TXD out	2		Orange	2	RXD	—	—	
RXD	3	in	Red	3	TXD	—	—	
Chg Ctrl	4	in	Black	4	DTR	—	—	
Sig Gnd in/out	5		Shield	5	Sig Gnd	—	—	
DSR out	6		Yellow	6	DSR	—	—	
Pwr On	7	in	Brown	7	RTS	—	—	
CTS out	8		Green	8	CTS	—	—	
Charge out	9		Blue	9	RI	—	—	
V+ In	10	in	—	—		White	1	V+ In
V– In	11	in	—	—		Black	2	V– Out
PPS —	12		—	—		—	—	

Table B.7 lists the pinouts for the GPS Pathfinder Pro XR and Pro XRS receiver's NMEA/RTCM cable.

Table B.7 NMEA/RTCM cable pinout (P/N30232-00)

To GPS Pathfinder Pro XR and Pro XRS receiver				NMEA/RTCM output connectors		
Conn P1			**9 Cond Cbl #1**	**Conn P2 DE9-M**	**7 Conn Cbl #1**	**Conn P3 DE9-F**
Event In	1	in	—	—	—	—
TX– (232)	2	out	—	—	Orange	2 TXD
RX– (232)	3	in	Red	2 RXD	—	—
Chg Ctrl	4	in	—	—	Shield	
Sig Gnd	5	in/out	Shield	5 Sig Gnd	—	5 Sig Gnd
TX+ (422)	6	out	—	—	—	
Pwr On	7	in	—	—	—	—
RX+ (422)	8	out	—	—	—	—
Charge	9	out	Yellow	9 Pwr	—	—
V+ In	10	in	—	—	—	—
V– In	11	in	—	—	—	—
PPS	12	—	—	—	Brown	4 DTR

GPS Pathfinder Pro XRS

High-performance GPS with a world of real-time options

The versatile GPS Pathfinder® Pro XRS receiver is the thoroughbred of GPS receivers. Offering a full range of accurate real-time correction sources, great performance in all GPS conditions, and rugged design for the toughest environments, the Pro XRS is an essential tool for collecting and maintaining GPS data.

Built to meet your demands

With the Pro XRS, you don't have to worry whether your GPS receiver can stand up to harsh conditions. All its components are sealed in a robust casing. Waterproof, dustproof, and shock-resistant, the Pro XRS can work anywhere you can.

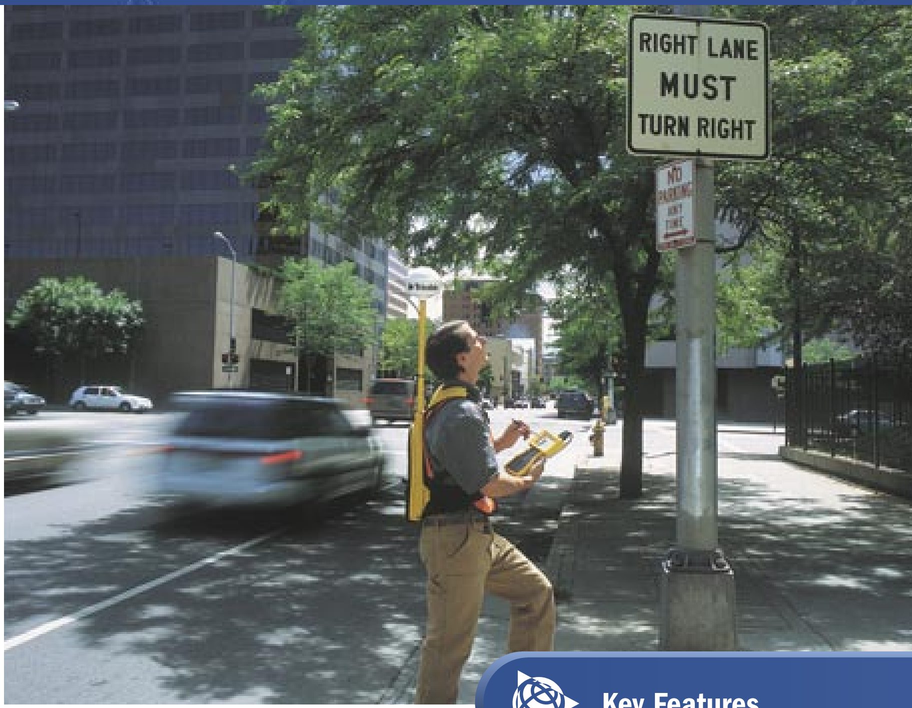
Just as tough is the custom-designed ergonomic backpack. But it's light and comfortable, so you can wear it all day.

You're spoiled for real-time choice

If you're navigating in the field, or finding your way back to a previously recorded feature, you've got all the real-time options covered. Corrections from a radiobeacon, a satellite differential service such as OmniSTAR, or a satellite-based augmentation system (SBAS) like WAAS[1] or EGNOS[2] are not just built in, they're seamlessly integrated into the receiver. Want the freedom to connect to an external correction source like a virtual reference station (VRS)? You've got it. This array of real-time sources makes the Pro XRS the most adaptable real-time GPS receiver around.

High quality, accurate data for your GIS

With the Pro XRS, you can be sure that the data you collect meets your high standards. Offering submeter accuracy in real time, and centimeter-level postprocessed accuracy, it's the obvious choice for collecting the high quality GPS data you need in your GIS. And it has advanced design features, like EVEREST™ multipath rejection technology, to ensure you get only the best positions.



Get the results you want

The GPS Pathfinder Pro XRS's advanced design gives you complete control over GPS quality. You can focus on productivity, to keep working even in adverse GPS conditions. Or you can configure the receiver to deliver only the most precise positions. It's up to you.

Flexible data collection options

Pick the field device and software that fits your workflow. The Pro XRS is ready to use with a variety of field computers, including Trimble's own range of handheld computers: the GIS TSCe™ field device, the Trimble® Recon™ handheld, and the GeoExplorer® series.

Choosing software? Try the TerraSync™ software, for a complete solution from the field to the office and back. Choose off-the-shelf GPS field software. Or use the GPS Pathfinder Tools SDK to build your own application that's totally customized to your needs.

Key Features

- Real-time submeter accuracy
- Integrated satellite, beacon, and WAAS/EGNOS differential receiver
- EVEREST multipath rejection
- Rugged design
- Ergonomic, comfortable backpack system
- Choice of field device and field software

All you need

You need equipment that's as adaptable and hard-working as you are. So when you're choosing GPS equipment, don't compromise. Get a GPS Pathfinder Pro XRS receiver and have it all.

Trimble®

Reference Materials

If you have a problem and cannot find the information you need in the product documentation, *contact your local Distributor*. Alternatively, go to the Trimble Support page at www.trimble.com/support.html, and then do one of the following:

- Browse the available online support resources.
- Request technical assistance from Trimble Support, click the submit an inquiry link, fill in the form, and then click **Send.**

Trimble: www.trimble.com/support.html

Survey Controller: www.trimble.com/tsce.html

Survey Pro: www.tdsway.com

GIS TSCe: www.trimble.com/gistsce.html

ActiveSync™: www.microsoft.com/windowsmobile/resources/downloads/pocketpc/default.mspx

Windows CE: www.microsoft.com/windows/embedded/ce.net

Hardware Specifications

Feature	**TSCe**
Processor	Intel StrongARM SA-1110, 206 MHz
Memory	64 MB low-power SDRAM
Storage	512 MB non-volatile flash disk
Screen	1/4 VGA transflective color LCD
Touch Screen	Passive - 87% transmissivity
Keyboard	57 key tactile action
9-Pin serial port	RS232 COM1
26-Pin MultiPort	RS232 COM2, Ethernet 10BaseT, USB client, power in/out and audio in/out
Infrared	IrDA Type1 COM3
Audio	Integrated speaker and microphone
Batteries	NiMH rechargeable pack, 3800 mAH, 18.5 W-h, 4.8 V
AC Adaptor	Line voltage: 100 - 240 V AC 47-63 Hz

MicroTSG (Thermosalinograph)

SBE 45

The SBE 45 MicroTSG Thermosalinograph is an externally powered, high-accuracy instrument, designed for shipboard determination of sea surface (pumped-water) conductivity and temperature. Salinity and sound velocity can also be computed. The MicroTSG is constructed of plastic and titanium to ensure long life with minimum maintenance.

OPERATION OVERVIEW

Communication with the MicroTSG is over an internal, 3-wire, RS-232C link, providing real-time data transmission. Commands can be sent to the MicroTSG to provide status display, data acquisition setup, data display and capture, and diagnostic tests. User-selectable operating modes include:

- **Polled sampling** – On command, the MicroTSG takes one sample and sends the data to the computer.
- **Autonomous sampling** – At pre-programmed intervals, the MicroTSG samples and sends the data to the computer. The MicroTSG does not enter quiescent (sleep) state between samples.
- **Serial Line Sync** – A pulse on the serial line causes the MicroTSG to wake up, sample, and enter quiescent state automatically.

Calibration coefficients stored in EEPROM allow the MicroTSG to transmit data in engineering units.

SENSORS

The MicroTSG retains the temperature and conductivity sensors used in the SBE 21 Thermosalinograph, but has improved acquisition electronics that increase accuracy and resolution, and lower power consumption. The MicroTSG's aged and pressure-protected thermistor has a long history of exceptional accuracy and stability (typical drift is less than 0.002 °C per year). Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

The MicroTSG's internal-field conductivity cell is unaffected by external fouling, and uses expendable anti-foulant devices.

OPTIONAL PN90402 - SBE 45 POWER, NAVIGATION, and REMOTE TEMPERATURE INTERFACE BOX

An optional AC- or DC-powered Interface Box:

- Provides isolated DC power and an optically isolated RS-232 data interface.
- Contains a NMEA 0183 port for appending navigation information from a NMEA navigation device to the data stream.
- Contains an RS-232 port for appending the output of an optional remote temperature sensor (SBE 38), allowing for measurement of sea surface temperature with minimal thermal contamination from the ship's hull.
- Outputs the data stream (MicroTSG, NMEA navigation device, and SBE 38 data) to the computer over an RS-232 interface.

SOFTWARE

The MicroTSG is supplied with a powerful Win 95/98/NT/2000/XP software package, SEASOFT©-Win32. SEASOFT's modular programs include:

- SEATERM — terminal program for instrument setup and data display.
- SEASAVE — real-time data acquisition and display
- SBE Data Processing — filtering, aligning, averaging, and plotting of data and derived variables.

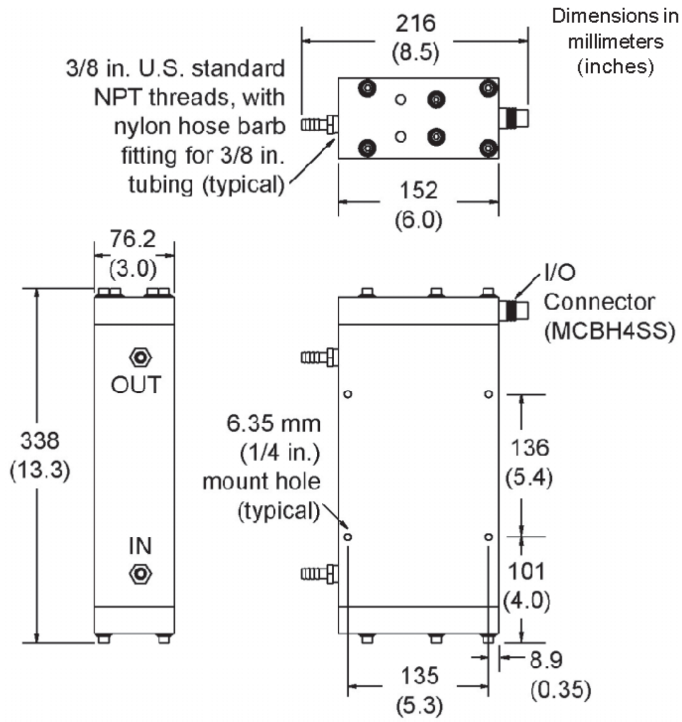
SBE
Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

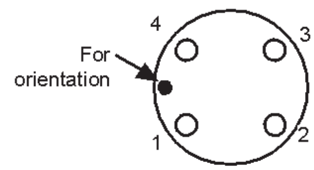
MicroTSG (Thermosalinograph) SBE 45

SPECIFICATIONS

Measurement Range	
Conductivity:	0-7 S/m (0-70 mS/cm)
*Temperature *:*	-5 to 35 °C
Initial Accuracy	
Conductivity:	0.0003 S/m (0.003 mS/cm)
*Temperature *:*	0.002 °C
Salinity:	0.005 PSU, typical
Typical Stability *(per month)*	
Conductivity:	0.0003 S/m (0.003 mS/cm)
*Temperature *:*	0.0002 °C
Salinity:	0.003 PSU, typical
Resolution	
Conductivity:	0.00001 S/m (0.0001 mS/cm)
*Temperature *:*	0.0001 °C
Salinity:	0.0002 PSU, typical
Calibration Range	
Conductivity:	0-6 S/m (60 mS/cm); physical calibration 2.6-6 S/m (26-60 mS/cm), plus zero conductivity (air)
*Temperature *:*	+1 to +32 °C
Time Resolution	1 second
Clock Stability	13 seconds/month
Input Power	8-30 VDC
Acquisition Current	34 mA at 8 VDC; 30 mA at 12-30 VDC
Quiescent Current	10 microamps
Acquisition Rate	1 Hz maximum
Operating Pressure	34.5 decibars (50 psi) maximum
Flow Rate	10 to 30 ml/sec (0.16 to 0.48 gal/min)
Materials	PVC housing
Weight	4.6 kg (10.2 lbs)

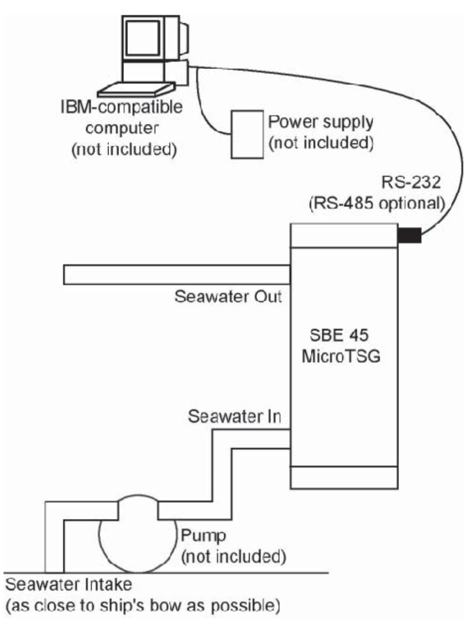
* For specifications for optional SBE 38 remote temperature sensor, see SBE 38 datasheet.



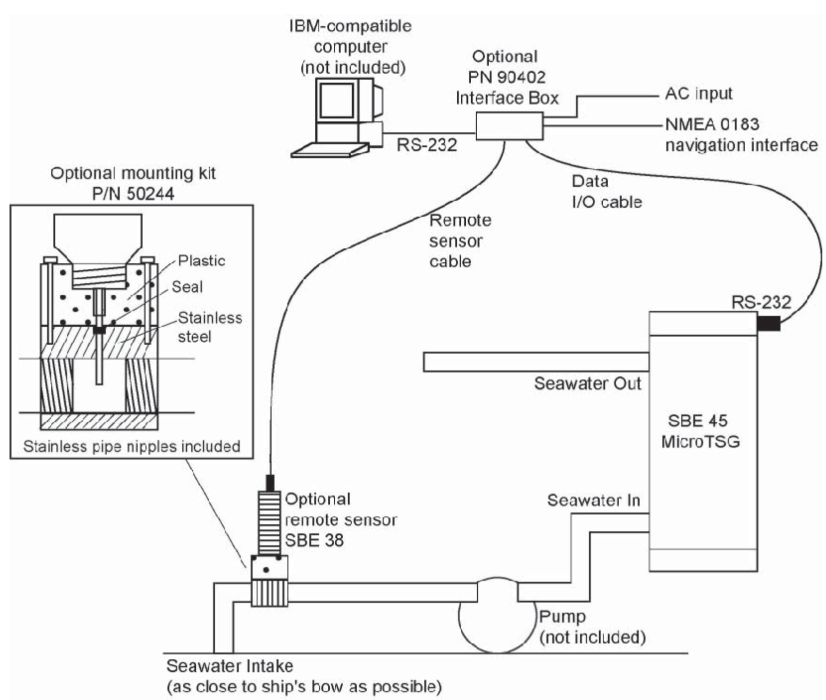


Pin	Signal
1	Common
2	RS-232 RX from computer
3	RS-232 TX to computer
4	External power in (8 - 30 VDC)

System Schematic: SBE 45



System Schematic: SBE 45 with Optional PN 90402 Interface Box and Remote Temperature Sensor



03/04

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface

Serial Number: 19P36026-4585

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

LIMITED LIABILITY STATEMENT

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use of servicing of this system.

WARNING !!

Do not submerge this instrument (S/N 19P36026-4585)
beyond the depth rating of the lowest rated component listed below!

Main Housing (Titanium)	7000 meters
Pressure Sensor (3500 dBar) Druck	**3500 meters**
Pump (SBE 5M)	10500 meters

SYSTEM CONFIGURATION 14 June 2004

Model SBE 19plus	**S/N 19P36026-4585**
Instrument Type	**SBE 19plus SeaCaT Profiler**
Firmware Version	**1.4D**
Communications	**9600 baud, 8 data bits, no parity, one stop bit**
Memory	**8192K**
Housing	**7000 meter (3AL-4V Titanium)**
0 Conductivity Raw Frequency	**2630.97 Hz**
Pressure Sensor	**Strain Gauge: 3500 dBar, S/N 5433**
Number of Voltages Sampled:	**0**
Serial RS-232C Sensor	**None**

Data Format:

Count	**Temperature**
Frequency	**Conductivity**
Count	**Pressure, Strain gauge**

Pump (SBE 5M)	**050647**
Voltage Delay Setting (standard)	**(standard) 0 seconds**

IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

SEASOFT-Win32

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   For the SBE 17 and 25 only: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.

   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

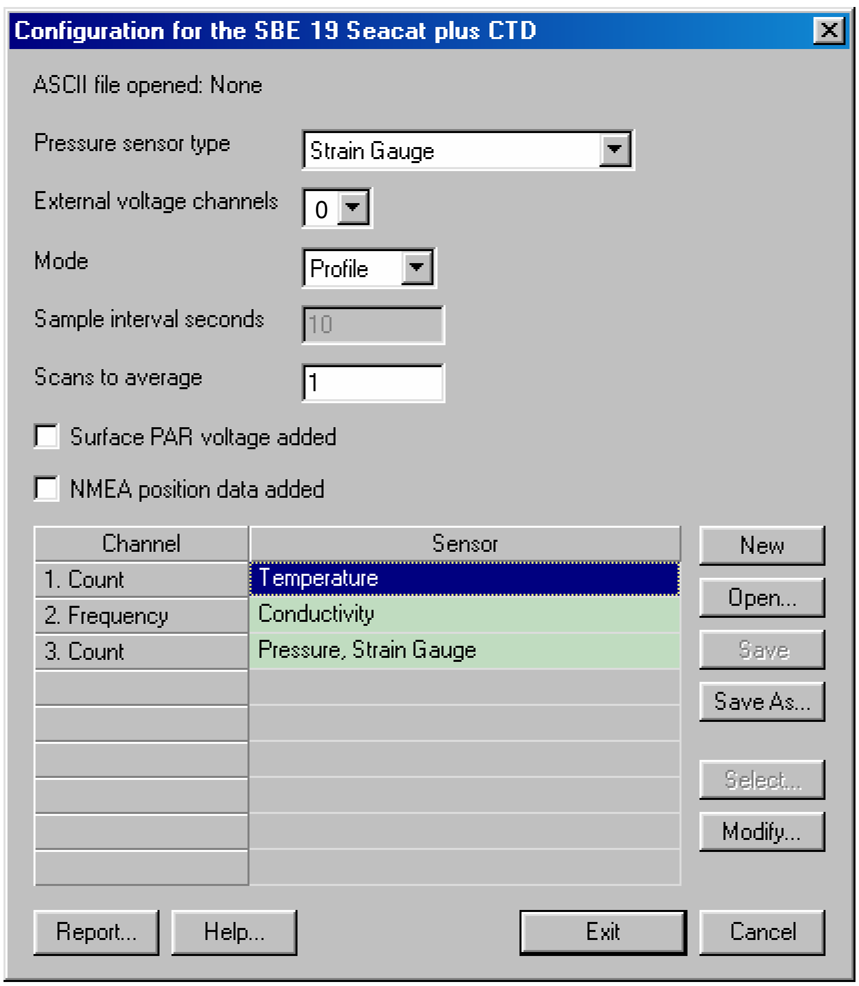
To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or **SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

NOTE:
SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



SPECIFICATIONS

SEACAT Profiler

SBE 19*plus*

The SBE 19*plus* is the next generation *Personal CTD*, bringing numerous improvements in accuracy, resolution (in fresh as well as salt water), reliability, and ease-of-use to the wide range of research, monitoring, and engineering applications pioneered by its legendary SEACAT predecessor. The 19*plus* samples faster (4 Hz vs 2), is more accurate (0.005 vs 0.01 in T, 0.0005 vs 0.001 in C, and 0.1% vs 0.25% — with *seven* times the resolution — in D), and has more memory (8 Mbyte vs 1). There is more power for auxiliary sensors (500 ma vs 50), and they are acquired at higher resolution (14 bit vs 12). Cabling is simpler and more reliable because there are four differential auxiliary inputs on two separate connectors, and a dedicated connector for the pump. All exposed metal parts are titanium, instead of aluminum, for long life and minimum maintenance.

The 19*plus* can be operated without a computer from even the smallest boat, with data recorded in non-volatile FLASH memory and processed later on your PC. Simultaneous with recording, real-time data can be transmitted over single-core, armored cable directly to your PC's serial port (maximum transmission distance dependent on number of auxiliary sensors, baud rate, and cable properties). The 19*plus'* faster sampling and pump-controlled TC-ducted flow configuration significantly reduces salinity spiking caused by ship heave, and allows slower descent rates for improved resolution of water column features. Auxiliary sensors for dissolved oxygen, pH, turbidity, fluorescense, PAR, and ORP can be added, and for moored deployments the 19*plus* can be set to *time-series* mode using software commands. External power and two-way real-time communication over 10,000 meters of cable can be provided with the SBE 36 CTD Deck Unit and Power and Data Interface Module (PDIM).

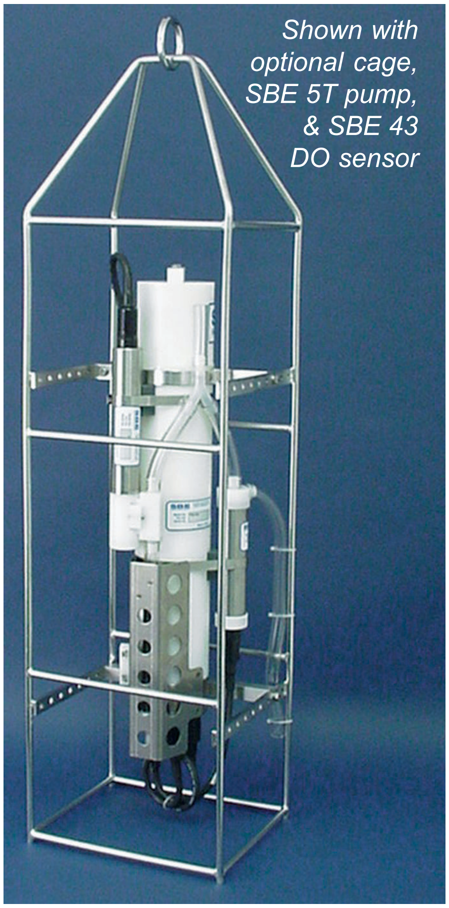
The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

Accuracy, convenience, portability, software, and support; compelling reasons why the 19*plus* is today's best low-cost CTD.

CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger



Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor

SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

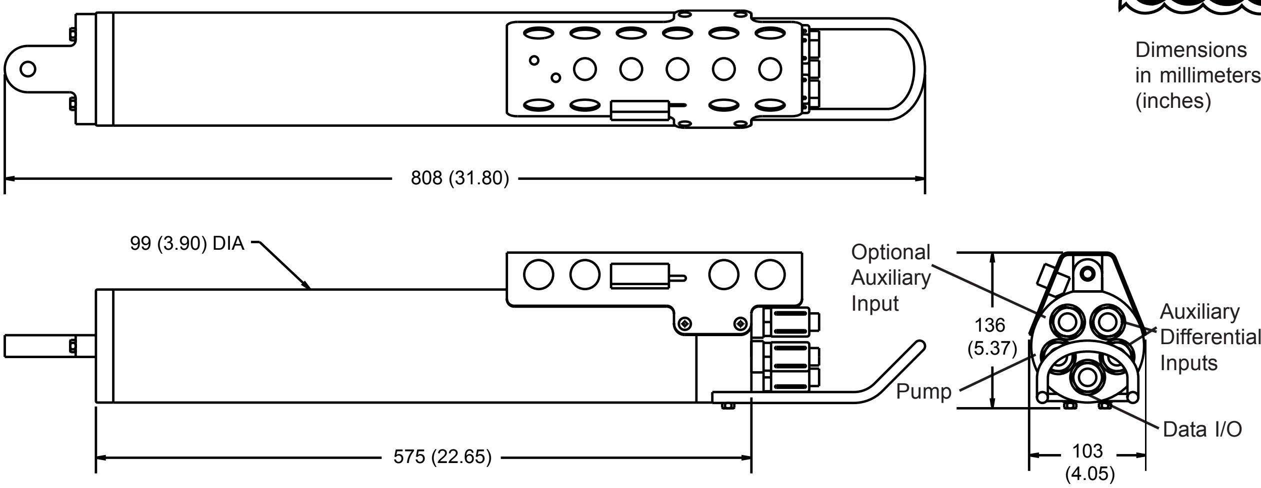
SBE

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

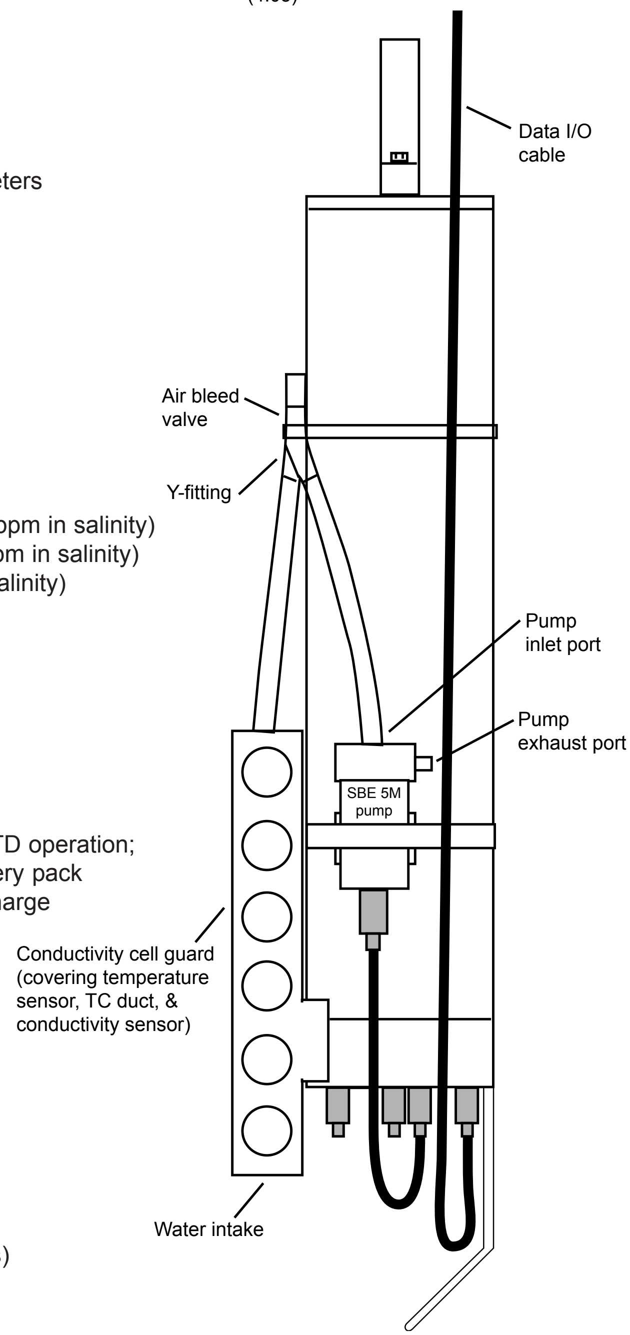
Email: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

SEACAT Profiler

SBE 19*plus*



SPECIFICATIONS



Measurement Range

Temperature	-5 to +35 °C
Conductivity	0 to 9 S/m
Pressure	0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters

Initial Accuracy

Temperature	0.005 °C
Conductivity	0.0005 S/m
Pressure	0.1% of full scale range

Typical Stability (*per month*)

Temperature	0.0002 °C
Conductivity	0.0003 S/m
Pressure	0.004% of full scale range

Resolution

Temperature	0.0001 °C
Conductivity	0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity)
	0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity)
	0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity)
Pressure	0.002% of full scale range

Memory 8 Mbyte non-volatile FLASH memory

Data Storage

Recorded Parameter	Bytes/Sample
T + C	6
pressure	5
each external voltage	2

Real-Time Clock 32,768 Hz TCXO accurate to ±1 minute/year

Internal Batteries 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

External Power Supply 9 - 28 VDC

Power Requirements

Sampling	65 mA
SBE 5M pump	95 mA
Quiescent	30 μA

Auxiliary Voltage Sensors

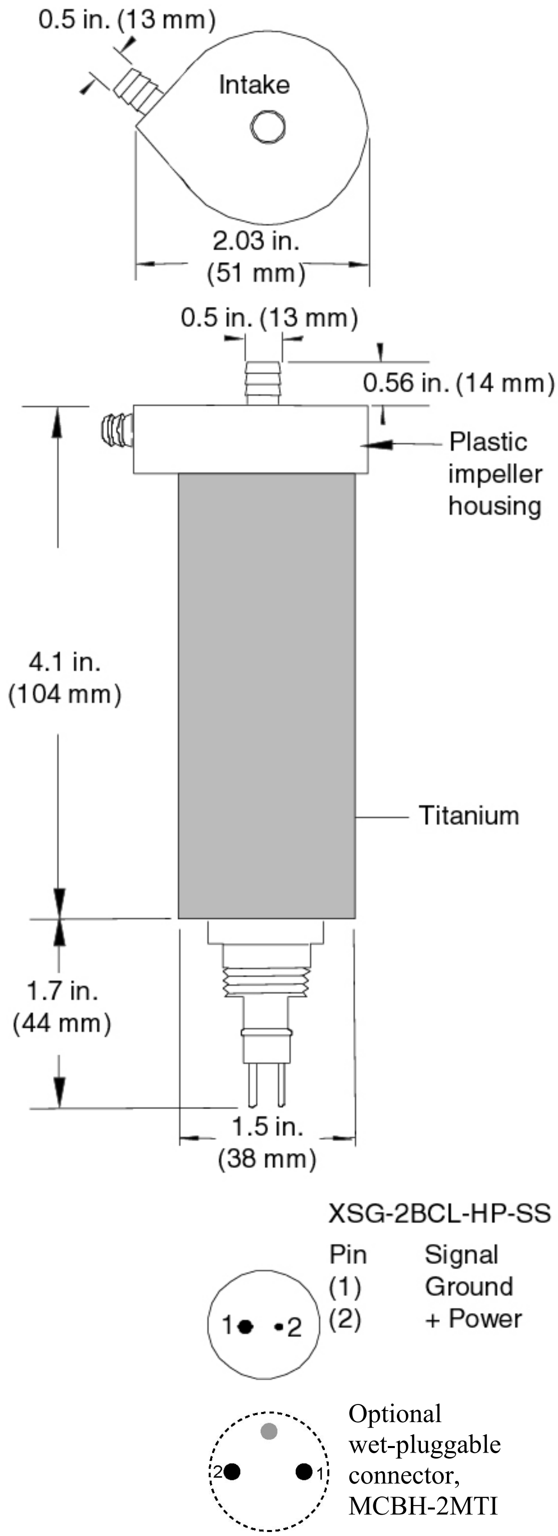
Auxiliary power out	up to 500 mA at 10.5 - 11 VDC
A/D resolution	14 bits
Input range	0 - 5 VDC

Housing Materials — Depth Rating — Weight

Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)
3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)

Mini Submersible Pump SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.



APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:
- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

SPECIFICATIONS

Option 5M-1 (continuous duty):
Input voltage range 9 - 18 VDC

Flow Rate 25 ml/s   supply current 95 ma

Note: Supply current is independent of operating voltage.

Option 5M-2 (pulsed duty):
Input voltage range 6 - 18 VDC

Pulse Duration	*Flow Volume*	*Electrical Charge*
0.5 seconds	15 ml	0.148 amp-seconds
1.0 seconds	21 ml	0.283 amp-seconds
1.5 seconds	31 ml	0.418 amp-seconds
2.0 seconds	40 ml	0.553 amp-seconds

Weight
In Air: 0.42 kg (0.91 lbs)
In Water: 0.28 kg (0.60 lbs)

06/03

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel: (425) 643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0647

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	8.015	VDC	Current	7.73	mA
Vin 9V voltage across C2:	8.014	VDC	Current	7.4	mA
Vin 6V voltage across C2:	5.888	VDC	Current	7.61	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 121 mA

APPLICATION NOTES

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 2D **Revised December 2002**

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor's output reading is proportional to its dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material will cause low conductivity readings.

If the cell is allowed to dry out between usage, salt crystals may form on (and in) the platinized electrode surfaces. When the instrument is next used, there will be a delay before these crystals are dissolved - in the meantime, sensor accuracy may be affected. Therefore, we recommend that the cell be kept filled with distilled or de-ionized water between uses. A length of 7/16" ID Tygon tubing is provided for this purpose, to be connected in such a way that any air entrapped will be in the Tygon tube rather than in the cell.

An additional important benefit of keeping the cell ends closed with Tygon is to keep air-borne contaminants (which are abundant on most research vessels) from entering the cell.

If it is not practical to keep the cell filled with distilled (or de-ionized) water between use (for example, in Arctic environments where freezing is a hazard), flush the cell with clean fresh water (preferably distilled or de-ionized) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Experience indicates that in normal intermittent use (such as in CTD profiling operations), drift rates of 0.0003 S/m (0.003 mmho/cm) or less per month can be expected **without any cleaning** if the procedures described above are followed.

PRECAUTIONS!!!!!!

The conductivity cell is primarily made of glass, and therefore is subject to breakage if mishandled. It is especially important to use the right size Tygon tubing, since if you use tubing with a too small ID, it will be difficult to remove the tubing, and the cell end may break if excessive force is used. **The correct size tubing for all instruments produced since 1980 is 7/16" ID, 9/16" OD, 1/16" wall**. Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID Tygon is required for these older instruments. It is better to use Tygon (brand) than other plastic tubing, since it tends to remain flexible over a wide temperature range and with age.

Do not insert any sort of cleaning probe (e.g., Q-tip) into the interior of the cell. If the platinized (black) electrode surface is touched, it may be damaged and require the electrodes to be replatinized.

If a cell is filled with water, do not subject it to low temperatures that will freeze the water and break the cell. **Remove the water before shipment during the winter, or to polar regions at any season**. No adverse affects have been observed as a result of temporary *dry* storage, particularly if the cell is rinsed with fresh water before storage.

CELL CLEANING

Routine Cleaning (inside of cell not visibly dirty)

Fill the cell with a 1% solution of Triton X-100* and let soak for 30 minutes. This is most easily done by using a length of 7/16" ID Tygon tubing to form a closed loop including the cell. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the cell with distilled (or de-ionized) water until the next usage.

Cleaning Severely Fouled Cells (visible deposits or marine growths on the inside of the cell)

Clamp the instrument so that the cell is vertical, and attach a length of 7/16" Tygon tubing to the lower end of the cell. Use masking or other tape to secure the open end of the Tygon about even with the top end of the cell. Pour Muriatic Acid (37% HCl) into the open end of the Tygon until the cell is filled to near the top and let soak for 1 to 2 minutes only. **Avoid breathing the acid fumes!!** Drain the acid from the cell and flush for 5 minutes with warm (not hot) fresh water. Also rinse the exterior of the instrument to remove any spilled acid from the surface. Then fill the cell with 1% Triton* solution, let stand for 5 minutes, and flush with warm fresh water for 1 minute. Refill with distilled or de-ionized water until the next usage.

If this process does not remove the visible deposits, mechanically clean the cell with a small (0.275" diameter). soft-bristled nylon bottle brush and 1% Triton solution. **NOTE: Be extremely careful when cleaning, because the platinum electrodes are thin and could be damaged if you use a brush that is too large or too stiff. The electrodes must be replatinized after *brush* cleaning. Our service department will clean and replatinize your cell for a nominal fee.**

*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable because of their known composition. It is better to use a non-ionic detergent since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 6 July 1994

DETERMINATION OF SOUND VELOCITY FROM CTD DATA

Use of CTD measurement for determination of sound velocity is appealing because these instruments are simpler and more rugged and because their resolution, accuracy, and stability lead to far better precision than can be obtained with direct SV measuring devices. For example, specifications of 0.01 mS/cm conductivity, 0.01 degrees C temperature, and 1 meter in depth are readily achieved with good quality CTD equipment. Assuming that the relationship between C, T, and D on the one hand and SV on the other is exactly known (see below), the resulting uncertainty in SV would be as follows:

from temperature error (0.01 deg C)	0.021 meters/second
from conductivity error (0.01 mS/cm)	0.011 meters/second
from salinity error (0.01 psu)	0.012 meters/second
from depth error (1 meter)	0.017 meters/second

The equivalent SV errors (considered at 15 degrees C, 42.9 mS/cm, 35 psu, and 0 pressure, i.e, typical open-ocean surface conditions) are much smaller than those usually claimed for direct-measurement instruments.

The question about the absolute accuracy of the inference of SV from CTD data is more difficult to answer. The main reason for this is apparently the result of differences in the instrumentation used by various researchers and is compounded by the difficulty of performing direct measurements of sound velocity under controlled conditions of temperature, salinity, and (especially) pressure. For example, 3 widely used equations (Wilson, 1959; Del Grosso, 1972; Millero and Chen, 1977) show differences in absolute sound speed on the order of 0.5 meter/second for various combinations of water temperature, salinity, and pressure, despite being based on careful measurements made under laboratory conditions.

The work of Millero and Chen is, however, the most modern, and it builds upon and attempts to incorporate the work of earlier investigators. Accordingly, the SV/CTD relationship described by these researchers in their paper of 1977 was used as a major component in the derivation of the Equation of State (Unesco technical papers in marine science no. 44). Millero and Chen's 1977 equation is also the one endorsed by the Unesco/SCOR/ICES/IASPO Joint Panel on Oceanographic Tables and Standards which comprises the internationally recognized authority for measurements of ocean parameters (in Sea-Bird's SEASOFT software, users may select any of the 3 equations mentioned above).

We draw the following conclusions from the research papers listed above:

1) Investigators using specialized equipment under scrupulously controlled laboratory conditions report measurements of SV vs. changes in temperature, salinity, and pressure which differ by 0.5 meters/second and more. *It is unrealistic to expect that commercial direct-measurement instruments will be more accurate under field conditions than the laboratory equipment used by successions of careful researchers.*

2) The claimed 'accuracy' of commercial direct-measurement SV probes probably more legitimately represents their 'precision' (compare with CTD/SV uncertainties tabulated above) than their absolute accuracy. The relationship between what these instruments read and true sound velocity is probably just as dependent on the same vagaries that are also the only significant sources of error when employing the CTD approach.

3) Because of the uncertainties in the time-delays associated with the acoustic transducers and electronics (and because of the difficulty of measuring with sufficient accuracy the length of the acoustic path), direct-measurement probes must be calibrated in water. As suggested by the research under controlled laboratory conditions, this is not an easy task, especially over a range of temperature, pressure, and salinity. On the other hand, a CTD probe can easily be calibrated using accepted methods.

4) A CTD can predict absolute SV to something better than 0.5 meter/second (a judgement seconded by Professor Millero in a private conversation), while its relative accuracy (precision) is probably better than 0.05 meter/s under the most demanding conditions of field use.

5) The very high precision associated with CTD measurements and the existence of an internationally accepted relationship (even if imperfect) between CTD and SV permits very consistent intercomparison and a high degree of uniformity among CTD-derived SV data sets, no matter when and where taken.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 10 **Revised May 2004**

COMPRESSIBILITY COMPENSATION OF SEA-BIRD CONDUCTIVITY SENSORS

Sea-Bird conductivity sensors provide precise characterization of deep ocean water masses. To achieve the accuracy of which the sensors are capable, an accounting for the effect of hydrostatic loading (pressure) on the conductivity cell is necessary. Conductivity calibration certificates show an equation containing the appropriate pressure-dependent correction term, which has been derived from mechanical principles and confirmed by field observations. The form of the equation varies somewhat, as shown below:

SBE 4, 9, 9*plus*, 16, 19, 21, 25, and 26/26*plus*

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(g + h f^2 + i f^3 + j f^4) / 10}{1 + [CTcor]\, t + [CPcor]\, p} + \text{offset} \qquad (\textbf{recommended})$$

or

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(a f^m + b f^2 + c + dt) / 10}{1 + [CPcor]\, p} + \text{offset}$$

SBE 16*plus*, 19*plus*, 37, 45, and 49

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{g + h f^2 + i f^3 + j f^4}{1 + [CTcor]\, t + [CPcor]\, p} + \text{offset}$$

where

- a, b, c, d, m, and CPcor are the calibration coefficients used for older sensors (prior to January 1995); Sea-Bird continues to calculate and print these coefficients on the calibration sheets for use with old software, but recommends use of the g, h, I, j, CTcor, CPcor form of the equation for most accurate results
- g, h, I, j, CTcor, and CPcor are the calibration coefficients used for newer sensors
- **CPcor is the correction term for pressure effects on conductivity**
- slope and offset are correction coefficients used to make corrections for sensor drift between calibrations; set to 1.0 and 0 respectively on initial calibration by Sea-Bird (see Application Note 31 for details on calculating slope and offset)
- f is the instrument frequency (kHz)
- t is the water temperature (°C)
- p is the water pressure (decibars)

Sea-Bird CTD data acquisition, display, and post-processing software *SEASOFT* automatically implements these equations.

DISCUSSION OF PRESSURE CORRECTION

Conductivity cells do not measure the specific conductance (the desired property), but rather the conductance of a *specific geometry* of water. The ratio of the cell's length to its cross-sectional area (*cell constant*) is used to relate the measured conductance to specific conductance. Under pressure, the conductivity cell's length and diameter are reduced, leading to a lower indicated conductivity. The magnitude of the effect is not insignificant, reaching 0.0028 S/m at 6800 dbars.

The compressibility of the borosilicate glass used in the conductivity cell (and all other homogeneous, noncrystalline materials) can be characterized by E (Young's modulus) and ν (Poisson's ratio). For the Sea-Bird conductivity cell, $E = 9.1 \times 10^6$ psi, $\nu = 0.2$, and the ratio of indicated conductivity divided by true conductivity is:

$1 + s$
where $s = (\text{CPcor})(p)$
Typical value for CPcor is -9.57×10^{-8} for pressure in decibars **or** -6.60×10^{-8} for pressure in psi

Note: This equation, and the mathematical derivations below, deals only with the pressure correction term, and does not address the temperature correction term.

MATHEMATICAL DERIVATION OF PRESSURE CORRECTION

For a cube under hydrostatic load:

$$\Delta L / L = s = -p\,(1 - 2\nu) / E$$

where

- p is the hydrostatic pressure
- E is Young's modulus
- ν is Poisson's ratio
- $\Delta L / L$ and *s* are strain (change in length per unit length)

Since this relationship is linear in the forces and displacements, the relationship for strain also applies for the length, radius, and wall thickness of a cylinder.

To compute the effect on conductivity, note that $R_0 = \rho L / A$, where R_0 is resistance of the material at 0 pressure, ρ is volume resistivity, L is length, and A is cross-sectional area. For the conductivity cell $A = \pi r^2$, where r is the cell radius. Under pressure, the new length is $L(1 + s)$ and the new radius is $r(1 + s)$. If R_p is the cell resistance under pressure:

$$R_p = \rho L (1 + s) / (\pi r^2 [1 + s]^2) = \rho L / \pi r^2 (1 + s) = R_0 / (1 + s)$$

Since conductivity is 1/R:

$$C_p = C_0 (1 + s) \quad \text{and} \quad C_0 = C_p / (1 + s) = C_p / (1 + [\text{Cpcor}]\,[p])$$

where

- C_0 is conductivity at 0 pressure
- C_p is conductivity measured at pressure

A less rigorous determination may be made using the material's bulk modulus. For small displacements in a cube:

$$\Delta V / V = 3\Delta L / L = -3p\,(1 - 2\nu) / E \quad \text{or} \quad \Delta V/V = -p / K$$

where

- $\Delta V / V$ is the change in volume per volume or volume strain
- K is the bulk modulus. K is related to E and ν by $K = E / 3(1 - 2\nu)$.

In this case, $\Delta L / L = -p / 3K$.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 14 **January 1989**

1978 PRACTICAL SALINITY SCALE

Should you not be already familiar with it, we would like to call your attention to the January 1980 issue of the IEEE Journal of Oceanic Engineering, which is dedicated to presenting the results of a multi-national effort to obtain a uniform repeatable Practical Salinity Scale, based upon electrical conductivity measurements. This work has been almost universally accepted by researchers, and all instruments delivered by Sea-Bird since February 1982 have been supplied with calibration data based upon the new standard.

The value for conductivity at 35 ppt, 15 degrees C, and 0 pressure [C(35,15,0)] was not agreed upon in the IEEE reports -- Culkin & Smith used 42.914 mmho/cm (p 23), while Poisson used 42.933 mmho/cm (p 47). It really does not matter which value is used, provided that the same value is used during data reduction that was used to compute instrument calibration coefficients. Our instrument coefficients are computed using C(35,15,0) = 42.914 mmho/cm.

The PSS 1978 equations and constants for computing salinity from *in-situ* measurements of conductivity, temperature, and pressure are given in the 'Conclusions' section of the IEEE journal (p 14) and are reproduced back of this note. In the first equation, 'R' is obtained by dividing the conductivity value measured by your instrument by C(35,15,0), or 42.914 mmho/cm. Note that the PSS equations are based upon conductivity in units of mmho/cm, which are equal in magnitude to units of mS/cm. **If you are working in conductivity units of Siemens/meter (S/m), multiply your conductivity values by 10 before using the PSS 1978 equations**.

Also note that the equations assume pressure relative to the sea-surface. Absolute pressure gauges (as used in all Sea-Bird CTD instruments) have a vacuum on the reference side of their sensing diaphragms and indicate atmospheric pressure (nominally 10.1325 dBar) at the sea-surface. This reading must be subtracted to obtain pressure as required by the PSS equations. The pressure reading displayed when using Sea-Bird's SEASOFT CTD acquisition, display, and post-processing software is the corrected sea-surface pressure and is used by SEASOFT to compute salinity, density, etc in accordance with the PSS equations.

1978 PRACTICAL SALINITY SCALE EQUATIONS, from IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14.

CONCLUSIONS

Using Newly generated data, a fit has been made giving the following algorithm for the calculation of salinity from data of the form:

$$R = \frac{C(S,T,P)}{C(35,15,0)}$$

T in °C (IPTS '68), P in decibars.

$$R_T = \frac{R}{R_P r_T};\quad R_P = 1 + \frac{P \times (A_1 + A_2 P + A_3 P^2)}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 R T}$$

$$r_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4$$

$A_1 = 2.070 \times 10^{-5}$ $B_1 = 3.426 \times 10^{-2}$

$A_2 = -6.370 \times 10^{-10}$ $B_2 = 4.464 \times 10^{-4}$

$A_3 = 3.989 \times 10^{-15}$ $B_3 = 4.215 \times 10^{-1}$

$B_4 = -3.107 \times 10^{-3}$

$c_0 = 6.766097 \times 10^{-1}$

$c_1 = 2.00564 \times 10^{-2}$

$c_2 = 1.104259 \times 10^{-4}$

$c_3 = -6.9698 \times 10^{-7}$

$c_4 = 1.0031 \times 10^{-9}$

$$S = \sum_{j=0}^{5} a_j R_T^{j/2} + \frac{(T-15)}{1 + k(T-15)} \sum_{j=0}^{5} b_j R_T^{j/2}$$

$a_0 = 0.0080$ $b_0 = 0.0005$ $k = 0.0162.$

$a_1 = -0.1692$ $b_1 = -0.0056$

$a_2 = 25.3851$ $b_2 = -0.0066$

$a_3 = 14.0941$ $b_3 = -0.0375$

$a_4 = -7.0261$ $b_4 = 0.0636$

$a_5 = 2.7081$ $b_5 = -0.0144$

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE 27Druck **NOVEMBER 2003**

Minimizing Strain Gauge Pressure Sensor Errors

The following Sea-Bird instruments use strain gauge pressure sensors manufactured by GE Druck:

- SBE 16*plus* and 16*plus*-IM SEACAT (not 16*) with optional strain gauge pressure sensor
- SBE 19*plus* SEACAT Profiler (not 19*)
- SBE 25 SEALOGGER CTD, which uses SBE 29 Strain-Gauge Pressure Sensor (built after March 2001)
- SBE 37 MicroCAT (37-IM, -IMP, -SM, -SMP, and -SI) with optional pressure sensor (built after September 2000)
- SBE 39 Temperature Recorder with optional pressure sensor (built after September 2000)
- SBE 49 FastCAT CTD Sensor
- SBE 50 Digital Oceanographic Pressure Sensor

*** Note:** SBE 16 and SBE 19 SEACATs were originally supplied with other types of pressure sensors. However, a few of these instruments have been retrofitted with Druck sensors.

The Druck sensors are designed to respond to pressure in nominal ranges 0 - 20 meters, 0 - 100 meters, 0 - 350 meters, 0 – 1000 meters, 0 – 2000 meters, 0 – 3500 meters, and 0 – 7000 meters (with pressures expressed in meters of deployment depth capability). The sensors offer an initial accuracy of 0.1% of full scale range.

DEFINITION OF PRESSURE TERMS

The term *psia* means *pounds per square inch, absolute* (*absolute* means that the indicated pressure is referenced to a vacuum).

For oceanographic purposes, pressure is most often expressed in *decibars* (1 dbar = 1.4503774 psi). A dbar is 0.1 bar; a bar is approximately equal to a standard atmosphere (1 atmosphere = 1.01325 bar). For historical reasons, pressure at the water surface (rather than absolute or total pressure) is treated as the reference pressure (0 dbar); this is the value required by the UNESCO formulas for computation of salinity, density, and other derived variables.

Some oceanographers express pressure in Newtons/meter^2 or *Pascals* (the accepted SI unit). A Pascal is a very small unit (1 psi = 6894.757 Pascals), so the mega-Pascal (MPa = 10^6 Pascals) is frequently substituted (1 MPa = 100 dbar).

Since the pressure sensors used in Sea-Bird instruments are *absolute* types, their raw data inherently indicate atmospheric pressure (about 14.7 psi) when in air at sea level. Sea-Bird outputs pressure in one of the following ways:

- For CTDs that output **raw data** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49**) and are supported by SEASOFT's SEASAVE (real-time data acquisition) and SBE Data Processing (data processing) software – In SEASOFT, user selects pressure output in psi (*not* psia) or dbar. SEASOFT subtracts 14.7 psi from the raw absolute reading and outputs the remainder as psi or converts the remainder to dbar.
- For the **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- For all other instruments that can output **converted data in engineering units** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, and 49**) – Instrument subtracts 14.7 psi from the raw absolute reading and converts the remainder to dbar.

Note: SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49 can output raw **or** converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

Despite the common nomenclature (CTD = **C**onductivity - **T**emperature - **D**epth), all CTDs measure *pressure*, which is not quite the same thing as depth. The relationship between pressure and depth is a complex one involving water density and compressibility as well as the strength of the local gravity field, but it is convenient to think of a decibar as essentially equivalent to a meter, an approximation which is correct within 3% for almost all combinations of salinity, temperature, depth, and gravitational constant.

SEASOFT offers two methods for estimating depth from pressure.

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0^o C, and the compressibility of the water (with its accompanying density variation) is taken into account. This is the method recommended in UNESCO Technical Paper No. 44 and is a logical approach in that by far the greatest part of the deep-ocean water column approximates these values of salinity and temperature. Since pressure is also proportional to gravity and the major variability in gravity depends on latitude, the user's latitude entry is used to estimate the magnitude of the local gravity field.
  - SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - User is prompted to enter latitude if Depth [salt water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - SBE 37-SI and 50 - Latitude is entered in the instrument's EEPROM using the **LATITUDE=** command in SEASOFT's SEATERM (terminal program) software.
  - SBE 39 – User is prompted to enter latitude if conversion of pressure to depth is requested when converting an uploaded .asc file to a .cnv file in SEATERM.
- For fresh water applications, compressibility is not significant in the shallow depths encountered and is ignored, as is the latitude-dependent gravity variation. Fresh water density is presumed to be 1 gm/cm, and depth (in meters) is calculated as 1.019716 * pressure (in dbars).

CHOOSING THE RIGHT SENSOR

Initial accuracy and resolution are expressed as a percentage of the full scale range for the pressure sensor. The initial accuracy is 0.1% of the full scale range. Resolution is 0.002% of full scale range, except for the SBE 25 (0.015% resolution). For best accuracy and resolution, select a pressure sensor full scale range to correspond to no more than the greatest depths to be encountered. The effect of this choice on CTD accuracy and resolution is shown below:

Range (meters)	Maximum Initial Error (meters)	SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, & 50 - Resolution (meters)	SBE 25 - Resolution (meters)
0 – 20	0.02	0.0004	0.003
0 – 100	0.10	0.002	0.015
0 – 350	0.35	0.007	0.052
0 – 1000	1.0	0.02	0.15
0 - 2000	2.0	0.04	0.30
0 - 3500	3.5	0.07	0.52
0 - 7000	7.0	0.14	1.05

The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within ± *maximum error* (expressed as equivalent depth) throughout the sensor's operating range. Note that a 7000-meter sensor reading + 7 meters at the water surface is operating within its specifications; the same sensor would be expected to indicate 7000 meters ± 7 meters when at full depth.

Resolution is the magnitude of indicated increments of depth. For example, a 7000-meter sensor on an SBE 25 (resolution 1.05 meters) subjected to slowly increasing pressure will produce readings approximately following the sequence *0, 1.00, 2.00, 3.00* (meters). Resolution is limited by the design configuration of the CTD's A/D converter. For the SBE 25, this restricts the possible number of discrete pressure values for a given sample to somewhat less than 8192 (13 bits); an approximation of the ratio 1 : 7000 is the source of the SBE 25's 0.015% resolution specification.

Note: SEASOFT (and other CTD software) presents temperature, salinity, and other variables as a function of depth or pressure, so the CTD's pressure resolution limits the number of plotted data points in the profile. For example, an SBE 25 with a 7000-meter sensor might acquire several values of temperature and salinity during the time required to descend from 1- to 2-meters depth. However, all the temperature and salinity values will be graphed in clusters appearing at either 1 or 2 meters on the depth axis.

High-range sensors used in shallow water generally provide better accuracy than their *absolute* specifications indicate. With careful use, they may exhibit *accuracy* approaching their *resolution* limits. For example, a 3500-meter sensor has a nominal accuracy (irrespective of actual operating depth) of ± 3.5 meters. Most of the error, however, derives from variation over time and temperature of the sensor's *offset*, while little error occurs as a result of changing *sensitivity*.

MINIMIZING ERRORS

Offset Errors

The primary *offset* error due to drift over time can be eliminated by comparing CTD readings in air before beginning the profile to readings from a barometer. Follow this procedure:

1. Allow the instrument to equilibrate in a reasonably constant temperature environment for at least 5 hours. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature; allowing the instrument to equilibrate before starting will provide the most accurate calibration correction.

2. Place the instrument in the orientation it will have when deployed.

3. Set the pressure offset to 0.0:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, or 50).

4. Collect pressure data from the instrument using SEASAVE or SEATERM (see instrument manual for details). If the instrument is not outputting data in decibars, convert the output to decibars.

5. Compare the instrument output to the reading from a good barometer placed at the same height as the pressure sensor. Calculate *offset* (decibars) = barometer reading (converted to decibars) – instrument reading (decibars).

6. Enter calculated offset in decibars:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, or 50).

Note: For instruments that store calibration coefficients in EEPROM and also use a .con file (SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49), set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the .con file.

Offset Correction Example
Pressure measured by a barometer is 14.65 psia. Pressure displayed from instrument is -2.5 dbars.
Convert barometer reading to dbars using the relationship: (psia – 14.7) * 0.6894759 = dbars
Barometer reading = (14.65 – 14.7) * 0.6894759 = -0.034 dbars
Offset = -0.034 – (-2.5) = + 2.466 dbar
Enter offset in .con file (if applicable) and in instrument EEPROM (if applicable).

Another source of *offset* error results from temperature-induced drifts. Because Druck sensors are carefully temperature compensated, errors from this source are small. Offset errors can be estimated for the conditions of your profile, and eliminated when post-processing the data in SBE Data Processing by the following procedure:

1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.

2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature as a result of being submerged in the water during the profile.

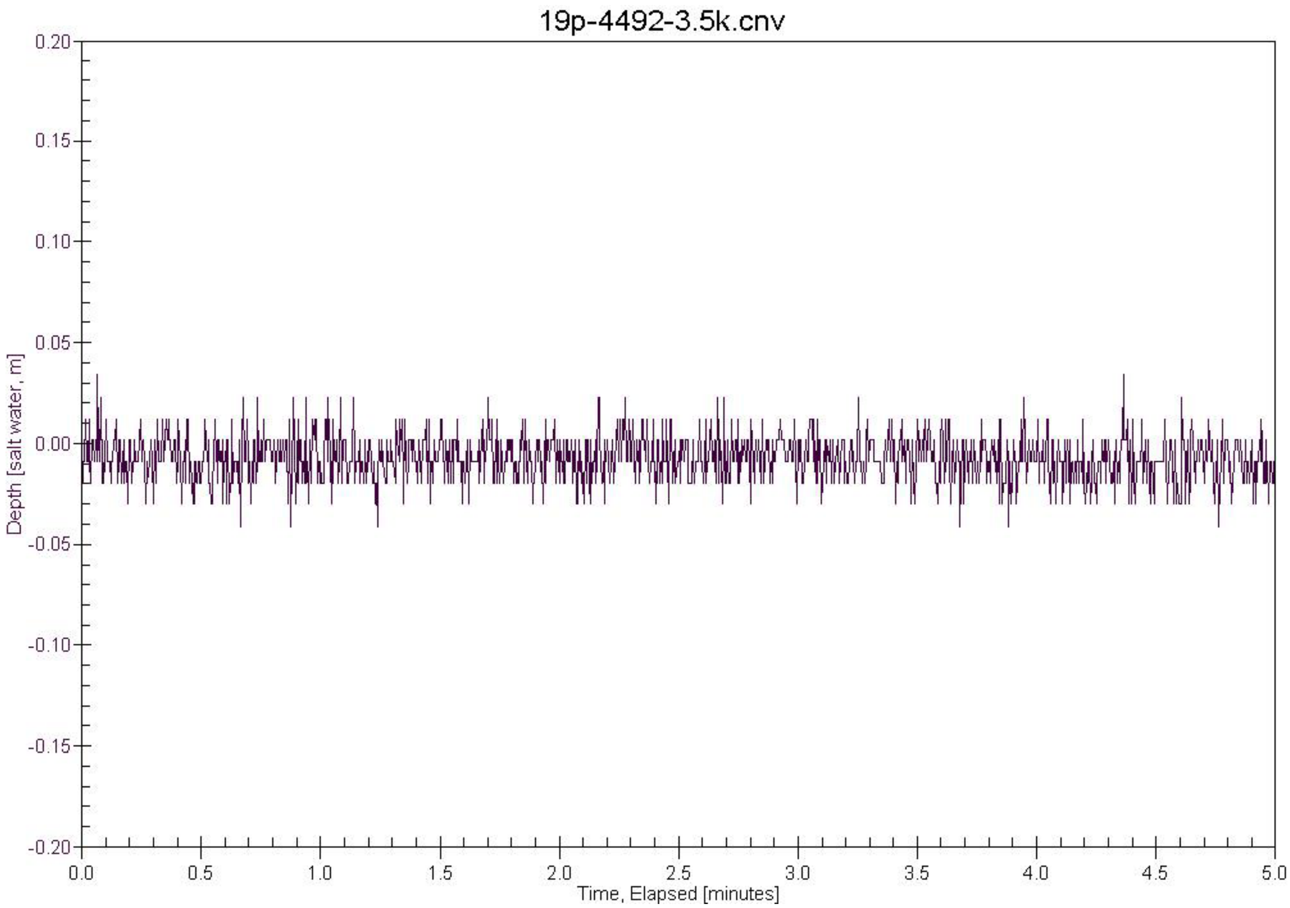
3. Calculate the average of the pre- and post-cast readings. Enter the negative of the average value (in decibars) as the *offset* in the .con file.

Hysteresis Errors

Hysteresis is the term used to describe the failure of pressure sensors to repeat previous readings after exposure to other (typically higher) pressures. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis.

Power Turn-On Transient

Druck pressure sensors exhibit virtually no power turn-on transient. The plot below, for a 3500-meter pressure sensor in an SBE 19*plus* SEACAT Profiler, is representative of the power turn-on transient for all pressure sensor ranges.



Thermal Transient

Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature, so the thermal transient resulting from submersion in water must be considered when deploying the instrument.

During calibration, the sensors are allowed to *warm-up* before calibration points are recorded. Similarly, for best depth accuracy the user should allow the CTD to *warm-up* for several minutes before beginning a profile; this can be part of the *soak* time in the surface water. *Soaking* also allows the CTD housing to approach thermal equilibrium (minimizing the housing's effect on measured temperature and conductivity) and permits a Beckman- or YSI-type dissolved oxygen sensor (if present) to polarize.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 31 **September 2001**

Computing Temperature and Conductivity *Slope* and *Offset* Correction Coefficients from Laboratory Calibrations and Salinity Bottle Samples

Conductivity Sensors

SEASOFT's prompt for *slope* and *offset* values when the conductivity sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors use slope = 1.0, offset = 0.0. The correction formula is:

(corrected conductivity) = slope * (computed conductivity) + offset

The conductivity sensor usually drifts by changing span (the slope of the calibration curve), and changes are typically toward lower conductivity readings with time. Offset error in conductivity (error at 0 S/m) is usually due to electronics drift, which is usually less than ±0.0001 S/m per year. Offsets greater than ±0.0002 S/m are symptomatic of sensor malfunction. Sea-Bird, therefore, recommends drift corrections to conductivity sensors be made by assuming no offset error, unless there is strong evidence to the contrary or a special need.

As an example of computing these correction coefficients, if we had the following calibration data:

true conductivity: 3.5 S/m
instrument reading: 3.49965 S/m

slope = 3.5 / 3.49965 = 1.000100

Correcting for Conductivity Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a conductivity sensor is calibrated (pre-cruise), then immediately used at-sea, and then returned for post-cruise calibration. The pre- and post-cruise calibration data can be used to generate a slope correction for data taken between the pre- and post-cruise calibrations.

If α is the conductivity computed from the **pre-cruise bath data** (temperature and frequency) using **post-cruise calibration coefficients** and β is the true conductivity in the **pre-cruise bath**, then:

$$\textbf{Postslope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)}$$

(postslope is typically < 1.0)

Beginning in February 1995, the value for postslope was calculated and printed on the conductivity calibration sheet.

To correct conductivity data taken between pre- and post-cruise calibrations:

Let:

n = number of days between pre- and post-cruise calibrations
b = number of days between pre-cruise calibration and the cast to be corrected
islope = interpolated slope; this is the value to enter in the .con file
postslope = slope from calibration sheet as calculated above

islope = 1.0 + (b / n) ((1 / postslope) - 1.0)

In the .con file, use the **pre-cruise calibration coefficients** and use **islope** for the value of slope.*

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

For typical conductivity drift rates (equivalent to -0.003 PSU/month), islope would not need to be recalculated more frequently than at weekly intervals.

* You can also calculate preslope. If α is the conductivity computed from the **post-cruise bath data** (temperature and frequency) using **pre-cruise calibration coefficients** and β is the true conductivity in the **post-cruise bath**, then:

Preslope = $$\frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)}$$ (preslope is typically > 1.0)

In this case, pre-cruise calibration coefficients would be used and:
islope = 1.0 + (b / n) (preslope - 1.0)

Correcting for Conductivity Drift Based on Salinity Bottles Taken At-Sea

For this situation the **pre-cruise** calibration coefficients are used to compute conductivity and CTD salinity. Salinity samples are obtained using water sampler bottles during CTD profiles, and the difference between CTD salinity and bottle salinity is used to determine the drift in conductivity.

In using this method to correct conductivity, it is important to realize that differences between CTD salinity and hydrographic bottle salinity are due to errors in conductivity, temperature, and pressure measurements (as well as errors in obtaining and analyzing bottle salinity values). All CTD temperature and pressure errors and bottle errors must first be corrected before attributing the remaining salinity difference as CTD conductivity error and proceeding with conductivity corrections.

Suppose that at a Pacific Ocean station, three salinity bottles are taken during a CTD profile and assume for this discussion that shipboard analysis of the bottle salinities is perfect. The bottle salinities and the **uncorrected** CTD data might be:

Approximate Depth (m)	Bottle Salinity	CTD Raw Salinity	CTD Raw Conductivity (S/m)	CTD Temperature (°C)	CTD Pressure (dbar)
200	34.9770	34.9705	4.63421	18.3924	202.7
1000	34.4710	34.4634	3.25349	3.9841	1008.8
4000	34.6850	34.6778	3.16777	1.4527	4064.1

The uncorrected salinity differences (CTD salinity - bottle salinity) are approximately -0.007 ppt. To determine conductivity drift, the CTD temperature and pressure data must first be corrected. Suppose that the error in temperature measurements is +0.0015 C uniformly at all temperatures, and the error in pressure is +0.5 dbar uniformly at all pressures. The drift offsets are obtained by projecting the drift history of both sensors from pre-cruise calibrations. If these offsets are entered in the .con file, the correct CTD temperature and pressure will be the reported *raw* values and will need no further correction. In addition, the CTD *raw* salinity will be reported using the correct CTD temperature and pressure. This correction method also assumes that the pressure coefficient for the conductivity cell is correct. The CTD data with **corrected** temperature and pressure are:

Correct CTD Pressure (dbar)	Correct CTD Temperature (°C)	CTD Conductivity (S/m)	CTD Salinity T,P Corrected	Bottle Salinity
202.2	18.3909	4.63421	34.9719	34.9770
1008.3	3.9826	3.25349	34.4652	34.4710
4063.6	1.4512	3.16777	34.6796	34.6850

The (CTD-bottle) salinity difference of -0.005 ppt is now properly assigned as conductivity error, equivalent to about -0.0005 S/m at 4.0 S/m. By plotting the conductivity error versus conductivity, it is evident that the drift is primarily a slope change.

The program SEACALC (in SEASOFT-DOS) can be used to compute bottle conductivity. Enter bottle salinity for *salinity*, CTD corrected temperature for *temperature*, and CTD corrected pressure for *pressure*.

CTD Conductivity (S/m)	Bottle Conductivity (S/m)	[CTD - Bottle] Conductivity (S/m)
4.63421	4.63481	-0.00060
3.25349	3.25398	-0.00049
3.16777	3.16821	-0.00044

If α is the CTD conductivity computed with **pre-cruise** coefficients and β is the true bottle conductivity then:

slope = $$\frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)}$$ (slope is typically > 1.0)

Using the above data, the slope correction coefficient for conductivity at this station is **slope = +1.000137**. Following Sea-Bird's recommendation of assuming no offset error in conductivity, **offset is set to 0.0**.

For typical Sea-Bird sensors that are calibrated regularly, 70 - 90% of the CTD salinity error is due to conductivity calibration drift, 10 - 30% is due to temperature calibration drift, and only 0% - 10% is due to pressure calibration drift.

Temperature Sensors

SEASOFT's prompt for *slope* and *offset* values when the temperature sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors, use slope = 1.0, offset = 0.0. The correction formula is:

(corrected temperature) = slope * (computed temperature) + offset

where :
slope = (true temperature span) / (instrument temperature span)
offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*

As an example of computing the correction coefficients, if we had the following calibration data:

true temperature	0.0 °C	25.0 °C
instrument reading	0.0015 °C	25.0013 °C

slope = (true temperature span) / (instrument temperature span)
= (25.0 - 0.0) / (25.0013 - 0.0015) = 1.000008000

offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*
= (0.0 - 0.0015) * (1.000008000) = -0.00150002

For this example Sea-Bird would recommend the drift correction values (entered in the .con file)
slope = 1.0 offset = -0.0015

Sea-Bird temperature sensors usually drift by changing offset (an error of equal magnitude at all temperatures). In general, the drift can be toward higher or lower temperature with time; however, for a specific sensor the drift will remain the same sign (direction) for many consecutive years. A large span error (change in calibration slope) indicates an unusual aging of electronic components and is symptomatic of sensor malfunction. Sea-Bird therefore recommends that drift corrections to temperature sensors be made by assuming no slope error, unless there is strong evidence to the contrary or a special need.

Sensors with serial numbers less than 1050 drift more typically toward higher temperature with time, while sensors with serial numbers greater than 1050 drift more typically toward lower temperature with time. Many years of experience with hundreds of sensors indicates that the drift is smooth and uniform with time, allowing users to make very accurate drift corrections to field data based only on pre- and post-cruise laboratory calibrations.

Calibration checks at-sea are advisable for consistency checks of the sensor drift rate and for early detection of sensor malfunction. However, data from reversing thermometers is rarely accurate enough to make calibration corrections that are better than those possible by shore-based laboratory calibrations. A proven alternate consistency check is to use dual SBE 3 temperature sensors on a CTD and to track the difference in drift rates between the two sensors. In the deep ocean, where temperatures are uniform, the difference in temperature measured by two sensors can be resolved to better than 0.0002 °C and will change smoothly with time as predicted by the difference in drift rates of the two sensors.

The temperature sensors rarely exhibit span errors larger than 0.005 °C over the range -5 to 35 °C even after years of drift. A span error that increases by more than ±0.0002 [°C per °C per year] is symptomatic of sensor malfunction. Previous to January 1993 some calibrations have been delivered that include span errors up to 0.004 °C in 30 °C (span error of 0.000133) because of undetected systematic errors in calibration. Temperature calibrations preformed at Sea-Bird after January 1995 have span error less than 0.0002 °C in 30 °C.

Correcting for Temperature Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a temperature sensor is calibrated (pre-cruise), then immediately used at-sea for 4 months, and then returned for post-cruise calibration. Converting the **post-cruise calibration data** using the **pre-cruise coefficients**, we obtain the estimates:

Real Temperature........ 0.0°....... 25.0°C
Instrument Reading..... 0.002°... 25.001°C

These calibration data correspond to offset error = +0.002 °C, and span error = -0.00004 [°C per °C] at the end of 4 months of use. The correction coefficients are **slope= 1.000040002, offset= -0.00200008.** Note the difference between the error value and the value of the correction coefficient.

For preliminary work at sea, use the **pre-cruise calibration coefficients** and **slope = 1.0, offset = 0.0**. Temperature data obtained during the cruise is corrected for drift using properly scaled values of correction coefficients. Data from the end of the second month at sea would be converted using **pre-cruise coefficients** and **slope=1.00002, offset= -0.001**. At the end of the 4-month cruise, data could be converted by either using **pre-cruise** coefficients and **slope=1.00004, offset= -0.002**, or by using **post-cruise** coefficients and **slope= +1.0, offset = 0.0**.

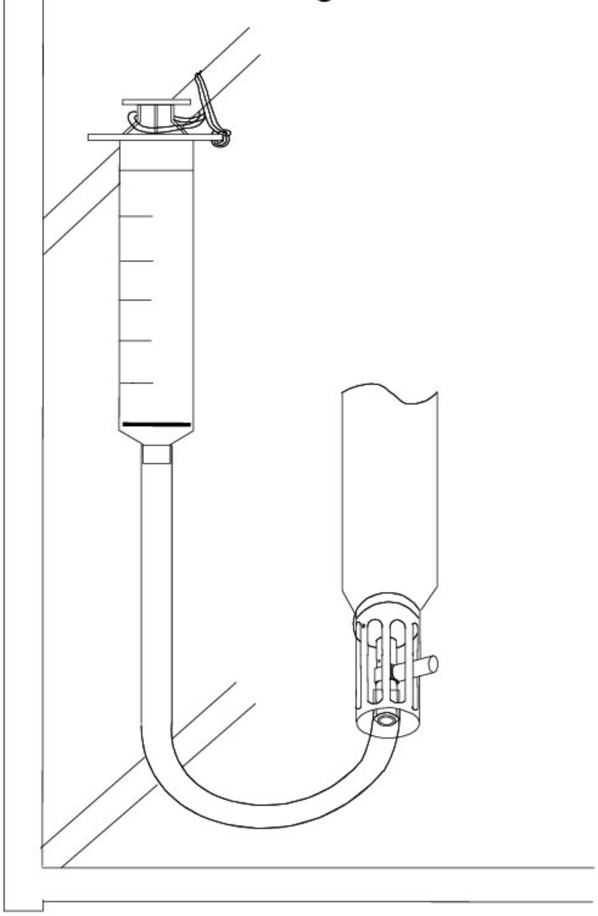
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 34 **January 1992**

CONDUCTIVITY CELL FILLING AND STORAGE DEVICE P/N 50087
INSTRUCTIONS FOR USE

Figure 1



Sea-Bird recommends keeping the conductivity cell full of purified water (except in freezing environments) during periods when the CTD is not being used. This is important in keeping the cell free from contamination and in keeping the electrodes wetted and ready for immediate use.

CTDs with pumped conductivity cells (SBE 911, SBE 25, and some SEACATs) are shipped with syringe and tubing assembly (P/N 50087) as an accessory for filling and storing the conductivity cell. The tubing assembly consists of a length of 1/4 inch I.D. tube connected to a short piece of 7/16 inch I.D. tube by a plastic reducing union.

To fill the conductivity cell, draw about 40-60 cc of purified water into the syringe, connect the plastic tubing to the TC duct intake on the temperature sensor [Figure 1], (or to the open end of the conductivity cell on systems without the TC duct [Figure 2]) and inject water into the cell and pump plumbing.

For CTDs with a TC duct, remove the plastic reducing union and connect the smaller diameter tubing directly to the TC duct. For CTDs without a TC duct, leave the reducing union and large diameter tubing attached and carefully connect the tubing directly to the end of the glass conductivity cell [Figure 2].

After filling the conductivity cell, loop the rubber band around a bar on the CTD cage and back over the top of the syringe to secure the apparatus for storage.

REMEMBER TO REMOVE THE SYRINGE AND TUBING ASSEMBLY BEFORE DEPLOYMENT!

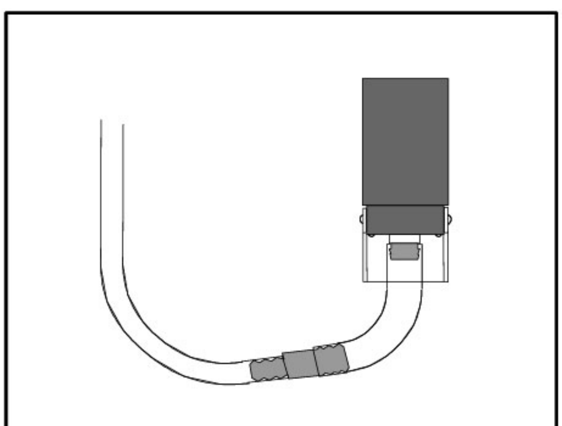


Figure 2

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 40 **Revised November 2002**

SBE 5T PUMP SPEED ADJUSTMENT INSTRUCTIONS

Equipment: DC power supply
Frequency counter

Drawings: 31441 (schematic)
40630 (3000 rpm pump)
40631 (1300 rpm pump)

The pump housing must be disassembled to adjust the pump speed. Referencing above drawings:

1. Remove the white plastic end cap retainer ring located at the connector end of the pump by twisting in a counter-clockwise motion.

2. Install a 2-pin dummy plug with locking sleeve (P/N 17044.1) over the bulkhead connector. This will provide a good grip on the pump connector and will protect the connector pins.
   Rotate the connector back and forth while carefully pulling the end cap away from the housing. Pull the end cap (piston o-ring seal) out of the housing. The motor and electronics assembly are attached to the end cap and will come out as a unit.

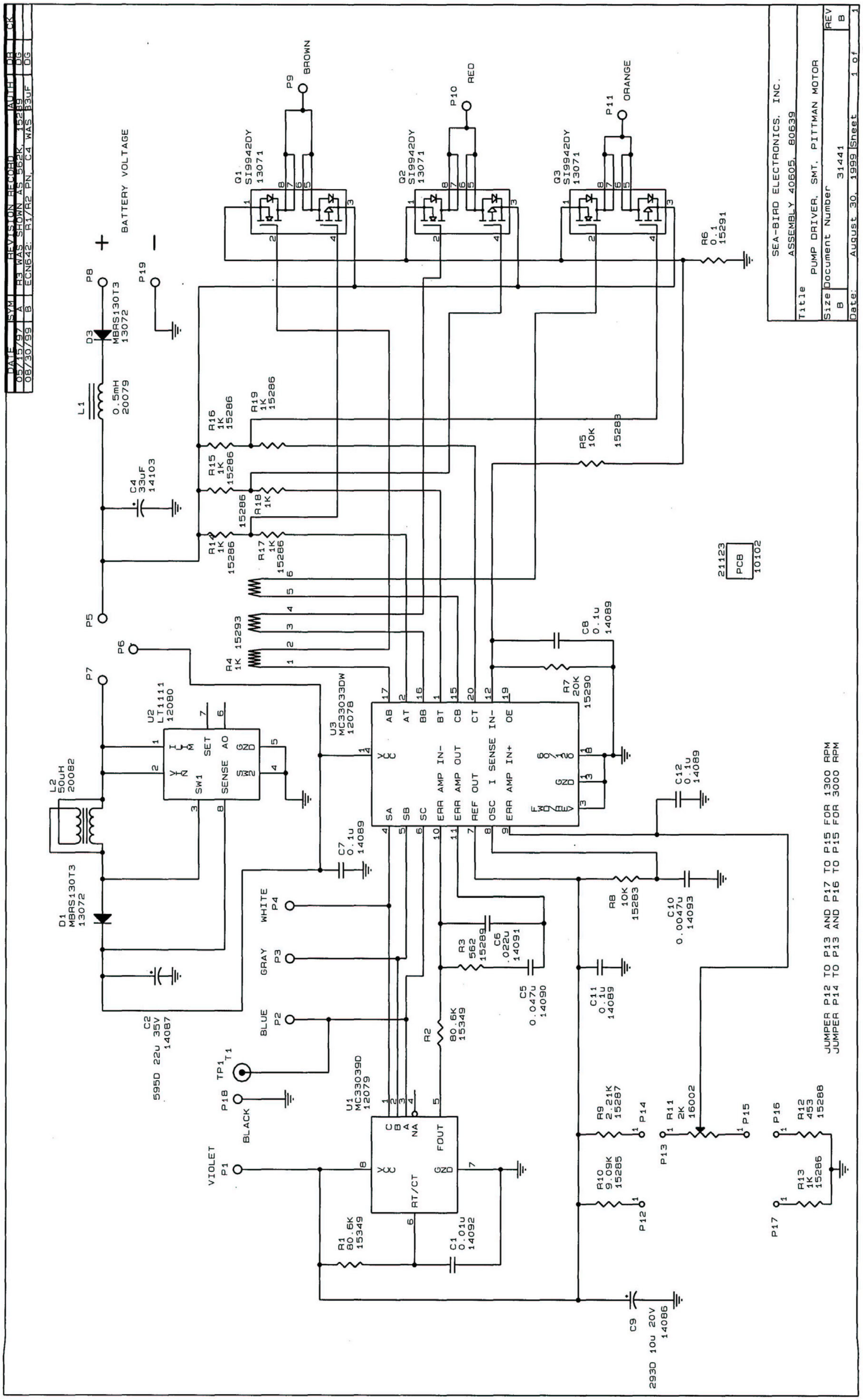
3. Connect the positive lead of your frequency counter to the yellow test post (T1) (drawing 40630/40631). Connect the frequency counter ground (negative) to the power supply ground (negative).

4a. **For low voltage pump** (pump with **LV** in the serial number), supply 6 volts DC power to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

4b. **For normal voltage pump**, supply 12 volts to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

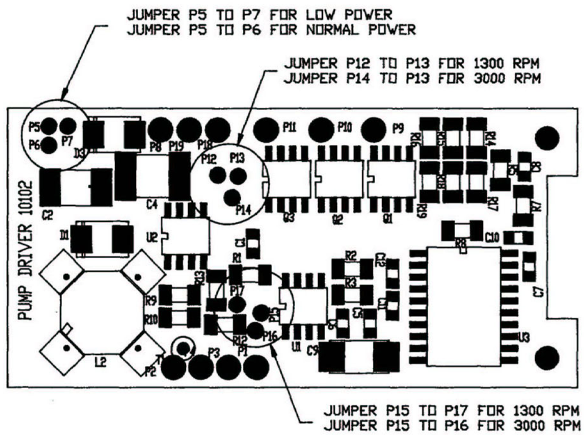
5. A 2K ohm potentiometer (R11, drawing 40630/40631) is located on the back side of the board. Adjust the potentiometer to obtain the frequency corresponding to the desired speed (Frequency * 30 = RPM). With the Pittman 18.2Ω motor (P/N 3711B113), set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust the speed as desired, up to the nominal maximum of 2000 rpm. With the Pittman 7.4Ω motor (P/N 3711B112), set the jumper position P15 to P16 (3000 rpm) and P14 to P13 (3000 rpm), and adjust the speed as desired, up to the nominal maximum of 4500 rpm. To adjust speed of the 7.4Ω motor below approximately 2200 rpm, set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust speed using the potentiometer.

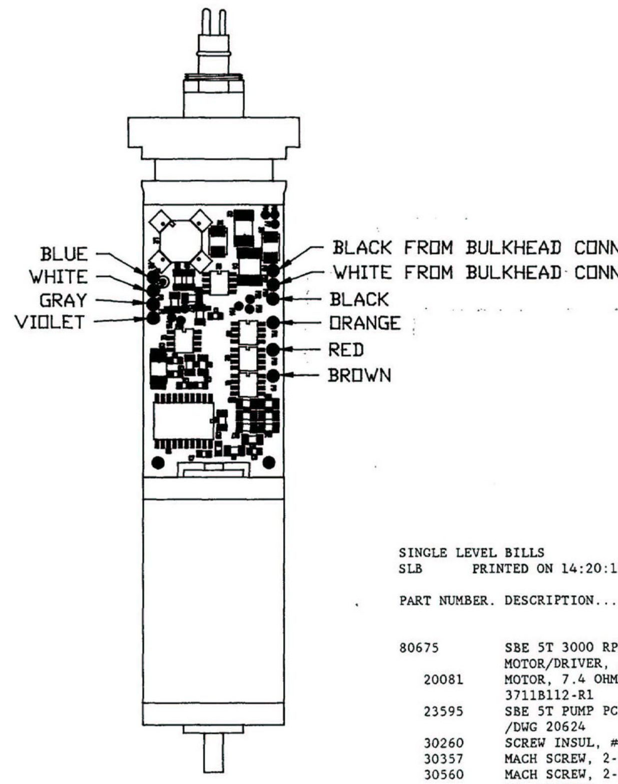
6. Disconnect the frequency counter and the power supply. **Make sure the O-ring and mating surfaces are clean.** Lightly lubricate before inserting the connector end cap into the housing cylinder. Replace the pump end cap retainer.

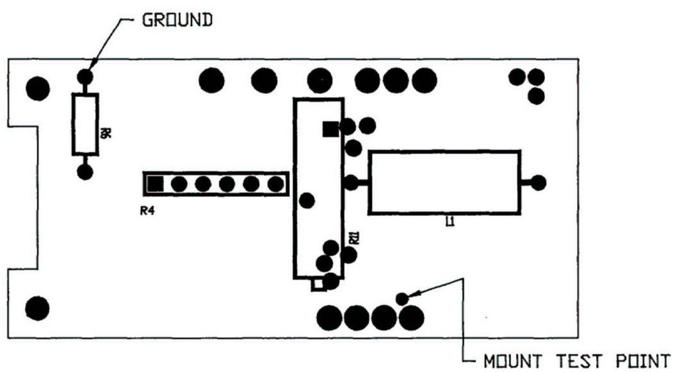


REVISION RECORD
DATE SYM AUTH DR CK
05/15/97 A R3 WAS SHOWN AS 562K, 15289 DG
08/30/99 B ECN642: R1/R2 PN, C4 WAS 33uF DG
BATTERY VOLTAGE
SEA-BIRD ELECTRONICS, INC.
ASSEMBLY 40605, 80639
Title PUMP DRIVER, SMT, PITTMAN MOTOR
Size B Document Number 31441 REV B
Date: August 30, 1999 Sheet 1 of 1
JUMPER P12 TO P13 AND P17 TO P15 FOR 1300 RPM
JUMPER P14 TO P13 AND P16 TO P15 FOR 3000 RPM

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	SEE HISTORY	P.G.	BW	







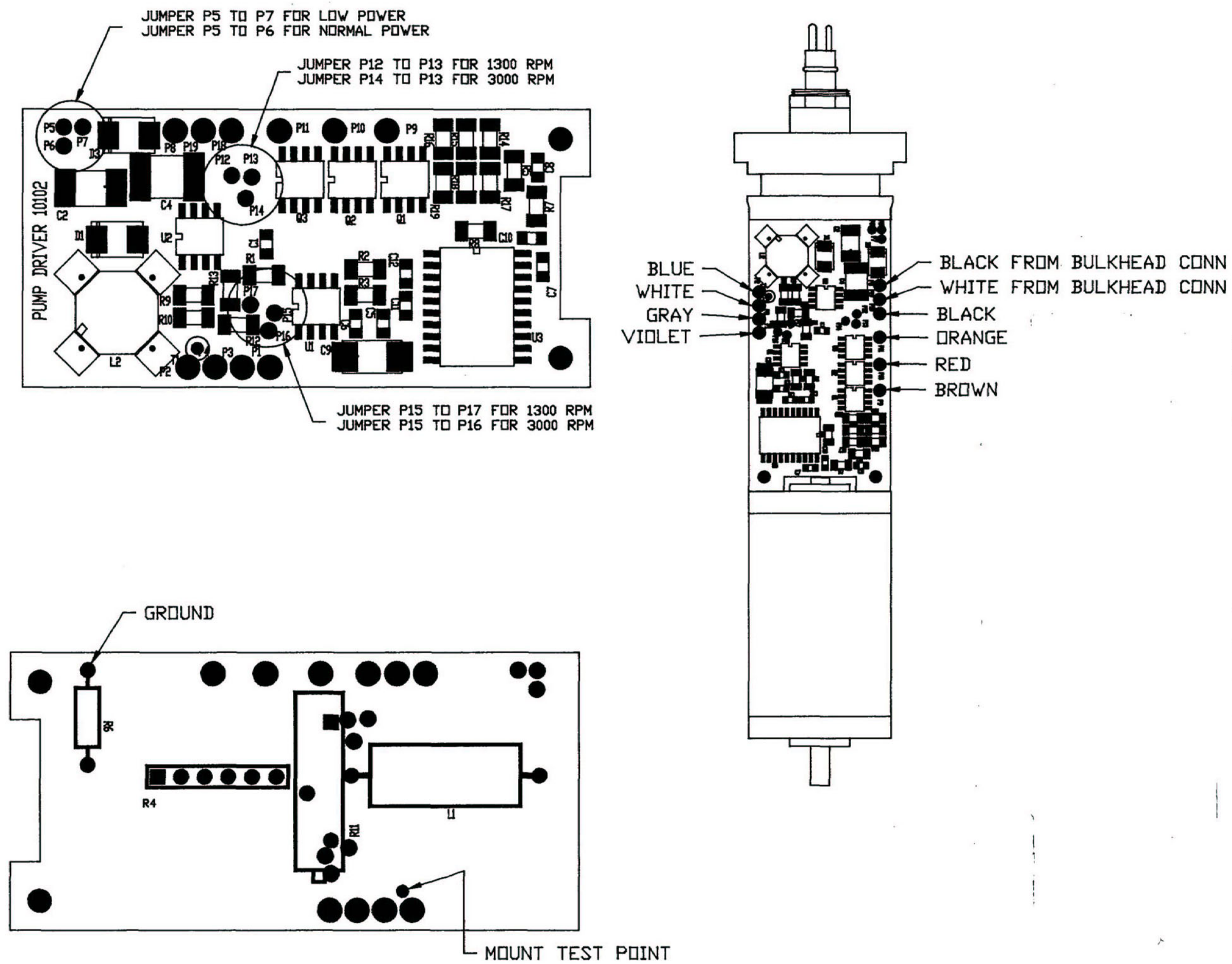
SINGLE LEVEL BILLS PAGE 1
SLB PRINTED ON 14:20:10 06 JUL 1994

PART NUMBER.	DESCRIPTION..................	QPA.....	ITM NBR	REF DESIG...........	DRAWING..... NUMBER
80675	SBE 5T 3000 RPM PUMP MOTOR/DRIVER, /DWG 40630				40630
20081	MOTOR, 7.4 OHM, PITTMAN 3711B112-R1	1.0000			
23595	SBE 5T PUMP PCB MOUNT BLOCK, /DWG 20624	1.0000			20624
30260	SCREW INSUL, # 2 X 1/8, IN-2/2	2.0000			
30357	MACH SCREW, 2-56 X 1/4 PH, SS	2.0000			
30560	MACH SCREW, 2-56 X 9/16 FH, SS, PHILIPS	2.0000			
80639	PUMP DRIVER, SMT, /DWG 40605	1.0000			40605 31441

***

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N 80675, 31441	SCALE	DRAWN BY DJM / APPROVED BY
DECIMAL	TITLE SBE 5T 3000 RPM PUMP		
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40630	REV A

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	SEE HISTORY	P.G.	BAF	



SLB PRINTED ON 14:20:10 06 JUL 1994

PART NUMBER.	DESCRIPTION..................	QPA.....
80676	SBE 5T 1300 RPM, NORM POWER MOTOR, /DWG 40631	
20080	MOTOR, PUMP, 18 OHM PITTMAN 3711B113-R1	1.0000
23595	SBE 5T PUMP PCB MOUNT BLOCK, /DWG 20624	1.0000
30260	SCREW INSUL, # 2 X 1/8, IN-2/2	2.0000
30357	MACH SCREW, 2-56 X 1/4 PH, SS	2.0000
30560	MACH SCREW, 2-56 X 9/16 FH, SS, PHILIPS	2.0000
80639	PUMP DRIVER, SMT, /DWG 40605	1.0000

***

SLB PRINTED ON 14:20:10 06 JUL 1994

PART NUMBER.	DESCRIPTION..................	QPA.....
80681	SBE 5T 1300 RPM LO-VOLT MOT/DRVR /DWG 40631	
20080	MOTOR, PUMP, 18 OHM PITTMAN 3711B113-R1	1.0000
23595	SBE 5T PUMP PCB MOUNT BLOCK, /DWG 20624	1.0000
30260	SCREW INSUL, # 2 X 1/8, IN-2/2	2.0000
30357	MACH SCREW, 2-56 X 1/4 PH, SS	2.0000
30560	MACH SCREW, 2-56 X 9/16 FH, SS, PHILIPS	2.0000
80639	PUMP DRIVER, SMT, /DWG 40605	1.0000

***

TOLERANCES	SEA-BIRD ELECTRONICS, INC			
FRACTIONAL	P/N 80681, 80676, 3144	SCALE	DRAWN BY DJM	APPROVED BY
DECIMAL	TITLE SBE 5T 1300 RPM PUMP			
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40631		REV A

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 42 **Revised September 2001**

ITS-90 TEMPERATURE SCALE

Beginning January 1995, Sea-Bird temperature calibration certificates list a new set of coefficients labeled *g*, *h*, *i*, *j*, and *F0*. These coefficients correspond to ITS90 (T90) temperatures and should be entered by those researchers working with SEASOFT-DOS Versions 4.208 and higher (and all versions of SEASOFT-Win32). For the convenience of users who prefer to use older SEASOFT versions, the new certificates also list *a*, *b*, *c*, *d*, and *F0* coefficients corresponding to IPTS68 (T68) temperatures as required by SEASOFT-DOS versions older than 4.208.

It is important to note that the international oceanographic research community will continue to use T68 for computation of salinity and other seawater properties. Therefore, following the recommendations of Saunders (1990) and as supported by the Joint Panel on Oceanographic Tables and Standards (1991), SEASOFT-DOS 4.200 and later and all versions of SEASOFT-Win32 convert between T68 and T90 according to the linear relationship:

$$T_{68} = 1.00024 * T_{90}$$

The use of T68 for salinity and other seawater calculations is automatic in all SEASOFT programs. However, when selecting **temperature** as a display/output variable, you will be prompted to specify which standard (T90 or T68) is to be used to compute temperature. SEASOFT recognizes whether you have entered T90 or T68 coefficients in the configuration (.con) file, and computes T90 temperature directly or calculates it from the Saunders linear approximation, depending on which coefficients were used and which display variable type is selected.

For example, if *g, h, i, j, F0* coefficients (T90) are entered in the .con file and you select temperature variable type as T68, SEASOFT computes T90 temperature directly and multiplies it by 1.00024 to display T68. Conversely, if *a, b, c, d,* and *F0* coefficients (T68) are entered in the .con file and you select temperature variable type as T90, SEASOFT computes T68 directly and divides by 1.00024 to display T90.

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

Also beginning January 1995, Sea-Bird's own temperature metrology laboratory (based upon water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge) converted to T90. These T90 standards are now employed in calibrating *all* Sea-Bird temperature sensors, and as the reference temperature used in conductivity calibrations. Accordingly, all calibration certificates show T90 (g, h, i, j) coefficients that result directly from T90 standards, and T68 coefficients (a, b, c, d) computed using the Saunders linear approximation.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 57 **Revised May 2003**

I/O Connector Care and Installation

This Application Note describes the proper care and installation of standard I/O connectors for Sea-Bird CTD instruments. Once properly installed, the connections require minimal care. Unless access to the bulkhead is required, the connections can be left in place indefinitely.

The Application Note is divided into three sections:
- Connector Cleaning and Installation
- Locking Sleeve Installation
- Cold Weather Tips

Connector Cleaning and Installation

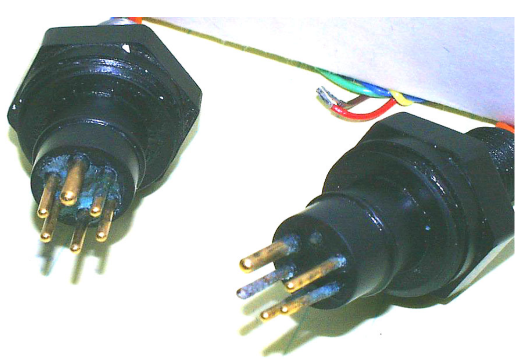
1. Carefully clean the bulkhead connector and the inside of the mating inline (cable end) connector with a Kimwipe. Remove all grease, hair, dirt, and other contamination.


Clean bulkhead connector


Clean inside of connector

2. Inspect the connectors:
   A. Inspect the pins on the bulkhead connector for signs of corrosion. The pins should be bright and shiny, with no discoloration. If the pins are discolored or corroded, clean with alcohol and a Q-tip.
   B. Inspect the bulkhead connector for chips, cracks, or other flaws that may compromise the seal.
   C. Inspect the inline connector for cuts, nicks, breaks, or other problems that may compromise the seal.

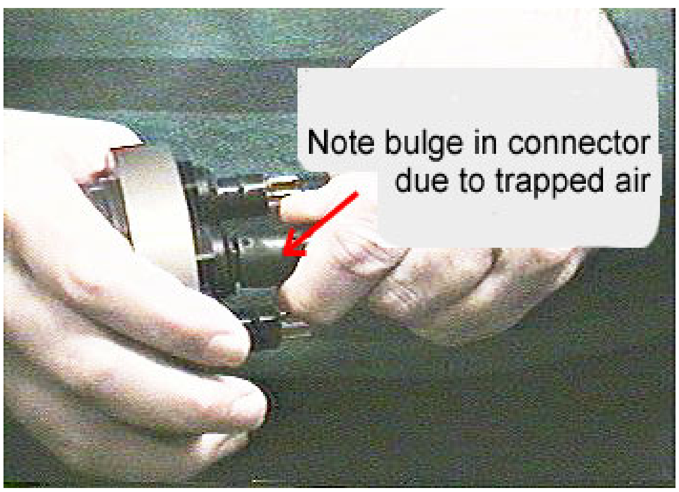
   Replace severely corroded or otherwise damaged connectors - contact SBE for instructions or a Return Authorization Number (RMA number).


Corroded pins on bulkhead connectors - Connector on right has a missing pin

3. Using a tube of 100% silicone grease (Dow DC-4 or equivalent), squeeze approximately half the size of a pea onto the end of your finger.

CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

4. Apply a light, even coating of grease to the molded ridge around the base of the bulkhead connector. The ridge looks like an o-ring molded into the bulkhead connector base and fits into the groove of the mating inline connector.

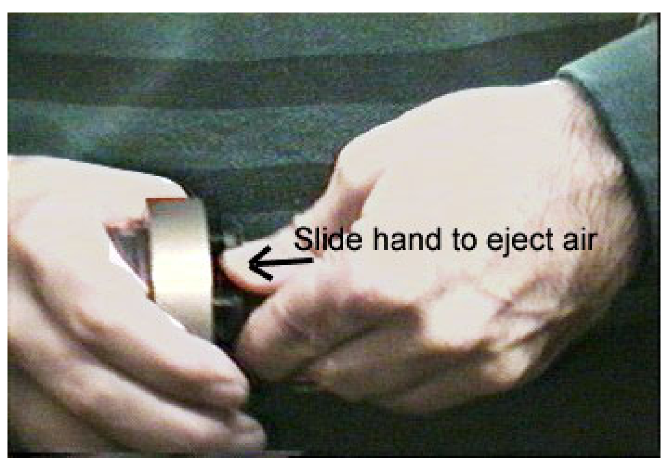


5. Mate the inline connector to the bulkhead, being careful to align the pins with the sockets. Do not twist the inline connector on the bulkhead connector. Twisting can lead to bent pins, which will soon break.

6. Push the connector all the way onto the bulkhead. There may be an audible pop, which is good. With some newer cables, or in cold weather, there may not be an initial audible pop.

7. After the cable is mated, run your fingers along the inline connector toward the bulkhead, *milking* any trapped air out of the connector. You should hear the air being ejected.

   CAUTION:
   Failure to eject the trapped air will result in the connector leaking.



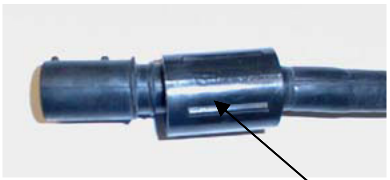
Locking Sleeve Installation

After the connectors are mated, install the locking sleeve. The locking sleeve secures the inline connector to the bulkhead connector and prevents the cable from being inadvertently removed.
Important points regarding locking sleeves:

- Tighten the locking sleeve by hand. **Do not** use a wrench or pliers to tighten the locking sleeve. Overtightening will gall the threads, which can bind the locking sleeve to the bulkhead connector. Attempting to remove a tightly bound locking sleeve may instead result in the bulkhead connector actually unthreading from the end cap. A loose bulkhead connector will lead to a flooded instrument. **Pay particular attention when removing a locking sleeve to ensure the bulkhead connector is not loosened**.

- It is a common misconception that the locking sleeve provides watertight integrity. **It does not, and continued re-tightening of the locking sleeve will not *fix* a leaking connector**.

- As part of routine maintenance at the end of every cruise, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.



Locking Sleeve

Cold Weather Tips

In cold weather, the connector may be hard to install and remove.

Removing a *frozen* inline connector:

1. Wrap the connector with a washrag or other cloth.

2. Pour hot water on the cloth and let the connector sit for a minute or two. The connector should thaw and become flexible enough to be removed.

Installing an inline connector:
When possible, mate connectors in warm environments before the cruise and leave them connected.
If not, warm the connector sufficiently so it is flexible. A flexible connector will install properly.

By following these procedures, you will have many years of reliable service from your cables!

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 67 **October 2001**

Editing Sea-Bird .hex Data Files

After acquiring real-time .hex data or uploading .hex data from CTD memory, users sometimes want to edit the header to add or change explanatory notes about the cast. Some text editing programs modify the file in ways that are not visible to the user (such as adding or removing carriage returns and line feeds), but that corrupt the format and prevent further processing by SEASOFT (both DOS and Windows versions). **This Application Note provides details on one way to edit a .hex data file with a text editor while retaining the required format.** The procedure described below has been found to work correctly on computers running Win 98, Win 2000, and Win NT. If the editing is not performed using this technique, SEASOFT may reject the data file and give you an error message.

1. Make a back-up copy of your .hex data file before you begin.

2. Run **WordPad**.

3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.

4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below, with the added lines in bold:

   * Sea-Bird SBE 21 Data File:
   * FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
   * Software Version Seasave Win32 v1.10
   * Temperature SN = 2366
   * Conductivity SN = 2366
   * System UpLoad Time = Oct 15 1999 10:57:19
   *** Testing adding header lines**
   *** Must start with an asterisk**
   *** Can be placed anywhere between System Upload Time and END of header**
   * NMEA Latitude = 30 59.70 N
   * NMEA Longitude = 081 37.93 W
   * NMEA UTC (Time) = Oct 15 1999 10:57:19
   * Store Lat/Lon Data = Append to Every Scan and Append to .NAV File When <Ctrl F7> is Pressed
   ** Ship: Sea-Bird
   ** Cruise: Sea-Bird Header Test
   ** Station:
   ** Latitude:
   ** Longitude:
   END

5. In the File menu, select Save (**not** Save As). If you are running Windows 2000, the following message displays:
   You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?
   Ignore the message and click *Yes*.

6. In the File menu, select Exit.

NOTE: This Application Note **does not apply to .dat data files**. Sea-Bird is not aware of a technique for editing a .dat file that will not corrupt the file.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 68

Revised **March 2004**

Using USB Ports to Communicate with Sea-Bird Instruments

Most Sea-Bird instruments use the RS-232 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, many newer PCs and laptop computers have USB port(s) instead of RS-232 serial port(s).

USB serial adapters are available commercially. These adapters plug into the USB port, and allow one or more serial devices to be connected through the adapter. Sea-Bird tested USB serial adapters from three manufacturers with our instruments, and verified compatibility. These manufacturers and the tested adapters are:

- **Keyspan** (www.keyspan.com) - High Speed USB Serial Adapter (part # USA-19QW) and USB 4-Port Serial Adapter (part # USA-49W)
- **Edgeport** (www.ionetworks.com) - Standard Serial Converter Edgeport/2 (part # 301-1000-02)
- **IOGEAR** (www.iogear.com) – USB 1.1 to Serial Converter Cable (model # GUC232A)

Other USB adapters from these manufacturers, and adapters from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing of any other adapters with the instrument before deployment, to verify that there is no problem.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 69 **July 2002**

Conversion of Pressure to Depth

Sea-Bird's SEASOFT software can calculate and output depth, if the instrument data includes pressure. Additionally, some Sea-Bird instruments (such as the SBE 37-SI or SBE 50) can be set up by the user to internally calculate depth, and to output depth along with the measured parameters.

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

Because most fresh water applications are shallow, and high precision in depth not too critical, Sea-Bird software uses a very simple approximation to calculate depth:

depth (meters) = pressure (decibars) * 1.019716

Seawater Applications

Sea-Bird uses the formula in UNESCO Technical Papers in Marine Science No. 44. This is an empirical formula that takes compressibility (that is, density) into account. An ocean water column at 0 °C (t = 0) and 35 PSU (s = 35) is assumed.

The gravity variation with latitude and pressure is computed as:

$$g\ (\mathrm{m/sec^2}) = 9.780318 * [\ 1.0 + (\ 5.2788\times10^{-3} + 2.36\times10^{-5} * x) * x\ ] + 1.092\times10^{-6} * p$$

where
$x = [\sin(\text{latitude} / 57.29578)\ ]^2$
p = pressure (decibars)

Then, depth is calculated from pressure:

$$\text{depth (meters)} = [(((-1.82\times10^{-15} * p + 2.279\times10^{-10}) * p - 2.2512\times10^{-5}) * p + 9.72659) * p] / g$$

where
p = pressure (decibars)
g = gravity (m/sec^2)

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 71 — September 2003

Desiccant Use and Regeneration (drying)

This application note applies to all Sea-Bird instruments intended for underwater use. The application note covers:
- When to replace desiccant
- Storage and handling of desiccant
- Regeneration (drying) of desiccant
- Material Safety Data Sheet (MSDS) for desiccant

When to Replace Desiccant Bags

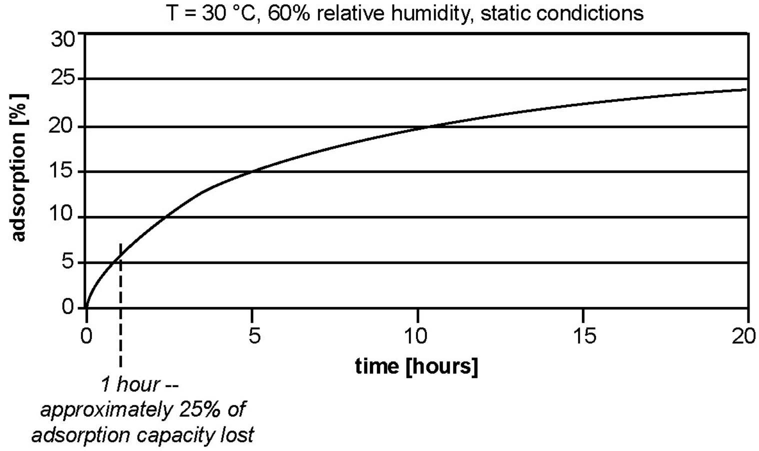
Before delivery of the instrument, a desiccant package is placed in the housing, and the electronics chamber is filled with dry Argon. These measures help prevent condensation. To ensure proper functioning:
1. Install a new desiccant bag each time you open the housing and expose the electronics.
2. If possible, dry gas backfill each time you open the housing and expose the electronics. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the chamber.

What do we mean by *expose the electronics*?
- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 37-SM, 37-SMP, 37-IM, 37-IMP, 44; PN 90208 Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39 and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

Testing by Süd-Chemie (desiccant's manufacturer) at 60% relative humidity and 30 °C shows that approximately 25% of the desiccant's adsorbing capacity is used up after only 1 hour of exposure to a constantly replenished supply of moisture in the air. In other words, if you take a bag out of a container and leave it out on a workbench for 1 hour, one-fourth of its capacity is gone before you ever install it in the instrument. Therefore:
- Keep desiccant bags in a tightly sealed, impermeable container until you are ready to use them. Open the container, remove a bag, and quickly close the container again.
- Once you remove the bag(s) from the sealed container, rapidly install the bag(s) in the instrument housing and close the housing. **Do not use the desiccant bag(s) if exposed to air for more than a total of 30 minutes.**

Adsorption Rate for Sorb-It®
(from http://www.s-cpp.com/pdf/DesiccantPerfData.pdf)
T = 30 °C, 60% relative humidity, static condictions



Regeneration (drying) of Desiccant

Replacement desiccant bags are available from Sea-Bird:

- PN 60039 is a metal can containing 25 1-gram desiccant bags and 1 humidity indicator card. The 1-gram bags are used in our smaller diameter housings, such as the SBE 3 (*plus*, F, and S), 4 (M and C), 5T, 37 (-SI, -SM, -SMP, -IM, and –IMP), 38, 39, 43, 44, 45, 48, 49, and 50.
- PN 31180 is a 1/3-ounce desiccant bag, used in our SBE 16*plus*, 16*plus*-IM, 19*plus*, and 21.
- PN 30051 is a 1-ounce desiccant bag. The 1-ounce bags are used in our larger diameter housings, such as the SBE 9*plus*, 16, 17*plus*, 19, 25, 26, 32, AFM, and PDIM.

However, if you run out of bags, you can regenerate your existing bags using the following procedure provided by the manufacturer (Süd-Chemie Performance Packaging, a Division of United Catalysts, Inc.):

MIL-D-3464 Desiccant Regeneration Procedure

Regeneration of the United Desiccants' Tyvek Desi Pak® or Sorb-It® bags or United Desiccants' X-Crepe Desi Pak® or Sorb-It® bags can be accomplished by the following method:

1. Arrange the bags on a wire tray in a single layer to allow for adequate air flow around the bags during the drying process. The oven's inside temperature should be room or ambient temperature (25 – 29.4 °C [77 – 85 °F]). **A convection, circulating, forced-air type oven is recommended for this regeneration process. Seal failures may occur if any other type of heating unit or appliance is used.**

2. When placed in forced air, circulating air, or convection oven, allow a minimum of 3.8 to 5.1 cm (1.5 to 2.0 inches) of air space between the top of the bags and the next metal tray above the bags. If placed in a radiating exposed infrared-element type oven, shield the bags from direct exposure to the heating element, giving the closest bags a minimum of 40.6 cm (16 inches) clearance from the heat shield. Excessive surface film temperature due to infrared radiation will cause the Tyvek material to melt and/or the seals to fail. Seal failure may also occur if the temperature is allowed to increase rapidly. This is due to the fact that the water vapor is not given sufficient time to diffuse through the Tyvek material, thus creating internal pressure within the bag, resulting in a seal rupture. Temperature should not increase faster than 0.14 to 0.28 °C (0.25 to 0.50 °F) per minute.

3. Set the temperature of the oven to 118.3 °C (245 °F), and allow the bags of desiccant to reach equilibrium temperature. **WARNING**: Tyvek has a melt temperature of 121.1 – 126.7 °C (250 – 260 °F) (Non MIL-D-3464E activation or reactivation of both silica gel and Bentonite clay can be achieved at temperatures of 104.4 °C [220 °F]).

4. Desiccant bags should be allowed to remain in the oven at the assigned temperature for 24 hours. At the end of the time period, the bags should be immediately removed and placed in a desiccator jar or dry (0% relative humidity) airtight container for cooling. If this procedure is not followed precisely, any water vapor driven off during reactivation may be re-adsorbed during cooling and/or handling.

5. After the bags of desiccant have been allowed to cool in an airtight desiccator, they may be removed and placed in either an appropriate type polyliner tightly sealed to prevent moisture adsorption, or a container that prevents moisture from coming into contact with the regenerated desiccant.

NOTE: Use only a metal or glass container with a tight fitting metal or glass lid to store the regenerated desiccant. Keep the container lid **closed tightly** to preserve adsorption properties of the desiccant.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	SiO_2.x H_2O

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water, lifting upper and lower eyelids occasionally. Get prompt medical attention.

First Aid (Skin) - Wash with soap and water.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

SÜD-CHEMIE
Creating Performance Technology

ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

Application Note 56 **Revised September 2003**

Interfacing to RS-485 Sensors

A few Sea-Bird instruments use the RS-485 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, most personal computers (PCs) do not come with an RS-485 port. This Application Note covers interfacing our RS-485 instruments with a PC by the following methods:

- Connecting the instrument to an external RS-485/RS-232 Interface Converter that plugs into an existing RS-232 port on the PC.

OR

- Installing an RS-485 interface card (and associated software) in the PC, and then connecting the instrument directly to the new RS-485 port in the PC.

External RS-485/RS-232 Interface Converter

RS-485/RS-232 Interface Converters are available commercially. These converters plug into the RS-232 port on the PC, and allow an RS-485 device to be connected through the converter. Sea-Bird tested a converter from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested converter is:

Black Box (www.blackbox.com) –
IC520A-F with RS-232 DB-25 female connector and RS-485 terminal block connector

Other converters from this manufacturer, and converters from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other converters with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the IC520A-F Converter:

1. Connect the Converter to the PC:
   - If the PC has a 25-pin male RS-232 connector, plug the Converter directly into the PC connector.
   - If the PC has a 9-pin male RS-232 connector, plug the Converter into a 25-pin to 9-pin adapter (such as Black Box FA520A-R2 Adapter). Plug the 25-pin to 9-pin adapter into the PC.

2. On the Converter, measure the voltage between XMT+ and ground and between XMT- and ground. Connect whichever has the highest voltage to RS-485 'A' and the other to RS-485 'B'. The ground terminal can be left unconnected.

RS-485 Interface Card and Port in the PC

An RS-485 Interface Card installs in the PC, and allow an RS-485 device to be connected to the RS-485 port. These Interface Cards are available commercially. When using with a Sea-Bird instrument:

- **RS-485 Transmitter -**
  The Interface Card must be configured to automatically handle the RS-485 driver enable.

- **Two-Wire Interface -**
  TX+ and RX+ on the Interface Card must be connector together and to 'A' on the instrument.
  TX- and RX- on the Interface Card must be connected together and to 'B' on the instrument.
  Note: Some Interface Cards have a jumper to make the connections internally, while for other Cards the connections must be made in a jumper cable.

- **Terminal Program Compatibility -**
  If the Interface Card uses shared interrupts, SEATERM (our Windows terminal program) must be used to communicate with the instrument.
  If the Interface Card is configured as a standard COM port, either SEATERM or our DOS-based terminal programs may be used to communicate with the instrument.

Sea-Bird tested two Interface Cards from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested cards are:

National Instruments (www.ni.com) -
AT-485/2
PCI-485/2

Other Cards from this manufacturer, and Cards from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other Cards with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the AT-485/2 or PCI-485/2 Interface Card:

1. Install the RS-485 driver software (provided with Interface Card) on your PC before installing the Interface Card.

2. Install the RS-485 Interface Card.

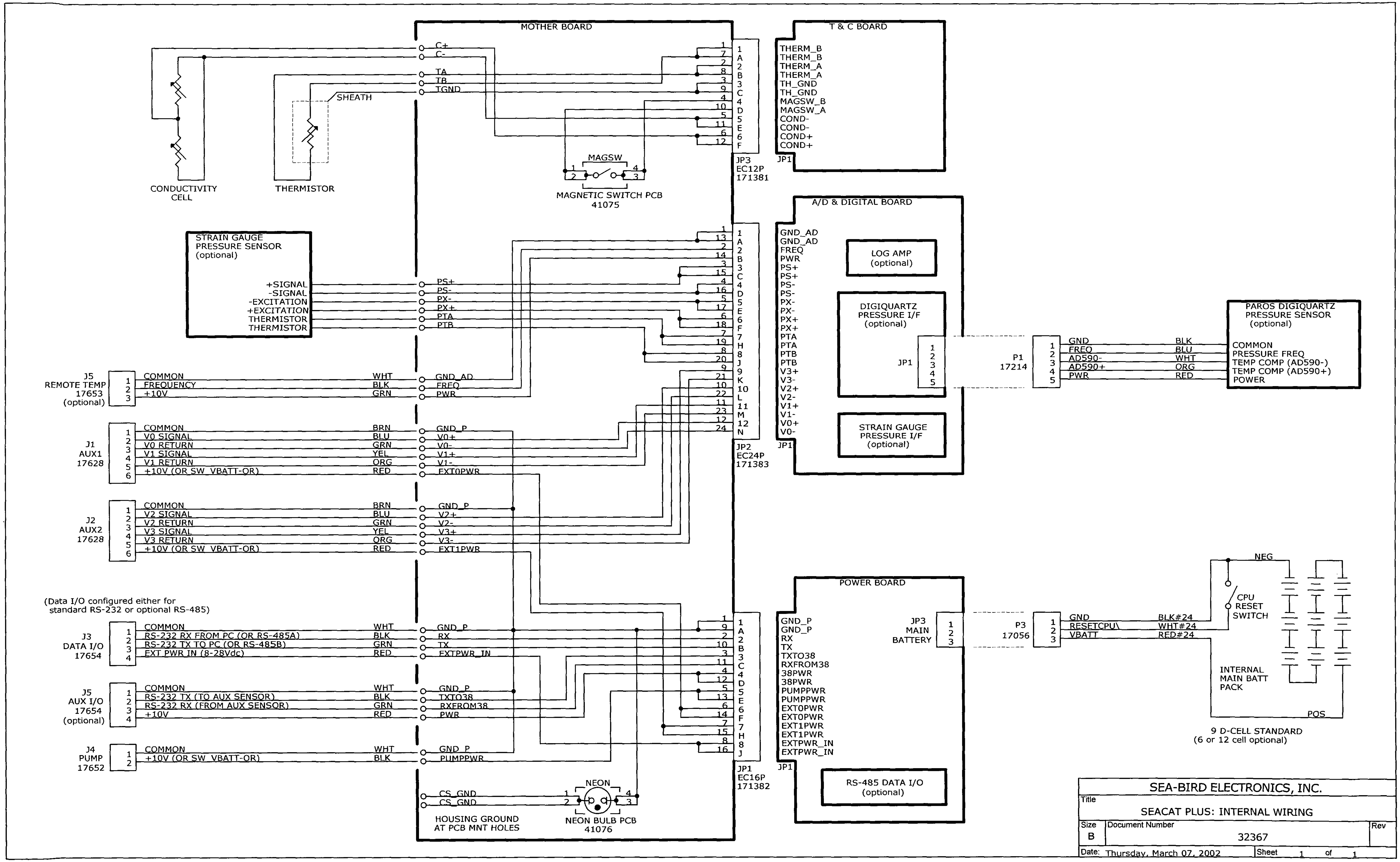
3. Configure the RS-485 Interface Card in your PC (directions are for a PC running Windows XP):
   A. Right click on My Computer and select Properties.
   B. In the System Properties dialog box, click on the Hardware tab. Click the Device Manager button.
   C. In the Device Manager window, double click on Ports. Double click on the desired RS-485 port.
   D. In the Communications Port Properties dialog box, click the Port Settings tab.
   Click the Advanced button.
   E. In the Advanced Settings dialog box, set Transceiver Mode to 2 wire TxRdy Auto.

4. Make a jumper cable (**do not use a standard adapter cable**) to connect the Interface Card to the instrument's I/O cable. Pin outs are shown for a Sea-Bird 9-pin (current production) or 25-pin (older production) I/O cable:

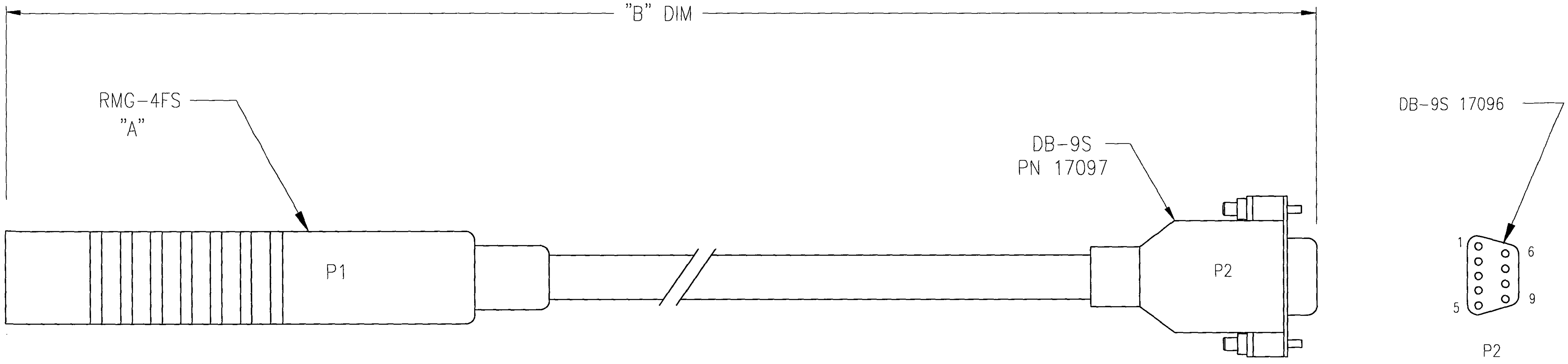
DB-9S (connect to PC)	**DB-9P** (connect to Sea-Bird I/O cable PN 801385)	**DB-25P** (connect to Sea-Bird I/O cable PN 801046)
pin 1 common	pin 5 common	pin 7 common
pin 4 TX+	pin 3 'A'	pin 2 'A'
pin 8 RX+	pin 3 'A'	pin 2 'A'
pin 5 TX-	pin 2 'B'	pin 3 'B'
pin 9 RX-	pin 2 'B'	pin 3 'B'

5. Run SEATERM (these Cards use shared interrupts, so the DOS terminal programs cannot be used):
   A. In SEATERM's Configure menu, select the desired instrument.
   B. In the Configuration Options dialog box, set Mode to RS-485 and set COMM Port to the appropriate RS-485 port.

DRAWINGS


MOTHER BOARD
T & C BOARD
THERM_B
THERM_B
THERM_A
THERM_A
TH_GND
TH_GND
MAGSW_B
MAGSW_A
COND-
COND-
COND+
COND+
JP1
C+
C-
TA
TB
TGND
SHEATH
CONDUCTIVITY CELL
THERMISTOR
MAGSW
MAGNETIC SWITCH PCB 41075
JP3 EC12P 171381
A/D & DIGITAL BOARD
GND_AD
GND_AD
FREQ
PWR
PS+
PS+
PS-
PS-
PX-
PX-
PX+
PX+
PTA
PTA
PTB
PTB
V3+
V3-
V2+
V2-
V1+
V1-
V0+
V0-
JP1
LOG AMP (optional)
DIGIQUARTZ PRESSURE I/F (optional)
JP1
STRAIN GAUGE PRESSURE I/F (optional)
P1 17214
GND BLK
FREQ BLU
AD590- WHT
AD590+ ORG
PWR RED
PAROS DIGIQUARTZ PRESSURE SENSOR (optional)
COMMON
PRESSURE FREQ
TEMP COMP (AD590-)
TEMP COMP (AD590+)
POWER
STRAIN GAUGE PRESSURE SENSOR (optional)
+SIGNAL
-SIGNAL
-EXCITATION
+EXCITATION
THERMISTOR
THERMISTOR
PS+
PS-
PX-
PX+
PTA
PTB
JP2 EC24P 171383
J5 REMOTE TEMP 17653 (optional)
COMMON WHT GND_AD
FREQUENCY BLK FREQ
+10V GRN PWR
J1 AUX1 17628
COMMON BRN GND_P
V0 SIGNAL BLU V0+
V0 RETURN GRN V0-
V1 SIGNAL YEL V1+
V1 RETURN ORG V1-
+10V (OR SW_VBATT-OR) RED EXT0PWR
J2 AUX2 17628
COMMON BRN GND_P
V2 SIGNAL BLU V2+
V2 RETURN GRN V2-
V3 SIGNAL YEL V3+
V3 RETURN ORG V3-
+10V (OR SW_VBATT-OR) RED EXT1PWR
(Data I/O configured either for standard RS-232 or optional RS-485)
J3 DATA I/O 17654
COMMON WHT GND_P
RS-232 RX FROM PC (OR RS-485A) BLK RX
RS-232 TX TO PC (OR RS-485B) GRN TX
EXT PWR IN (8-28Vdc) RED EXTPWR_IN
J5 AUX I/O 17654 (optional)
COMMON WHT GND_P
RS-232 TX (TO AUX SENSOR) BLK TXTO38
RS-232 RX (FROM AUX SENSOR) GRN RXFROM38
+10V RED PWR
J4 PUMP 17652
COMMON WHT GND_P
+10V (OR SW_VBATT-OR) BLK PUMPPWR
CS_GND
CS_GND
HOUSING GROUND AT PCB MNT HOLES
NEON
NEON BULB PCB 41076
JP1 EC16P 171382
POWER BOARD
GND_P
GND_P
RX
TX
TXTO38
RXFROM38
38PWR
38PWR
PUMPPWR
PUMPPWR
EXT0PWR
EXT0PWR
EXT1PWR
EXT1PWR
EXTPWR_IN
EXTPWR_IN
JP1
JP3 MAIN BATTERY
RS-485 DATA I/O (optional)
P3 17056
GND BLK#24
RESETCPU\ WHT#24
VBATT RED#24
NEG
CPU RESET SWITCH
INTERNAL MAIN BATT PACK
POS
9 D-CELL STANDARD (6 or 12 cell optional)
SEA-BIRD ELECTRONICS, INC.
Title
SEACAT PLUS: INTERNAL WIRING
Size B
Document Number 32367
Rev
Date: Thursday, March 07, 2002
Sheet 1 of 1

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



ASSY P/N	"A" CABLE P/N	"B" DIM
801225	17741	8 FEET

ROCHESTER 3-N-5 OR EQUIV.
3 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	RED	PIN 2

ESSEX ROYAL 18/4 OR EQUIV.
4 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	GREEN	PIN 2
PIN 4	RED	N/C

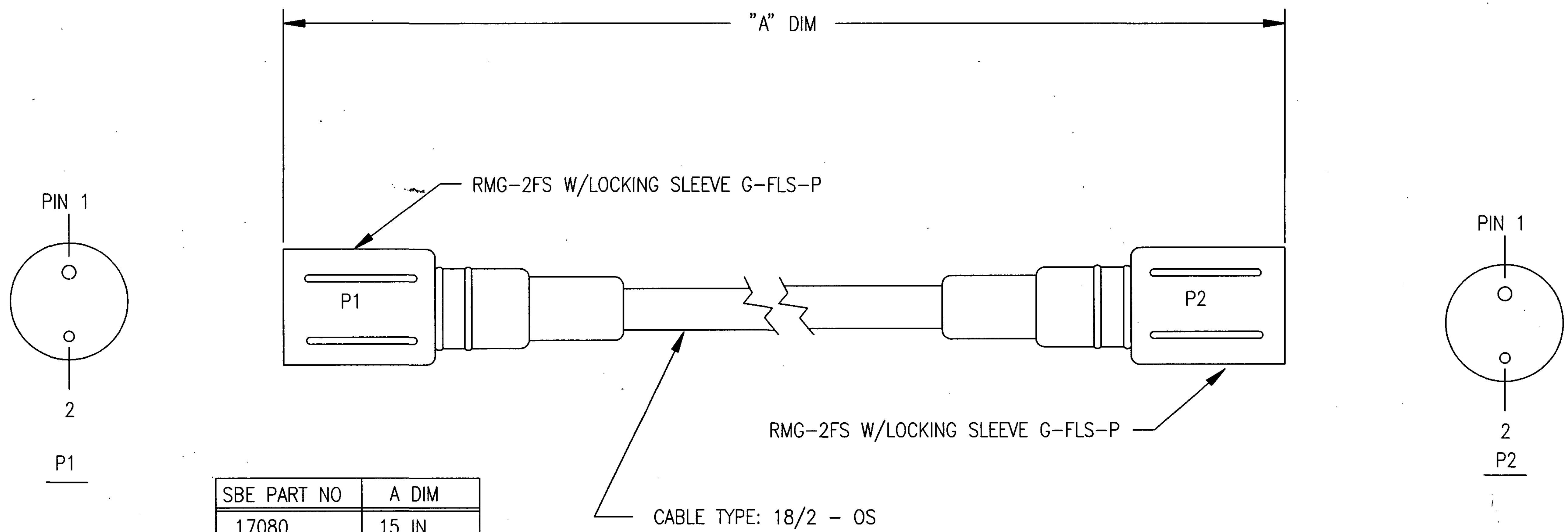
SEA-BIRD ELECTRONICS, INC

P/N	SCALE	DRAWN BY	APPROVED BY
SEE TABLE	–	PMc	

RMG-4FS TO DB-9S CABLE ASSEMBLY

DATE	DWG NO.	SHEET	REV
6/26/00	32421	1 of 1	–

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



SBE PART NO	A DIM
17080	15 IN
17100	40 IN
17101	6 FT
17127	60 IN
17133	44 IN
17159	36 IN
17188	34 IN
17200	79 IN
17259	120 IN
17285	12 IN
17394	29 IN
17450	24 IN
17584	48 IN
171229	10 M
171249	130 CM

P1	P2
PIN 1	PIN 1
PIN 2	PIN 2

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE N.T.S.	DRAWN BY CEG / APPROVED BY CB
DECIMAL	TITLE CABLE, 2 PIN / 2 PIN RMG-2FS W/LOCKING SLEEVE		
ANGULAR	DATE 9.21.98	DRAWING NUMBER 30565	REV

WARRANTY POLICY 2003

5-YEAR LIMITED WARRANTY (NEW PRODUCTS)

For a period of five years after the date of original shipment from our factory, products manufactured by Sea-Bird are warranted to function properly and be free of defects in materials and workmanship. Should a Sea-Bird instrument fail during the warranty period, return it freight pre-paid to our factory. We will repair it (or at our option, replace it) at no charge, and pay the cost of shipping it back to you. Certain products and components have modified coverage under this warranty as described below.

LIMITED WARRANTY ON SERVICE & REPAIRS

Service work, repairs, replacement parts and modifications are warranted to be free of defects in materials or workmanship for the remainder of the original 5-year warranty or one year from the date of shipment from our factory after repair or service, which ever is longer. Certain products and components have modified coverage under this warranty as described below.

MODIFICATIONS / EXCEPTIONS / EXCLUSIONS

1. The SBE 43 DO sensor is warranted to function properly for 5 years. Under normal use however, the electrolyte in an SBE 43 DO sensor will require replenishment after about 3 years. Purchase of an SBE 43 includes one free electrolyte replenishment (as necessitated by chemical depletion of electrolyte) anytime during the warranty period. To obtain the replenishment, return the sensor freight pre-paid to our factory. We will refurbish it for free (electrolyte refill, membrane replacement, and recalibration) and pay the cost of shipping it back to you. Membrane damage or depletion of electrolyte caused by membrane damage is not covered by this warranty.

2. Because pH and other dissolved oxygen (DO) electrodes have a limited life caused by the depletion of their chemical constituents during normal storage and use, our warranty applies differently to such electrodes. Electrodes in SBE 13 and 23 DO sensors, SBE 18 pH sensors, and SBE 27 pH/ORP sensors are covered under warranty for the first 90 days only. Other components of the sensor are covered for 5 years.

3. Equipment manufactured by other companies (e.g., fluorometers, transmissometers, PAR, optical backscatter sensors, altimeters, etc.) are warranted only to the limit of the warranties provided by their original manufacturers.

4. Batteries, zinc anodes, or other consumable/expendable items are not covered under this warranty.

5. This warranty is void if in our opinion the instrument has been damaged by accident, mishandled, altered, or repaired by the customer where such treatment has affected its performance or reliability. In the event of such abuse by the customer, costs for repairs plus two-way freight costs will be borne by the customer. Instruments found defective should be returned to the factory carefully packed, as the customer will be responsible for freight damage.

6. Incidental or consequential damages or costs incurred as a result of product malfunction are not the responsibility of SEA-BIRD ELECTRONICS, INC

Warranty Administration Policy

Sea-Bird Electronics, Inc. and its authorized representatives or resellers provide warranty support only to the original purchaser. Warranty claims, requests for information or other support, and orders for post-warranty repair and service, by end-users that did not purchase directly from Sea-Bird or an authorized representative or reseller, must be made through the original purchaser. The intent and explanation of our warranty policy follows:

1. Warranty repairs are only performed by Sea-Bird.

2. Repairs or attempts to repair Sea-Bird products performed by customers (owners) shall be called *owner repairs*.

3. Our products are designed to be maintained by competent owners. Owner repairs of Sea-Bird products will NOT void the warranty coverage (as stated above) simply as a consequence of their being performed.

4. Owners may make repairs of any part or assembly, or replace defective parts or assemblies with Sea-Bird manufactured spares or authorized substitutes without voiding warranty coverage of the entire product, or parts thereof. Defective parts or assemblies removed by the owner may be returned to Sea-Bird for repair or replacement within the terms of the warranty, without the necessity to return the entire instrument. If the owner makes a successful repair, the repaired part will continue to be covered under the original warranty, as if it had never failed. Sea-Bird is not responsible for any costs incurred as a result of owner repairs or equipment downtime.

5. We reserve the right to refuse warranty coverage *on a claim by claim basis* based on our judgment and discretion. We will not honor a warranty claim if in our opinion the instrument, assembly, or part has been damaged by accident, mishandled, altered, or repaired by the customer *where such treatment has affected its performance or reliability*.

6. For example, if the CTD pressure housing is opened, a PC board is replaced, the housing is resealed, and then it floods on deployment, we do not automatically assume that the owner is to blame. We will consider a claim for warranty repair of a flooded unit, subject to our inspection and analysis. If there is no evidence of a fault in materials (e.g., improper or damaged o-ring, or seal surfaces) or workmanship (e.g., pinched o-ring due to improper seating of end cap), we would cover the flood damage under warranty.

7. In a different example, a defective PC board is replaced with a spare and the defective PC board is sent to Sea-Bird. We will repair or replace the defective PC board under warranty. The repaired part as well as the instrument it came from will continue to be covered under the original warranty.

8. As another example, suppose an owner attempts a repair of a PC board, but solders a component in backwards, causing the board to fail and damage other PC boards in the system. In this case, the evidence of the backwards component will be cause for our refusal to repair the damage under warranty. However, this incident will NOT void future coverage under warranty.

9. If an owner's technician attempts a repair, we assume his/her qualifications have been deemed acceptable to the owner. The equipment owner is free to use his/her judgment about who is assigned to repair equipment, and is also responsible for the outcome. The decision about what repairs are attempted and by whom is entirely up to the owner.

Service Request Form

To return your instrument for calibration or other service, please take a few moments to provide us with the information we need, so we can serve you better.

PLEASE:

1. **Get a Returned Material Authorization (RMA) number from Sea-Bird (*phone 425-643-9866, fax 425-643-9954, or email seabird@seabird.com*). Reference the RMA number on this form, on the outside shipping label for the equipment, and in all correspondence related to this service request.**
2. **Fill out 1 form for each type (model) of instrument.**
3. **Include this form when shipping the instrument to Sea-Bird for servicing.**
4. **Fax us a copy of this form on the day you ship.** ***FAX: (425) 643-9954***

RETURNED MATERIAL AUTHORIZATION (RMA) NUMBER

RMA Number: ______________________________

CONTACT INFORMATION

Your name: ______________________________

Institution/Organization/Company: ______________________________

Shipping/Delivery address for packages: ______________________________

____

____

Telephone: ______________________ Fax: ______________________

e-mail: ______________________

SERVICE INFORMATION

Date Shipped: ______________________________

Sea-Bird Model Number (for example, SBE 37-SM): ______________________________

Quantity: ______________________________

Serial Numbers: ______________________________

____

____

(**Note**: **Specify instrument serial numbers below** if specific services are required for some instruments. For example, if 10 instruments are being returned for calibration, and 1 of the 10 also requires repairs, specify the serial number for the instrument requiring the repairs in the appropriate section of the form.)

SEASOFT Version you have been using with this instrument(s): ______________________

[ ] Perform Routine Services:

____Calibration (includes basic diagnostic):

___Temperature ___Conductivity ___Pressure ___DO ___pH

(Please allow a minimum of 3 weeks after we receive the instrument(s) to complete calibration.)

____Full System Diagnostic and Check Out

____Other (specify): ______________________________

____

[ ] System Upgrade or Conversion:

Specify (include instrument serial number if multiple instruments are part of shipment): ____________

____

____

[ ] Diagnose and Repair Operational Faults:

Please send a disk containing the raw data (.hex or .dat files) which shows the problems you describe. Also send the .con files you used to acquire or display the data.

Problem Description (continue on additional pages if needed; include instrument serial number if multiple instruments are part of shipment): ______________________________

____

____

____

____

PAYMENT/BILLING INFORMATION
Credit Card: Sea-Bird accepts payment by MasterCard, VISA, or American Express.
[ ] MasterCard [ ] Visa [ ] American Express
Account Number: ______________________________ Expiration Date: __________
Credit Card Holder Name (printed or typed): ______________________________
Credit Card Holder Signature: ______________________________
Credit Card Billing Address (if different than shipping address):
____
____
____

Invoice/Purchase Order: If you prefer us to invoice you, please complete the following or enclose a copy of your Purchase Order:
Purchase Order Number: ______________________________
Billing Address (if different than shipping address):
____
____
____

Instructions for Returning Goods to Sea-Bird

You can ship any of the following ways:

1. **Domestic Shipments (USA) -** Ship prepaid (via UPS, FedEx, DHL, etc.) directly to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954
2. **Foreign Shipments** - Ship via prepaid airfreight to:
   Sea-Bird Electronics, Inc.
   1808 136th Place NE
   Bellevue, WA 98005, USA
   Telephone: (425) 643-9866 Fax: (425) 643-9954
   Notify: MTI Worldwide Logistics for Customs Clearance
   Seattle, WA, USA
   Telephone: (206) 431-4366 Fax: (206) 431-4374
   (Please note Airport of Destination: ***SEA*** for Seattle, WA)
3. **Ship via EXPRESS COURIER directly to Sea-Bird Electronics** (UPS, FedEx, or DHL; **do not ship via TNT SKYPACK**). Courier services will clear Customs and deliver the package to Sea-Bird. It is not necessary to notify our customs broker.
   Include a **commercial invoice** showing the description of the instruments, and **value for Customs purposes only**. On the invoice, include the statement that **"Goods are of USA Origin".**
   Failure to include this statement in your invoice will result in US Customs assessing duties on the shipment, which we will in turn pass on to the customer/shipper.

Note:
Due to changes in EU and Chinese regulations, if Sea-Bird receives an instrument from the EU or China in a crate containing coniferous solid wood, we will return the instrument in a new crate made with mahogany and plywood. We will charge for the replacement crates based on the dimensions of the crate we receive. The charge will be determined as follows:

1. Multiply the crate length x width x height in centimeters (overall volume in cm3, not internal volume).
2. Determine the price based on your calculated overall volume and the following chart:

Overall Volume (cm3)	Example Instrument	Price (USD)
less than 52,000	37-SM MicroCAT	$45
52,000 to less than 65,000	SEACAT, no cage	$70
65,000 to 240,000	CTD in cage	$125
more than 240,000	--	consult factory

These prices are valid only for crate replacement required in conjunction with the return of a customer's instrument after servicing, and only when the instrument was shipped to Sea-Bird in a crate originally supplied by Sea-Bird.

SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface

Serial Number: 19P36026-4616 and -4617

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

WARNING !!

Do not submerge this instrument (S/N 19P36026-4616)
beyond the depth rating of the lowest rated component listed below!

Main Housing (Plastic)	**600 meters**
Pressure Sensor (1000 dBar) Druck	1000 meters
Pump (SBE 5M)	10500 meters

WARNING !!

**Do not submerge this instrument (S/N 19P36026-4617)
beyond the depth rating of the lowest rated component listed below!**

Main Housing (Plastic)	**600 meters**
Pressure Sensor (1000 dBar) Druck	1000 meters
Pump (SBE 5M)	10500 meters

SYSTEM CONFIGURATION 14 June 2004

Model SBE 19plus	**S/N 19P36026-4616**
Instrument Type	**SBE 19plus SeaCaT Profiler**
Firmware Version	**1.4D**
Communications	**9600 baud, 8 data bits, no parity, one stop bit**
Memory	**8192K**
Housing	**600 meter (Celcon plastic)**
0 Conductivity Raw Frequency	**2686.52 Hz**
Pressure Sensor	**Strain Gauge: 1000 dBar, S/N 5512**
Number of Voltages Sampled:	**0**
Serial RS-232C Sensor	**None**

Data Format:

Count	**Temperature**
Frequency	**Conductivity**
Count	**Pressure, Strain gauge**

Pump (SBE 5M)	**050651**
Voltage Delay Setting (standard)	**(standard) 0 seconds**

SYSTEM CONFIGURATION 14 June 2004

Model SBE 19plus	**S/N 19P36026-4617**
Instrument Type	**SBE 19plus SeaCaT Profiler**
Firmware Version	**1.4D**
Communications	**9600 baud, 8 data bits, no parity, one stop bit**
Memory	**8192K**
Housing	**600 meter (Celcon plastic)**
0 Conductivity Raw Frequency	**2801.47 Hz**
Pressure Sensor	**Strain Gauge: 1000 dBar, S/N 5513**
Number of Voltages Sampled:	**0**
Serial RS-232C Sensor	**None**
Data Format:	
Count	**Temperature**
Frequency	**Conductivity**
Count	**Pressure, Strain gauge**
Pump (SBE 5M)	**050649**
Voltage Delay Setting (standard)	**(standard) 0 seconds**

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

FAX: (425) 643-9954
Tel: (425) 643-9866
Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET for 4616

Serial Number: 0651

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.947	VDC	Current	11.8	mA
Vin 9V voltage across C2:	7.948	VDC	Current	11.0	mA
Vin 6V voltage across C2:	5.868	VDC	Current	10.2	mA

Pump submerged test, no load, Vin 12VDC   Average current draw in water: 124 mA

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

FAX: (425) 643-9954
Tel: (425) 643-9866
Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET for 4617

Serial Number: 0649

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.947	VDC	Current	11.8	mA
Vin 9V voltage across C2:	7.948	VDC	Current	11.0	mA
Vin 6V voltage across C2:	5.868	VDC	Current	10.2	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 124 mA

IMPORTANT SOFTWARE & HARDWARE CONFIGURATION INFORMATION

Sea-Bird supplies two versions of our software package for communication, real-time data acquisition, and data analysis and display:

- SEASOFT-Win32 - Windows software for PC running Win 95/98/NT/2000/XP
- SEASOFT-DOS - DOS software for IBM-PC/AT/386/486 or compatible computer with a hard drive

Detailed information on the use of the **Windows** software follows:

SEASOFT-Win32

SEASOFT-Win32 software was supplied on a CD-ROM with your CTD. This software package is designed to run on a PC running Win 95/98/NT/2000/XP. The CD-ROM also contains software manuals that describe the appropriate applications for the various programs, the procedure for installing the software, and instructions on using the programs. There are three primary programs used with the CTD for setup, data collection and retrieval, data display, and data processing:

- SEATERM - terminal program for setup of the CTD and uploading of data from the CTD memory (**Note**: If using the CTD with the 90208 Auto Fire Module or SBE 17*plus* V2 SEARAM, use SeatermAF instead of SEATERM)
- SEASAVE - real-time data acquisition program
- SBE Data Processing - data processing program

Instructions for using the software are found in their Help files.

To communicate with the CTD to set it up or to upload data from the CTD memory to the computer hard drive, **SEATERM** must have information about the CTD hardware configuration (communication parameters, internal firmware, etc.) and about the computer. To communicate with the CTD, double click on Seaterm.exe:

1. In the Configure menu, select the CTD. The Configuration Options dialog box appears.
   A. On the COM Settings tab, select the firmware version (if applicable), baud rate, data bits, and parity to match the CTD's configuration sheet. If necessary, change the com port to match the computer you are using.
   B. On the Upload Settings tab, enter upload type (all as a single file, etc.) as desired.
   For the SBE 17 and 25 only: enter the serial number for the SBE 3 (temperature) and SBE 4 (conductivity) modular sensors, exactly as they appear in the configuration (.con) file.
   C. On the Header Information tab, change the settings as desired.

   Click OK when done. SEATERM saves the settings in a SEATERM.ini file.
2. On the Toolbar, click Connect to communicate with the CTD.
3. To set up the CTD prior to deployment:
   On the Toolbar, click Status. SEATERM sends the Status command and displays the response. Verify that the CTD setup matches your desired deployment. If not, send commands to modify the setup.
4. To upload data from the CTD:
   On the Toolbar, click Upload to upload data from the CTD memory to the computer.

Sea-Bird CTDs store and/or transmit data from their primary and auxiliary sensors in the form of binary or hexadecimal number equivalents of the sensors' frequency or voltage outputs. This is referred to as the *raw* data. The calculations required to convert from *raw* data to *engineering* units of the measured parameters (temperature, conductivity, pressure, dissolved oxygen, pH, etc.) are performed using the software, either in real time, or after the data has been stored in a file. SEASAVE creates the file in real time. As noted above, SEATERM uploads the recorded data and creates the file on the computer hard drive.

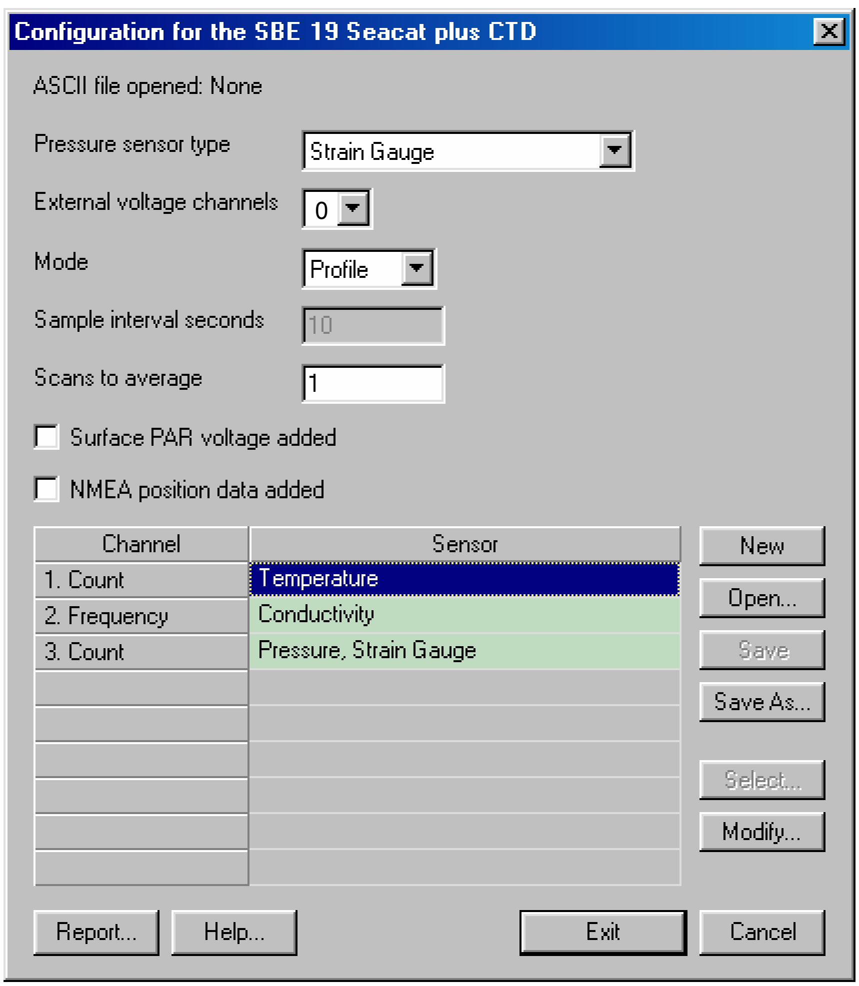
To successfully store data to a file on the computer and subsequently convert it to engineering units, the software must know the CTD type, CTD configuration, and calibration coefficients for the sensors installed on the CTD. This information is unique to each CTD, and is contained in a *configuration* file. The configuration file, which has a .con extension, was written onto a floppy disk and the CD-ROM shipped with the CTD. The .con file for a given CTD is named with the last four digits of the serial number for that CTD (e.g., 1234.con). The configuration file is created or modified (e.g., changing coefficients after recalibration, or adding another sensor) by using the Configure menu in **SEASAVE** or **SBE Data Processing**. The configuration file is used by SEASAVE to convert raw data to engineering units when it acquires, stores, and displays real-time data. The configuration file is also used by some modules in SBE Data Processing (Data Conversion and Derive) that convert raw data to engineering units during data processing.

The instrument type and instrument configuration settings of the .con file and the required setup for the SEATERM.ini file for the CTD *as delivered* are documented below. The calibration coefficients for the CTD's sensors are contained in the calibration coefficient section of the CTD manual.

NOTE:
SEATERM will not upload data correctly without a properly configured SEATERM.ini file. SEASAVE and SBE Data Processing will not interpret the data correctly without the correct .con file.

SEASOFT CONFIGURATION:

The correct instrument type for your instrument is SBE 19plus SEACAT Profiler. The correct settings for the configuration of your instrument as delivered are documented below:



SPECIFICATIONS

SEACAT Profiler

SBE 19*plus*

The SBE 19*plus* is the next generation *Personal CTD*, bringing numerous improvements in accuracy, resolution (in fresh as well as salt water), reliability, and ease-of-use to the wide range of research, monitoring, and engineering applications pioneered by its legendary SEACAT predecessor. The 19*plus* samples faster (4 Hz vs 2), is more accurate (0.005 vs 0.01 in T, 0.0005 vs 0.001 in C, and 0.1% vs 0.25% — with *seven* times the resolution — in D), and has more memory (8 Mbyte vs 1). There is more power for auxiliary sensors (500 ma vs 50), and they are acquired at higher resolution (14 bit vs 12). Cabling is simpler and more reliable because there are four differential auxiliary inputs on two separate connectors, and a dedicated connector for the pump. All exposed metal parts are titanium, instead of aluminum, for long life and minimum maintenance.

The 19*plus* can be operated without a computer from even the smallest boat, with data recorded in non-volatile FLASH memory and processed later on your PC. Simultaneous with recording, real-time data can be transmitted over single-core, armored cable directly to your PC's serial port (maximum transmission distance dependent on number of auxiliary sensors, baud rate, and cable properties). The 19*plus'* faster sampling and pump-controlled TC-ducted flow configuration significantly reduces salinity spiking caused by ship heave, and allows slower descent rates for improved resolution of water column features. Auxiliary sensors for dissolved oxygen, pH, turbidity, fluorescense, PAR, and ORP can be added, and for moored deployments the 19*plus* can be set to *time-series* mode using software commands. External power and two-way real-time communication over 10,000 meters of cable can be provided with the SBE 36 CTD Deck Unit and Power and Data Interface Module (PDIM).

The 19*plus* uses the same temperature and conductivity sensors proven in 5000 SEACAT and MicroCAT instruments, and a superior new micro-machined silicon strain gauge pressure sensor developed by Druck, Inc. Improvements in design, materials, and signal acquisition techniques yield a low-cost instrument with superior performance that is also easy to use. Calibration coefficients, obtained in our computer-controlled high-accuracy calibration baths, are stored in EEPROM memory. They permit data output in ASCII engineering units (degrees C, Siemens/m, decibars, Salinity [PSU], sound velocity [m/sec], etc.). The 19*plus* can be factory-configured to emulate the .hex output format and 2 Hz data rate of old SEACATs for compatibility with existing software or instrument fleets.

Accuracy, convenience, portability, software, and support; compelling reasons why the 19*plus* is today's best low-cost CTD.

CONFIGURATION AND OPTIONS

A standard SBE 19*plus* is supplied with:
- Plastic housing for depths to 600 meters
- Strain-gauge pressure sensor
- 8 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries
- Impulse glass-reinforced epoxy bulkhead connectors: 4-pin I/O, 2-pin pump, and two 6-pin (two differential auxiliary A/D inputs each)
- SBE 5M miniature pump and T-C Duct

Options include:
- Titanium housing for depths to 7000 meters
- Sensors for oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity
- SBE 5T pump in place of SBE 5M for use with dissolved oxygen and/or other pumped sensors
- Stainless steel cage
- MCBH *Micro* connectors
- Ni-Cad batteries and charger

Shown with optional cage, SBE 5T pump, & SBE 43 DO sensor

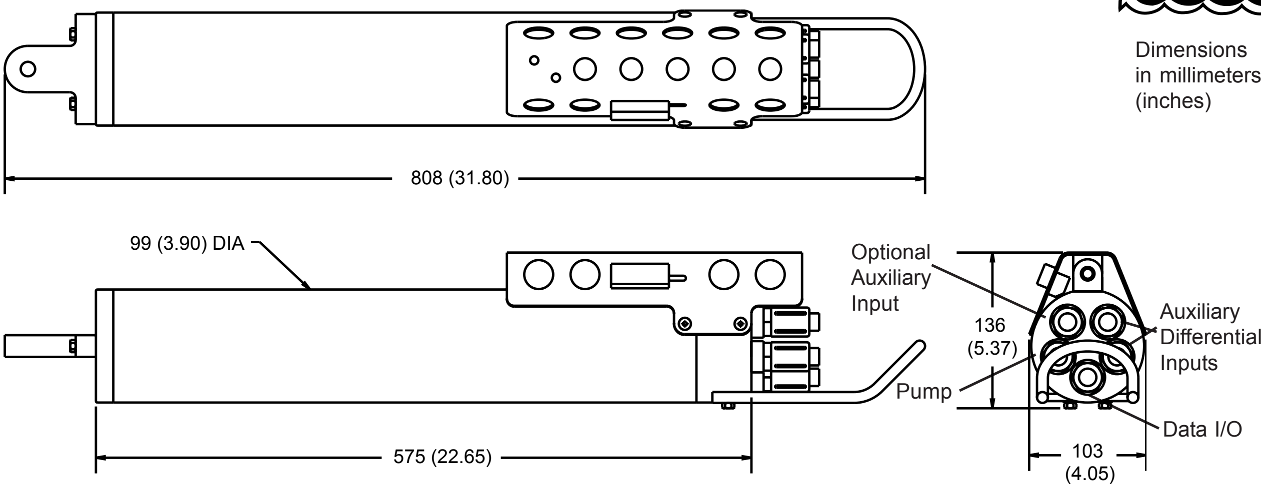
SOFTWARE

SEASOFT©-Win32, our complete Windows 95/98/NT/2000/XP software package, is included at no extra charge. Its modular programs include:
- SEATERM© — communication and data retrieval
- SEASAVE© — real-time data acquisition and display
- SBE Data Processing© — filtering, aligning, averaging, and plotting of CTD and auxiliary sensor data and derived variables

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
Email: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

SEACAT Profiler

SBE 19*plus*



SPECIFICATIONS

Measurement Range

Temperature	-5 to +35 °C
Conductivity	0 to 9 S/m
Pressure	0 to 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters

Initial Accuracy

Temperature	0.005 °C
Conductivity	0.0005 S/m
Pressure	0.1% of full scale range

Typical Stability (*per month*)

Temperature	0.0002 °C
Conductivity	0.0003 S/m
Pressure	0.004% of full scale range

Resolution

Temperature	0.0001 °C
Conductivity	0.00005 S/m (most oceanic waters; resolves 0.4 ppm in salinity)
	0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity)
	0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity)
Pressure	0.002% of full scale range

Memory 8 Mbyte non-volatile FLASH memory

Data Storage

Recorded Parameter	Bytes/Sample
T + C	6
pressure	5
each external voltage	2

Real-Time Clock 32,768 Hz TCXO accurate to ±1 minute/year

Internal Batteries 9 alkaline D-cells provide 60 hours continuous CTD operation; optional 9-cell rechargeable nickel-cadmium battery pack provides approximately 24 hours operation per charge

External Power Supply 9 - 28 VDC

Power Requirements

Sampling	65 mA
SBE 5M pump	95 mA
Quiescent	30 μA

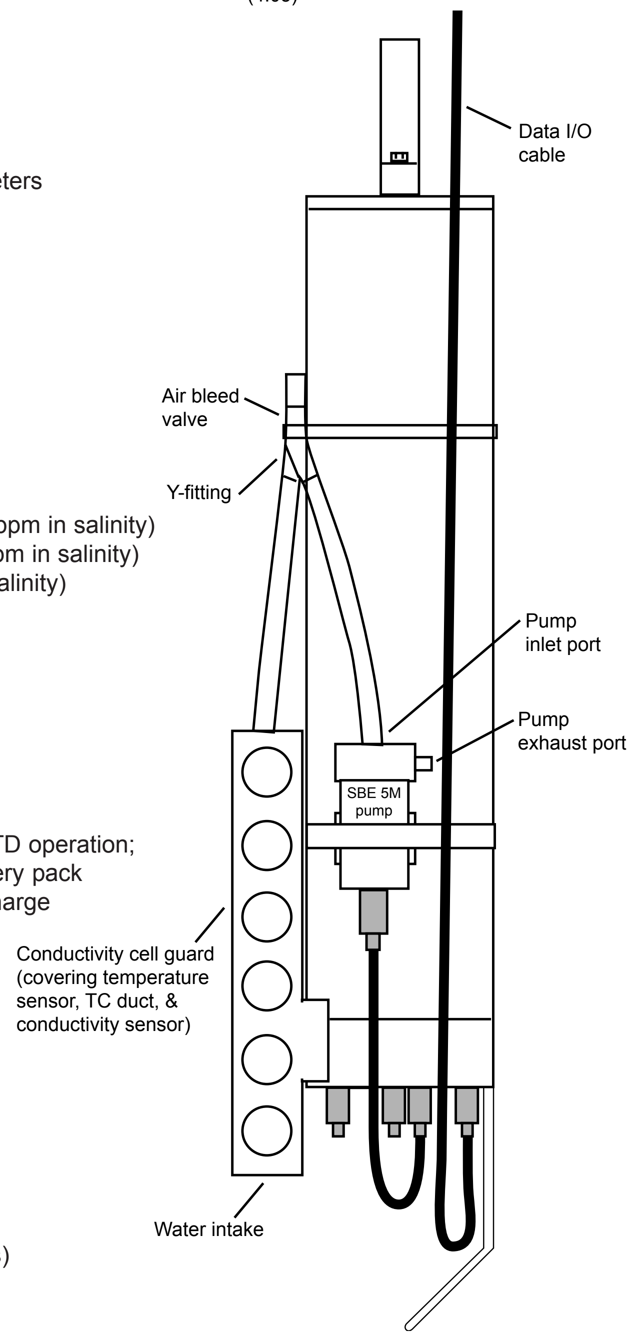
Auxiliary Voltage Sensors

Auxiliary power out	up to 500 mA at 10.5 - 11 VDC
A/D resolution	14 bits
Input range	0 - 5 VDC

Housing Materials — Depth Rating — Weight

Acetal Copolymer *Plastic* housing — 600 meter (1950 feet) — 7.3 kg (16 lbs)

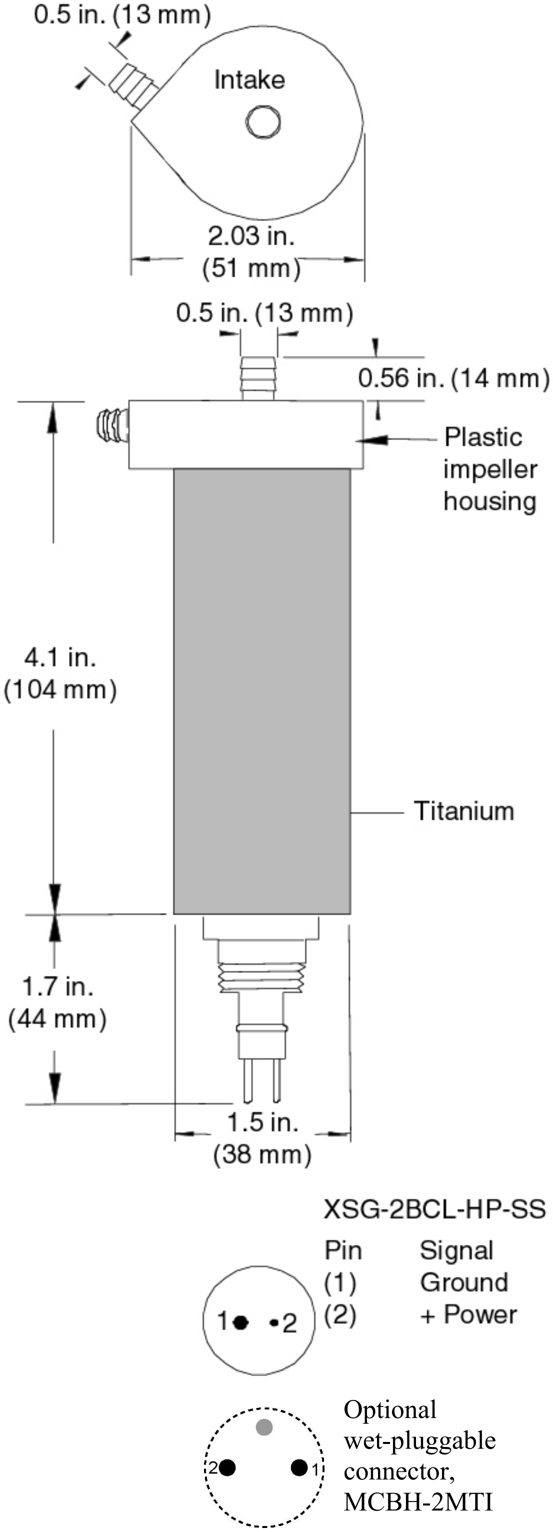
3AL-2.5V *Titanium* housing — 7000 meter (22,900 feet) — 13.7 kg (30 lbs)



Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
Email: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

Mini Submersible Pump SBE 5M

The SBE 5M pump module consists of a centrifugal pump head and a long-life, DC ball bearing motor contained in a compact, titanium, pressure housing usable to 10,500 meters deep. The pump impeller and electric drive motor are coupled magnetically through the housing, providing high reliability by eliminating moving seals. Motor speed and pumping rate remain constant over the entire input voltage range. The motor drive electronics is intrinsically protected against accidental reversed polarity.



APPLICATIONS

The SBE 5M is standard on the SBE 19 and 19*plus* SEACAT Profiler CTD. It is optional on the SBE 16, 16*plus*, and 16*plus*-IM SEACAT C-T Recorder. The pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. For applications requiring pumping through additional sensors (for example, a dissolved oxygen sensor), use the SBE 5T pump instead.

Specify:
- Option 5M-1 for profiling (continuous duty) applications such as the SBE 19*plus*.
- Option 5M-2 for moored (pulsed duty) applications such as the SBE 16*plus* or 16*plus*-IM.

Contact Sea-Bird for use in other applications.

SPECIFICATIONS

Option 5M-1 (continuous duty):
Input voltage range 9 - 18 VDC

Flow Rate 25 ml/s supply current 95 ma

Note: Supply current is independent of operating voltage.

Option 5M-2 (pulsed duty):
Input voltage range 6 - 18 VDC

Pulse Duration	*Flow Volume*	*Electrical Charge*
0.5 seconds	15 ml	0.148 amp-seconds
1.0 seconds	21 ml	0.283 amp-seconds
1.5 seconds	31 ml	0.418 amp-seconds
2.0 seconds	40 ml	0.553 amp-seconds

Weight
In Air: 0.42 kg (0.91 lbs)
In Water: 0.28 kg (0.60 lbs)

06/03

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel: (425) 643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0651

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.929	VDC	Current	9.29	mA
Vin 9V voltage across C2:	7.928	VDC	Current	8.8	mA
Vin 6V voltage across C2:	5.885	VDC	Current	7.99	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 120 mA

APPLICATION NOTES

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 2D **Revised December 2002**

INSTRUCTIONS FOR CARE AND CLEANING OF CONDUCTIVITY CELLS

Since any conductivity sensor's output reading is proportional to its dimensions, it is important to keep the cell clean of internal coatings. Also, cell electrodes contaminated with oil, biological growths, or other foreign material will cause low conductivity readings.

If the cell is allowed to dry out between usage, salt crystals may form on (and in) the platinized electrode surfaces. When the instrument is next used, there will be a delay before these crystals are dissolved - in the meantime, sensor accuracy may be affected. Therefore, we recommend that the cell be kept filled with distilled or de-ionized water between uses. A length of 7/16" ID Tygon tubing is provided for this purpose, to be connected in such a way that any air entrapped will be in the Tygon tube rather than in the cell.

An additional important benefit of keeping the cell ends closed with Tygon is to keep air-borne contaminants (which are abundant on most research vessels) from entering the cell.

If it is not practical to keep the cell filled with distilled (or de-ionized) water between use (for example, in Arctic environments where freezing is a hazard), flush the cell with clean fresh water (preferably distilled or de-ionized) and close the cell with Tygon. Also, remember to keep the Tygon in a clean place (so that it does not pick up contaminants) while the instrument is in use.

Experience indicates that in normal intermittent use (such as in CTD profiling operations), drift rates of 0.0003 S/m (0.003 mmho/cm) or less per month can be expected **without any cleaning** if the procedures described above are followed.

PRECAUTIONS!!!!!!

The conductivity cell is primarily made of glass, and therefore is subject to breakage if mishandled. It is especially important to use the right size Tygon tubing, since if you use tubing with a too small ID, it will be difficult to remove the tubing, and the cell end may break if excessive force is used. **The correct size tubing for all instruments produced since 1980 is 7/16" ID, 9/16" OD, 1/16" wall**. Instruments shipped prior to 1980 had smaller retaining ridges at the ends of the cell, and 3/8" ID Tygon is required for these older instruments. It is better to use Tygon (brand) than other plastic tubing, since it tends to remain flexible over a wide temperature range and with age.

Do not insert any sort of cleaning probe (e.g., Q-tip) into the interior of the cell. If the platinized (black) electrode surface is touched, it may be damaged and require the electrodes to be replatinized.

If a cell is filled with water, do not subject it to low temperatures that will freeze the water and break the cell. **Remove the water before shipment during the winter, or to polar regions at any season**. No adverse affects have been observed as a result of temporary *dry* storage, particularly if the cell is rinsed with fresh water before storage.

CELL CLEANING

Routine Cleaning (inside of cell not visibly dirty)

Fill the cell with a 1% solution of Triton X-100* and let soak for 30 minutes. This is most easily done by using a length of 7/16" ID Tygon tubing to form a closed loop including the cell. After the soak, drain and flush with warm (not hot) fresh water for 1 minute. Refill the cell with distilled (or de-ionized) water until the next usage.

Cleaning Severely Fouled Cells (visible deposits or marine growths on the inside of the cell)

Clamp the instrument so that the cell is vertical, and attach a length of 7/16" Tygon tubing to the lower end of the cell. Use masking or other tape to secure the open end of the Tygon about even with the top end of the cell. Pour Muriatic Acid (37% HCl) into the open end of the Tygon until the cell is filled to near the top and let soak for 1 to 2 minutes only. **Avoid breathing the acid fumes!!** Drain the acid from the cell and flush for 5 minutes with warm (not hot) fresh water. Also rinse the exterior of the instrument to remove any spilled acid from the surface. Then fill the cell with 1% Triton* solution, let stand for 5 minutes, and flush with warm fresh water for 1 minute. Refill with distilled or de-ionized water until the next usage.

If this process does not remove the visible deposits, mechanically clean the cell with a small (0.275" diameter). soft-bristled nylon bottle brush and 1% Triton solution. **NOTE: Be extremely careful when cleaning, because the platinum electrodes are thin and could be damaged if you use a brush that is too large or too stiff. The electrodes must be replatinized after *brush* cleaning. Our service department will clean and replatinize your cell for a nominal fee.**

*Triton X-100 (a trade name of J. T. Baker, Inc) is a concentrated liquid non-ionic detergent available at most chemical or scientific supply stores. Other liquid detergents can probably also be used, but scientific grades are preferable because of their known composition. It is better to use a non-ionic detergent since conductivity readings taken immediately after use are less likely to be affected by any residual detergent left in the cell.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 6 July 1994

DETERMINATION OF SOUND VELOCITY FROM CTD DATA

Use of CTD measurement for determination of sound velocity is appealing because these instruments are simpler and more rugged and because their resolution, accuracy, and stability lead to far better precision than can be obtained with direct SV measuring devices. For example, specifications of 0.01 mS/cm conductivity, 0.01 degrees C temperature, and 1 meter in depth are readily achieved with good quality CTD equipment. Assuming that the relationship between C, T, and D on the one hand and SV on the other is exactly known (see below), the resulting uncertainty in SV would be as follows:

from temperature error (0.01 deg C)	0.021 meters/second
from conductivity error (0.01 mS/cm)	0.011 meters/second
from salinity error (0.01 psu)	0.012 meters/second
from depth error (1 meter)	0.017 meters/second

The equivalent SV errors (considered at 15 degrees C, 42.9 mS/cm, 35 psu, and 0 pressure, i.e, typical open-ocean surface conditions) are much smaller than those usually claimed for direct-measurement instruments.

The question about the absolute accuracy of the inference of SV from CTD data is more difficult to answer. The main reason for this is apparently the result of differences in the instrumentation used by various researchers and is compounded by the difficulty of performing direct measurements of sound velocity under controlled conditions of temperature, salinity, and (especially) pressure. For example, 3 widely used equations (Wilson, 1959; Del Grosso, 1972; Millero and Chen, 1977) show differences in absolute sound speed on the order of 0.5 meter/second for various combinations of water temperature, salinity, and pressure, despite being based on careful measurements made under laboratory conditions.

The work of Millero and Chen is, however, the most modern, and it builds upon and attempts to incorporate the work of earlier investigators. Accordingly, the SV/CTD relationship described by these researchers in their paper of 1977 was used as a major component in the derivation of the Equation of State (Unesco technical papers in marine science no. 44). Millero and Chen's 1977 equation is also the one endorsed by the Unesco/SCOR/ICES/IASPO Joint Panel on Oceanographic Tables and Standards which comprises the internationally recognized authority for measurements of ocean parameters (in Sea-Bird's SEASOFT software, users may select any of the 3 equations mentioned above).

We draw the following conclusions from the research papers listed above:

1) Investigators using specialized equipment under scrupulously controlled laboratory conditions report measurements of SV vs. changes in temperature, salinity, and pressure which differ by 0.5 meters/second and more. *It is unrealistic to expect that commercial direct-measurement instruments will be more accurate under field conditions than the laboratory equipment used by successions of careful researchers.*

2) The claimed 'accuracy' of commercial direct-measurement SV probes probably more legitimately represents their 'precision' (compare with CTD/SV uncertainties tabulated above) than their absolute accuracy. The relationship between what these instruments read and true sound velocity is probably just as dependent on the same vagaries that are also the only significant sources of error when employing the CTD approach.

3) Because of the uncertainties in the time-delays associated with the acoustic transducers and electronics (and because of the difficulty of measuring with sufficient accuracy the length of the acoustic path), direct-measurement probes must be calibrated in water. As suggested by the research under controlled laboratory conditions, this is not an easy task, especially over a range of temperature, pressure, and salinity. On the other hand, a CTD probe can easily be calibrated using accepted methods.

4) A CTD can predict <u>absolute</u> SV to something better than 0.5 meter/second (a judgement seconded by Professor Millero in a private conversation), while its <u>relative accuracy</u> (precision) is probably better than 0.05 meter/s under the most demanding conditions of field use.

5) The very high precision associated with CTD measurements and the existence of an internationally accepted relationship (even if imperfect) between CTD and SV permits very consistent intercomparison and a high degree of uniformity among CTD-derived SV data sets, no matter when and where taken.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 10 **Revised May 2004**

COMPRESSIBILITY COMPENSATION OF SEA-BIRD CONDUCTIVITY SENSORS

Sea-Bird conductivity sensors provide precise characterization of deep ocean water masses. To achieve the accuracy of which the sensors are capable, an accounting for the effect of hydrostatic loading (pressure) on the conductivity cell is necessary. Conductivity calibration certificates show an equation containing the appropriate pressure-dependent correction term, which has been derived from mechanical principles and confirmed by field observations. The form of the equation varies somewhat, as shown below:

SBE 4, 9, 9*plus*, 16, 19, 21, 25, and 26/26*plus*

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(g + h f^2 + i f^3 + j f^4)/10}{1 + [CTcor]\, t + [CPcor]\, p} + \text{offset} \qquad (\textbf{recommended})$$

or

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{(a f^m + b f^2 + c + dt)/10}{1 + [CPcor]\, p} + \text{offset}$$

SBE 16*plus*, 19*plus*, 37, 45, and 49

$$\text{Conductivity (Siemens/meter)} = \text{slope}\ \frac{g + h f^2 + i f^3 + j f^4}{1 + [CTcor]\, t + [CPcor]\, p} + \text{offset}$$

where

- a, b, c, d, m, and CPcor are the calibration coefficients used for older sensors (prior to January 1995); Sea-Bird continues to calculate and print these coefficients on the calibration sheets for use with old software, but recommends use of the g, h, I, j, CTcor, CPcor form of the equation for most accurate results
- g, h, I, j, CTcor, and CPcor are the calibration coefficients used for newer sensors
- **CPcor is the correction term for pressure effects on conductivity**
- slope and offset are correction coefficients used to make corrections for sensor drift between calibrations; set to 1.0 and 0 respectively on initial calibration by Sea-Bird (see Application Note 31 for details on calculating slope and offset)
- f is the instrument frequency (kHz)
- t is the water temperature (°C)
- p is the water pressure (decibars)

Sea-Bird CTD data acquisition, display, and post-processing software *SEASOFT* automatically implements these equations.

DISCUSSION OF PRESSURE CORRECTION

Conductivity cells do not measure the specific conductance (the desired property), but rather the conductance of a *specific geometry* of water. The ratio of the cell's length to its cross-sectional area (*cell constant*) is used to relate the measured conductance to specific conductance. Under pressure, the conductivity cell's length and diameter are reduced, leading to a lower indicated conductivity. The magnitude of the effect is not insignificant, reaching 0.0028 S/m at 6800 dbars.

The compressibility of the borosilicate glass used in the conductivity cell (and all other homogeneous, noncrystalline materials) can be characterized by E (Young's modulus) and ν (Poisson's ratio). For the Sea-Bird conductivity cell, $E = 9.1 \times 10^6$ psi, ν = 0.2, and the ratio of indicated conductivity divided by true conductivity is:

$1 + s$
where s = (CPcor) (p)
Typical value for CPcor is -9.57×10^{-8} for pressure in decibars **or** -6.60×10^{-8} for pressure in psi

Note: This equation, and the mathematical derivations below, deals only with the pressure correction term, and does not address the temperature correction term.

MATHEMATICAL DERIVATION OF PRESSURE CORRECTION

For a cube under hydrostatic load:

$$\Delta L / L = s = -p\,(1 - 2\nu) / E$$

where

- p is the hydrostatic pressure
- E is Young's modulus
- ν is Poisson's ratio
- ΔL / L and s are strain (change in length per unit length)

Since this relationship is linear in the forces and displacements, the relationship for strain also applies for the length, radius, and wall thickness of a cylinder.

To compute the effect on conductivity, note that $R_0 = \rho L / A$, where R_0 is resistance of the material at 0 pressure, ρ is volume resistivity, L is length, and A is cross-sectional area. For the conductivity cell $A = \pi r^2$, where r is the cell radius. Under pressure, the new length is L (1 + s) and the new radius is r (1 + s). If R_p is the cell resistance under pressure:

$$R_p = \rho L\,(1 + s) / (\pi r^2 [1 + s]^2) = \rho L / \pi r^2 (1 + s) = R_0 / (1 + s)$$

Since conductivity is 1/R:

$$C_p = C_0 (1 + s) \quad \text{and} \quad C_0 = C_p / (1 + s) = C_p / (1 + [\text{Cpcor}]\,[p])$$

where

- C_0 is conductivity at 0 pressure
- C_p is conductivity measured at pressure

A less rigorous determination may be made using the material's bulk modulus. For small displacements in a cube:

$$\Delta V / V = 3\Delta L / L = -3p\,(1 - 2\nu) / E \quad \text{or} \quad \Delta V/V = -p / K$$

where

- ΔV / V is the change in volume per volume or volume strain
- K is the bulk modulus. K is related to E and ν by $K = E / 3\,(1 - 2\nu)$.

In this case, $\Delta L / L = -p / 3K$.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 14 **January 1989**

1978 PRACTICAL SALINITY SCALE

Should you not be already familiar with it, we would like to call your attention to the January 1980 issue of the IEEE Journal of Oceanic Engineering, which is dedicated to presenting the results of a multi-national effort to obtain a uniform repeatable Practical Salinity Scale, based upon electrical conductivity measurements. This work has been almost universally accepted by researchers, and all instruments delivered by Sea-Bird since February 1982 have been supplied with calibration data based upon the new standard.

The value for conductivity at 35 ppt, 15 degrees C, and 0 pressure [C(35,15,0)] was not agreed upon in the IEEE reports -- Culkin & Smith used 42.914 mmho/cm (p 23), while Poisson used 42.933 mmho/cm (p 47). It really does not matter which value is used, provided that the same value is used during data reduction that was used to compute instrument calibration coefficients. Our instrument coefficients are computed using C(35,15,0) = 42.914 mmho/cm.

The PSS 1978 equations and constants for computing salinity from *in-situ* measurements of conductivity, temperature, and pressure are given in the 'Conclusions' section of the IEEE journal (p 14) and are reproduced back of this note. In the first equation, 'R' is obtained by dividing the conductivity value measured by your instrument by C(35,15,0), or 42.914 mmho/cm. Note that the PSS equations are based upon conductivity in units of mmho/cm, which are equal in magnitude to units of mS/cm. **If you are working in conductivity units of Siemens/meter (S/m), multiply your conductivity values by 10 before using the PSS 1978 equations**.

Also note that the equations assume pressure relative to the sea-surface. Absolute pressure gauges (as used in all Sea-Bird CTD instruments) have a vacuum on the reference side of their sensing diaphragms and indicate atmospheric pressure (nominally 10.1325 dBar) at the sea-surface. This reading must be subtracted to obtain pressure as required by the PSS equations. The pressure reading displayed when using Sea-Bird's SEASOFT CTD acquisition, display, and post-processing software is the corrected sea-surface pressure and is used by SEASOFT to compute salinity, density, etc in accordance with the PSS equations.

1978 PRACTICAL SALINITY SCALE EQUATIONS, from IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14.

CONCLUSIONS

Using Newly generated data, a fit has been made giving the following algorithm for the calculation of salinity from data of the form:

$$R = \frac{C(S,T,P)}{C(35,15,0)}$$

T in °C (IPTS '68), P in decibars.

$$R_T = \frac{R}{R_P r_T}; R_P = 1 + \frac{P \times (A_1 + A_2 P + A_3 P^2)}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 R T}$$

$$r_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4$$

$A_1 = 2.070 \times 10^{-5}$ $B_1 = 3.426 \times 10^{-2}$

$A_2 = -6.370 \times 10^{-10}$ $B_2 = 4.464 \times 10^{-4}$

$A_3 = 3.989 \times 10^{-15}$ $B_3 = 4.215 \times 10^{-1}$

$B_4 = -3.107 \times 10^{-3}$

$c_0 = 6.766097 \times 10^{-1}$

$c_1 = 2.00564 \times 10^{-2}$

$c_2 = 1.104259 \times 10^{-4}$

$c_3 = -6.9698 \times 10^{-7}$

$c_4 = 1.0031 \times 10^{-9}$

$$S = \sum_{j=0}^{5} a_j R_T^{j/2} + \frac{(T-15)}{1 + k(T-15)} \sum_{j=0}^{5} b_j R_T^{j/2}$$

$a_0 = 0.0080$ $b_0 = 0.0005$ $k = 0.0162.$

$a_1 = -0.1692$ $b_1 = -0.0056$

$a_2 = 25.3851$ $b_2 = -0.0066$

$a_3 = 14.0941$ $b_3 = -0.0375$

$a_4 = -7.0261$ $b_4 = 0.0636$

$a_5 = 2.7081$ $b_5 = -0.0144$

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE 27Druck **NOVEMBER 2003**

Minimizing Strain Gauge Pressure Sensor Errors

The following Sea-Bird instruments use strain gauge pressure sensors manufactured by GE Druck:

- SBE 16*plus* and 16*plus*-IM SEACAT (not 16*) with optional strain gauge pressure sensor
- SBE 19*plus* SEACAT Profiler (not 19*)
- SBE 25 SEALOGGER CTD, which uses SBE 29 Strain-Gauge Pressure Sensor (built after March 2001)
- SBE 37 MicroCAT (37-IM, -IMP, -SM, -SMP, and -SI) with optional pressure sensor (built after September 2000)
- SBE 39 Temperature Recorder with optional pressure sensor (built after September 2000)
- SBE 49 FastCAT CTD Sensor
- SBE 50 Digital Oceanographic Pressure Sensor

*** Note:** SBE 16 and SBE 19 SEACATs were originally supplied with other types of pressure sensors. However, a few of these instruments have been retrofitted with Druck sensors.

The Druck sensors are designed to respond to pressure in nominal ranges 0 - 20 meters, 0 - 100 meters, 0 - 350 meters, 0 – 1000 meters, 0 – 2000 meters, 0 – 3500 meters, and 0 – 7000 meters (with pressures expressed in meters of deployment depth capability). The sensors offer an initial accuracy of 0.1% of full scale range.

DEFINITION OF PRESSURE TERMS

The term *psia* means *pounds per square inch, absolute* (*absolute* means that the indicated pressure is referenced to a vacuum).

For oceanographic purposes, pressure is most often expressed in *decibars* (1 dbar = 1.4503774 psi). A dbar is 0.1 bar; a bar is approximately equal to a standard atmosphere (1 atmosphere = 1.01325 bar). For historical reasons, pressure at the water surface (rather than absolute or total pressure) is treated as the reference pressure (0 dbar); this is the value required by the UNESCO formulas for computation of salinity, density, and other derived variables.

Some oceanographers express pressure in Newtons/meter^2 or *Pascals* (the accepted SI unit). A Pascal is a very small unit (1 psi = 6894.757 Pascals), so the mega-Pascal (MPa = 10^6 Pascals) is frequently substituted (1 MPa = 100 dbar).

Since the pressure sensors used in Sea-Bird instruments are *absolute* types, their raw data inherently indicate atmospheric pressure (about 14.7 psi) when in air at sea level. Sea-Bird outputs pressure in one of the following ways:

- For CTDs that output **raw data** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49**) and are supported by SEASOFT's SEASAVE (real-time data acquisition) and SBE Data Processing (data processing) software – In SEASOFT, user selects pressure output in psi (*not* psia) or dbar. SEASOFT subtracts 14.7 psi from the raw absolute reading and outputs the remainder as psi or converts the remainder to dbar.
- For the **SBE 50** – User selects pressure output in psia (including atmospheric pressure) or dbar. Calculation of dbar is as described above.
- For all other instruments that can output **converted data in engineering units** (**SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, and 49**) – Instrument subtracts 14.7 psi from the raw absolute reading and converts the remainder to dbar.

Note: SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49 can output raw **or** converted data.

RELATIONSHIP BETWEEN PRESSURE AND DEPTH

Despite the common nomenclature (CTD = **C**onductivity - **T**emperature - **D**epth), all CTDs measure *pressure*, which is not quite the same thing as depth. The relationship between pressure and depth is a complex one involving water density and compressibility as well as the strength of the local gravity field, but it is convenient to think of a decibar as essentially equivalent to a meter, an approximation which is correct within 3% for almost all combinations of salinity, temperature, depth, and gravitational constant.

SEASOFT offers two methods for estimating depth from pressure.

- For oceanic applications, salinity is presumed to be 35 PSU, temperature to be 0^o C, and the compressibility of the water (with its accompanying density variation) is taken into account. This is the method recommended in UNESCO Technical Paper No. 44 and is a logical approach in that by far the greatest part of the deep-ocean water column approximates these values of salinity and temperature. Since pressure is also proportional to gravity and the major variability in gravity depends on latitude, the user's latitude entry is used to estimate the magnitude of the local gravity field.
  - ➢ SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, and 49 - User is prompted to enter latitude if Depth [salt water] is selected as a display variable in SEASAVE or as an output variable in the Data Conversion or Derive module of SBE Data Processing.
  - ➢ SBE 37-SI and 50 - Latitude is entered in the instrument's EEPROM using the **LATITUDE=** command in SEASOFT's SEATERM (terminal program) software.
  - ➢ SBE 39 – User is prompted to enter latitude if conversion of pressure to depth is requested when converting an uploaded .asc file to a .cnv file in SEATERM.
- For fresh water applications, compressibility is not significant in the shallow depths encountered and is ignored, as is the latitude-dependent gravity variation. Fresh water density is presumed to be 1 gm/cm, and depth (in meters) is calculated as 1.019716 * pressure (in dbars).

CHOOSING THE RIGHT SENSOR

Initial accuracy and resolution are expressed as a percentage of the full scale range for the pressure sensor. The initial accuracy is 0.1% of the full scale range. Resolution is 0.002% of full scale range, except for the SBE 25 (0.015% resolution). For best accuracy and resolution, select a pressure sensor full scale range to correspond to no more than the greatest depths to be encountered. The effect of this choice on CTD accuracy and resolution is shown below:

Range (meters)	Maximum Initial Error (meters)	SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, & 50 - Resolution (meters)	SBE 25 - Resolution (meters)
0 – 20	0.02	0.0004	0.003
0 – 100	0.10	0.002	0.015
0 – 350	0.35	0.007	0.052
0 – 1000	1.0	0.02	0.15
0 - 2000	2.0	0.04	0.30
0 - 3500	3.5	0.07	0.52
0 - 7000	7.0	0.14	1.05

The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within ± *maximum error* (expressed as equivalent depth) throughout the sensor's operating range. Note that a 7000-meter sensor reading + 7 meters at the water surface is operating within its specifications; the same sensor would be expected to indicate 7000 meters ± 7 meters when at full depth.

Resolution is the magnitude of indicated increments of depth. For example, a 7000-meter sensor on an SBE 25 (resolution 1.05 meters) subjected to slowly increasing pressure will produce readings approximately following the sequence *0, 1.00, 2.00, 3.00* (meters). Resolution is limited by the design configuration of the CTD's A/D converter. For the SBE 25, this restricts the possible number of discrete pressure values for a given sample to somewhat less than 8192 (13 bits); an approximation of the ratio 1 : 7000 is the source of the SBE 25's 0.015% resolution specification.

Note: SEASOFT (and other CTD software) presents temperature, salinity, and other variables as a function of depth or pressure, so the CTD's pressure resolution limits the number of plotted data points in the profile. For example, an SBE 25 with a 7000-meter sensor might acquire several values of temperature and salinity during the time required to descend from 1- to 2-meters depth. However, all the temperature and salinity values will be graphed in clusters appearing at either 1 or 2 meters on the depth axis.

High-range sensors used in shallow water generally provide better accuracy than their *absolute* specifications indicate. With careful use, they may exhibit *accuracy* approaching their *resolution* limits. For example, a 3500-meter sensor has a nominal accuracy (irrespective of actual operating depth) of ± 3.5 meters. Most of the error, however, derives from variation over time and temperature of the sensor's *offset*, while little error occurs as a result of changing *sensitivity*.

MINIMIZING ERRORS

Offset Errors

The primary *offset* error due to drift over time can be eliminated by comparing CTD readings in air before beginning the profile to readings from a barometer. Follow this procedure:

1. Allow the instrument to equilibrate in a reasonably constant temperature environment for at least 5 hours. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature; allowing the instrument to equilibrate before starting will provide the most accurate calibration correction.

2. Place the instrument in the orientation it will have when deployed.

3. Set the pressure offset to 0.0:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, or 50).

4. Collect pressure data from the instrument using SEASAVE or SEATERM (see instrument manual for details). If the instrument is not outputting data in decibars, convert the output to decibars.

5. Compare the instrument output to the reading from a good barometer placed at the same height as the pressure sensor. Calculate *offset* (decibars) = barometer reading (converted to decibars) – instrument reading (decibars).

6. Enter calculated offset in decibars:
   - In the .con file, using SEASAVE or SBE Data Processing (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 25, or 49).
   - In the CTD's EEPROM, using the appropriate command in SEATERM (for SBE 16*plus*, 16*plus*-IM, 19*plus*, 37, 39, 49, or 50).

Note: For instruments that store calibration coefficients in EEPROM and also use a .con file (SBE 16*plus*, 16*plus*-IM, 19*plus*, and 49), set the pressure offset (Steps 3 and 6 above) in both the EEPROM and in the .con file.

Offset Correction Example
Pressure measured by a barometer is 14.65 psia. Pressure displayed from instrument is -2.5 dbars.
Convert barometer reading to dbars using the relationship: (psia – 14.7) * 0.6894759 = dbars
Barometer reading = (14.65 – 14.7) * 0.6894759 = -0.034 dbars
Offset = -0.034 – (-2.5) = + 2.466 dbar
Enter offset in .con file (if applicable) and in instrument EEPROM (if applicable).

Another source of *offset* error results from temperature-induced drifts. Because Druck sensors are carefully temperature compensated, errors from this source are small. Offset errors can be estimated for the conditions of your profile, and eliminated when post-processing the data in SBE Data Processing by the following procedure:

1. **Immediately** before beginning the profile, take a pre-cast *in air* pressure reading.

2. **Immediately** after ending the profile, take a post-cast *in air* pressure reading with the instrument at the same elevation and orientation. This reading reflects the change in the instrument temperature as a result of being submerged in the water during the profile.

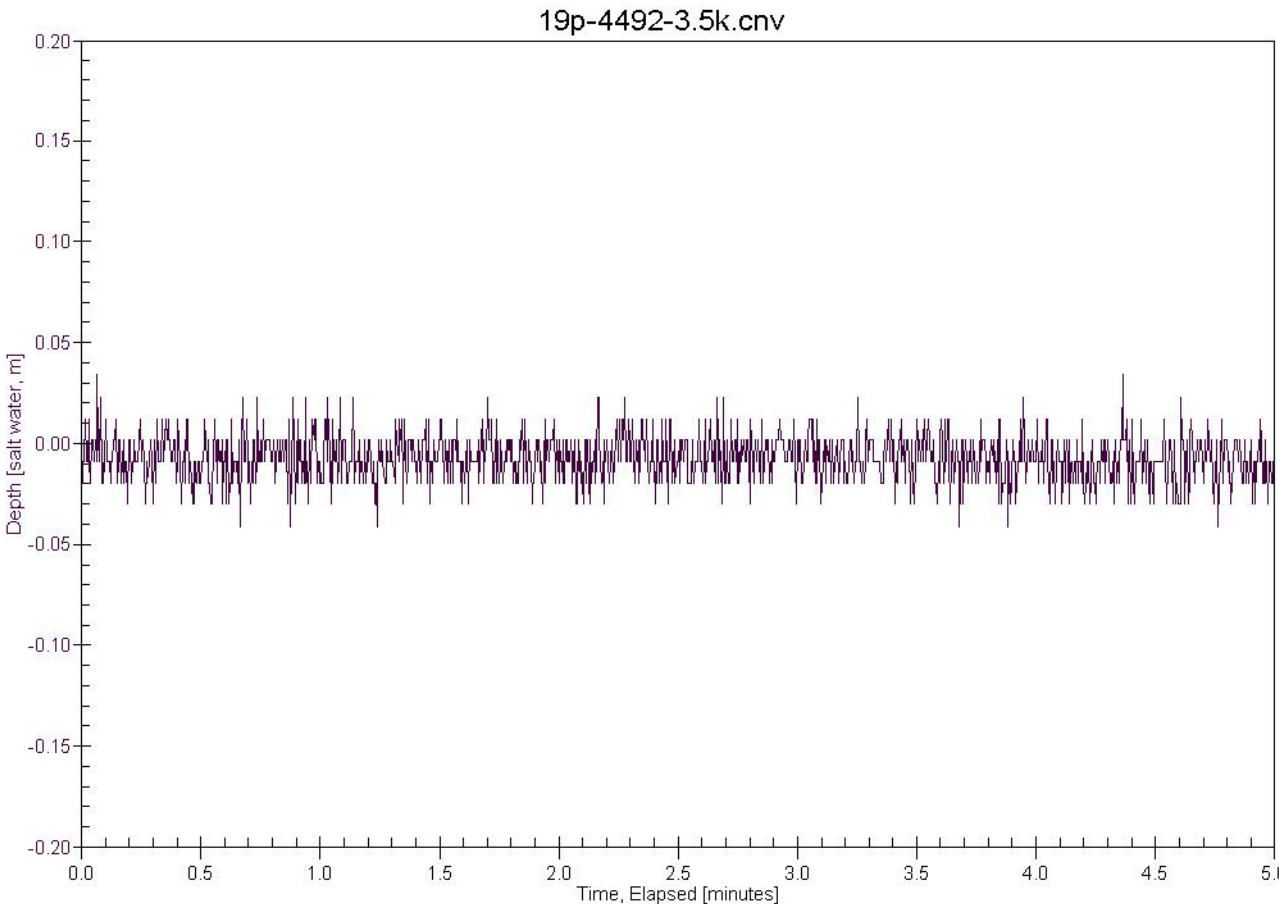
3. Calculate the average of the pre- and post-cast readings. Enter the negative of the average value (in decibars) as the *offset* in the .con file.

Hysteresis Errors

Hysteresis is the term used to describe the failure of pressure sensors to repeat previous readings after exposure to other (typically higher) pressures. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis.

Power Turn-On Transient

Druck pressure sensors exhibit virtually no power turn-on transient. The plot below, for a 3500-meter pressure sensor in an SBE 19*plus* SEACAT Profiler, is representative of the power turn-on transient for all pressure sensor ranges.



Thermal Transient

Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature, so the thermal transient resulting from submersion in water must be considered when deploying the instrument.

During calibration, the sensors are allowed to *warm-up* before calibration points are recorded. Similarly, for best depth accuracy the user should allow the CTD to *warm-up* for several minutes before beginning a profile; this can be part of the *soak* time in the surface water. *Soaking* also allows the CTD housing to approach thermal equilibrium (minimizing the housing's effect on measured temperature and conductivity) and permits a Beckman- or YSI-type dissolved oxygen sensor (if present) to polarize.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 31 **September 2001**

Computing Temperature and Conductivity *Slope* and *Offset* Correction Coefficients from Laboratory Calibrations and Salinity Bottle Samples

Conductivity Sensors

SEASOFT's prompt for *slope* and *offset* values when the conductivity sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors use slope = 1.0, offset = 0.0. The correction formula is:

(corrected conductivity) = slope * (computed conductivity) + offset

The conductivity sensor usually drifts by changing span (the slope of the calibration curve), and changes are typically toward lower conductivity readings with time. Offset error in conductivity (error at 0 S/m) is usually due to electronics drift, which is usually less than ±0.0001 S/m per year. Offsets greater than ±0.0002 S/m are symptomatic of sensor malfunction. Sea-Bird, therefore, recommends drift corrections to conductivity sensors be made by assuming no offset error, unless there is strong evidence to the contrary or a special need.

As an example of computing these correction coefficients, if we had the following calibration data:

true conductivity:	3.5 S/m
instrument reading:	3.49965 S/m

slope = 3.5 / 3.49965 = 1.000100

Correcting for Conductivity Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a conductivity sensor is calibrated (pre-cruise), then immediately used at-sea, and then returned for post-cruise calibration. The pre- and post-cruise calibration data can be used to generate a slope correction for data taken between the pre- and post-cruise calibrations.

If α is the conductivity computed from the **pre-cruise bath data** (temperature and frequency) using **post-cruise calibration coefficients** and β is the true conductivity in the **pre-cruise bath**, then:

$$\textbf{Postslope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)}$$

(postslope is typically < 1.0)

Beginning in February 1995, the value for postslope was calculated and printed on the conductivity calibration sheet.

To correct conductivity data taken between pre- and post-cruise calibrations:

Let:

n = number of days between pre- and post-cruise calibrations
b = number of days between pre-cruise calibration and the cast to be corrected
islope = interpolated slope; this is the value to enter in the .con file
postslope = slope from calibration sheet as calculated above

islope = 1.0 + (b / n) ((1 / postslope) - 1.0)

In the .con file, use the **pre-cruise calibration coefficients** and use **islope** for the value of slope.*

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

For typical conductivity drift rates (equivalent to -0.003 PSU/month), islope would not need to be recalculated more frequently than at weekly intervals.

* You can also calculate preslope. If α is the conductivity computed from the **post-cruise bath data** (temperature and frequency) using **pre-cruise calibration coefficients** and β is the true conductivity in the **post-cruise bath**, then:

$$\textbf{Preslope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)} \qquad \text{(preslope is typically > 1.0)}$$

In this case, pre-cruise calibration coefficients would be used and:
islope = 1.0 + (b / n) (preslope - 1.0)

Correcting for Conductivity Drift Based on Salinity Bottles Taken At-Sea

For this situation the **pre-cruise** calibration coefficients are used to compute conductivity and CTD salinity. Salinity samples are obtained using water sampler bottles during CTD profiles, and the difference between CTD salinity and bottle salinity is used to determine the drift in conductivity.

In using this method to correct conductivity, it is important to realize that differences between CTD salinity and hydrographic bottle salinity are due to errors in conductivity, temperature, and pressure measurements (as well as errors in obtaining and analyzing bottle salinity values). All CTD temperature and pressure errors and bottle errors must first be corrected before attributing the remaining salinity difference as CTD conductivity error and proceeding with conductivity corrections.

Suppose that at a Pacific Ocean station, three salinity bottles are taken during a CTD profile and assume for this discussion that shipboard analysis of the bottle salinities is perfect. The bottle salinities and the **uncorrected** CTD data might be:

Approximate Depth (m)	Bottle Salinity	CTD Raw Salinity	CTD Raw Conductivity (S/m)	CTD Temperature (°C)	CTD Pressure (dbar)
200	34.9770	34.9705	4.63421	18.3924	202.7
1000	34.4710	34.4634	3.25349	3.9841	1008.8
4000	34.6850	34.6778	3.16777	1.4527	4064.1

The uncorrected salinity differences (CTD salinity - bottle salinity) are approximately -0.007 ppt. To determine conductivity drift, the CTD temperature and pressure data must first be corrected. Suppose that the error in temperature measurements is +0.0015 C uniformly at all temperatures, and the error in pressure is +0.5 dbar uniformly at all pressures. The drift offsets are obtained by projecting the drift history of both sensors from pre-cruise calibrations. If these offsets are entered in the .con file, the correct CTD temperature and pressure will be the reported *raw* values and will need no further correction. In addition, the CTD *raw* salinity will be reported using the correct CTD temperature and pressure. This correction method also assumes that the pressure coefficient for the conductivity cell is correct. The CTD data with **corrected** temperature and pressure are:

Correct CTD Pressure (dbar)	Correct CTD Temperature (°C)	CTD Conductivity (S/m)	CTD Salinity T,P Corrected	Bottle Salinity
202.2	18.3909	4.63421	34.9719	34.9770
1008.3	3.9826	3.25349	34.4652	34.4710
4063.6	1.4512	3.16777	34.6796	34.6850

The (CTD-bottle) salinity difference of -0.005 ppt is now properly assigned as conductivity error, equivalent to about -0.0005 S/m at 4.0 S/m. By plotting the conductivity error versus conductivity, it is evident that the drift is primarily a slope change.

The program SEACALC (in SEASOFT-DOS) can be used to compute bottle conductivity. Enter bottle salinity for *salinity*, CTD corrected temperature for *temperature*, and CTD corrected pressure for *pressure*.

CTD Conductivity (S/m)	Bottle Conductivity (S/m)	[CTD - Bottle] Conductivity (S/m)
4.63421	4.63481	-0.00060
3.25349	3.25398	-0.00049
3.16777	3.16821	-0.00044

If α is the CTD conductivity computed with **pre-cruise** coefficients and β is the true bottle conductivity then:

$$\textbf{slope} = \frac{\sum_{i=1}^{n} (\alpha_i)(\beta_i)}{\sum_{i=1}^{n} (\alpha_i)(\alpha_i)} \qquad \text{(slope is typically > 1.0)}$$

Using the above data, the slope correction coefficient for conductivity at this station is **slope = +1.000137**. Following Sea-Bird's recommendation of assuming no offset error in conductivity, **offset is set to 0.0**.

For typical Sea-Bird sensors that are calibrated regularly, 70 - 90% of the CTD salinity error is due to conductivity calibration drift, 10 - 30% is due to temperature calibration drift, and only 0% - 10% is due to pressure calibration drift.

Temperature Sensors

SEASOFT's prompt for *slope* and *offset* values when the temperature sensor is selected when setting up the configuration (.con) file permits the user to make corrections for sensor drift between calibrations. For newly calibrated sensors, use slope = 1.0, offset = 0.0. The correction formula is:

(corrected temperature) = slope * (computed temperature) + offset

where :
slope = (true temperature span) / (instrument temperature span)
offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*

As an example of computing the correction coefficients, if we had the following calibration data:

true temperature	0.0 °C	25.0 °C
instrument reading	0.0015 °C	25.0013 °C

slope = (true temperature span) / (instrument temperature span)
= (25.0 - 0.0) / (25.0013 - 0.0015) = 1.000008000

offset = (true temperature - instrument reading) * slope *measured at 0.0 °C*
= (0.0 - 0.0015) * (1.000008000) = -0.00150002

For this example Sea-Bird would recommend the drift correction values (entered in the .con file)
slope = 1.0 offset = -0.0015

Sea-Bird temperature sensors usually drift by changing offset (an error of equal magnitude at all temperatures). In general, the drift can be toward higher or lower temperature with time; however, for a specific sensor the drift will remain the same sign (direction) for many consecutive years. A large span error (change in calibration slope) indicates an unusual aging of electronic components and is symptomatic of sensor malfunction. Sea-Bird therefore recommends that drift corrections to temperature sensors be made by assuming no slope error, unless there is strong evidence to the contrary or a special need.

Sensors with serial numbers less than 1050 drift more typically toward higher temperature with time, while sensors with serial numbers greater than 1050 drift more typically toward lower temperature with time. Many years of experience with hundreds of sensors indicates that the drift is smooth and uniform with time, allowing users to make very accurate drift corrections to field data based only on pre- and post-cruise laboratory calibrations.

Calibration checks at-sea are advisable for consistency checks of the sensor drift rate and for early detection of sensor malfunction. However, data from reversing thermometers is rarely accurate enough to make calibration corrections that are better than those possible by shore-based laboratory calibrations. A proven alternate consistency check is to use dual SBE 3 temperature sensors on a CTD and to track the difference in drift rates between the two sensors. In the deep ocean, where temperatures are uniform, the difference in temperature measured by two sensors can be resolved to better than 0.0002 °C and will change smoothly with time as predicted by the difference in drift rates of the two sensors.

The temperature sensors rarely exhibit span errors larger than 0.005 °C over the range -5 to 35 °C even after years of drift. A span error that increases by more than ±0.0002 [°C per °C per year] is symptomatic of sensor malfunction. Previous to January 1993 some calibrations have been delivered that include span errors up to 0.004 °C in 30 °C (span error of 0.000133) because of undetected systematic errors in calibration. Temperature calibrations preformed at Sea-Bird after January 1995 have span error less than 0.0002 °C in 30 °C.

Correcting for Temperature Drift Based on Pre- and Post-Cruise Laboratory Calibrations

Suppose a temperature sensor is calibrated (pre-cruise), then immediately used at-sea for 4 months, and then returned for post-cruise calibration. Converting the **post-cruise calibration data** using the **pre-cruise coefficients**, we obtain the estimates:

Real Temperature........ 0.0°....... 25.0°C
Instrument Reading..... 0.002°... 25.001°C

These calibration data correspond to offset error = +0.002 °C, and span error = -0.00004 [°C per °C] at the end of 4 months of use. The correction coefficients are **slope= 1.000040002, offset= -0.00200008.** Note the difference between the error value and the value of the correction coefficient.

For preliminary work at sea, use the **pre-cruise calibration coefficients** and **slope = 1.0, offset = 0.0**. Temperature data obtained during the cruise is corrected for drift using properly scaled values of correction coefficients. Data from the end of the second month at sea would be converted using **pre-cruise coefficients** and **slope=1.00002, offset= -0.001**. At the end of the 4-month cruise, data could be converted by either using **pre-cruise** coefficients and **slope=1.00004, offset= -0.002**, or by using **post-cruise** coefficients and **slope= +1.0, offset = 0.0**.

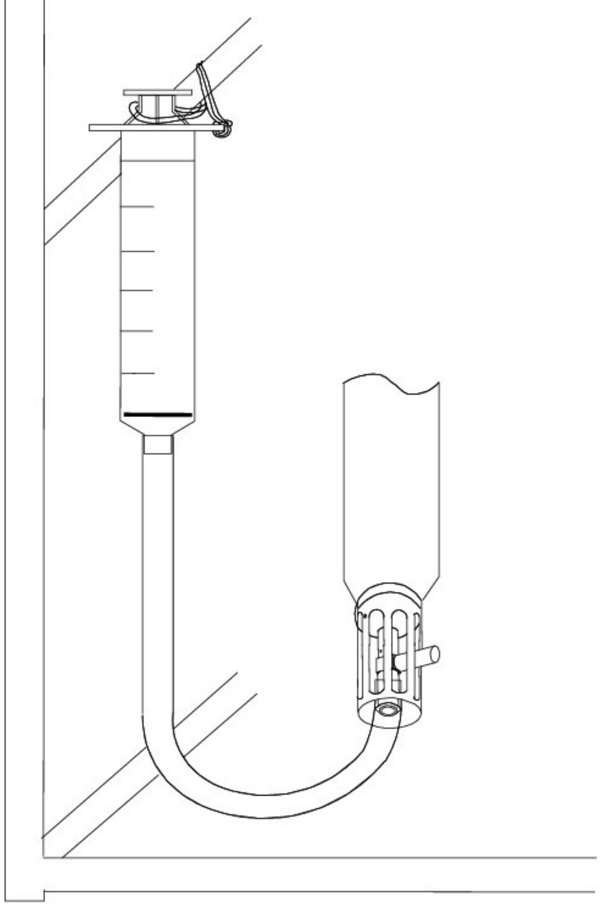
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 34 **January 1992**

CONDUCTIVITY CELL FILLING AND STORAGE DEVICE P/N 50087 INSTRUCTIONS FOR USE

Figure 1



Sea-Bird recommends keeping the conductivity cell full of purified water (except in freezing environments) during periods when the CTD is not being used. This is important in keeping the cell free from contamination and in keeping the electrodes wetted and ready for immediate use.

CTDs with pumped conductivity cells (SBE 911, SBE 25, and some SEACATs) are shipped with syringe and tubing assembly (P/N 50087) as an accessory for filling and storing the conductivity cell. The tubing assembly consists of a length of 1/4 inch I.D. tube connected to a short piece of 7/16 inch I.D. tube by a plastic reducing union.

To fill the conductivity cell, draw about 40-60 cc of purified water into the syringe, connect the plastic tubing to the TC duct intake on the temperature sensor [Figure 1], (or to the open end of the conductivity cell on systems without the TC duct [Figure 2]) and inject water into the cell and pump plumbing.

For CTDs with a TC duct, remove the plastic reducing union and connect the smaller diameter tubing directly to the TC duct. For CTDs without a TC duct, leave the reducing union and large diameter tubing attached and carefully connect the tubing directly to the end of the glass conductivity cell [Figure 2].

After filling the conductivity cell, loop the rubber band around a bar on the CTD cage and back over the top of the syringe to secure the apparatus for storage.

REMEMBER TO REMOVE THE SYRINGE AND TUBING ASSEMBLY BEFORE DEPLOYMENT!

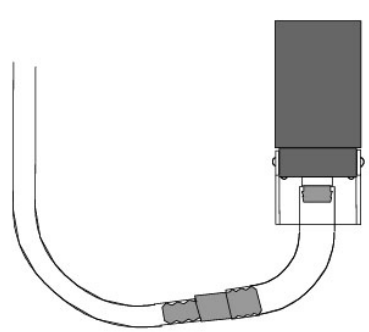


Figure 2

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 40 **Revised November 2002**

SBE 5T PUMP SPEED ADJUSTMENT INSTRUCTIONS

Equipment: DC power supply
Frequency counter

Drawings: 31441 (schematic)
40630 (3000 rpm pump)
40631 (1300 rpm pump)

The pump housing must be disassembled to adjust the pump speed. Referencing above drawings:

1. Remove the white plastic end cap retainer ring located at the connector end of the pump by twisting in a counter-clockwise motion.

2. Install a 2-pin dummy plug with locking sleeve (P/N 17044.1) over the bulkhead connector. This will provide a good grip on the pump connector and will protect the connector pins.
Rotate the connector back and forth while carefully pulling the end cap away from the housing. Pull the end cap (piston o-ring seal) out of the housing. The motor and electronics assembly are attached to the end cap and will come out as a unit.

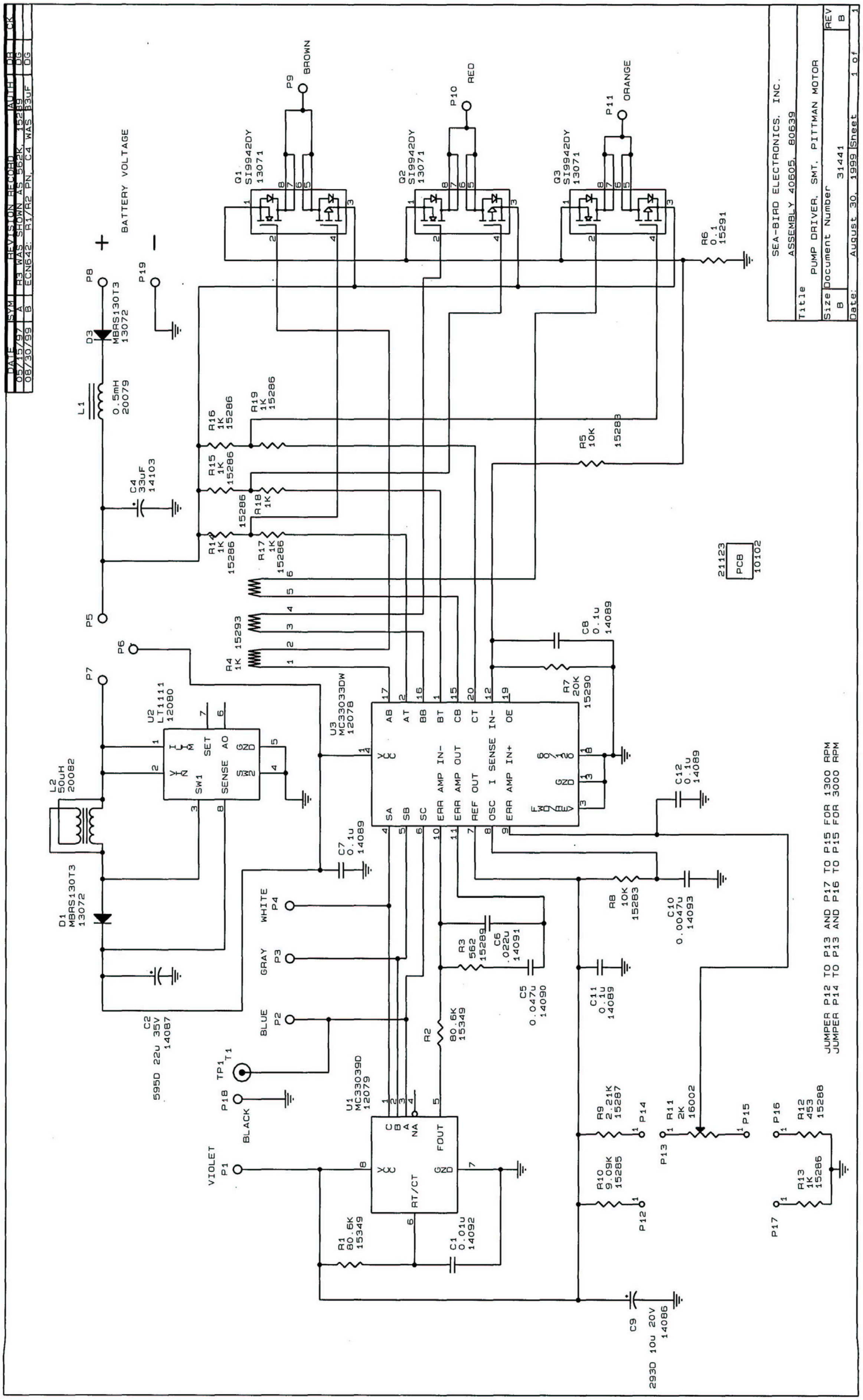
3. Connect the positive lead of your frequency counter to the yellow test post (T1) (drawing 40630/40631). Connect the frequency counter ground (negative) to the power supply ground (negative).

4a. **For low voltage pump** (pump with **LV** in the serial number), supply 6 volts DC power to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

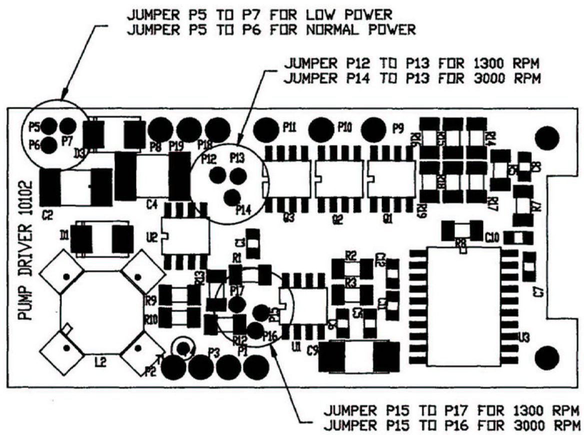
4b. **For normal voltage pump**, supply 12 volts to either the bulkhead connector (large pin is common, small pin is positive) or connect directly to the PCB (P8 is positive, P19 or P18 is common, drawing 40630/40631).

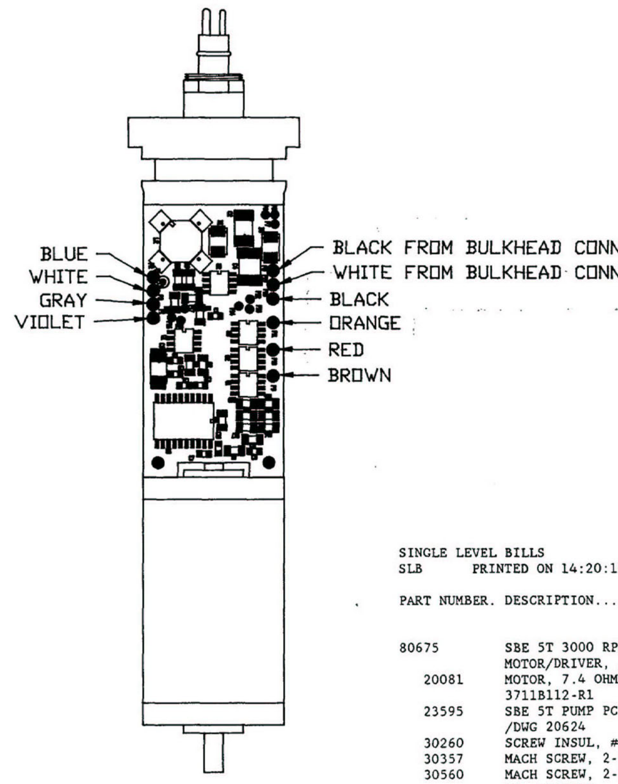
5. A 2K ohm potentiometer (R11, drawing 40630/40631) is located on the back side of the board. Adjust the potentiometer to obtain the frequency corresponding to the desired speed (Frequency * 30 = RPM). With the Pittman 18.2Ω motor (P/N 3711B113), set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust the speed as desired, up to the nominal maximum of 2000 rpm. With the Pittman 7.4Ω motor (P/N 3711B112), set the jumper position P15 to P16 (3000 rpm) and P14 to P13 (3000 rpm), and adjust the speed as desired, up to the nominal maximum of 4500 rpm. To adjust speed of the 7.4Ω motor below approximately 2200 rpm, set the jumper position P15 to P17 (1300 rpm) and P12 to P13 (1300 rpm), and adjust speed using the potentiometer.

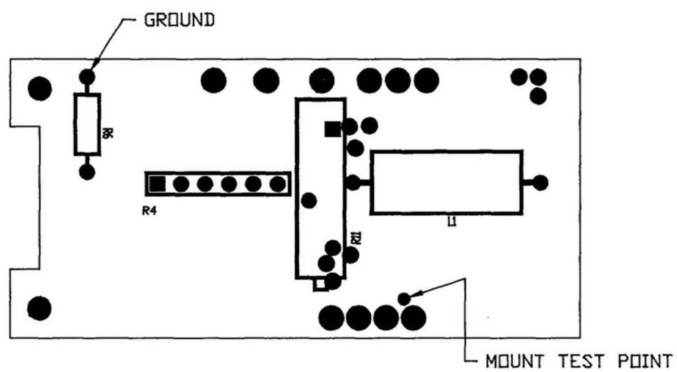
6. Disconnect the frequency counter and the power supply. **Make sure the O-ring and mating surfaces are clean.** Lightly lubricate before inserting the connector end cap into the housing cylinder. Replace the pump end cap retainer.


SEA-BIRD ELECTRONICS, INC.
ASSEMBLY 40605, 80639
Title
PUMP DRIVER, SMT, PITTMAN MOTOR
Size B Document Number 31441 REV B
Date: August 30, 1999 Sheet 1 of 1
JUMPER P12 TO P13 AND P17 TO P15 FOR 1300 RPM
JUMPER P14 TO P13 AND P16 TO P15 FOR 3000 RPM
BATTERY VOLTAGE

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	SEE HISTORY	P.G.	BW	







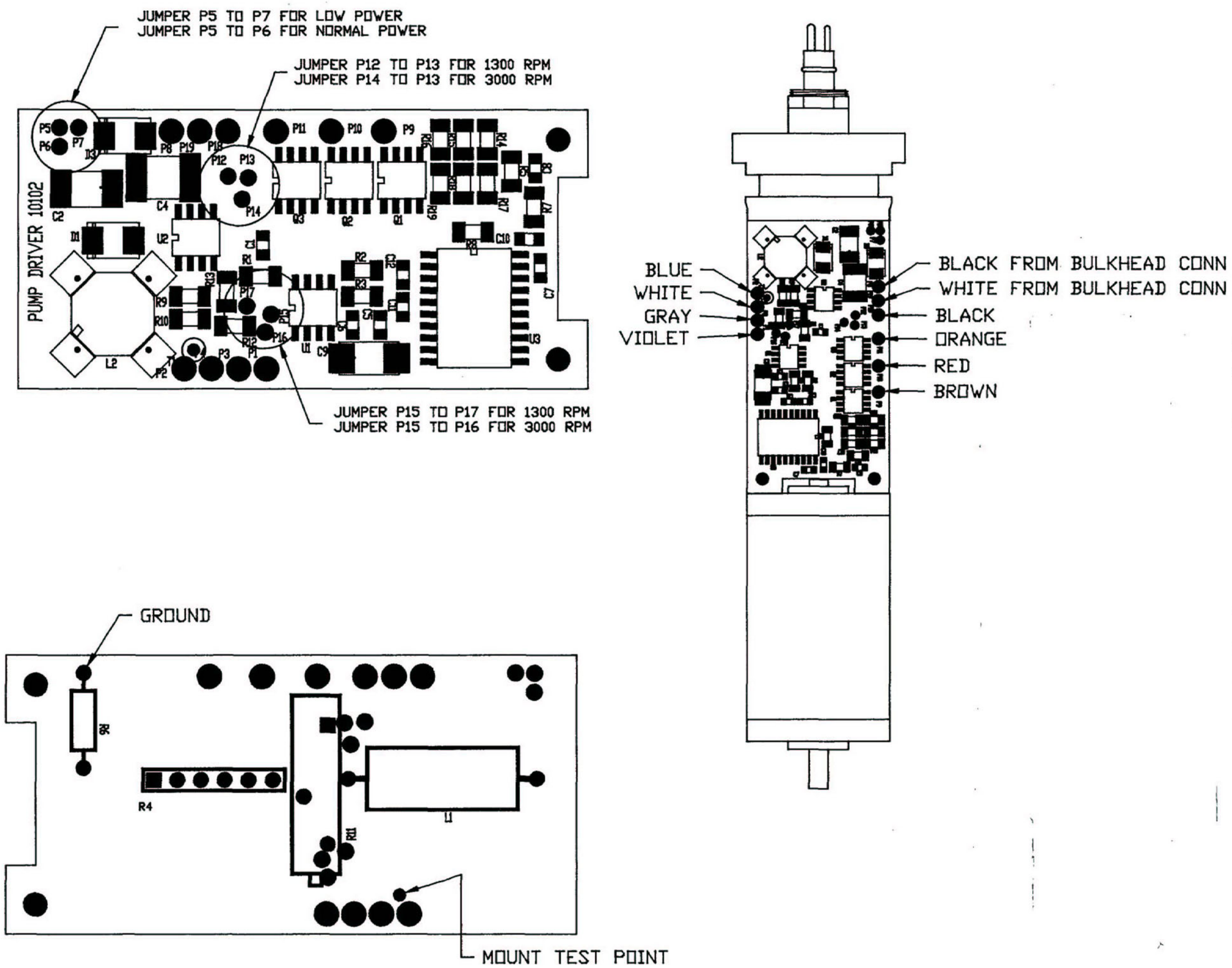
SINGLE LEVEL BILLS PAGE 1
SLB PRINTED ON 14:20:10 06 JUL 1994

PART NUMBER.	DESCRIPTION..................	QPA.....	ITM NBR	REF DESIG...........	DRAWING..... NUMBER
80675	SBE 5T 3000 RPM PUMP MOTOR/DRIVER, /DWG 40630				40630
20081	MOTOR, 7.4 OHM, PITTMAN 3711B112-R1	1.0000			
23595	SBE 5T PUMP PCB MOUNT BLOCK, /DWG 20624	1.0000			20624
30260	SCREW INSUL, # 2 X 1/8, IN-2/2	2.0000			
30357	MACH SCREW, 2-56 X 1/4 PH, SS	2.0000			
30560	MACH SCREW, 2-56 X 9/16 FH, SS, PHILIPS	2.0000			
80639	PUMP DRIVER, SMT, /DWG 40605	1.0000			40605 31441

***

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N 80675,31441	SCALE	DRAWN BY DJM / APPROVED BY
DECIMAL	TITLE SBE 5T 3000 RPM PUMP		
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40630	REV A

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
7/6/94	A	SEE HISTORY	P.G.	BAF	




```
SLB       PRINTED ON 14:20:10  06 JUL 1994

PART NUMBER. DESCRIPTION.................... QPA.....

80676          SBE 5T 1300 RPM, NORM POWER
               MOTOR, /DWG 40631
   20080       MOTOR, PUMP, 18 OHM PITTMAN       1.0000
               3711B113-R1
   23595       SBE 5T PUMP PCB MOUNT BLOCK,      1.0000
               /DWG 20624
   30260       SCREW INSUL, # 2 X 1/8, IN-2/2    2.0000
   30357       MACH SCREW, 2-56 X 1/4 PH, SS     2.0000
   30560       MACH SCREW, 2-56 X 9/16 FH,       2.0000
               SS, PHILIPS
   80639       PUMP DRIVER, SMT, /DWG 40605      1.0000

***

SLB       PRINTED ON 14:20:10  06 JUL 1994

PART NUMBER. DESCRIPTION.................... QPA.....

80681          SBE 5T 1300 RPM LO-VOLT
               MOT/DRVR /DWG 40631
   20080       MOTOR, PUMP, 18 OHM PITTMAN       1.0000
               3711B113-R1
   23595       SBE 5T PUMP PCB MOUNT BLOCK,      1.0000
               /DWG 20624
   30260       SCREW INSUL, # 2 X 1/8, IN-2/2    2.0000
   30357       MACH SCREW, 2-56 X 1/4 PH, SS     2.0000
   30560       MACH SCREW, 2-56 X 9/16 FH,       2.0000
               SS, PHILIPS
   80639       PUMP DRIVER, SMT, /DWG 40605      1.0000

***
```

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N 80676', 80681, 31441	SCALE	DRAWN BY DJM / APPROVED BY
DECIMAL	TITLE SBE 5T 1300 RPM PUMP		
ANGULAR	DATE 2/11/93	DRAWING NUMBER 40631	REV A

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 42 **Revised September 2001**

ITS-90 TEMPERATURE SCALE

Beginning January 1995, Sea-Bird temperature calibration certificates list a new set of coefficients labeled *g*, *h*, *i*, *j*, and *F0*. These coefficients correspond to ITS90 (T90) temperatures and should be entered by those researchers working with SEASOFT-DOS Versions 4.208 and higher (and all versions of SEASOFT-Win32). For the convenience of users who prefer to use older SEASOFT versions, the new certificates also list *a*, *b*, *c*, *d*, and *F0* coefficients corresponding to IPTS68 (T68) temperatures as required by SEASOFT-DOS versions older than 4.208.

It is important to note that the international oceanographic research community will continue to use T68 for computation of salinity and other seawater properties. Therefore, following the recommendations of Saunders (1990) and as supported by the Joint Panel on Oceanographic Tables and Standards (1991), SEASOFT-DOS 4.200 and later and all versions of SEASOFT-Win32 convert between T68 and T90 according to the linear relationship:

$$T_{68} = 1.00024 * T_{90}$$

The use of T68 for salinity and other seawater calculations is automatic in all SEASOFT programs. However, when selecting **temperature** as a display/output variable, you will be prompted to specify which standard (T90 or T68) is to be used to compute temperature. SEASOFT recognizes whether you have entered T90 or T68 coefficients in the configuration (.con) file, and computes T90 temperature directly or calculates it from the Saunders linear approximation, depending on which coefficients were used and which display variable type is selected.

For example, if *g, h, i, j, F0* coefficients (T90) are entered in the .con file and you select temperature variable type as T68, SEASOFT computes T90 temperature directly and multiplies it by 1.00024 to display T68. Conversely, if *a, b, c, d,* and *F0* coefficients (T68) are entered in the .con file and you select temperature variable type as T90, SEASOFT computes T68 directly and divides by 1.00024 to display T90.

Note: The CTD configuration (.con) file is edited using the Configure menu (in SEASAVE or SBE Data Processing in our SEASOFT-Win32 suite of programs) or SEACON (in SEASOFT-DOS).

Also beginning January 1995, Sea-Bird's own temperature metrology laboratory (based upon water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge) converted to T90. These T90 standards are now employed in calibrating *all* Sea-Bird temperature sensors, and as the reference temperature used in conductivity calibrations. Accordingly, all calibration certificates show T90 (g, h, i, j) coefficients that result directly from T90 standards, and T68 coefficients (a, b, c, d) computed using the Saunders linear approximation.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 57 **Revised May 2003**

I/O Connector Care and Installation

This Application Note describes the proper care and installation of standard I/O connectors for Sea-Bird CTD instruments. Once properly installed, the connections require minimal care. Unless access to the bulkhead is required, the connections can be left in place indefinitely.

The Application Note is divided into three sections:

- Connector Cleaning and Installation
- Locking Sleeve Installation
- Cold Weather Tips

Connector Cleaning and Installation

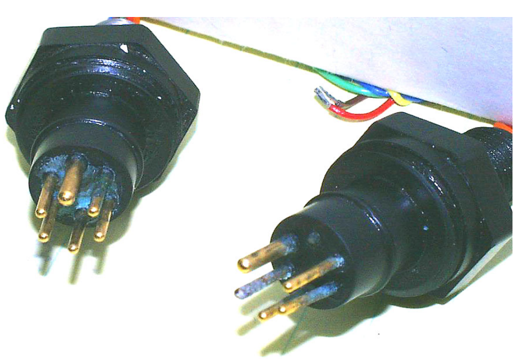
1. Carefully clean the bulkhead connector and the inside of the mating inline (cable end) connector with a Kimwipe. Remove all grease, hair, dirt, and other contamination.

Clean bulkhead connector

Clean inside of connector

2. Inspect the connectors:
   A. Inspect the pins on the bulkhead connector for signs of corrosion. The pins should be bright and shiny, with no discoloration. If the pins are discolored or corroded, clean with alcohol and a Q-tip.
   B. Inspect the bulkhead connector for chips, cracks, or other flaws that may compromise the seal.
   C. Inspect the inline connector for cuts, nicks, breaks, or other problems that may compromise the seal.

   Replace severely corroded or otherwise damaged connectors - contact SBE for instructions or a Return Authorization Number (RMA number).

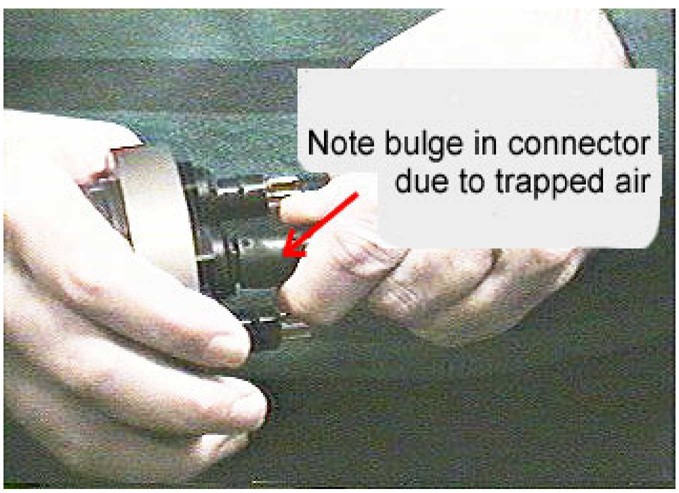


Corroded pins on bulkhead connectors -
Connector on right has a missing pin

3. Using a tube of 100% silicone grease (Dow DC-4 or equivalent), squeeze approximately half the size of a pea onto the end of your finger.

CAUTION:
Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

4. Apply a light, even coating of grease to the molded ridge around the base of the bulkhead connector. The ridge looks like an o-ring molded into the bulkhead connector base and fits into the groove of the mating inline connector.

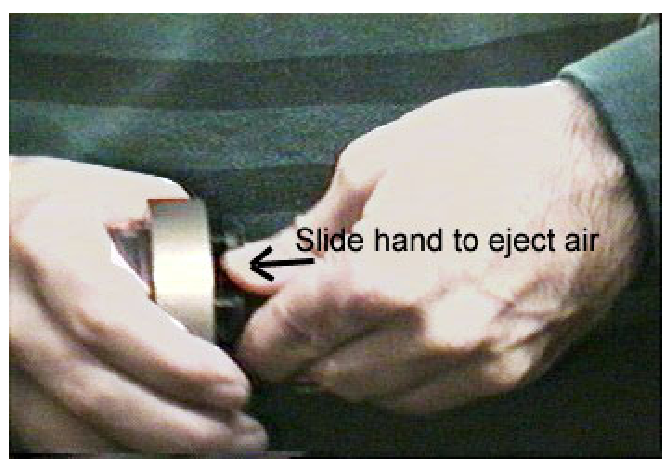


5. Mate the inline connector to the bulkhead, being careful to align the pins with the sockets. Do not twist the inline connector on the bulkhead connector. Twisting can lead to bent pins, which will soon break.

6. Push the connector all the way onto the bulkhead. There may be an audible pop, which is good. With some newer cables, or in cold weather, there may not be an initial audible pop.

7. After the cable is mated, run your fingers along the inline connector toward the bulkhead, *milking* any trapped air out of the connector. You should hear the air being ejected.

   CAUTION:
   Failure to eject the trapped air will result in the connector leaking.



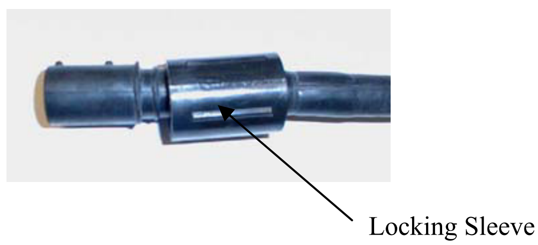
Locking Sleeve Installation

After the connectors are mated, install the locking sleeve. The locking sleeve secures the inline connector to the bulkhead connector and prevents the cable from being inadvertently removed.
Important points regarding locking sleeves:

- Tighten the locking sleeve by hand. **Do not** use a wrench or pliers to tighten the locking sleeve. Overtightening will gall the threads, which can bind the locking sleeve to the bulkhead connector. Attempting to remove a tightly bound locking sleeve may instead result in the bulkhead connector actually unthreading from the end cap. A loose bulkhead connector will lead to a flooded instrument. **Pay particular attention when removing a locking sleeve to ensure the bulkhead connector is not loosened**.

- It is a common misconception that the locking sleeve provides watertight integrity. **It does not, and continued re-tightening of the locking sleeve will not *fix* a leaking connector**.

- As part of routine maintenance at the end of every cruise, remove the locking sleeve, slide it up the cable, and rinse the connection (still mated) with fresh water. This will prevent premature cable failure.



Cold Weather Tips

In cold weather, the connector may be hard to install and remove.

Removing a *frozen* inline connector:

1. Wrap the connector with a washrag or other cloth.

2. Pour hot water on the cloth and let the connector sit for a minute or two. The connector should thaw and become flexible enough to be removed.

Installing an inline connector:
When possible, mate connectors in warm environments before the cruise and leave them connected.
If not, warm the connector sufficiently so it is flexible. A flexible connector will install properly.

By following these procedures, you will have many years of reliable service from your cables!

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 67 October 2001

Editing Sea-Bird .hex Data Files

After acquiring real-time .hex data or uploading .hex data from CTD memory, users sometimes want to edit the header to add or change explanatory notes about the cast. Some text editing programs modify the file in ways that are not visible to the user (such as adding or removing carriage returns and line feeds), but that corrupt the format and prevent further processing by SEASOFT (both DOS and Windows versions). **This Application Note provides details on one way to edit a .hex data file with a text editor while retaining the required format.** The procedure described below has been found to work correctly on computers running Win 98, Win 2000, and Win NT. If the editing is not performed using this technique, SEASOFT may reject the data file and give you an error message.

1. Make a back-up copy of your .hex data file before you begin.

2. Run **WordPad**.

3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.

4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below, with the added lines in bold:

```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
* Software Version Seasave Win32 v1.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999  10:57:19
* Testing adding header lines
* Must start with an asterisk
* Can be placed anywhere between System Upload Time and END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999  10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append to .NAV File When <Ctrl F7> is Pressed
** Ship:      Sea-Bird
** Cruise:    Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```

5. In the File menu, select Save (**not** Save As). If you are running Windows 2000, the following message displays:
   You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?

   Ignore the message and click *Yes*.

6. In the File menu, select Exit.

NOTE: This Application Note **does not apply to .dat data files**. Sea-Bird is not aware of a technique for editing a .dat file that will not corrupt the file.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 68

Revised March 2004

Using USB Ports to Communicate with Sea-Bird Instruments

Most Sea-Bird instruments use the RS-232 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, many newer PCs and laptop computers have USB port(s) instead of RS-232 serial port(s).

USB serial adapters are available commercially. These adapters plug into the USB port, and allow one or more serial devices to be connected through the adapter. Sea-Bird tested USB serial adapters from three manufacturers with our instruments, and verified compatibility. These manufacturers and the tested adapters are:

- **Keyspan** (www.keyspan.com) - High Speed USB Serial Adapter (part # USA-19QW) and USB 4-Port Serial Adapter (part # USA-49W)
- **Edgeport** (www.ionetworks.com) - Standard Serial Converter Edgeport/2 (part # 301-1000-02)
- **IOGEAR** (www.iogear.com) – USB 1.1 to Serial Converter Cable (model # GUC232A)

Other USB adapters from these manufacturers, and adapters from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing of any other adapters with the instrument before deployment, to verify that there is no problem.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 69 **July 2002**

Conversion of Pressure to Depth

Sea-Bird's SEASOFT software can calculate and output depth, if the instrument data includes pressure. Additionally, some Sea-Bird instruments (such as the SBE 37-SI or SBE 50) can be set up by the user to internally calculate depth, and to output depth along with the measured parameters.

Sea-Bird uses the following algorithms for calculating depth:

Fresh Water Applications

Because most fresh water applications are shallow, and high precision in depth not too critical, Sea-Bird software uses a very simple approximation to calculate depth:

depth (meters) = pressure (decibars) * 1.019716

Seawater Applications

Sea-Bird uses the formula in UNESCO Technical Papers in Marine Science No. 44. This is an empirical formula that takes compressibility (that is, density) into account. An ocean water column at 0 °C (t = 0) and 35 PSU (s = 35) is assumed.

The gravity variation with latitude and pressure is computed as:

$$g\ (\text{m/sec}^2) = 9.780318 * [\ 1.0 + (\ 5.2788\text{x}10^{-3} + 2.36\text{x}10^{-5} * x) * x\ ] + 1.092\text{x}10^{-6} * p$$

where
$x = [\sin(\text{latitude} / 57.29578)\ ]^2$
p = pressure (decibars)

Then, depth is calculated from pressure:

$$\text{depth (meters)} = [(((-1.82\text{x}10^{-15} * p + 2.279\text{x}10^{-10}) * p - 2.2512\text{x}10^{-5}) * p + 9.72659) * p] / g$$

where
p = pressure (decibars)
g = gravity (m/sec^2)

SBE
Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 71 — September 2003

Desiccant Use and Regeneration (drying)

This application note applies to all Sea-Bird instruments intended for underwater use. The application note covers:

- When to replace desiccant
- Storage and handling of desiccant
- Regeneration (drying) of desiccant
- Material Safety Data Sheet (MSDS) for desiccant

When to Replace Desiccant Bags

Before delivery of the instrument, a desiccant package is placed in the housing, and the electronics chamber is filled with dry Argon. These measures help prevent condensation. To ensure proper functioning:

1. Install a new desiccant bag each time you open the housing and expose the electronics.
2. If possible, dry gas backfill each time you open the housing and expose the electronics. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the chamber.

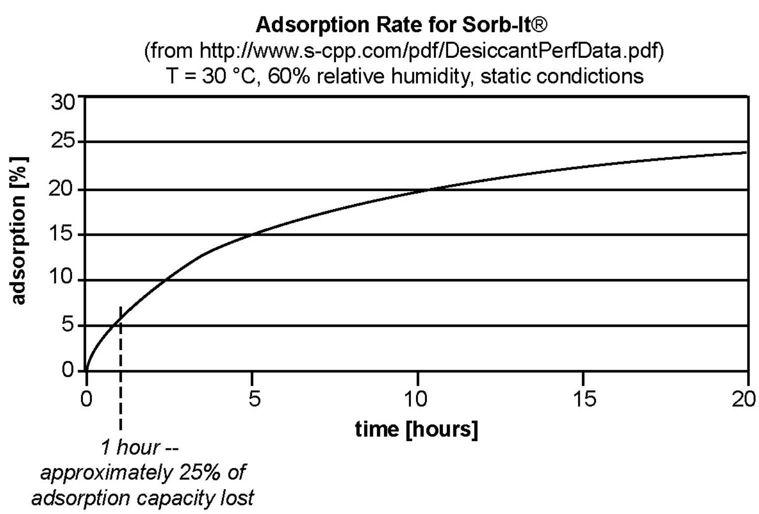
What do we mean by *expose the electronics*?

- For most battery-powered Sea-Bird instruments (such as SBE 16, 16*plus*, 16*plus*-IM, 17*plus*, 19, 19*plus*, 25, 37-SM, 37-SMP, 37-IM, 37-IMP, 44; PN 90208 Auto Fire Module [AFM]), there is a bulkhead between the battery and electronics compartments. Battery replacement does not affect desiccation of the electronics, as the batteries are removed without removing the electronics and no significant gas exchange is possible through the bulkhead. Therefore, opening the battery compartment to replace the batteries does not expose the electronics; you do not need to install a new desiccant bag in the electronics compartment each time you open the battery compartment. For these instruments, install a new desiccant bag if you open the electronics compartment to access the printed circuit boards.
- For the SBE 39 and 48, the electronics must be removed or exposed to access the battery. Therefore, install a new desiccant bag each time you open the housing to replace a battery.

Storage and Handling

Testing by Süd-Chemie (desiccant's manufacturer) at 60% relative humidity and 30 °C shows that approximately 25% of the desiccant's adsorbing capacity is used up after only 1 hour of exposure to a constantly replenished supply of moisture in the air. In other words, if you take a bag out of a container and leave it out on a workbench for 1 hour, one-fourth of its capacity is gone before you ever install it in the instrument. Therefore:

- Keep desiccant bags in a tightly sealed, impermeable container until you are ready to use them. Open the container, remove a bag, and quickly close the container again.
- Once you remove the bag(s) from the sealed container, rapidly install the bag(s) in the instrument housing and close the housing. **Do not use the desiccant bag(s) if exposed to air for more than a total of 30 minutes.**



Regeneration (drying) of Desiccant

Replacement desiccant bags are available from Sea-Bird:

- PN 60039 is a metal can containing 25 1-gram desiccant bags and 1 humidity indicator card. The 1-gram bags are used in our smaller diameter housings, such as the SBE 3 (*plus*, F, and S), 4 (M and C), 5T, 37 (-SI, -SM, -SMP, -IM, and –IMP), 38, 39, 43, 44, 45, 48, 49, and 50.
- PN 31180 is a 1/3-ounce desiccant bag, used in our SBE 16*plus*, 16*plus*-IM, 19*plus*, and 21.
- PN 30051 is a 1-ounce desiccant bag. The 1-ounce bags are used in our larger diameter housings, such as the SBE 9*plus*, 16, 17*plus*, 19, 25, 26, 32, AFM, and PDIM.

However, if you run out of bags, you can regenerate your existing bags using the following procedure provided by the manufacturer (Süd-Chemie Performance Packaging, a Division of United Catalysts, Inc.):

MIL-D-3464 Desiccant Regeneration Procedure

Regeneration of the United Desiccants' Tyvek Desi Pak® or Sorb-It® bags or United Desiccants' X-Crepe Desi Pak® or Sorb-It® bags can be accomplished by the following method:

1. Arrange the bags on a wire tray in a single layer to allow for adequate air flow around the bags during the drying process. The oven's inside temperature should be room or ambient temperature (25 – 29.4 °C [77 – 85 °F]). **A convection, circulating, forced-air type oven is recommended for this regeneration process. Seal failures may occur if any other type of heating unit or appliance is used.**

2. When placed in forced air, circulating air, or convection oven, allow a minimum of 3.8 to 5.1 cm (1.5 to 2.0 inches) of air space between the top of the bags and the next metal tray above the bags. If placed in a radiating exposed infrared-element type oven, shield the bags from direct exposure to the heating element, giving the closest bags a minimum of 40.6 cm (16 inches) clearance from the heat shield. Excessive surface film temperature due to infrared radiation will cause the Tyvek material to melt and/or the seals to fail. Seal failure may also occur if the temperature is allowed to increase rapidly. This is due to the fact that the water vapor is not given sufficient time to diffuse through the Tyvek material, thus creating internal pressure within the bag, resulting in a seal rupture. Temperature should not increase faster than 0.14 to 0.28 °C (0.25 to 0.50 °F) per minute.

3. Set the temperature of the oven to 118.3 °C (245 °F), and allow the bags of desiccant to reach equilibrium temperature. **WARNING**: Tyvek has a melt temperature of 121.1 – 126.7 °C (250 – 260 °F) (Non MIL-D-3464E activation or reactivation of both silica gel and Bentonite clay can be achieved at temperatures of 104.4 °C [220 °F]).

4. Desiccant bags should be allowed to remain in the oven at the assigned temperature for 24 hours. At the end of the time period, the bags should be immediately removed and placed in a desiccator jar or dry (0% relative humidity) airtight container for cooling. If this procedure is not followed precisely, any water vapor driven off during reactivation may be re-adsorbed during cooling and/or handling.

5. After the bags of desiccant have been allowed to cool in an airtight desiccator, they may be removed and placed in either an appropriate type polyliner tightly sealed to prevent moisture adsorption, or a container that prevents moisture from coming into contact with the regenerated desiccant.

NOTE: Use only a metal or glass container with a tight fitting metal or glass lid to store the regenerated desiccant. Keep the container lid **closed tightly** to preserve adsorption properties of the desiccant.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	SiO_2.x H_2O

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water, lifting upper and lower eyelids occasionally. Get prompt medical attention.

First Aid (Skin) - Wash with soap and water.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

SÜD-CHEMIE
Creating Performance Technology
ISO 9002 CERTIFIED

Sud-Chemie Performance Packaging
101 Christine Dr.
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 864-9296

MATERIAL SAFETY DATA SHEET – August 13, 2002
SORB-IT®
Packaged Desiccant

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

Application Note 56 **Revised September 2003**

Interfacing to RS-485 Sensors

A few Sea-Bird instruments use the RS-485 protocol for transmitting setup commands to the instrument and receiving data from the instrument. However, most personal computers (PCs) do not come with an RS-485 port. This Application Note covers interfacing our RS-485 instruments with a PC by the following methods:

- Connecting the instrument to an external RS-485/RS-232 Interface Converter that plugs into an existing RS-232 port on the PC.

  OR
- Installing an RS-485 interface card (and associated software) in the PC, and then connecting the instrument directly to the new RS-485 port in the PC.

External RS-485/RS-232 Interface Converter

RS-485/RS-232 Interface Converters are available commercially. These converters plug into the RS-232 port on the PC, and allow an RS-485 device to be connected through the converter. Sea-Bird tested a converter from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested converter is:

Black Box (www.blackbox.com) –
IC520A-F with RS-232 DB-25 female connector and RS-485 terminal block connector

Other converters from this manufacturer, and converters from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other converters with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the IC520A-F Converter:

1. Connect the Converter to the PC:
   - If the PC has a 25-pin male RS-232 connector, plug the Converter directly into the PC connector.
   - If the PC has a 9-pin male RS-232 connector, plug the Converter into a 25-pin to 9-pin adapter (such as Black Box FA520A-R2 Adapter). Plug the 25-pin to 9-pin adapter into the PC.

2. On the Converter, measure the voltage between XMT+ and ground and between XMT- and ground. Connect whichever has the highest voltage to RS-485 ‘A’ and the other to RS-485 ‘B’. The ground terminal can be left unconnected.

RS-485 Interface Card and Port in the PC

An RS-485 Interface Card installs in the PC, and allow an RS-485 device to be connected to the RS-485 port. These Interface Cards are available commercially. When using with a Sea-Bird instrument:

- **RS-485 Transmitter -**
  The Interface Card must be configured to automatically handle the RS-485 driver enable.

- **Two-Wire Interface -**
  TX+ and RX+ on the Interface Card must be connector together and to ‘A’ on the instrument.
  TX- and RX- on the Interface Card must be connected together and to ‘B’ on the instrument.
  Note: Some Interface Cards have a jumper to make the connections internally, while for other Cards the connections must be made in a jumper cable.

- **Terminal Program Compatibility -**
  If the Interface Card uses shared interrupts, SEATERM (our Windows terminal program) must be used to communicate with the instrument.
  If the Interface Card is configured as a standard COM port, either SEATERM or our DOS-based terminal programs may be used to communicate with the instrument.

Sea-Bird tested two Interface Cards from one manufacturer with our instruments, and verified compatibility. The manufacturer and tested cards are:

National Instruments (www.ni.com) -
AT-485/2
PCI-485/2

Other Cards from this manufacturer, and Cards from other manufacturers, **may** also be compatible with Sea-Bird instruments. We recommend testing other Cards with the instrument before deployment, to verify that there is no problem.

Follow this procedure to use the AT-485/2 or PCI-485/2 Interface Card:

1. Install the RS-485 driver software (provided with Interface Card) on your PC before installing the Interface Card.

2. Install the RS-485 Interface Card.

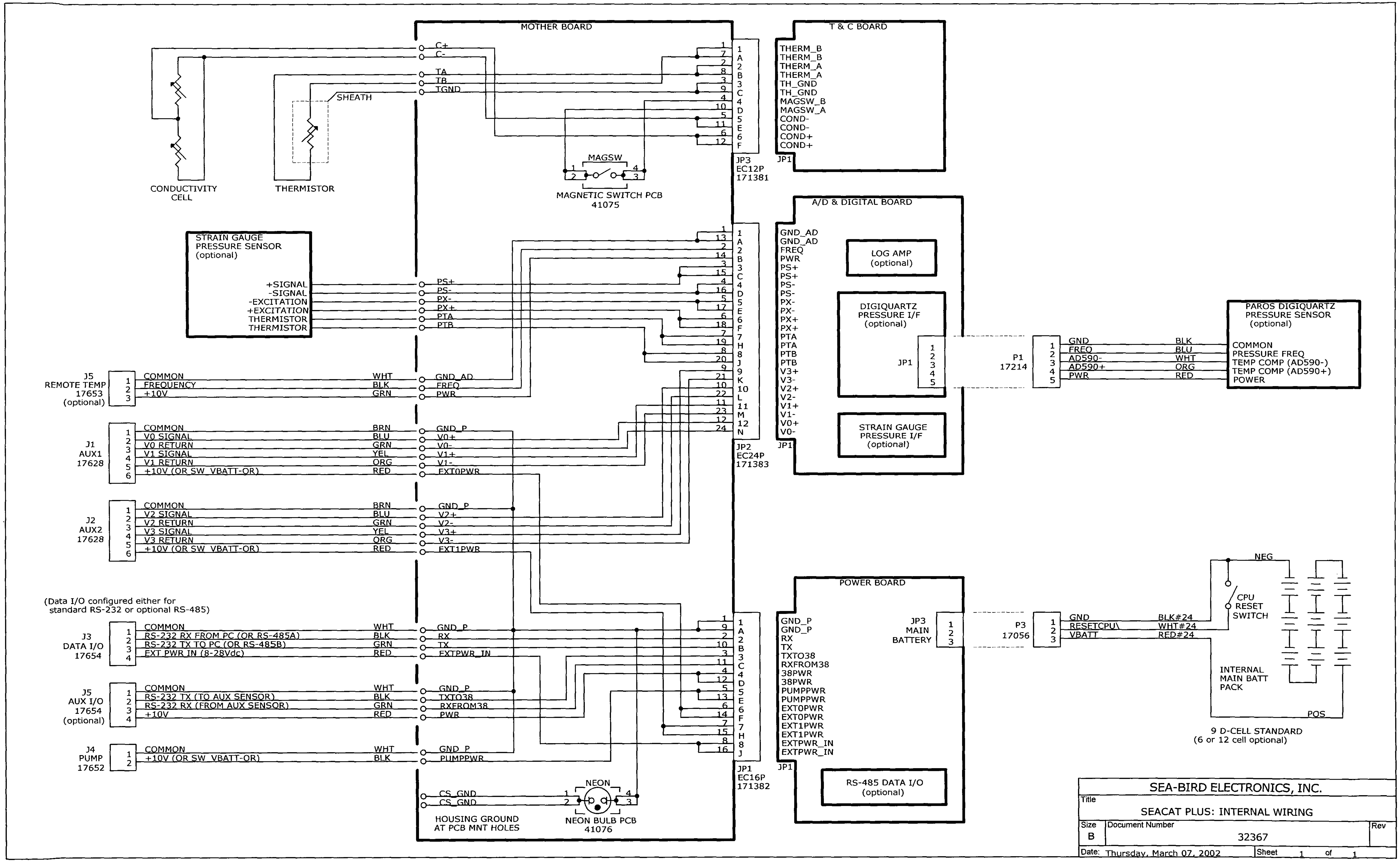
3. Configure the RS-485 Interface Card in your PC (directions are for a PC running Windows XP):
   A. Right click on My Computer and select Properties.
   B. In the System Properties dialog box, click on the Hardware tab. Click the Device Manager button.
   C. In the Device Manager window, double click on Ports. Double click on the desired RS-485 port.
   D. In the Communications Port Properties dialog box, click the Port Settings tab.
   Click the Advanced button.
   E. In the Advanced Settings dialog box, set Transceiver Mode to 2 wire TxRdy Auto.

4. Make a jumper cable (**do not use a standard adapter cable**) to connect the Interface Card to the instrument's I/O cable. Pin outs are shown for a Sea-Bird 9-pin (current production) or 25-pin (older production) I/O cable:

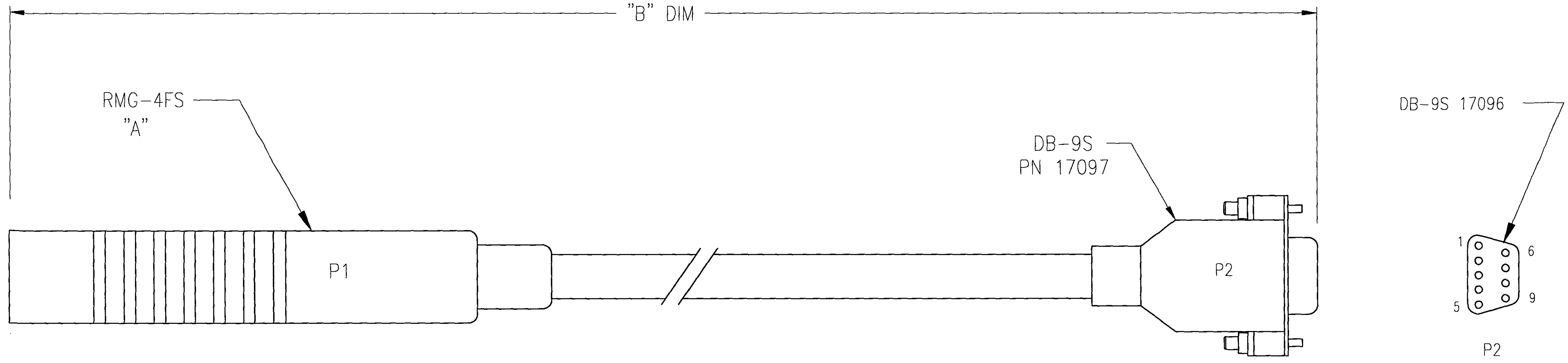
DB-9S (connect to PC)	**DB-9P** (connect to Sea-Bird I/O cable PN 801385)	**DB-25P** (connect to Sea-Bird I/O cable PN 801046)
pin 1 common	pin 5 common	pin 7 common
pin 4 TX+	pin 3 'A'	pin 2 'A'
pin 8 RX+	pin 3 'A'	pin 2 'A'
pin 5 TX-	pin 2 'B'	pin 3 'B'
pin 9 RX-	pin 2 'B'	pin 3 'B'

5. Run SEATERM (these Cards use shared interrupts, so the DOS terminal programs cannot be used):
   A. In SEATERM's Configure menu, select the desired instrument.
   B. In the Configuration Options dialog box, set Mode to RS-485 and set COMM Port to the appropriate RS-485 port.

DRAWINGS


MOTHER BOARD
T & C BOARD
THERM_B
THERM_B
THERM_A
THERM_A
TH_GND
TH_GND
MAGSW_B
MAGSW_A
COND-
COND-
COND+
COND+
JP1
C+
C-
TA
TB
TGND
SHEATH
CONDUCTIVITY CELL
THERMISTOR
MAGSW
MAGNETIC SWITCH PCB 41075
JP3 EC12P 171381
A/D & DIGITAL BOARD
GND_AD
GND_AD
FREQ
PWR
PS+
PS+
PS-
PS-
PX-
PX-
PX+
PX+
PTA
PTA
PTB
PTB
V3+
V3-
V2+
V2-
V1+
V1-
V0+
V0-
LOG AMP (optional)
DIGIQUARTZ PRESSURE I/F (optional)
STRAIN GAUGE PRESSURE I/F (optional)
P1 17214
GND
FREQ
AD590-
AD590+
PWR
BLK
BLU
WHT
ORG
RED
PAROS DIGIQUARTZ PRESSURE SENSOR (optional)
COMMON
PRESSURE FREQ
TEMP COMP (AD590-)
TEMP COMP (AD590+)
POWER
STRAIN GAUGE PRESSURE SENSOR (optional)
+SIGNAL
-SIGNAL
-EXCITATION
+EXCITATION
THERMISTOR
THERMISTOR
PS+
PS-
PX-
PX+
PTA
PTB
J5 REMOTE TEMP 17653 (optional)
COMMON
FREQUENCY
+10V
GND_AD
FREQ
PWR
J1 AUX1 17628
COMMON
V0 SIGNAL
V0 RETURN
V1 SIGNAL
V1 RETURN
+10V (OR SW_VBATT-OR)
BRN
BLU
GRN
YEL
ORG
RED
GND_P
V0+
V0-
V1+
V1-
EXT0PWR
JP2 EC24P 171383
J2 AUX2 17628
COMMON
V2 SIGNAL
V2 RETURN
V3 SIGNAL
V3 RETURN
+10V (OR SW_VBATT-OR)
GND_P
V2+
V2-
V3+
V3-
EXT1PWR
(Data I/O configured either for standard RS-232 or optional RS-485)
J3 DATA I/O 17654
COMMON
RS-232 RX FROM PC (OR RS-485A)
RS-232 TX TO PC (OR RS-485B)
EXT PWR IN (8-28Vdc)
WHT
BLK
GRN
RED
GND_P
RX
TX
EXTPWR_IN
J5 AUX I/O 17654 (optional)
COMMON
RS-232 TX (TO AUX SENSOR)
RS-232 RX (FROM AUX SENSOR)
+10V
GND_P
TXTO38
RXFROM38
PWR
J4 PUMP 17652
COMMON
+10V (OR SW_VBATT-OR)
GND_P
PUMPPWR
CS_GND
CS_GND
HOUSING GROUND AT PCB MNT HOLES
NEON
NEON BULB PCB 41076
JP1 EC16P 171382
POWER BOARD
GND_P
GND_P
RX
TX
TXTO38
RXFROM38
38PWR
38PWR
PUMPPWR
PUMPPWR
EXT0PWR
EXT0PWR
EXT1PWR
EXT1PWR
EXTPWR_IN
EXTPWR_IN
JP3 MAIN BATTERY
RS-485 DATA I/O (optional)
P3 17056
GND
RESETCPU\
VBATT
BLK#24
WHT#24
RED#24
NEG
CPU RESET SWITCH
INTERNAL MAIN BATT PACK
POS
9 D-CELL STANDARD (6 or 12 cell optional)
SEA-BIRD ELECTRONICS, INC.
Title
SEACAT PLUS: INTERNAL WIRING
Size
B
Document Number
32367
Rev
Date: Thursday, March 07, 2002
Sheet 1 of 1

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



ASSY P/N	"A" CABLE P/N	"B" DIM
801225	17741	8 FEET

ROCHESTER 3-N-5 OR EQUIV.
3 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	RED	PIN 2

ESSEX ROYAL 18/4 OR EQUIV.
4 CONDUCTOR PIGTAIL

P1 RMG-4FS	COLOR	P2 DB-9S
PIN 1	WHITE	PIN 5
PIN 2	BLACK	PIN 3
PIN 3	GREEN	PIN 2
PIN 4	RED	N/C

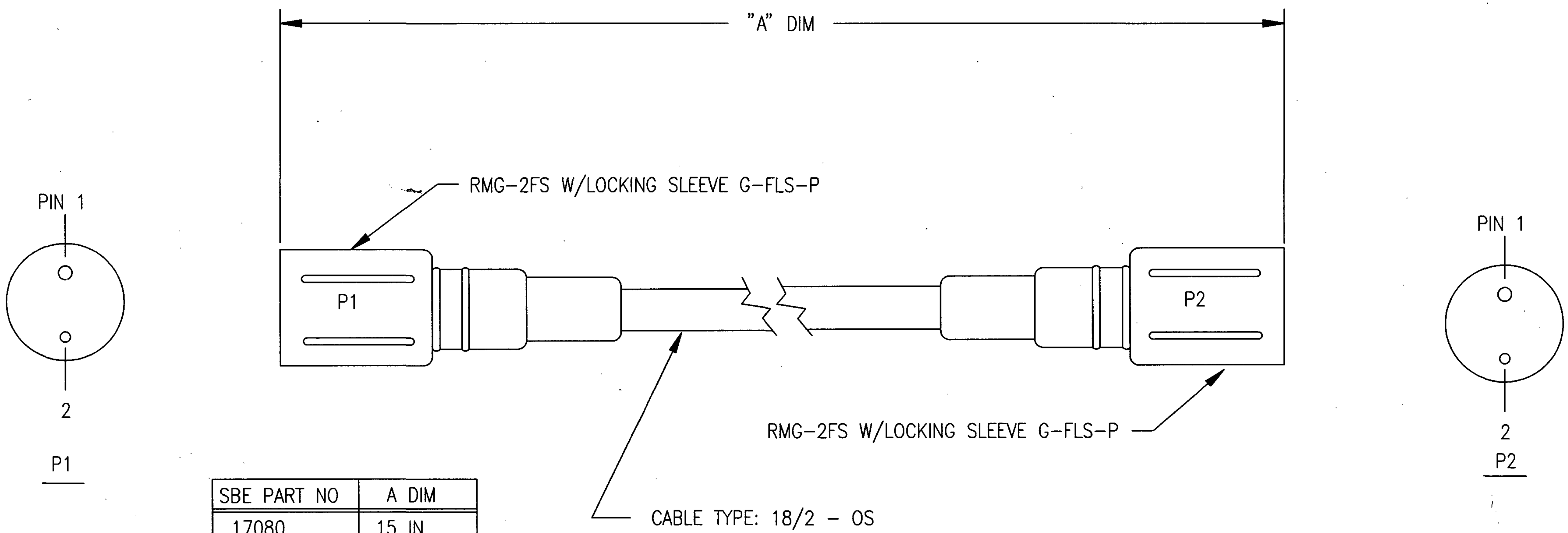
SEA-BIRD ELECTRONICS, INC

P/N	SCALE	DRAWN BY	APPROVED BY
SEE TABLE	–	PMc	

RMG-4FS TO DB-9S CABLE ASSEMBLY

DATE	DWG NO.	SHEET	REV
6/26/00	32421	1 of 1	–

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



SBE PART NO	A DIM
17080	15 IN
17100	40 IN
17101	6 FT
17127	60 IN
17133	44 IN
17159	36 IN
17188	34 IN
17200	79 IN
17259	120 IN
17285	12 IN
17394	29 IN
17450	24 IN
17584	48 IN
171229	10 M
171249	130 CM

P1	P2
PIN 1	PIN 1
PIN 2	PIN 2

TOLERANCES	SEA-BIRD ELECTRONICS, INC		
FRACTIONAL	P/N SEE TABLE	SCALE N.T.S.	DRAWN BY CEG / APPROVED BY CB
DECIMAL	TITLE CABLE, 2 PIN / 2 PIN RMG-2FS W/LOCKING SLEEVE		
ANGULAR	DATE 9.21.98	DRAWING NUMBER 30565	REV

LEICA NA2 · NAK2

Universal automatic level

Leica Geosystems

LEICA NA2
The classical level from Leica Geosystems

The NA2 universal automatic level meets all requirements regarding precision, convenience and reliability.

It was designed by surveyors and development engineers with years of experience and who know what a field instrument has to be able to do.

The NA2 soon pays for itself, because it can be used for all types of surveying job; on building sites for routine levelling, in engineering projects, and for geodetic control at all levels of accuracy.

Universal application

- Levelling of all types and all orders of accuracy
- Precise levelling and settlement determinations on buildings
- Routine heighting for the construction of roads, railways, pipelines, tunnels and so forth
- Setting-out work and control measurements on the construction site
- Area levelling of high accuracy
- Tacheometric levelling with the K-version on flat terrain by combining stadia and angular measurements with height readings
- Deformation measurement and monitoring of bridges

Quickly set up, simple to use

Strong tripods

In principle, the NA2 can be set up on any Leica Geosystems tripod. In practice, for all-round purposes, we recommend the heavy-duty GST20 telescopic-leg tripod. For precise levelling the GST40 fixed-leg tripod is suitable because of its extreme rigidity.

The modular relationship between instrument and tripod is an advantage when transport space is limited.

Centring is easy

The circular level only needs to be centred approximately to bring the compensator well into its working range of ~30', and so setting-up goes quicker.

The bubble is viewed positively via a pentaprism and is monitored down the eyepiece.

Play-free footscrews

The pitch of the smooth-running and backlash-free footscrews is such that the bubble can be centred in a very short time.

Independent of temperature

Unlike the tubular level of a traditional instrument, the NA2 universal automatic level is relatively insensitive to direct solar radiation and an umbrella need only be considered for the most precise levelling.

Adjust the line of sight automatically

Easy to level up

The advantage of this instrument is that, as soon as the bubble is centred, the line of sight is horizontal for all pointings of the telescope. The observer is freed of the time-consuming centring procedure involved with the traditional tubular level, and can concentrate on the business of staff readings.

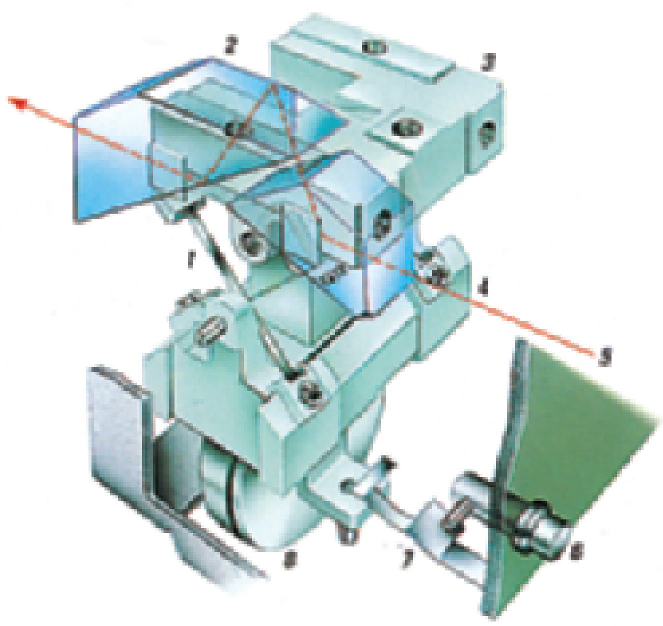
Robust and automatic

The compensator is essentially a pendulum with a prism (4).

The suspension system comprises four flexed tapes (1) made of a special alloy to ensure faultless functioning even at extreme temperatures. The compensator, which is located between the focusing lens and the crosshair reticle, is pneumatically damped against mechanical vibration and is screened against magnetic fields.

Minimum maintenance

In the unlikely event that the compensator is damaged (and this can only happen as a result of extremely harsh treatment) it is replaced easily, being held only by three screws.



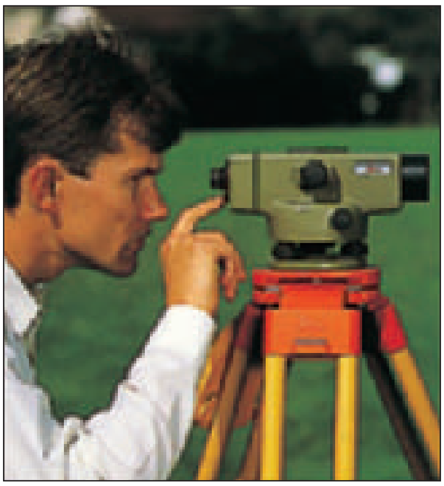
2/NAK2 compensator

'uspension tapes
'rism (fixed)
'ompensator body
'endulum with prism
ine of sight
'ush-button
'pring which taps pendulum
'neumatic damping mechanism

Push-button control – added security

With most automatics one taps the tripod or instrument to check if the compensator is functioning. Leica Geosystems offers a far more sophisticated solution.

Pressing the button under the NA2 eyepiece gives the compensator a gentle tap, so that you see the staff image swing smoothly away and then float gently back to give the horizontal line of sight. This check, which takes less than a second, is technically perfect, as the pendulum itself is activated and swings through its full range. It is also immediately apparent if the bubble is not centred.



Top-class optics

Top-class optics

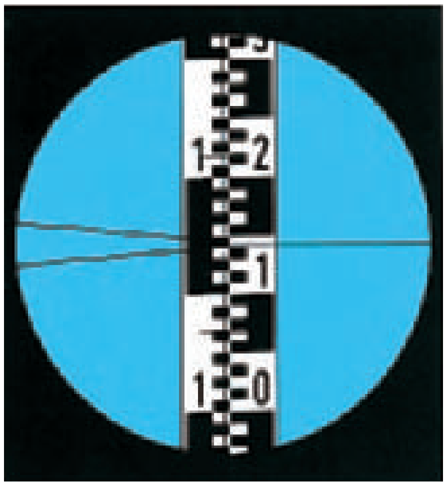
The telescope is of excellent quality and gives a bright, high-contrast, erect image, even in poor light – an essential for accurate levelling. With the standard eyepiece the magnification is 32×, the optimum for most applications of the instrument. Optional eyepieces are available; the 40× may be preferred for precise levelling, the 25× in hot, shimmer conditions. Eyepiece exchange takes only a second or so.

The focusing knob has a coarse/fine movement:
– coarse, for rapid setting with minimum turning
– fine, for the final delicate touch to give the perfect image.

Fatigue-free viewing

The reticle has:
– a single horizontal hair for reading normal staffs
– a wedge-shaped hair for use with invar staffs
– stadia hairs for distance measurement and three-wire levelling.

The general layout of the controls, the smooth friction-braked rotation of the instrument, and the endless horizontal drive with bilateral knobs, all combine to make the instrument easy to use.



NA2 field of view with metric levelling staff
Reading at horizontal hair: 1.143 m

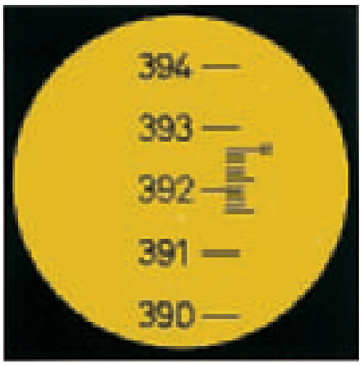
At an advantage on unstable ground

If a tubular level is used on unstable ground it tilts out of range and has to be continuously reset. By contrast, the pendulum of the NA2 "compensates" and keeps the line of sight horizontal.

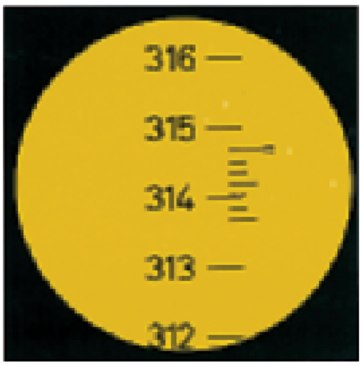
Angle measurement with the NAK2

Civil engineers and contractors often require a circle for angle measurement and setting-out work. Even simple detail surveys, by taking angle, distance and height, and plotting with the polar method, can be done with a level.

The model NAK2 has an internal glass circle which is read via a scale microscope and which can be set to any value by turning the rim around the base of the instrument.



NAK2
circle reading (400 gon)
392.66 gon



NAK2
circle reading (360°)
314°42'

High-performance accessories for precise levelling

GPM3 parallel-plate micrometer

This optional accessory slips over the telescope objective and blends perfectly with the smooth lines of the NA2. With a compensator setting accuracy of ±0.3“ (equivalent to 0.01 mm in 10 m) and a micrometer reading to 0.1 mm direct and 0.01 mm by estimation, the NA2 with GPM3 is an ideal combination for precise levelling, deformation studies, and even optical tooling. The micrometer drive for raising and lowering the line of sight is conveniently located and readings are taken on a glass scale viewed through an eyepiece just above the telescope eyepiece. This optical reading system, which is digital apart from the last and estimated figure in the metric and inch versions, is superior to the usual metal drum system.

GPM6 parallel-plate micrometer

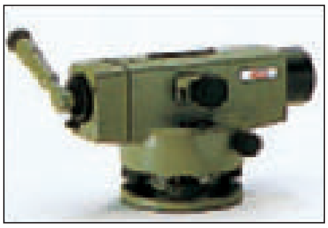
There are tasks for which a micrometer is needed, yet for which the very high accuracy of the GPM3 is not essential.

To meet this requirement, a simpler micrometer attachment, the GPM6 with drum reading, is available for the NA2.

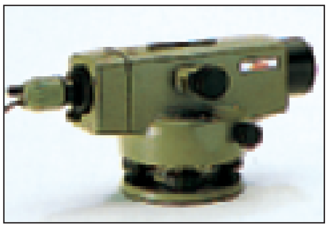
The GPM6 fits on to the telescope objective in the same manner as the GPM3, but the graduation is engraved on a metal drum.

Eyepiece accessories for specialized tasks

Because of the bayonet fastening of the interchangeable eyepiece, all theodolite eyepiece accessories can be used with the NA2.



- Diagonal eyepiece for observing from above, below, and from the side; useful in cramped spaces



- Eyepiece lamp for converting the NA2 into a horizontal collimator for laboratory work

- Autocollimation eyepiece for setting machine parts and instrument components precisely vertical

Compact

The rugged NA2 is indifferent to weather conditions and is extremely reliable in the rough world of the building site. The pendulum compensator is protected against knocks and shocks. There is a highly-effective vibration-damping mechanism.

Precise

The high setting accuracy ensures that the line of sight stays put. The attachable parallel-plate micrometer renders the NA2 ideal for precise fine levelling.

Reliable, automatic, maintenance-free

The instantaneous check facility with the push-button control not only makes work easier; it also promotes confidence.

Easy handling

The convenient, well-arranged controls are designed for maximum convenience. The bilateral, endless horizontal drive promotes rapid fine-pointing.

Quick levelling-up

The instrument is quickly set up with the three rapid-action footscrews. Their self-adjusting threads make subsequent resetting unnecessary.

Superb telescope

Telescope with excellently-corrected optics for bright, high-contrast images. All optical components are coated on both sides.

Effortless focusing

The erect image seen down the telescope is quickly and accurately brought into focus with the convenient rapid and fine focusing knob.

Abundant accessories; many applications

Additional items such as the parallel-plate micrometer, the laser eyepiece, or theodolite eyepiece accessories, offer almost unlimited possibilities.

LEICA NA2 · NAK2
Proven reliability ensures precise results

Versatile accessories for demonstrable success

A comprehensive program of accessories enables you to expand the performance and applications range of each instrument. This way, you can match your equipment exactly to requirements.

The possibilities are described in brochure “Survey accessories” 710 883en.

Robust container for safe transport

The NA2 is supplied in a foam-padded container made of high performance synthetic material. The foam padding absorbs all jolts and shocks. The container provides perfect protection for the NA2.

Technical data

Standard deviation for 1 km double-run levelling, depending on type of staff and on procedure	up to 0.7 mm
With parallel-plate micrometer	0.3 mm
Telescope	erect image
Standard eyepiece	32×
FOK73 eyepiece (optional)	40×
FOK117 (optional)	25×
Clear objective aperture	45 mm
Field of view at 100 m	2.2 m
Shortest focusing distance	1.6 m
Multiplication factor	100
Additive constant	0
Working range of compensator	~30′
Setting accuracy of compensator (stand. dev.)	0.3“
Sensitivity of circular level	8′/2 mm
Glass circle (K version)	400 gon (360°)
Graduation diameter	70 mm
Graduation interval	1 gon (1°)
Reading by estimation to	10 mgon (1′)
Water- and dust resistance	IP53
Temperature range:	
Operation	–20°C to +50°C (– 4°F to 122°F)
Storage	–40°C to +70°C (–40°F to 158°F)

Parallel-plate micrometer (optional accessory)	Range	Interval	Estimation
GPM3, with glass scale	10 mm	0.1 mm	0.01 mm
GPM6, with metal drum	10 mm	0.2 mm	0.05 mm

TQM ISO 9001 / ISO 14001

Total Quality Management – Our commitment to total customer satisfaction

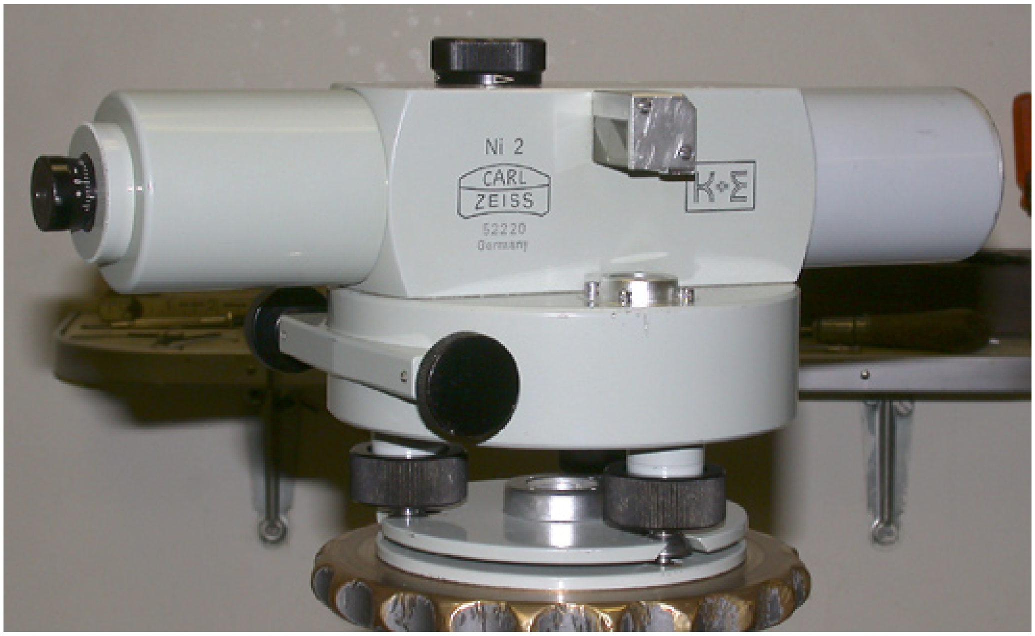
Ask your local Leica Geosystems agent for more information about our TQM program.

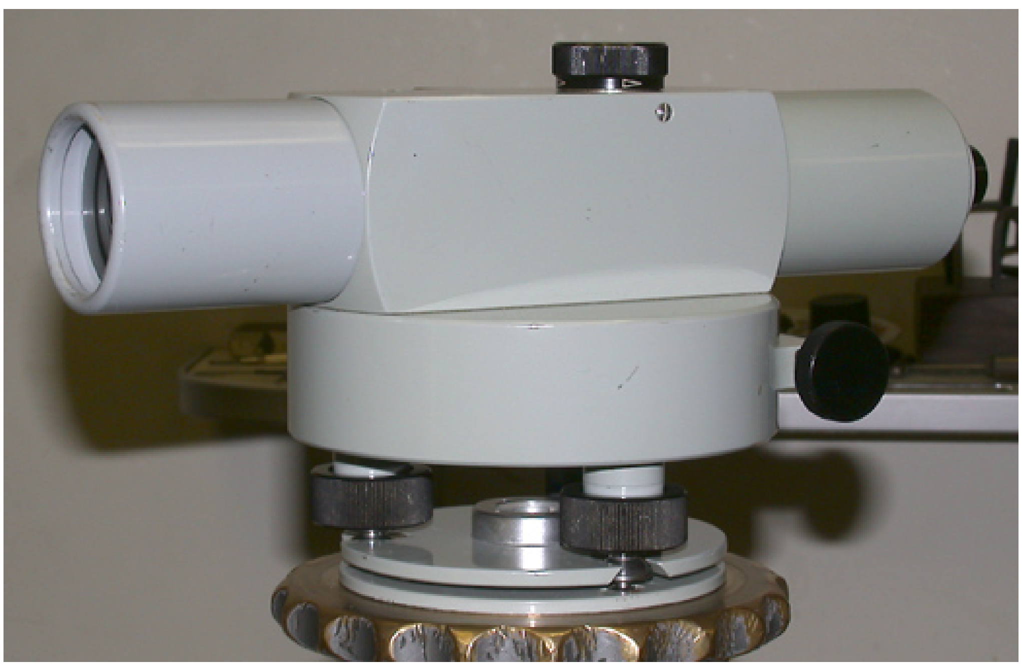
710 837en – V.03 – RDV

Leica Geosystems

*Leica Geosystems AG
CH-9435 Heerbrugg
(Switzerland)
Phone +41 71 727 31 31
Fax +41 71 727 46 73
www.leica-geosystems.com*

Carl Zeiss NI-2 Level





Contents

Optical Data

Telescope with Zeiss T-coating

Magnification	32 ×
Aperture	1 58 in (40 mm)
Shortest sighting distance	11 ft (3 3 m)
Field of view	23 ft at 1000 ft

Estimation of 1/1000 ft. on 1/100 ft. graduation up to 120 ft (1 mm on a 1 cm graduation up to 120 m)

Circular Level

Sensitivity	15 per 2 mm

Circle (on request)

Material	Glass
Diameter	2 95 in (75 mm)
Graduation	360° or 400^g
Graduation interval	1° or 1^g

Readings through reading microscope

Magnification	17 ×
Scale interval	10 or $0\,1^g$
Estimation to	1 or $0\,01^g$

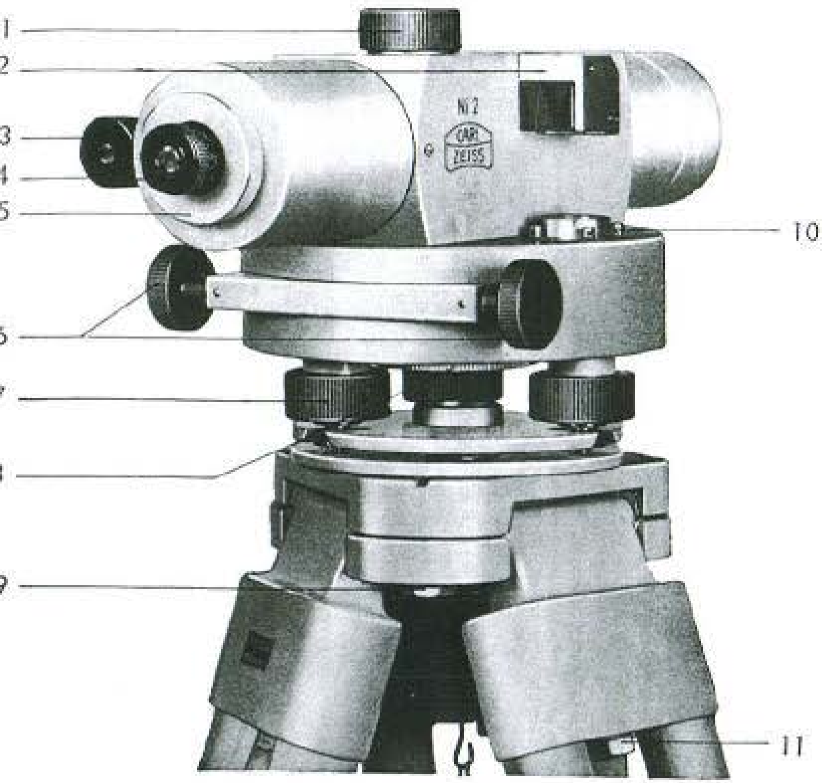


Fig. 1 Ni 2 with horizontal circle

(about 1/3 natural size)

1 Focus control with quick-fine movement
2 Viewing prism for circular level
3 Eyepiece of reading microscope for circle
4 Telescope eyepiece with dioptre scale
5 Screw cover over reticle adjusting screw
6 Lateral fine movement controls
7 Leveling screw
8 Knurled setting ring for circle orientation
9 Adjusting screw for tripod hinges
10 Adjusting screws for circular level
11 Clamping screw for tripod leg fitting

Mechanical Data

Dimensions:

Length of telescope	10.6 in. (27 cm.)
Height of instrument	5.1 in. (13 cm.)
Diameter of base	5.1 in. (13 cm.)
External dimensions of case	13×6.9×6.1 in. (33×17.5×15.6 cm.)
S 3 tripod extending from	3 ft. 5 in. to 5 ft. 7 in. (approx.) (102–170 cm.)
S 2 tripod extending from	3 ft. 5 in. to 5 ft. 7 in. (approx.) (102–170 cm.)

Weights:

Ni 2 without circle	4.6 lbs. (2.1 kg.)
Ni 2 with circle	5.3 lbs. (2.4 kg.)
Case for Ni 2 without circle	6.4 lbs. (2.9 kg.)
Case for Ni 2 with circle, with plumb bob	6.6 lbs. (3.0 kg.)
Parallel plate micrometer in leather case	1.3 lbs. (0.6 kg.)
Torch with supports	0.7 lbs. (0.3 kg.)
Leather case for torch	1.7 lbs. (0.7 kg.)
S 3 tripod	11.6 lbs. (5.3 kg.)
S 2 tripod	13.6 lbs. (6.2 kg.)
Leveling staff (03) 4 m. folding to 2 m.	12 lbs. (5.5 kg.)
Leveling staff (05) 3 m. folding to 1.5 m.	6.4 lbs. (2.9 kg.)
Invar staff (06) 3 m., rigid	9 lbs. (4.0 kg.)
"Scotch light" staves, additional weight	0.45 lbs. (0.2 kg.)

01 Tripod leg
only, not n
stiffness o
(1 m.) apar
tips moder

02 Lift instrum
secure tigh

03 Center circ
hairs on a
the eyepiec

Caution: D
over an ex
dried with
allowed to
of the cont

04 Aim telesc
edge of the

05 For fine se
the fine mo

06 Focus for
focus cont
matically ir

07 Read staff
necessary
slightly tap
movement

Positioning Data Link™

PDL™

High Performance Data Link

Designed for Survey Systems

19,200 Baud Rate
Higher Over-the-Air Link Rate
Extends Your Battery Life

Enhanced User Interface
Change Channels in the Field
View Status Information

Compatible with GPS RTK Equipment Worldwide
Complete Kit Solutions Available
for Your Application

Reliable
Rugged, All Season Operation

2 Year Warranty
Lower Cost of Ownership

Surveyors utilizing Global Positioning Systems require a rugged radio modem data link for precise positioning information. The PDL is compact and lightweight and offers power efficient operation. It is easy to use, and provides high performance and rugged dependability for the toughest survey environments.

PDL Products are designed to easily mount on all standard tripods and range poles. Complete kit solutions are available.

PACIFIC CREST
CORPORATION

Positioning Data Link™

	High Power Base	Low Power Base	Rover
General Specifications			
DTE – DCE Interface	3 Wire, RS-232, 38.4k Baud Maximum.		
User Interface	On/Off Button. Channel Button with AutoBase™ and AutoRover.™ Digital Display. Modem/Power Status Indicators. RF Power Select Toggle Switch.	On/Off Button. Channel Button with AutoBase™ and AutoRover.™ Digital Display. Modem/Power Status Indicators.	On/Off Button. Channel Button with AutoBase™ and AutoRover.™ Digital Display. Modem/Power Status Indicators.
Power			
External	9 – 16 VDC.		
Internal Battery	N/A	N/A.	Lithium Ion Battery Pack.
During TX (nominal)	110 Watts.	11 Watts.	N/A.
During RX (nominal)	1.9 Watts.	0.9 Watts.	0.3 Watts.
Antenna			
External	50 Ohm, BNC.	50 Ohm, NMO.	50 Ohm, NMO.
Modem Specifications			
Link Rate/Modulation	19,200 bps/4 Level FSK. 9600 bps/4 Level FSK. 9600 bps/GMSK. 4800 bps/GMSK.		
Link Protocols	Transparent, Packet Switched, Digipeater, TRIMTALK.™	Transparent, Packet Switched, Digipeater, TRIMTALK.™	Transparent, Packet Switched, TRIMTALK.™
Forward Error Correction	Hamming Code (12, 8) with Data Interleaving.		
Radio Specifications			
Frequency Bands	Refer to price list for available frequency bands.		
Frequency Control	Synthesized 12.5k Hertz Resolution. ±2.5 ppm Stability.		
RF Power Select	Low/High. Factory Programmable.	N/A.	
RF Transmitter Output	3/35 Watts Maximum.	0.5 – 2 Watts.	0 Watt (Receive Only).
Sensitivity	-116 dBm (12 dB SINAD).		
Adjacent Channel Selectivity	>-60 dB.	>-70 dB at 9600 bps/GMSK. >-60 dB at 19,000 bps/4 Level FSK.	>-60 dB.
Type Certification	All models are type accepted and certified for operation in the U.S. and Canada. For detailed information concerning your country's type certification, please contact your sales representative.		
Environmental Specifications			
Operating Temperature	-22° to +140° F (-30° to +60° C).		-4° to +140° F (-20° to +85° C).
Storage Temperature	-67° to +185° F (-55° to +85° C).		-4° to +185° F (-20° to +85° C).
Vibration/Shock	ANSI/ASAE EP455.		
Enclosure	IEC 60529 I.P. 66. Water Tight and Dust Proof.		
Mechanical Specifications			
Dimensions	6.23" W x 2.77" H x 6.58" L. (15.8 cm W x 7.0 cm H x 16.7 cm L).	8.25" L x 2.40" Diameter. (21.0 cm L x 6.1 cm Diameter).	8.25" L x 2.40" Diameter. (21.0 cm L x 6.1 cm Diameter).
Weight	2.96 lbs. (1.34 Kg).	0.65 lbs. (0.30 Kg).	0.75 lbs. (0.34 Kg).
Data/Power Connector	5 Pin LEMO #1 Shell.	5 Pin LEMO #0 Shell.	5 Pin LEMO #0 Shell.
Mount	Tripod Bracket.	5/8" – 11 Range Pole.	5/8" – 11 Range Pole.

PACIFIC CREST CORPORATION

990 Richard Avenue, Suite 110, Santa Clara, CA 95050
1-800-795-1001, Tel: 408-653-2070, Fax: 408-748-9984
Web: www.paccrst.com, E-mail: sales@paccrst.com

INSTANT-RTK TECHNOLOGY

Z-Xtreme Survey System

Z-Xtreme

The Ashtech® Z-Xtreme™ from Thales Navigation professional products is a rugged, weather-proof, dual-frequency GPS receiver designed to provide surveyors with cost-effective, centimeter-accurate positions in a variety of system configurations.

The Z-Xtreme receiver begins with state-of-the-art satellite electronics coupled with patented Z-Tracking™ to deliver the highest GPS signal reception level. A removable battery and flash memory card provide enough capacity to last all day for maximum utility. Components are completely integrated inside a weather-proof, high impact plastic housing, ensuring your investment is safe, rain or shine. Use the easy-to-operate interface on the front panel for important functions such as site information entry, survey status, and set-up of RTK base stations without the additional cost of a handheld controller. The result: Z-Xtreme with Instant-RTK® outperforms all other receivers in its class!

ZX-Solutions

The Z-Xtreme survey system from Thales Navigation provides a range of solutions designed for the vast array of positioning needs – from entry level static or kinematic post-processed surveys, all the way up to real-time functions such as stake out. The entry level ZX-Solutions™ system dramatically increases your productivity for control surveys and other post-processed applications. Add an optional kinematic kit to make topographic feature collection more cost effective. Use Ashtech Solutions™ software to easily process the field data, export results and generate reports. Purchase only what you need for the job at hand because ZX-Solutions is fully upgradeable.

ZX-SuperStation

Eclipse the productivity of optical instrument stake out with a ZX-SuperStation™. The ZX-SuperStation is a field-to-finish GPS surveying system that combines the Z-Xtreme receiver with a powerful data collector and wireless modems for centimeter accuracy in real-time. Instant-RTK gives you the ability to initialize the centimeter solution in a fraction of the time of conventional RTK systems. Powerful data collection software gives you the ability to efficiently perform GPS surveying techniques and to interface seamlessly with optical total stations.

TECHNICAL SPECIFICATIONS

Ashtech Technology

- 12 channel all-in-view operation
- Full-wavelength carrier on L1 and L2
- Z-Tracking
- Multipath mitigation
- Dual-frequency smoothing for improved code differential
- Instant-RTK

Performance Figures[1]

Static, Rapid Static
- Horizontal: 0.005 m + 1 ppm (0.016ft+1ppm)
- Vertical: 0.010 m + 1 ppm (0.033ft + 1ppm)

Post-Processed Kinematic
- Horizontal: 0.010 m + 1 ppm (0.033ft + 1ppm)
- Vertical: 0.020 m + 1 ppm (0.065ft+1ppm)

Real-Time Code Differential Position
- <1 m (3.28 ft)

Real-Time Z Kinematic Position (Fine Mode)
- Horizontal: 0.010 m + 2 ppm (0.033ft + 2 ppm)
- Vertical: 0.020 m + 2 ppm (0.065ft + 2 ppm)
- Azimuth (arc sec): 0.4 + 2.0/baseline (km)

RTK Occupation Time
- 2 seconds (typical - sub-centimeter accuracy with longer occupation time)

Instant-RTK Initialization
- 99.9% reliability
- Typically <2 seconds with 6 or more satellites, PDOP <5, baseline length <7 km (4.35 mi), open sky and low multipath conditions

RTK Operating Range
- Recommended: 10 km (6.21 mi)
- Maximum: 40 km (24.85 mi)

Standard Features

- 16 MB PCMCIA removable memory card
- NMEA 0183 output
- Selectable update rate from 999 sec to 10 Hz
- Event marker
- Point positioning
- 1 PPS timing signal
- Session programming
- Wide array of coordinate transformations
- Removable internal battery
- 8-character alphanumeric LED display with 4-button interface
- 3 function LED display - Radio,Memory, Satellites/Power
- Multi-function audible alarm
- Quick reference card holder
- External mount capabilities
- External power input
- 4 RS-232 ports (115200 baud max, 3 external, 1 internal)
- 1-year warranty
- Free factory technical support

Standard Accessories

- Communications software
- Padded system bag and hard case
- RS-232 data cable
- Receiver operating manual
- Quick reference field card

Technical Data

Environmental

Z-Xtreme Receiver
- Meets MIL-STD 810E for wind driven rain and dust
- Operating temperature: -30° to +55°C (-22° to 131°F)
- Storage temperature: -40° to +85°C (-40° to 185°F)

Geodetic 4 Antenna
- Meets IPX7 specifications for submersion
- Operating temperature: -55 to +75°C (-40° to 149°F)
- Storage temperature: -55° to +75°C (-67° to 167°F)

Physical

Weight
- Receiver: 1.59 kg (3.50 lb)
- Antenna: 0.82 kg (1.81 lb)
- Battery: 0.43 kg (0.95 lb)

Dimensions
- 76.2 H x 196.85 W x 222.25 D mm
- (0.25 H x 0.646 W x 0.729 D ft)

Power
- 10 - 28 VDC, 6.0 W

Internal battery
- Capacity: 6000 mAh
- >9 hours (typical) @ 25°C (77°F)
- Operating temperature: -30° to +55°C (-22° to 131°F)
- Storage temperature: -40 to +60°C (-40° to + 140°F)

PC card
- ATA Type II PCMCIA memory card (16 MB standard)
- Temperature range: -40° to +85°C (-40° to 185°F)
- Data capacity: 4500 epochs per 2 MB*

** Based on one session, eight satellites' data and full measurements. This number can vary significantly depending on the conditions of the session.*

Optional Features

- Real-time kinematic (base and rover modes) for cm-accuracy
- RTCM 2.2 (Types 1, 2, 3, 9, 16, 18, 19, 20, 21, 22)
- Internal UHF or spread spectrum radio for RTK rover operations
- External UHF or spread spectrum radio for RTK base and rover operations
- Geodetic 4 antenna ground plane kit
- Kinematic antenna kit
- Aircraft antenna kit
- AC power cable
- Choke ring antenna
- Long haul backpack kit
- All-on-a-pole kit

Optional Application Software

GPS data processing
- Ashtech Solutions

Land Surveying and Construction
- TDS Survey Pro
- Carlson SurvCE
- Ashtech Survey Control II
- Ashtech GPS Fieldmate

Mining and Land Seismic
- Ashtech Mine Surveyor II
- Ashtech Seismark II

1 *Specifications assume operation follows all the procedures recommended in the product manual utilizing Instant-RTK, post processing with Ashtech Solutions or Ashtech Office Suite for Survey. High-multipath areas, high PDOP values, low satellite visibility, and periods of adverse atmospheric conditions and/or other adverse circumstances will degrade system performance. All accuracy specifications are RMS values.*

Thales Navigation, Inc.
Corporate Headquarters, Santa Clara, CA, USA
+1 408 615 5100 * Fax +1 408 615 5200
Toll Free (Sales in USA/Canada) 1 800 922 2401
Email professionalsales@thalesnavigation.com
In Washington, DC +1 703 476 2212 * Fax +1 703 476 2214
In South America +56 2 234 56 43 * Fax +56 2 234 56 47
In China +86 10 6566 9866 * Fax +86 10 6566 0246

European Headquarters, Carquefou, France
+33 2 28 09 38 00 * Fax +33 2 28 09 39 39
Email professionalsalesemea@thalesnavigation.com
In Germany +49 81 6564 7930 * Fax +49 81 6564 7950
In Russia +7 095 956 5400 * Fax +7 095 956 5360
In UK +44 (0) 870 601 0000 * Fax +44 (0) 208 391 1672
In the Netherlands +31 78 61 57 988 * Fax +31 78 61 52 027
Web site www.thalesnavigation.com

THALES NAVIGATION

Nikon

TOP GUN®

DTM-310

ELECTRONIC TOTAL STATION

Valuable functions, superior cost-performance, longer battery life and enhanced software

Nikon has just taken the world-renowned Top Gun® DTM-300 total station to a whole new level. The new Top Gun® DTM-310's enhanced keyboard and on-board software enable easy code input in both alphabet and numbers, the way you've always wanted. It builds on existing features — such as the large four-line LCD and full numeric key pad — to improve overall convenience. And software upgrades make it easier to search and display data. In fact, the Top Gun® DTM-310 provides customers in any field — from civil construction to cadastral surveying and mapping — with greater ease of operation.

ENHANCED BASIC FUNCTIONS

- Large four-line display with full alphanumeric input on both faces
- Meets basic requirements for distance and angle measurement
- Resume function for quick startup and power management
- Enhanced, powerful built-in programs
- 500-point on-board data storage function
- 7.3 hours continuous measuring with one on-board battery
- Compact and lightweight
- Quick access to the 20 most recently stored codes

Convenient Alphanumeric Input

The inclusion of alphabetic input enables you to store codes in a combination of letters and numerals. Codes, target heights (HT) and point numbers are easily input for each new measurement. And codes can also be selected from the most recent 20 codes stored in the memory, eliminating the need to repeatedly input the same codes.

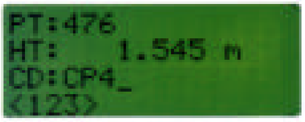
■ KEY DESCRIPTIONS

MSR: Distance measurement in normal measurement mode
DSP: Selects display item by scrolling display
TRK: Distance measurement in high-speed measurement mode
ANG: Horizontal angle zero-set, user-defined angle input or hold
XYZ: Coordinate measurement
RDM: Remote distance measurement (continuous or radial)
REM: Remote elevation measurement
STN: Station setup (known point, 2-point resection or 3-point resection)
S-O: Stakeout by inputting angle distance or coordinates
Illumination: Display illumination
REC: Data record to internal memory
ENT: Data entry or sending observation data to communication port in normal observation mode
FNC: Input of temperature and barometric pressure, prism constant, and height of target; simple COGO calculation; settings; view/edit stored data; communication (internal memory); vertical collimation correction

Enhanced, Powerful Built-in Programs

On-board data storage function

The DTM-310 memory stores up to 500 raw or coordinate records. Coordinate data can be manually input, measured or



uploaded from a PC. (Contact your Nikon distributor for download/upload and format conversion software.) Data can be instantly recalled and reviewed for station setup, stakeout and COGO.

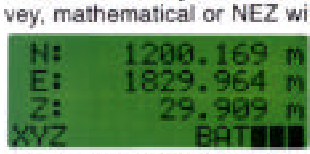
Station setup

For station setups, in addition to the known station setup obtained by inputting the coordinate of backsight or direction angles, a more simplified default station setup is also possible. This can be obtained by setting the station point coordinates at zero

while maintaining the prior orientation intact. Two- and three-point resections are also available. In the case of a three-point resection, it is possible to transfer the elevation from a bench mark.

XYZ coordinate measurement

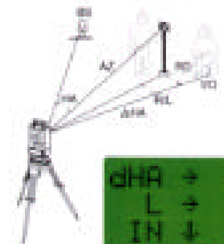
The coordinate system can be set to survey, mathematical or NEZ with indepen-



dent coordinate order settings. Azimuth zero-direction can be set to either north or south. Coordinate calculations are based on these settings. Point name, number, code and coordinate data can be stored in the data file. The target height can be changed at any time by pressing the FNC key.

Stakeout

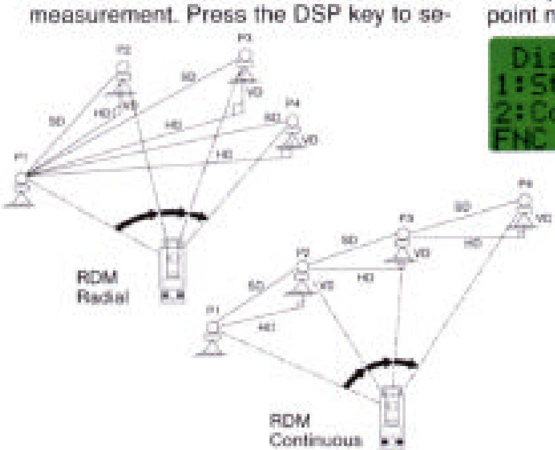
Lets you perform stakeouts by inputting angle and distances, or coordinates. Co-



ordinates can be searched and retrieved from the built-in memory. Zero-direction countdown and delta displays (Left/Right, In/Out, Cut/Fill) make for fast and simple stakeouts. Stakeout data can be also recorded in the internal memory.

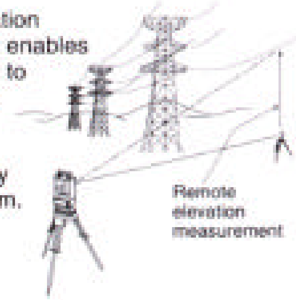
RDM

For continuous or radial remote distance measurement. Press the DSP key to select slope distance, elevation difference, horizontal distance, grade, legal grade ratio between two points, or azimuth from first to second points.



REM

Remote elevation measurement enables measurement to points (e.g., a power pole) where you cannot directly place the prism.

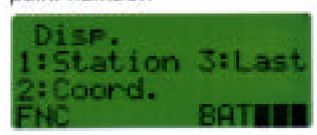


COGO calculation

Enables point-to-point inverse calculations, plus azimuth and distance calculations. Coordinates can be searched and retrieved from the on-board memory, and calculated coordinates can be saved.

Data display

The DTM-310 enables you to search data by tracing back from the most recent record, from specific station points, or from a simple point number.



7.3 Hours Continuous Operating Time

Internal battery BC-60 provides about 7.3 hours (with full charge, at 20°C, for distance/angle measurements) of continuous operation. The remaining battery power is indicated by the LCD. As Ni-MH battery BC-60 contains no harmful substance, recycling is not necessary. Quick recharge can be performed in about 2 hours with standard battery charger Q-70U/Q-70E. The Q-70U/Q-70E's discharging function preserves the batteries' minimum power and protects against deterioration.

Resume Function

This resume function can automatically revert to the orientation prior to power OFF, or automatically display the previous horizontal angle. It guarantees the safety of all previous data settings.

Basic Measurement Functions

- Built-in Automatic Vertical Compensation
- Vertical Angle Zero-Degree Set Handled in Three Modes
- Grade Display
- With Triple Prism, to 1.2km or 3,900 feet (under good conditions)
- ±(5 + 3ppm x D)mm Precision
- Automatic Environmental Compensation
- Selectable Angle Reading of 5/10", 0.5/1mgon, 0.02/0.05MIL
- Angle Measurement Accuracy of 5"/1.6mgon/ 0.02MIL (standard deviation based on DIN18723)

Standard Package

- DTM-310 main unit
- On-board battery BC-60
- Battery charger Q-70U/Q-70E
- Lens cap
- Plumb bob
- Tool set
- Plastic case
- Vinyl cover
- Instruction manual

Optional Accessories

- Diagonal eyepiece prism
- High-power (32x) and low-power (16x) eyepiece lenses
- Compass (tubular type) and compass adapter
- Zenith prism
- Solar filter
- Solar reticle
- External battery B4

On-board battery BC-60 and battery charger Q-70U/Q-70E

Specifications

Telescope	
Tube length	150mm/5.9 in.
Effective diameter of objective	36mm/1.41 in. (EDM aperture 40mm/1.57 in.)
Magnification	26x (standard)
Field of view	1°30'
Resolving power	3.5"
Minimum focusing distance	1.0m/3.3 ft.
Angle measurement	
Reading system	Incremental encoder
Unit of reading	Degree/Gon/6400MIL
Least count (selectable)	
(360°)	5" or 10"
(400G)	0.5mgon or 1mgon
(6400MIL)	0.02MIL or 0.05MIL
Accuracy (Standard deviation based on DIN 18723)	5"/1.6mgon/0.02MIL
Tilt sensor (Automatic Vertical Compensator)	Liquid type
Working range	±3'
Distance measurement	
Range (with Nikon prism)	
(Normal conditions: ordinary haze, visibility 20km/12.5 miles)	
with mini prism	380m/1,300 ft.
with single prism	800m/2,600 ft.
with triple prism	1,100m/3,700 ft.
(Good conditions: no haze, visibility 40km/25 miles)	
with mini prism	450m/1,500 ft.
with single prism	1,000m/3,300 ft.
with triple prism	1,200m/3,900 ft.
Accuracy	±(5 + 3ppm x D)mm, –10°C to +40°C/+14°F to +104°F ±(5 + 5ppm x D)mm, –20°C to +50°C/–4°F to +122°F
Maximum measurement display	1,230m/4,000 ft.
Least count	
Standard MSR mode	1mm/0.005 ft.
Tracking mode	10mm/0.05 ft.

Measuring intervals	
Standard MSR mode	4 sec.
Tracking mode	1.2 sec.
Measuring mode	Continuous/Single/Average (2 - 99)
Ambient temperature range	–20°C to +50°C (–4°F to +122°F)
Atmospheric correction range	
Temperature range	–40°C to +60°C (–40°F to +140°F)
Pressure range	400 to 999mmHg (1mmHg step) 15.8 to 39.3 in.Hg (0.1 in.Hg step) 533 to 1,332hPa (1hPa step)
Display	Dot-matrix LCD 16 characters x 4 lines
Level vial	
Sensitivity of plate level vial	30"/2mm
Sensitivity of circular level vial	10'/2mm
Leveling base	
Tribrach	Detachable
Optical plummet	
Image	Erect
Magnification	3x
Field of view	5°
Focusing range	0.5m/1.6 ft. to ∞
Power sources	
Type	Ni-MH 7.2V DC
Continuous operating time	7.3 hrs. or 8,760 measurements (for distance/angle measurement) 22 hrs. (for angle measurement only)
Quick battery charger (Q-70U/Q-70E)	
Input voltage	115V for Q-70U, 220/240V for Q-70E
Recharging time	1.5 hrs.
Dimensions (W x D x H)	
Main unit (with carrying handle)	164 x 177 x 335mm/6.5 x 7.0 x 13.2 in.
Weight	
Main unit w/battery	5.5kg/12.1 lbs.
Battery BC-60	0.5kg/1.1 lbs.
Carrying case	2.5kg/5.5 lbs.

These products (DTM-310 and battery charger Q-70U/E) are strategic products subject to Japanese/International export control regime. They should not be exported without authorization from the appropriate governmental authorities.

Specifications and equipment are subject to change without any notice or obligation on the part of the manufacturer. February 1997

ISO 9001 Certified
ISO 9001
Certificate No. 20242
NIKON CORPORATION
Instruments Division
Yokohama Plant

East Coast:
NIKON INC.
Instrument Group, Surveying Dept.
1300 Walt Whitman Road, Melville, NY 11747-3064
Phone: (516) 547-4200 **Telefax:** (516) 547-8669

West Coast:
NIKON INC.
Instrument Group, Surveying Dept.
19601 Hamilton Avenue, Torrance, CA 90502
Phone: (310) 516-7124 **Telefax:** (310) 719-9772

FIG Nikon is an official sponsor of FIG.

Nikon on the Net http://www.nikonusa.com/

E

This brochure is printed on 40% recycled paper. Printed in Japan Code No. 2CEHWS1 (9702-20)K Key#VRR

V. SPECIFICATIONS

1. Main Unit

● Telescope

Image	: Erect/unreversed
Magnification	: 26×
Effective diameter of objective	: 36mm
Field of view	: 1°30′
Minimum focusing distance	: 1.0m
Resolving power	: 3.5″

● Distance Measurement

Distance range of Nikon prisms	: 450m with mini prism 1000m with single prism 1200m or longer with triple prism * With visibility 40km (25miles)
Precision	: ±(5mm+3ppm×D) * With accurate measurement mode, at −10°C~+40°C/+14°F~+104°F D is measuring distance, mm unit ±(5mm+5ppm×D) at −20°C≦t<−10°C/ −4°F≦t<+14°F and +40°C<t≦50°C/ +104°F<t≦+122°F
Measuring time response	: 〔MSR〕 mode: About 4sec. (initial: about 5sec.) 〔TRK〕 mode (cm): About 1.2sec (initial: about 2.2sec.)
Least count	: 1mm
Display	: Up to 1230m
Display unit	: m/ft-INT/ft-US

● Angle Measurement

Accuracy	: 5″ (Standard deviation based on DIN 18723)
Reading system	: Photoelectric detection by incremental encoder single-sided reading
Display unit	: Degree/Gon/MIL

● Automatic Vertical Compensator

System	: Liquid-electric detection
Working range	: ±3′

● Optical plummet

Image	: Erect
Magnification	: 3×
Field of view	: 5°
Focusing range	: 0.5m~∞

● Clamps/tangent screws : Coaxial dual speed tangents

● Sensitivity of level vials

Plate level vial	: 30″/2mm
Circular level vial	: 10′/2mm

● Tribrach : Detachable

● Dimensions and weight

Main body	: 5.5kg (12lbs) including BC-6 battery pack
Case	: About 3.5kg (7.6lbs)

● Operating temperature range:

−20°C~50°C/−4°F~+122°F

SOKKIA

SET5F

Version 01-00

TOTAL STATION

Enhanced software with 3,000-point data memory.

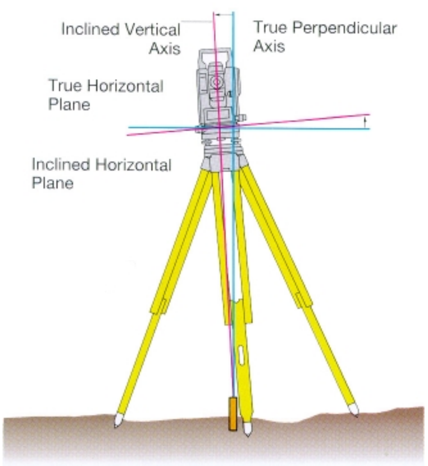
Flexible, Friendly and Featherweight

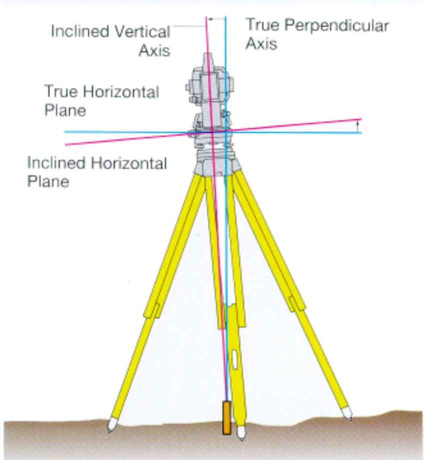
The SET5F's powerful EDM, dependable dual-axis compensator and 3,000-point data memory are conveniently packaged in a compact, lightweight body. Software [Version 01-00) has been enhanced for more effective survey work, and "softkey" assignments can be freely customized to suit all user needs.

Dependable Hardware

Proven Dual-axis Compensator

•Since its introduction with the Series C total station in 1989, Sokkia's dual-axis compensator has proven its reliability and accuracy at survey sites all over the world.
•The dual-axis tilt sensor monitors deviations of both the X and Y axes and the correct horizontal and vertical angle readings are automatically computed and applied. The result is easier and faster instrument leveling.





The High-performing EDM

•1,500m/4,900ft range with a single prism under good ambient conditions (40km/25miles visibility, with no haze, overcast, no scintillation).
•Outstanding precision; ±(3+2ppmxD)mm. This corresponds to a deviation of a mere ±3.2mm at a distance of 100m and ±5mm at 1,000m.
•Supreme speed; only 1.7 seconds initial measuring time in the rapid measurement mode.

	Average Conditions	Good Conditions
CP01 Compact Prism	700 m/2,300 ft.	
One AP01 Prism	1,200 m/3,900 ft.	1,500 m 4,900 ft.
Three AP01 Prisms	1,600 m/5,200 ft.	2,000 m 6,500 ft.

Powerful Telescope

•Highest magnification in its class: 30x
•Easy, accurate sighting of prisms or targets

Outstanding Mobility

•Total carrying weight (including instrument, tribrach, battery and hard case) is a mere 8 kg/18 lbs. The secret lies in the lightest and most compact carrying case of its kind (W390 x D255 x H220mm / W15.3 x D10.0 x H8.6in.), making the SET5F supremely portable.

•A convenient shoulder strap is provided as standard. An optional back pack (SC94) is ideal for longer day treks.

Enhanced Software

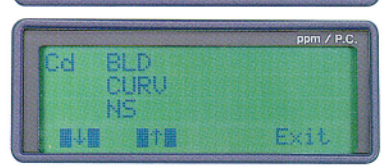
The SET5F can be easily customized to your preferred key assignments.

•The SET5F offers optimum keyboard flexibility. Any keyboard layout can be configured. For example, functions can be assigned to any key position on any page, and unused functions can be temporarily deleted.
•A powerful "softkey" feature facilitates input of coordinate values, feature codes, etc.

Key assignment mode

Spacious 3,000-point Internal Memory

•The SET5F's internal memory is large—holding a full 3,000 data points—and secure. For optimum convenience, measurements can be performed and recorded at the touch of a key.
•Up to five (5) job files can be created to efficiently organize multiple survey tasks.
•Forty (40) feature codes (max.13 charac-ters each) can be kept in the memory for easy recall as needed.

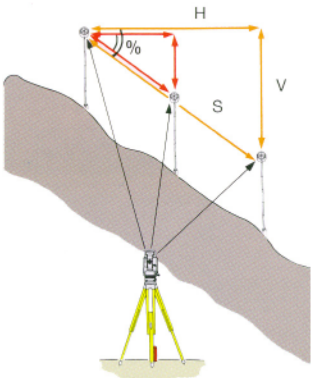


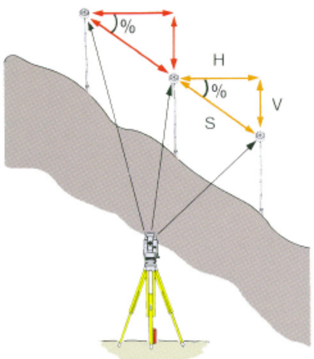
Sophisticated Application Software

Missing Line Measurement (MLM)

•The SET5F measures horizontal distance, slope distance, height difference, and slope in percent (%) between two prisms, all at the touch of a key.

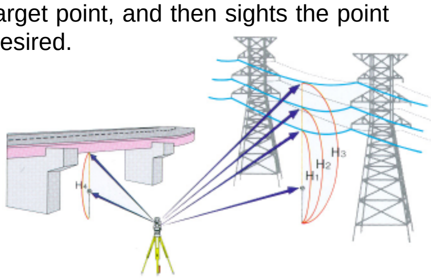
The SET5F brings full freedom to survey work.





Remote Elevation Measurement (REM)

•The SET5F can be used to easily determine the height of a point where a prism cannot be placed. The system sights a prism directly above or below the target point, and then sights the point desired.

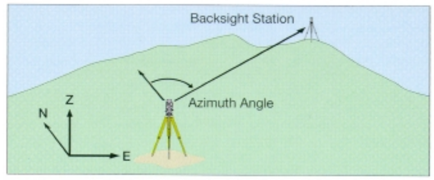


Angle Repetition

•For enhanced accuracy in the horizontal angle measurement, the SET5F can measure in repetition. It then calculates and displays the average of the multiple angle measurements.

Azimuth Angle Setting

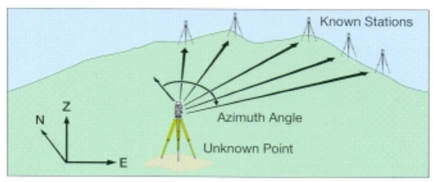
•Using the coordinates of the instrument station and a backlight point, the SET5F can automatically set the horizontal angle to the azimuth of the backlight.



Resection

•With 2 to 5 known points, the SET5F can be used to determine the azimuth and coordinates of the unknown instrument station.

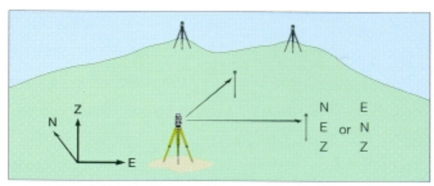
•When using 2 known points, both angles and distances are measured. When using 3 or more points, the distance does not always have to be measured.



3-D Coordinate Measurement

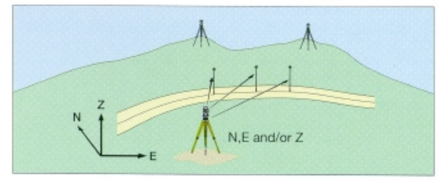
•The SET5F calculates 3-D coordinate values of measuring points.

•The operator may choose display settings either of "N, E, Z" or "E, N, Z."



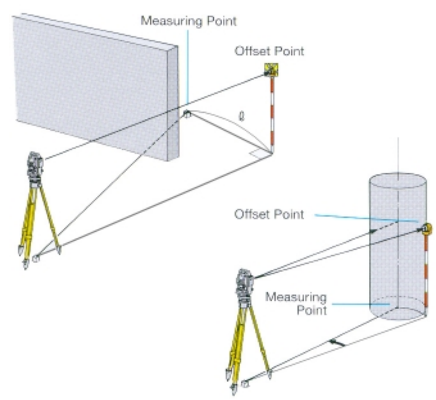
3-D Setting-out

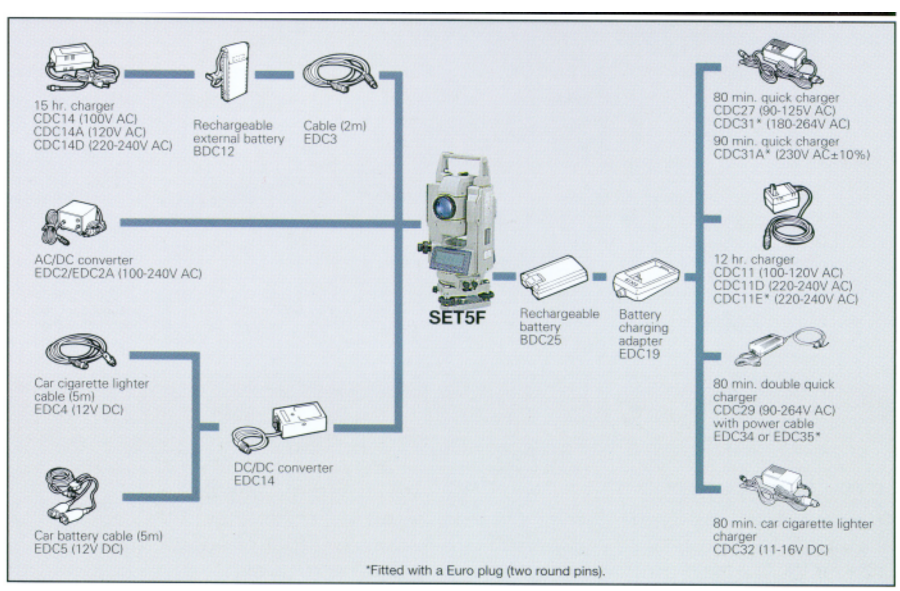
•The SET5F can be used to perform 3-dimensional setting-out with N, E and/or Z coordinates.



Offset Measurements

Two basic offset measurement methods are provided to measure the hidden points. One calls for input of the offset distance and the direction between the measuring point and the prism. The other uses a prism set on the left or right side of the measuring point at the same distance from the SET5F; the angles and distance to the prism are measured, and the measuring point is sighted. In both cases, the SET5F calculates the horizontal and vertical angles and distance, or the N, E, Z coordinates.





Standard Configuration

The SET5F comes with two (2) BDC25 rechargeable batteries EDC19 battery charging adapter CDC27, CDC31 or CDC31A quick charger, CP7 tubular compass, sunshade, lens cap, plumb bob, vinyl cover, tool kit, operator's manual, carrying case and shoulder strap.

Electronic Field Books (SDR33/SDR31)

Thanks to its advanced two-way communications port, the SET5F's functions can all be accessed by external controller. For example, by connecting one of the Sokkia's acclaimed Electronic Field Books (SDR33 or SDR31), complex field operations such as traverse adjustment, intersection, area calculations and roading can be carried out with remarkable ease.

Optional Accessories

DE17A	Diagonal Eyepiece
OF1/OF1A	Solar Filters
SC94	Back Pack

SET5F Specifications

Telescope		**Fully transiting, coaxial EDM**
Length		165mm (6.5in)
Objective aperture		45mm (1.8in)
Magnification, image		30x, Erect
Resolving power		3.0"
Field of view		1°30'(26m/1,000m)
Minimum focus		1.3m (4.3ft.)
Reticle illumination		Bright or Dim, selectable
Angle measurement		**Incremental encoder, diametrical detection**
Display resolution	H&V	1"/ 0.2 mgon/ 0.005 mil, 5"/1 mgon/ 0.02 mil
Angle unit	H&V	Degree/Gon/Mil
Accuracy	H&V	5" (1.5 mgon/ 0.02 mil) according to DIN18723
Dual-axis compensator		Liquid dual-axis tilt sensor, range: ±3' (±55 mgon)
Display mode	H	Clockwise/ Counterclockwise, Repetition, Oset, Hold available
	V	Zenith 0°/ Horizontal 0°/ Horizontal 0°±90°/ Slope%
Distance measurement		**Electro-optical with modulated infrared LED.**
Measuring range (slope distance)		A: Average conditions; slight haze, visibility about 20km(12 miles), sunny periods, weak scintillation. G: Good conditions; no haze, visibility about 40km (25 miles), overcast, no scintillation. Maximum ranges are achieved with Sokkia CP/AP prisms.
With CP01 compact prism		A: 1.3m (4.3ft.) to 700m (2,300ft.)
With one AP01 prism		A: 1.3m (4.3ft.) to 1,200m (3,900ft.), G: 1,500m (4,900ft.)
With three AP01 prism		A: 1.3m (4.3ft.) to 1,600m (5,200ft.), G: 2,000m (6,500ft.)
Distance unit		Meters or feet, selectable
Accuracy (Fine measurement)		±(3+2ppmxD)mm D=measuring range, unit=mm
Measuring unit and time	Fine	0.001 m Every 3.2 seconds (initial 4.7 seconds)
(slope distance)	Rapid	0.001 m 1.7 seconds
	Tracking	0.01 m Every 0.3 seconds (initial 1.4 seconds)
	Average	0.0001 m (average of 2 to 9 times measurement)
Atmospheric correction		Key-in the temperature and pressure, or -499 to +499ppm.
Prism constant		-99 to 0mm (1 mm steps)
Refraction & Earth-curvature correction		On/off selectable (K=0.142)
General		
Display		LCD dot matrix display (20 characters x 4 lines) on both faces with back light.
Keyboard		5 keys on both faces, free assignment of functions.
Resume function		On/off selectable
Sensitivity of levels		Plate level: 40"/2mm, Circular level: 10'/2mm (in tribrach)
Optical plummet		Image: erect, Magnification: 3x, Minimum focus: 0.5m (1.6ft.)
Interface		Asynchronous serial, RS-232C compatible, baud rate 1200/ 9600bps
2-way communication		Provided
Data storage		3,000-point data memory
Operating temperature		-20°C to +50°C (-4°F to +122°F)
Tilting/Trunnion axis height		236mm (9.3in) from tribrach bottom, 193mm (7.6in) from tribrach dish.
Size with handle and battery		W150 x D165 x H353mm, W5.9 x D6.5 x H13.9in.
Weight with handle and battery		5.4kg (11.9lbs)
Weight of parts		BDC25 battery: 240g (8.5oz.), Handle: 100g (3.5oz.), Tribrach: 740g (1.6 lbs), Case:2.4kg (5.3lbs)
Power supplies		
Battery level display		4 steps with warning message.
Automatic power cut-off		On/off selectable (30 minutes after the last operation)
Power source		BDC25 rechargeable battery, Ni-Cd 6V, 2 supplied as standard.
Working duration at 25°C (77°F) w/one BDC25 battery		Distance & angle measurement: about 5 hours, about 600 points (Fine & single measurement with 30 seconds intervals). Angle measurement only: about 9 hours.
Charging time		CDC27/31: about 80 minutes, CDC31A: about 90 minutes

SOKKIA CO.,LTD.
1-1, TOMIGAYA I-CHOME, SHIBUYA-KU, TOKYO, 151 JAPAN
PHONE +81-3-3465 5211 FAX +81-3-346-5203
INTERNATIONAL DEPT. PHONE +81-3-346-5201 FAX +81-3-3465-5202

FIG Sokkia is a sponsor of the International Federation of Surveyors.

ISO 9001 Certified
Certificate No. JQA-0557
ISO 9001/BS EN ISO 9001/EN 29001/JIS Z9901
SOKKIA CO.,LTD.

Appendix II

System Tracking

FA Hardware
Survey Software
HVF Database

S220 Hardware Serial Numbers		
Unit	**S/N**	**Comment**
POS/MV PCS	846	
POS/MV IMU	292	
POS/MV Port Ant.	SGN 98490013	
POS/MV Stbd Ant.	CGN 96200099	
DGPS Receiver	0426-16627-0001	
DGPS Ant.		
Reson 81-P Processor (8111)	35652	
Reson 81-P Processor (8160)	35385	
Reson 8111 Transducer		
Reson 8160 Transducer		

1010 Hardware Serial Numbers		
Unit	**S/N**	**Comment**
POS/MV PCS	788	
POS/MV IMU	294	
POS/MV Port Ant.	SGN 00160051	
POS/MV Stbd Ant.	SGN 00120116	
DGPS Receiver	0331-12579-0008	
DGPS Ant.		
Reson 81-P Processor	34497	
Reson 8101 Transducer	2701011	removed 10/6/04 for repair

1018 Hardware Serial Numbers		
Unit	**S/N**	**Comment**
POS/MV PCS	786	
POS/MV IMU	323	
POS/MV Port Ant.	SGN 99330009	
POS/MV Stbd Ant.	SGN 98370085	
DGPS Receiver	0328-12352-0001	
DGPS Ant.		
Reson 81-P Processor	35737	
Reson 8101 Transducer	3102026	

Ceeducer Hardware Serial Numbers		
Unit	**S/N**	**Comment**
Ceeducer Transducer		No S/N visible
Ceeducer GPS Ant.	0238-10468-0004	
Ceeducer Processor	409	

Trimble Backpack 1 Hardware Serial Numbers		
Unit	**S/N**	**Comment**
Pro XRS	0224078543	
Antenna	0220341062	

Trimble Backpack 2 Hardware Serial Numbers		
Unit	**S/N**	**Comment**
Pro XRS	0224090101	
Antenna	0220321059	

Licenses:

Caris License #	On	GIS	HIPS	Notebook	Expires	Type
CW9604043	FADC2	5	5	5	10/31/05	Red USB
CW9604041		1	1		08/31/05	Purple USB
CW9604042				1	10/31/05	Purple USB

ISIS Dongle #	On Processor	Isis	DelphMap	DelphNav	BathyPro	RT Bathy	81XX Server
TEI 03-1525	1018_ACQ	1					1
TEI 03-15250	1018_NAV	1	1	1	1	1	
TEI 03-1526	220_ACQ	1					1
TEI 03-15260	220_NAV	1	1	1	1	1	
TEI 03-1527	1010_ACQ	1					1
TEI 03-15270	1010_NAV	1	1	1	1	1	

Processor	Physical #	Pydro License #	Expires
FA_Process_1	00-0B-DB-5A-62-2B	dea12ac772937d0f31	02/01/05
FA_Process_2	00-11-11-0F-84-44	14fdc8d5d469ffbf3b	02/01/05
FA_Process_3	00-11-11-06-9D-42	14fdc8d5d408bae80e	02/01/05
FA_Process_4	00-01-02-69-5A-45	071585a354707b549a	02/01/05
FA_Process_6	00-0B-DB-56-68-2B	dea12ac772909a8c74	02/01/05
FA_Process_8	00-11-11-06-A1-B5	14fdc8d5db7aa97b5e	02/01/05
FA_Process_9	00-0B-DB-56-68-30	dea12ac7732dd4af42	02/01/05
FA_CST	00-11-11-06-A4-68	14fdc8d5d6a1d8ac82	02/01/05
FA_FOO	00-0B-DB-56-68-8C	dea12ac778e79bfc91	02/01/05

Fledermaus FLEXid	License #	Processor
9-45953CB6	2518891E2E69	FA_Process_8
9-65012FEB	B18BA0DE2D3F	FA_Process_3

MapInfo v7.5 & v7.8	Processor
MUIWEU0750026833	FA_Process_3
MIUWEU0750026834	FA_Process_6
MIUWEU0750025574	FA_CST
# UNKNOWN	FA_FOO

GPS Pathfinder S/N
011746-00300-04309-3BAD03D2
024156-00300-05068-0E94DA58

TerraSync Pro S/N
498295-00110-04309-7073A4A7
498295-00110-05068-EBD4EA8B

Isis Sonar:

	1010_ACQ	1018_ACQ	220_ACQ	FA_Process_4
v.6.5.0	d.u.	d.u.	d.u.	d.u.
v6.5.1	d.u.	d.u.	d.u.	d.u.
v6.6.0	d.u.	d.u.	d.u.	d.u.
v6.7.0	10/01/04	10/01/04	09/20/04	10/01/04

d.u.= date unknown; it was installed, but the date was not documented

Isis DelphNav/DelphMap:

	1010_NAV	1018_NAV	220_NAV
v2.10	d.u.	d.u.	d.u.
v2.11	10/01/04	10/01/04	09/20/04

d.u.= date unknown; it was installed, but the date was not documented

TerraSync:

	ToughBook1	ToughTab1	TSCe	FA-Mobile1	ToughBook2
v2.40		d.u.	d.u.	d.u.	
v2.41	10/5/2004	10/5/2004	10/5/2004	10/6/2004	10/13/2004

d.u.= date unknown; it was installed, but the date was not documented

Pathfinder:

	ToughBook1	ToughTab1	FA-Mobile1	ToughBook2	Olab
v3.00	9/30/2004	10/4/2004	d.u.	10/13/2004	d.u.

d.u.= date unknown; it was installed, but the date was not documented

CARIS HIPS & SIPS:

	FA_Process_1	FA_Process_2	FA_Process_3	FA_Process_4	FA_Process_6	FA_Process_8	FA_Process_9	FA_CST	FA_FOO	Comments
v5.4 full	05/05/04	08/02/04	08/02/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/11/04	
HF1	06/14/04									
HF2	06/14/04									
HF3	06/14/04									
HF4	06/14/04									
HF5	06/14/04									
HF6	06/14/04									
HF7	06/14/04									
HF8	06/14/04									
HF9	06/14/04									
HF10	06/14/04									
HF11	06/14/04									
HF12	06/14/04									
HF13	06/17/04									
HF14	06/18/04									
HF15										
SP1	07/27/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/26/04	
SP1+HF1	07/27/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/26/04	
SP1+HF2	08/03/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/26/04	
SP1+HF3	08/04/04	08/04/04	08/05/04	08/04/04	09/11/04	08/04/04	08/06/04	08/04/04	08/26/04	
SP1+HF4	08/26/04	08/26/04	08/26/04	08/26/04	09/11/04	08/26/04	08/26/04	08/26/04	08/26/04	
SP1+HF5	08/26/04	08/26/04	08/26/04	08/26/04	09/11/04	08/26/04	08/26/04	08/26/04	08/26/04	
SP1+HF6	08/26/04	08/26/04	08/26/04	08/26/04	09/11/04	08/26/04	08/26/04	08/26/04	08/26/04	
SP1+HF7	08/26/04	08/26/04	08/26/04	08/26/04	09/11/04	08/26/04	08/26/04	08/26/04	08/26/04	
SP1+HF8	10/06/04	10/07/04	09/26/04	10/08/04	09/23/04	09/22/04	09/23/04	10/07/04	10/07/04	
SP1+HF9	10/06/04	10/07/04	09/26/04	10/08/04	09/23/04	09/22/04	09/23/04	10/07/04	10/07/04	
SP1+HF10	10/06/04	10/07/04	10/07/04	10/08/04	10/07/04	10/05/04	10/07/04	10/07/04	10/07/04	
SP1+HF11	10/06/04	10/07/04	10/07/04	10/08/04	10/07/04	10/05/04	10/07/04	10/07/04	10/07/04	
SP1+HF12	10/06/04	10/07/04	10/07/04	10/08/04	10/07/04	10/05/04	10/07/04	10/07/04	10/07/04	
SP1+HF14	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	

CARIS Utilities:

	FA_Process_1	FA_Process_2	FA_Process_3	FA_Process_4	FA_Process_6	FA_Process_8	FA_Process_9	FA_CST	FA_FOO	Comments
LUv2.1.0	05/05/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
CPCR v2.0	06/14/04	08/02/04	08/02/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/11/04	
EasyENCv3.0	11/05/04	10/07/04	10/07/04	10/08/04	09/23/04	10/08/04	09/23/04	10/07/04	10/07/04	

CARIS GIS:

	FA_Process_1	FA_Process_2	FA_Process_3	FA_Process_4	FA_Process_6	FA_Process_8	FA_Process_9	FA_CST	FA_FOO	Comments
v4.4a	05/05/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
LUv2.1.0	05/05/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4	05/05/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF1	06/14/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF2	06/14/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF3	06/14/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF4	06/17/04	08/02/04	05/05/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF5	06/17/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF6	08/03/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF7	08/03/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF8	08/03/04	08/02/04	08/03/04	08/02/04	09/11/04	08/02/04	08/02/04	08/04/04	08/13/04	
SP4+HF9	08/26/04	08/26/04	08/26/04	08/26/04	09/11/04	08/26/04	08/26/04	08/26/04	08/26/04	
SP4+HF10	08/31/04	08/31/04	08/31/04	08/31/04	09/11/04	08/31/04	09/01/04	08/31/04	09/01/04	
SP4+HF11	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	
SP4+HF12	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	
SP4+HF13	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	
SP4+HF14	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	
SP4+HF15	11/05/04	11/05/04	11/04/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	11/06/04	

CARIS Notebook:

	FA_Process_1	FA_Process_2	FA_Process_3	FA_Process_4	FA_Process_6	FA_Process_8	FA_Process_9	FA_CST	FA_FOO	Comments
v2.1	05/14/04	08/06/04	08/09/04	08/06/04	09/11/04	08/02/04	08/06/04	08/06/04	08/13/04	
SP1	06/23/04	08/06/04	08/09/04	08/06/04	09/11/04	08/02/04	08/06/04	08/06/04	08/13/04	
SP1+HF1	08/06/04	08/06/04	08/09/04	08/06/04	09/11/04	08/06/04	08/06/04	08/06/04	08/13/04	

Pydro:

	FA_Process_1	FA_Process_2	FA_Process_3	FA_Process_4	FA_Process_6	FA_Process_8	FA_Process_9	FA_CST	FA_FOO	Comments
v4.5.1	06/14/04									
v4.6.1	08/03/04	08/05/04	08/05/04	08/05/04		08/05/04	08/05/04	08/06/04	08/13/04	
v4.6.1patches	08/03/04	08/05/04	08/05/04	08/05/04		08/05/04	08/05/04	08/06/04	08/13/04	
v4.7.1	08/05/04	08/05/04	08/05/04	08/05/04		08/05/04	08/05/04	08/06/04	08/13/04	
v4.8.2	08/26/04	08/26/04	08/25/04	08/26/04		08/26/04	08/26/04	08/26/04	08/26/04	
v4.8.3	08/31/04	08/31/04	08/31/04	08/31/04		08/31/04	09/01/04	08/31/04	09/01/04	
v4.9.0	09/12/04	09/12/04	09/12/04	09/12/04	09/12/04	09/12/04		09/12/04		
v4.9.1	09/30/04	10/04/04	10/04/04	10/08/04	10/07/04	10/5/2004	10/07/04	10/07/04	10/07/04	
v4.9.1a	10/04/04	10/04/04	10/04/04	10/08/04	10/07/04	10/05/04	10/07/04	10/07/04	10/07/04	You can import GP's w/ this version
v4.9.3	11/27/04	11/27/04	11/19/04	11/27/04	11/27/04	11/27/04	11/27/04	11/27/04	11/27/04	

Velocwin:

	OLAB	1010_NAV	1018_NAV	Comments
v8.5.2	07/31/04	8/10/2004	8/12/2004	
v8.6.0				doesn't apply directly to us

Fledermaus:

	FA_Process_3	FA_Process_8	FA_FOO	Comments
v6.1.0	07/28/04	07/28/04		
V6.1.1	08/03/04	08/03/04	08/13/04	
v6.1.2c	10/05/04	10/07/04	10/07/04	The keys alternate btwn, 3 & 8 currently have them

MapInfo:

	FA_Process_1	FA_CST	FA_Process_3	FA_FOO	FA_Process_6	Comments
v7.5 (4)	*06/15/04*	08/04/04	07/30/04	09/01/04	10/07/04	Removed from FA_Process_1
v7.8						Update to v7.5, only 2 licenses

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
1010_8101	Initial Creation of HVF for 1010	Local Drive Processor 3, Fa-proc (testing data)	5-Aug-2004	218	Needs Dynamic draft, Patch values	GF
1010_8101	Input Dynamic Draft Table	Local Drive Processor 3, Fa-proc (testing data)	17-Aug-2004	230	Needs patch values, Loading Std. Dev	GF
1010_8101	Updated Dynamic Draft Table (245 entry date)	from testing to H11362, H11363	10-Sep-2004	254	used DDSSM values confirmed w/ all 3 stop pts	LM
1010_8101	Changed value of Position Nav Std. Dev to 0.5	from H11362 to Testing, H11363	20-Sep-2004	264	As per POS/MV spec sheet	GF
1010_8101		copied to H11334, H11335, H11369	26-Sep-2004	270	moved into vsl config folders for OPR-O193, Rudyerd	LM
1010_8101	Updated values based on Rudyerd patch test 293	Updated testing and copied to H11334, H11335, H11369	20-Oct-2004	294	Changed Transducer	MW
1010_8101	input dynamic draft std dev	Updated testing and copied to H11334, H11335, H11369	20_oct-2004	294	updated tpe for delta draft std dev	GF
1010_8101	changed roll bias value to 1.07	updated H11369	9-Nov-2004	314	backdated to Dn313	GF
1010_8101	changed roll bias value to 1.07	updated H11334	15-Nov-2004	314	backdated to Dn313	GF
1010_8101	copied H11334 hvf to all projects for data management	H11335, H11369, H11362	15-Nov-2004	320		GF
1010_8101	copied H11334 hvf to testing data for data mngmnt	Testing Data	12-Jan-2005			LM

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
1018_8101	Initial Creation of HVF for 1018	Local Drive Processor 3	5-Aug-2004	218	Needs Dynamic draft, Patch values, Loading Std. Dev	GF
1018_8101	Update TPE Offsets, Input Dummy Dynamic Draft	Local Drive Processor 3, Fa-proc (testing data)	25-Aug-2004	238	Needs Real Dynamic Draft, Patch values, Loading Std. Dev	GF
1018_8101	Inputed Dynamic Draft Table (215 entry date)	from testing to H11362, H11363	9-Sep-2004	253	used DDSSM values, used only 1 stop pt	LM
1018_8101	Changed value of Position Nav Std. Dev to 0.5	from H11362 to Testing, H11363	20-Sep-2004	264	As per POS/MV spec sheet	GF
1018_8101	Changed value of Sensor Time Errors to 0.1, removed -0.1 from Swath 1	from H11362 to Testing	23-Sep-2004	267	swapped latency values from swath to sensors	GF
1018_8101		copied to H11334, H11335, H11369	26-Sep-2004	270	moved into vsl config folders for OPR-O193, Rudyerd	LM
1018_8101	Calc'd Patch & Applied New Values for reattached ducer	copied to H11334, H11335, H11369	4-Nov-2004	310	moved into vsl config folders for OPR-O193, Rudyerd	MW
1018_8101	corrected x value for IMU 2 Ducer (TPE and Swath 1)	copied to H11334, H11335, H11369, H11362	8-Nov-2004	313	moved into vsl config folders for Rudyerd, Descision	GF
1018_8101	X 0.272 changed to 0.302 (TPE and Swath 1) as above	testing data updated to match project HVFs	12-Jan-2005		sign error on x value fixed	

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
S220_8111	Initial Creation of HVF for 8111	Local Drive Processor 3	5-Aug-2004	218	Needs Dynamic draft, Patch values	GF
S220_8111	Updated device model to 8111	Local Drive Processor 3	31-Aug-2004	244	Needs Dynamic draft, Patch values	GF
S220_8111	"	Fa-proc (Testing Data)	7-Sep-2004	251	Needs Dynamic draft, Patch values	GF
S220_8111	Changed value of Position Nav Std. Dev to 0.5	to Testing	20-Sep-2004	264	As per POS/MV spec sheet	GF
S220_8111	Updated HVF w/ Cape Decision Patch values	in Testing & copied to H11362	20-Sep-2004	264	Dn 260 Patch test - Cape Decision	LM
S220_8111		copied to H11334, H11335, H11369	26-Sep-2004	270	moved into vsl config folders for OPR-O193, Rudyerd	LM
S220_8111	(TPE) Changed MRU to Trans Z from 4.585 to 4.753	in testing data & to be used from Dn 218 for all data	12-Jan-2005		Error Base of IMU to Top of IMU not acct'd for	LM
S220_8111	(TPE) Changed NAV to Trans X from 2.868 to 2.993	in testing data & to be used from Dn 218 for all data	12-Jan-2005		Error in interpretation of TPE value	LM
S220_8111	(TPE) Changed NAV to Trans Y from 8.252 to 19.145	in testing data & to be used from Dn 218 for all data	12-Jan-2005		Error in interpretation of TPE value	LM
S220_8111	(TPE) Changed NAV to Trans Z from 4.585 to 16.253	in testing data & to be used from Dn 218 for all data	12-Jan-2005		Error in interpretation of TPE value	LM
S220_8111	WaterlineHeight changed from -0.07 to 0.074	in testing data & to be used from Dn 218 for all data	12-Jan-2005		Error in sign of measurement	LM
S220_8111		Tstg HVF copied to H11362, H11334, H11335, H11369	12-Jan-2005		all data for S220_8111 to be remrgd, TPE recmptd & BASE surfaces recmptd	LM

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
S220_8160	Initial Creation of HVF for 8160	Local Drive Processor 3	5-Aug-2004	218	Needs Dynamic draft, Patch values	GF
S220_8160	updated value for MRU to Trans Z	in Testing	28-Oct-2004	302	offset from base to top of IMU not accounted for previously	GF
S220_8160	updated value for NAV to Trans Z, Trans Y	in Testing	28-Oct-2004	302	bad values	GF

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
Ceeducer	Initial Creation of HVF for Ceeducer VBES	Local Drive Processor 3, Fa-proc (testing data)	14-Sep-2004	257	No Offsets, offsets in Ceeducer itself	GF
Ceeducer		copied to H11334, H11335, H11369	26-Sep-2004	270	moved into vsl config folders for OPR-O193, Rudyerd	LM
Ceeducer	Added SVP	copied to H11334, H11335, H11369, H11362	30-Sep-2004	274	moved into vsl config folders for OPR-O193, Rudyerd, O167	GF

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
TRB1_DPNE	Initial Creation of HVF for Trimble backpack DP's	Tstg Data, H11362, H11334, H11335, H11369	30-Sep-2004	274	No Offsets, Backdated to Dn221	GF

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
TRB1_DPES	Initial Creation of HVF for Trimble backpack Echosounder DP's	in Tstg Data mvd to H11362, H11334, H11335, H11369	4-Oct-2004	278	Based on R7SB_03 from Rainier. No Offsets, Backdated to Dn221. RP is located on the pole at the waterline.	lm

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
TRB2_DPNE	Initial Creation of HVF for Trimble backpack DP's	in Tstg Data, H11362, H11334, H11335, H11369	25-Oct-2004	274	No Offsets, Backdated to Dn221	LM

HVF	Update Made	Locations Pushed To	Date	DN	Comments	By
TRB2_DPES	Initial Creation of HVF for Trimble backpack Echosounder DP's	in Tstg Data mvd to H11362, H11334, H11335, H11369	25-Oct-2004	278	Based on R7SB_03 from Rainier. No Offsets, Backdated to Dn221. RP is located on the pole at the waterline.	LM

Appendix III

Vessel Reports, Offsets, and Diagrams

Launch 1010

Vessel Report
1 .... HVF
2 .... Offsets
3 .... Patch Test
4 .... DDSSM and Settlement and Squat
5 .... POS Gams Calibration
6 .... Wire Diagram

Launch 1018

Vessel Report
1 .... HVF
2 .... Offsets
3 .... Patch Test
4 .... DDSSM and Settlement and Squat
5 .... POS Gams Calibration
6 .... Wire Diagram

S220

Vessel Report
1 .... HVF
2 .... Offsets
3 .... Patch Test
5 .... POS Gams Calibration
6 .... Wire Diagram

NOAA HYDROGRAPHIC SURVEY LAUNCH 1010
CALIBRATION REPORT 2004

Compiled by: SST Grant Froelich

Background:

NOAA Hydrographic Survey Launch (HSL) 1010 is a high speed, 29' aluminum Jensen survey launch. It is equipped with a Reson 8101 SWMB system mounted on a swing mount to the starboard of the keel and approximately centered fore and aft. The Reson 8101 operates at a frequency of 240 kHz and has a variable ping rate dependant upon depth. The maximum ping rate is user set to 20 Hz. The Reson 8101 has 101 1.5° x 1.5° beams and has an effective range of 120m depth. Multibeam data is collected in XTF format using TEI Isis Sonar v6.6. NOAA HSL 1010 is equipped with an Applanix Position and Orientation system for Marine Vessels (POS MV) 320 Version 3 consisting of a IMU-200 strap-down inertial measurement unit (IMU), a version 2.10d POS computer system (PCS) and two NovAtel GPS antennas. Differential correctors are supplied to the POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver. Sound velocity correctors are obtained by a SeaBird SeaCat SBE 19*plus* sound velocity profiler. NOAA HSL 1010 is also configured with Applanix TrueHeave[1] and "Precise Timing"[2]. Residual biases in sensor misalignment were assessed in CARIS HIPS & SIPS v5.4 (SP 1, HF's 1-7) calibration mode and applied to the HIPS Vessel File (HVF), 1010_8101.HVF.

Location, Date, Personnel:

Patch Test

Multiple patch tests were attempted with NOAA HSL 1010 in several different locations at the beginning of the 2004 field season. Due to various different mis-entries and mis-configurations, none of these were accepted into the final 1010_8101.HVF. The patch test conducted in the vicinity of Ketchikan, AK in

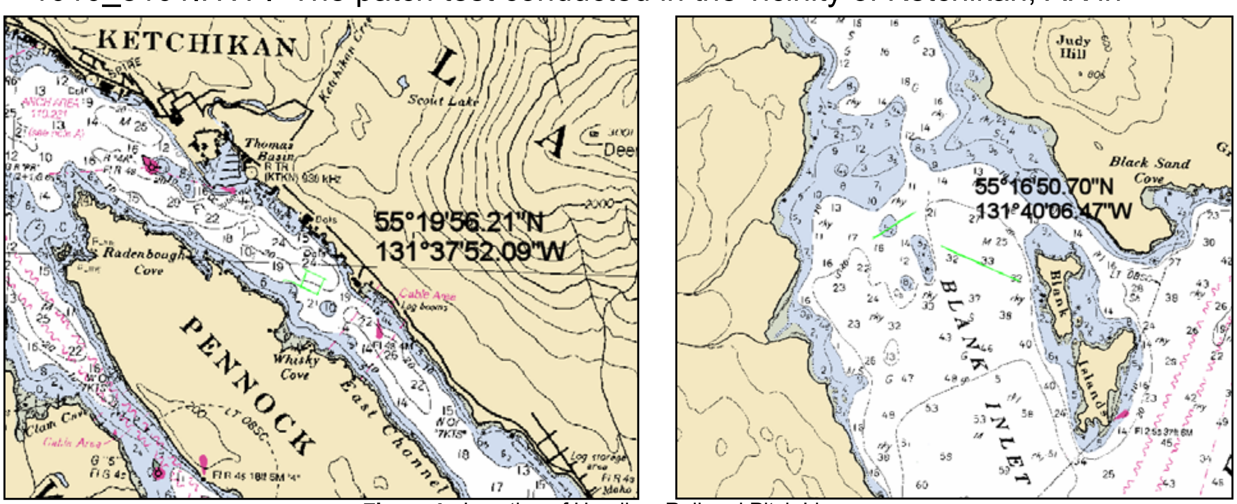


Figure 1. Location of Heading, Roll and Pitch Lines

[1] Applanix web site. http://www.applanix.com. June 2004
[2] Evans, Ben, LTJG, NOAA. Upgrading NOAA Multibeam Acquisition Systems to "Precise Timing". May 2004

Tongass Narrows and Blank Inlet on September 1st (Dn245) was accepted and processed for residual biases. The heading bias patch was conducted over a wreck lying in an average depth of 42m with a least depth of 24m at 55°19'56.21"N, 131°37'52.09"W. The roll bias patch was conducted over a flat area in approximately 60m of water at location 55°16'50.70"N, 131°40'06.47"W. The pitch bias patch was conducted in the same area on a 10m shoal (see Figure 1). The patch data was collected by SST Abrams, ENS Higgins, and LTJG Van Waes. The patch biases were processed by CST Morgan, SST Abrams, LT Wetzler, and PS Sampadian.

Dynamic Draft

Due to a mechanical malfunction, dynamic draft was not able to be collected on the same day. Dynamic draft lines were collected at location 55°12'58.36"N, 131°43'24.71"W in approximately 10m of water on September 3rd (Dn 247) (see Figure 2). The dynamic draft data was collected by SST Froelich, ENS Higgins and LT Wetzler. The dynamic draft data was processed using the Dynamic Draft Settlement and Squat Method (DDSSM) by LT Wetzler.

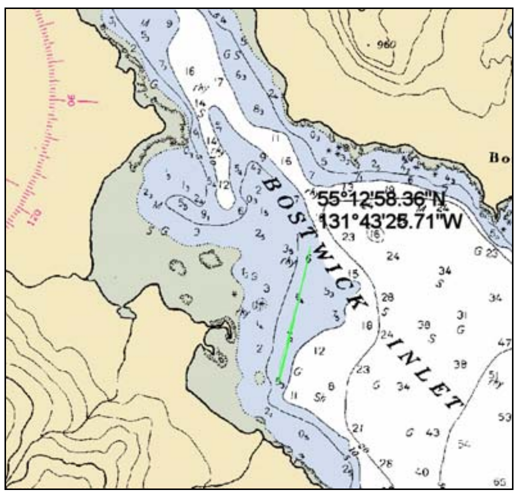


Figure 2. Location of Dynamic Draft

GAMS Calibration

POS MV GPS Azimuth Measurement Subsystem (GAMS) calibration occurred on August 27th (Dn240) in Ketchikan, Alaska. GAMS calibration was performed by SST Abrams, LT Wetzler and PS Sampadian.

Procedure:

All patch test and dynamic draft lines were "lightly" cleaned in CARIS swath mode to remove major data fliers. SVP and observed tides were applied.

<u>*Patch*</u>

Sensor Latency: One line from the dynamic draft or roll patch data was selected for latency biases. It was determined that either dynamic draft or roll data was suitable for sensor latency bias evaluation after examining previous patch test data. Those who chose to look at a dynamic draft line also looked at a roll line for comparison. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Abrams, LT Wetzler and PS Sampadian to determine the bias. Final values entered into 1010_8101.HVF were based on a consensus value between those involved.

Pitch: One pair of coincident lines was run over a shoal of 10m at the same speed in different directions. The lines were run at 5 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Abrams, LT Wetzler and PS Sampadian to determine the pitch bias. Final values entered into 1010_8101.HVF were based on a consensus value between those involved.

Roll: One pair of coincident lines was run over a flat area approximately 60m deep at the same speed in different directions. The lines were run at 6 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Abrams, LT Wetzler and PS Sampadian to determine the roll bias. Final values entered into 1010_8101.HVF were based on a consensus value between those involved.

Heading: One pair of parallel lines offset by 120m was run in opposite directions at the same speed over a known target. The lines were run at 6 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Abrams, LT Wetzler and PS Sampadian to determine the heading bias. Final values entered into 1010_8101.HVF were based on a consensus value between those involved.

The patch test acquisition and processing logs for Dn#245 are located in Appendix III-1010-3.

Patch Bias	Bias value
Sensor Latency	0.00 sec
Pitch	-0.90°
Roll	-0.38°
Heading	-0.32°

Table 1. Patch Test Bias Result

<u>Dynamic Draft</u>

One line was run nine times in the same direction but at different speeds. Six lines were collected at speeds ranging from 4.8 knots to 14.5 knots at an average depth of 13m. At three points along the line, data was collected with the engine in idle. The lines were reviewed in CARIS by LT Wetzler and statistical comparisons between the speeds and δ draft were made using Microsoft Excel. The dynamic draft, settlement and squat spreadsheet, 1010_DDSSM.xls, is located in Appendix III-1010-4.

Speed (knots)	Delta Draft (m)
0.0	0.000
4.8	0.079
5.6	0.118
7.8	0.137
10.3	0.022
11.7	-0.198
14.5	-0.378

Table 2.Dynamic Draft Results

POS MV GAMS Calibration

The GAMS heading calibration threshold was initially set to 0.300°. NOAA HSL 1010 was maneuvered in "figure 8's" to lower the heading accuracy as much as possible. The best heading accuracy value achieved during this process was 0.237°. The vessel steadied up on a constant heading and GAMS calibration was requested. The vessel maintained the constant heading until the calibration was complete. The POS MV settings were then saved to the file POSMV_Settings_082704.nvm (see Table 3).

Component	Value
Baseline Vector X	0.004 m
Baseline Vector Y	1.841 m
Baseline Vector Z	0.030 m
Two Antenna Separation	1.841 m
Heading Correction	0.000 °

Table 3. POS MV GAMS Calibration Results

The detailed POS/MV Calibration Report, 1010_POS_Calibration_082704.xls, is located in Appendix III-1010-5.

Recommendations:

These patch test calibration results should be used from September 1st, 2004 (Dn 245) and should be used until such a time or event warrants a new calibration.

These dynamic draft results should be used from September 3rd, 2004 (Dn 247) and should be used until such a time or event warrants a new test.

These POS MV GAMS calibration results should be used from August 27th, 2004 (Dn240) and should be used until such a time or event warrants a new calibration.

ADDENDUM 1
NOAA HYDROGRAPHIC SURVEY LAUNCH 1010
PATCH TEST REPORT OCTOBER 2004
ST Jennifer Keene

Background:
Residual biases for NOAA Hydrographic Survey Launch (HSL) 1010 were assessed in CARIS HIPS & SIPS v5.4 calibration mode and applied to the HIPS Vessel File (HVF), 1010_8101.HVF.

The transducer from HSL 1018 was transferred to HSL 1010 on October 18, 2004, because the original 1010 transducer had been removed for repairs. This swap required that the patch test biases be recalculated for HSL 1010.

Location, Date, Personnel:
The patch test was conducted on October 19th (DN 293) in Punchbowl Cove, off of Rudyerd Bay in Alaska. All data were acquired in the vicinity of 55°31'46"N, 130°46'46"W (See Figure 1). ST Keene, AST Kellner and LT Wetzler acquired the patch data. The data were processed in CARIS 5.4 for residual biases by ST Keene, AST Kellner, LT Wetzler, SST Froelich and ENS Higgins.

Dynamic Draft, Settlement & Squat data were not acquired at this time. Correctors from the September 3rd (DN 247) DDSSM data set should continue to be used in the HVF.

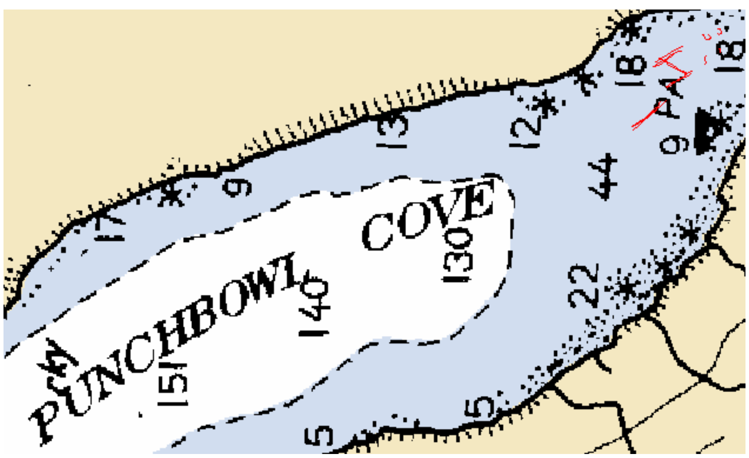


Figure 1 Location of Patch Test Lines

Equipment:

1 Reson 8101 Shallow Water Multibeam Echosounder
1 Applanix POS/MV Version 3.20 Strap-Down IMU
2 Novatel GPS Antennas
1 CSI wireless MBX-3S Automatic Differential GPS receiver
1 Seabird Seacat SBE 19*plus* sound velocity profiler
TEI Isis Sonar v6.6 w/ BathyPro Real Time Bathymetry
CARIS HIPS & SIPS v5.4 SP1, HF's1-12

Procedure:

All lines: All lines were "lightly" cleaned in CARIS Swath Editor to get rid of major data fliers. SVP and Zero Tides were applied.

Sensor Latency: Sensor latency data were acquired by turning the boat into its own wake and then putting it into neutral while data was acquired, in order to generate roll in the outer beams. The lines were reviewed in CARIS calibration mode independently by the processing personnel listed above, in order to determine the bias. Final values entered into 1010_8101.HVF were based on an average value of the individual results. Roll Time error was applied to Nav Time, Gyro Time and Pitch Time errors in the 1010_8101.HVF.

Pitch: One pair of coincident lines was run over a known rock on a slope at the same speed in different directions. The lines were run at eight knots. The lines were reviewed in CARIS calibration mode independently by processing personnel in order to determine the pitch bias. Final values entered into 1010_8101.HVF were based on an average value of the individual results.

Roll: One pair of coincident lines was run over an area approximately 60m deep at the same speed in different directions. The lines were run at eight knots. The lines were reviewed in CARIS calibration mode independently by the processing personnel in order to determine the roll bias. Final values entered into 1010_8101.HVF were based on an average value of the individual results.

Heading: Two parallel lines offset by approximately 120m were run in opposite directions at the same speed over a known rock. The lines were reviewed in CARIS calibration mode independently by processing personnel, as well as CST Morgan, in order to determine the heading bias. Final values entered into 1010_8101.HVF were based on a consensus value between those involved.

The patch test acquisition and processing logs for Dn#293 are located in Appendix III-1010-3.

Results:

The following table displays the results of this patch test, as well as the previous patch test, conducted in September.

PATCH BIAS	SEPTEMBER BIAS VALUE	OCTOBER BIAS VALUE
SENSOR LATENCY	0.00 sec	0.01 sec
PITCH	-0.90°	-0.43°
ROLL	-0.38°	0.23°
HEADING	-0.32°	-0.30°

Table 1 Patch test bias results

Recommendations:
The topography of the Punchbowl Cove is steep and deep, making it difficult to find a suitable location for the roll bias patch. The area in which the roll bias patch was conducted was not as flat as desired. This portion of the patch test may need to be repeated in a different area.

These patch test calibration results should be used from October 19th, 2004 (DN 293) until such a time or event warrants a new calibration.

The DDSSM results from September 3rd, 2004 (DN 247) should continue to be used until such a time or event warrants a new test.

ADDENDUM 2
NOAA HYDROGRAPHIC SURVEY LAUNCH 1010
PATCH TEST REPORT OCTOBER 2004

LT Mark Wetzler

Background:
Residual biases for NOAA Hydrographic Survey Launch (HSL) 1010 were assessed in CARIS HIPS & SIPS v5.4 calibration mode and applied to the HIPS Vessel File (HVF), 1010_8101.HVF.

As noted in Addendum 1 a transducer was attached to launch 1010, which was subsequently patch tested on October 19th, 2004 (DN 293). Around day 298 there was a suspicion that problems existed with the launches roll bias value. This was difficult to determine as there were also some extreme sound velocity issues present with the data. Once the data from DN 308 was processed it was apparent that there was a problem with the roll bias value. An investigation of the launch turned up 2 loose bolts which held the swing arm transducer mount in place. This prompted a roll bias test to be conducted on the next operational day.

Day Number	Sheet(s)	Roll Bias	Comment
293	Patch Test	0.23	Patch Test for Initial Bias
294	H11335	0.23	
295	H11335	0.23	
296	H11335	0.23	
297	H11334	0.23	
298	H11334	0.43	Roll Bias Calc From Data
299	H11334, H11335	1.00	Roll Bias Back Dated From DN 313
313	H11369	1.07	Roll Bias Calc From Testing

Table 1, Launch 1010 Roll Bias and Usage

Location, Date, Personnel:

The roll bias tests were conducted on November 8th, 2004 (DN 313) in the vicinity of New Eddystone Rock at 55°30'08.58" N 130°55'21.24" W. LT Wetzler, ENS Higgins and AST Kellner acquired the roll bias data. Data was processed in CARIS 5.4 and a value was determined by LT Wetzler.

Dynamic Draft, Settlement & Squat data were not acquired at this time. Correctors from the September 3rd (DN 247) DDSSM data set should continue to be used in the HVF.

Equipment:

1 Reson 8101 Shallow Water Multibeam Echosounder
1 Applanix POS/MV Version 3.20 Strap-Down IMU
2 Novatel GPS Antennas

1 CSI wireless MBX-3S Automatic Differential GPS receiver
1 Seabird Seacat SBE 19*plus* sound velocity profiler
TEI Isis Sonar v6.6 w/ BathyPro Real Time Bathymetry
CARIS HIPS & SIPS v5.4 SP1, HF's1-12

Procedure:
All lines: All lines were "lightly" cleaned in CARIS Swath Editor to get rid of major data fliers. SVP and Zero Tides were applied.

Roll: Prior to testing, the bolts on the swing arm mount were securely tightened. The testing consisted of acquiring data over a single line with a depth of 200 m. Four lines were run, 2 in the morning and 2 in the evening. On each set, the line was run at 8 knots and in opposite directions.

All other biases were kept static as they were not affected by the athwartships stability issues of the swing arm mount.

Results:
Data were examined from both the morning test and evening test. It was noted that from the start of the day to the end of the day, the roll bias value changed by 0.15°, from 1.00° to 1.15°. The average value of 1.07° was entered in the HVF for DN 313.

The following table displays the results of this patch test, as well as the previous patch test, conducted in September.

PATCH BIAS	SEPTEMBER BIAS VALUE	OCTOBER BIAS VALUE	DN 313
SENSOR LATENCY	0.00 sec	0.01 sec	0.01 sec
PITCH	-0.90°	-0.43°	-0.43°
ROLL	-0.38°	0.23°	1.07°
HEADING	-0.32°	-0.30°	-0.30°

Table 2 Patch test bias results

Implications of DN 313 Roll Bias Testing and resulting changes to the 1010 HVF

Once the magnitude of the roll bias issue was realized, prior data were reviewed. Data quality issues that were previously attributed to SV errors were found to also be partially due to roll bias errors.

Data were systematically examined by ST Keene in an effort to find locations within the previously acquired main scheme data that could be used for roll bias calibrations. In the data set from October 24, 2004 (DN 298), there were two lines of data acquired in opposite directions, which overlapped each other.

These lines were used to perform a roll bias calibration in CARIS Calibration Editor. The roll bias in the HVF for Launch 1010 was changed from 0.23° to 0.43° for DN 298.

This roll bias value of 0.43° was not large enough to correct errors in data acquired after DN 298. Therefore, the bias determined from the patch test conducted on the morning of DN 313 was used. A roll bias value of 1.00° was entered in the HVF, back dated to DN 299. The morning value was used instead of the averaged value from DN313, because it was closer in time to the data to which it was being applied.

Recommendations:
These roll bias results should be used for the 1010 HVF and are the best solutions which can be deduced by the hydrographer. The swing arm mount for the transducer needs to be re-engineered for stability and tested before the beginning of the CY 2005 field season.

The DDSSM results from September 3rd, 2004 (DN 247) should continue to be used until such a time or event warrants a new test.

Vessel Name: 1010_8101.hvf
Vessel created: December 09, 2004

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2004-218 00:00

Transduer #1:

Pitch Offset: -0.900
Roll Offset: -0.380
Azimuth Offset: -0.320

DeltaX: 0.262
DeltaY: -0.151
DeltaZ: 0.546

Manufacturer: Reson
Model: sb8101
Serial Number: (null)

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2004-293 00:00

Transduer #1:

Pitch Offset: -0.430
Roll Offset: 0.230
Azimuth Offset: -0.300

DeltaX: 0.262
DeltaY: -0.151
DeltaZ: 0.546

Manufacturer: Reson
Model: sb8101
Serial Number: 3102020

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2004-298 01:00

Transduer #1:

Pitch Offset: -0.430
Roll Offset: 0.430
Azimuth Offset: -0.300

DeltaX: 0.262
DeltaY: -0.151
DeltaZ: 0.546

Manufacturer: Reson
Model: sb8101
Serial Number:

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2004-299 01:00

Transduer #1:

Pitch Offset: -0.430
Roll Offset: 1.000
Azimuth Offset: -0.300

DeltaX: 0.262
DeltaY: -0.151
DeltaZ: 0.546

Manufacturer: Reson
Model: sb8101
Serial Number:

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2004-313 00:00

Transduer #1:

Pitch Offset: -0.430
Roll Offset: 1.070
Azimuth Offset: -0.300

DeltaX: 0.262
DeltaY: -0.151
DeltaZ: 0.546

Manufacturer: Reson
Model: sb8101
Serial Number:

Navigation Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 788

Gyro Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Latency 0.000

Heave Sensor:

Time Stamp: 2004-218 00:00

Comments TrueHeave Enabled
Apply Yes
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV V320
Serial Number: 788

Pitch Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Apply Yes
Latency 0.000
Pitch offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 788

Roll Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Apply Yes
Latency 0.000
Roll offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 788

Draft Sensor:

Time Stamp: 2004-218 00:00

Apply Yes
Comments (null)
Entry 1) Draft: 0.000   Speed: 0.000
Entry 2) Draft: -0.026 Speed: 4.000
Entry 3) Draft: -0.032 Speed: 6.000
Entry 4) Draft: -0.039 Speed: 8.000
Entry 5) Draft: 0.032   Speed: 10.000
Entry 6) Draft: 0.161   Speed: 12.000
Entry 7) Draft: 0.273   Speed: 14.000

Time Stamp: 2004-245 00:00

Apply Yes
Comments DDSSM
Entry 1) Draft: 0.000   Speed: 0.000
Entry 2) Draft: 0.079   Speed: 4.800
Entry 3) Draft: 0.118   Speed: 5.600
Entry 4) Draft: 0.137   Speed: 7.800
Entry 5) Draft: 0.022   Speed: 10.300
Entry 6) Draft: -0.198 Speed: 11.700
Entry 7) Draft: -0.378 Speed: 14.500

TPE

Time Stamp: 2004-218 00:00

Comments need loading
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.262
Y Head 1 -0.151
Z Head 1 0.546
Motion sensing unit to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000
Navigation antenna to the transducer 1
X Head 1 1.159
Y Head 1 1.048
Z Head 1 3.687
Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000'' of heave amplitude.
Measurement errors: 0.007
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500

```
      Transducer timing error: 0.001
      Navigation timing error: 0.001
      Gyro timing error: 0.001
      Heave timing error: 0.001
      PitchTimingStdDev: 0.001
      Roll timing error: 0.001
      Sound Velocity speed measurement error: 0.500
      Surface sound speed measurement error: 0.500
      Tide measurement error: 0.010
      Tide zoning error: 0.000
      Speed over ground measurement error: 0.030
      Dynamic loading measurement error: 0.000
      Static draft measurement error: 0.050
      Delta draft measurement error: 0.040
```

```
Svp Sensor:

      Time Stamp:  2004-218 00:00

      Comments (null)
      Svp #1:
      -------------
      Pitch Offset:     0.000
      Roll Offset:      0.000
      Azimuth Offset:   0.000

      DeltaX:     0.000
      DeltaY:     0.000
      DeltaZ:     0.000

      SVP #2:
      -------------
      Pitch Offset:     0.000
      Roll Offset:      0.000
      Azimuth Offset:   0.000

      DeltaX:     0.262
      DeltaY:     -0.151
      DeltaZ:     0.546
```

```
WaterLine:

      Time Stamp:  2004-218 00:00

      Comments (null)
      Apply Yes
      WaterLine -0.253
      WaterLineStdDev 0.000
```

Summary of Measurements:

Measurement	IMU to RP*	8101 to RP*	IMU to 8101	Port Ant to 8101	RP* to Waterline
Coord. Sys.	Caris	Caris	Caris	Caris	Caris
x	0.000	0.262	0.262	1.159	n/a
y	0.000	-0.151	-0.151	1.048	n/a
z	0.000	0.546	0.546	3.687	-0.25

*IMU is RP (Reference Pt)

Vessel Offsets for 1010_8101 are derived from the Horizontal, Vertical & XYZ worksheets in this spreadsheet.

Calculations

Coord. Sys. **Theodolite**

8101 to RP*	IMU to 8101			Port Ant to 8101			RP to Waterline		
	IMU (m)	x	3.516	Port Ant (m)	x	2.317	IMU (m)	x	3.516
		y	0.011		y	-0.886		y	0.011
		z	-1.183		z	1.958		z	-1.183
	8101 (m)	x	3.365	8101 (m)	x	3.365	BM A	x	-0.005
		y	0.273		y	0.273		y	-1.002
		z	-1.729		z	-1.729		z	-0.020
							BM A to IMU		
								x	n/a
								y	n/a
								z	-1.163
							BM A to Waterline		
								x	n/a
								y	n/a
								z	-0.913

see

Coord. Sys. **Theodolite**

IMU to 8101	IMU to 8101			Port Ant to 8101			RP to Waterline		
		x	-0.151		x	1.048		x	n/a
		y	0.262		y	1.159		y	n/a
		z	-0.546		z	-3.687		z	0.250
	Coord. Sys. CARIS			Coord. Sys. CARIS			Coord. Sys. CARIS		
		x	0.262		x	1.159		x	n/a
		y	-0.151		y	1.048		y	n/a
		z	0.546		z	3.687		z	-0.250

Port Ant to Stbd Ant	
Scaler Distance	1.842

IMU to Port Antenna		IMU to Heave	
Caris	Pos/Mv	Caris	Pos/Mv
-0.897	-1.199	-0.011	-0.574
-1.199	-0.897	-0.574	-0.011
-3.141	-3.141	-0.253	-0.253

Port Ant to Stbd Ant		
Port Ant (m)	x	2.317
	y	-0.889
	z	1.958
Stbd Ant (m)	x	2.324
	y	0.953
	z	1.929

IMU to Port Antenna		
IMU (m)	x	3.516
	y	0.011
	z	-1.183
Port Ant (m)	x	2.317
	y	-0.886
	z	1.958

IMU to Heave		
IMU (m)	y	0.011
x is n/a	z	-1.183
Heave Pt (m)		
(centerline)	y	0.000
BM B to Waterline (m)		
measured scalar dist		0.877
BM B		
x&y are n/a	z	-0.053
BM C to Waterline (m)		
(Heave Pt)	z	-0.93
IMU to Hv	x	-0.574
Location - from RA DAPR		

Port Ant to Stbd Ant	
Scalar Distance	1.842

IMU to Port Antenna	
x	-1.199
y	-0.897
z	3.141
Coord. Sys. **Pos/Mv**	
x	-1.199
y	-0.897
z	-3.141

IMU to Heave	
x	-0.574
y	-0.011
z	0.253
Coord. Sys. **Pos/Mv**	
x	-0.574
y	-0.011
z	-0.253

see Description tab

Horizontal

All offsets are in Theodolite Coordinate System

	BM CT	BS	**BM A**	m	S	DD	dA	Hd	Vd	**BM A**	
X	5.123977	HA	11	2	35	191.0431		5.22883	-1.793911	X	-0.0080
Y	-0.000827	VA	108	56	10	108.9361	-18.93611			Y	-1.0024
Z	0.845	SDx	5.528							Z	-0.0229
		HI	1.031								
		HT	0.105								

	BM CT	BS	**BM A**	m	S	DD	dA	Hd	Vd	**BM A**	
X	5.123977	HA	11	2	50	191.0472		5.223191	0.091931	X	-0.0024
Y	-0.000827	VA	88	59	30	88.99167	1.008333			Y	-1.0017
Z	0.845	SDx	5.224							Z	-0.0351
		HI	1.028								
		HT	2								

	BM CT	BS	**BM B**	m	S	DD	dA	Hd	Vd	**BM B**	
X	5.123977	HA	348	57	40	168.9611		5.227332	-1.825751	X	-0.0066
Y	-0.000827	VA	109	15	10	109.2528	-19.25278			Y	1.0001
Z	0.845	SDx	5.537							Z	-0.0548
		HI	1.031								
		HT	0.105								

	BM CT	BS	**BM B**	m	S	DD	dA	Hd	Vd	**BM B**	
X	5.123977	HA	348	57	20	168.9556		5.22166	0.05962	X	-0.0010
Y	-0.000827	VA	89	20	45	89.34583	0.654167			Y	0.9995
Z	0.845	SDx	5.222							Z	-0.0674
		HI	1.028								
		HT	2								

	BM CT	BS	**BM C**	m	S	DD	dA	Hd	Vd	**BM C**	
X	5.12892	HA	180	0	0	180		5.128883	-1.773947	X	0.0000
Y	0	VA	109	4	45	109.0792	-19.07917			Y	0.0000
Z	0.847926	SDx	5.427							Z	0.0000
		HI	1.031								
		HT	0.105								

	BM CT	BS	**BM C**	m	S	DD	dA	Hd	Vd	**BM C**	
X	5.1257	HA	0	0	0	180		5.125747	0.113336	X	0.0000
Y	0	VA	88	44	0	88.73333	1.266667			Y	0.0000
Z	0.8586	SDx	5.127							Z	-0.0001
		HI	1.028								
		HT	2								

	BM F	BS	**BM D**	m	S	DD	dA	Hd	Vd	**BM D**	
X	1.668082	HA	0	0	0	0		5.249724	-1.383634	X	6.9178
Y	-0.001217	VA	104	45	55	104.7653	-14.76528			Y	-0.0012
Z	1.649	SDx	5.429							Z	0.3394
		HI	1.234								
		HT	1.16								

	BM C	BS	**BM D**	m	S	DD	dA	Hd	Vd	**BM D**	
X	0	HA	0	0	0	0		6.906514	0.342484	X	6.9065
Y	0	VA	87	9	40	87.16111	2.838889			Y	0.0000
Z	0	SDx	6.915							Z	0.3805
		HI	1.225								
		HT	1.187								

	BM CT	BS	**BM D**	m	S	DD	dA	Hd	Vd	**BM D**	
X	5.123977	HA	180	1	25	0.023611		1.782119	-1.402809	X	6.9061
Y	-0.000827	VA	128	12	30	128.2083	-38.20833			Y	-0.0001
Z	0.845	SDx	2.268							Z	0.3932
		HI	1.031								
		HT	0.08								

	BM CT	BS	**BM D**	m	S	DD	dA	Hd	Vd	**BM D**	
X	5.123977	HA	180	1	35	0.026389		1.800322	0.049414	X	6.9243
Y	-0.000827	VA	88	25	40	88.42778	1.572222			Y	0.0000
Z	0.845	SDx	1.801							Z	0.3724
		HI	1.028								
		HT	1.55								

	TBM 2	BS	**BM D**	m	S	DD	dA	Hd	Vd	**BM D**	
X	18.8276	HA	2	4	10	182.0694		11.91991	2.88893	X	6.9154
Y	0.4290	VA	76	22	35	76.37639	13.62361			Y	-0.0014
Z	-2.1960	SDx	12.265							Z	0.3759
		HI	1.233								
		HT	1.55								

	BM CT	BS	**BM E**	m	S	DD	dA	Hd	Vd	**BM E**	
X	5.123977	HA	14	27	40	194.4611		3.568662	-0.176011	X	1.6684
Y	-0.000827	VA	92	49	25	92.82361	-2.823611			Y	-0.8920
Z	0.845	SDx	3.573							Z	1.6200
		HI	1.031								
		HT	0.08								

	BM CT	BS	**BM E**	m	S	DD	dA	Hd	Vd	**BM E**	

X	5.123977	HA	14	27	5	194.4514		3.57438	1.278054	X	1.6627
Y	-0.000827	VA	70	19	30	70.325	19.675			Y	-0.8928
Z	0.845	SDx	3.796							Z	1.6011
		HI	1.028								
		HT	1.55								
	TBM CT	BS	**BM F**	m	S	DD	dA	Hd	Vd	**BM F**	
X	5.123977	HA	180	0	0	180		3.456432	-0.062679	X	1.6675
Y	-0.000827	VA	91	2	20	91.03889	-1.038889			Y	-0.0008
Z	0.845	SDx	3.457							Z	1.6433
		HI	0.941								
		HT	0.08								
	BM CT	BS	**BM F**	m	S	DD	dA	Hd	Vd	**BM F**	
X	5.123977	HA	0	1	10	180.0194		3.448108	-0.141253	X	1.6759
Y	-0.000827	VA	92	20	45	92.34583	-2.345833			Y	-0.0020
Z	0.845	SDx	3.451							Z	1.6547
		HI	1.031								
		HT	0.08								
	BM CT	BS	**BM F**	m	S	DD	dA	Hd	Vd	**BM F**	
X	5.123977	HA	0	0	0	180		3.463146	1.316679	X	1.6608
Y	-0.000827	VA	69	11	0	69.18333	20.81667			Y	-0.0008
Z	0.845	SDx	3.705							Z	1.6397
		HI	1.028								
		HT	1.55								
	BM CT	BS	**BM G**	m	S	DD	dA	Hd	Vd	**BM G**	
X	5.123977	HA	344	29	55	164.4986		3.578828	-0.210271	X	1.6753
Y	-0.000827	VA	93	21	45	93.3625	-3.3625			Y	0.9557
Z	0.845	SDx	3.585							Z	1.5857
		HI	1.031								
		HT	0.08								
	BM CT	BS	**BM G**	m	S	DD	dA	Hd	Vd	**BM G**	
X	5.123977	HA	344	29	40	164.4944		3.593882	1.243713	X	1.6609
Y	-0.000827	VA	70	54	40	70.91111	19.08889			Y	0.9599
Z	0.845	SDx	3.803							Z	1.5667
		HI	1.028								
		HT	1.55								
	TBM2	BS	**BM H**	m	S	DD	dA	Hd	Vd	**BM H**	
X	18.8276	HA	180	0	0	180		15.55637	-0.418679	X	3.2712
Y	0.4290	VA	91	32	30	91.54167	-1.541667			Y	0.4290

Z	-2.1960	SDx	15.562							Z	-1.3537
		HI	1.171								
		HT	-0.09								
	TBM 2	BS	**BM H**	m	S	DD	dA	Hd	Vd	**BM H**	
X	18.8276	HA	0	0	50	180.0139		15.55449	-0.449948	X	3.2731
Y	0.4290	VA	91	39	25	91.65694	-1.656944			Y	0.4252
Z	-2.1960	SDx	15.561							Z	-1.3639
		HI	1.232								
		HT	-0.05								
	TBM 2	BS	**BM H**	m	S	DD	dA	Hd	Vd	**BM H**	
X	18.8276	HA	0	1	25	180.0236		15.5575	-0.449658	X	3.2701
Y	0.4290	VA	91	39	20	91.65556	-1.655556			Y	0.4226
Z	-2.1960	SDx	15.564							Z	-1.3627
		HI	1.233								
		HT	-0.05								
	TBM 2	BS	**BM I**	m	S	DD	dA	Hd	Vd	**BM I**	
X	18.8276	HA	359	59	35	179.9931		15.06194	-0.390392	X	3.7656
Y	0.4290	VA	91	29	5	91.48472	-1.484722			Y	0.4308
Z	-2.1960	SDx	15.067							Z	-1.3504
		HI	1.171								
		HT	-0.065								
	TBM 2	BS	**BM I**	m	S	DD	dA	Hd	Vd	**BM I**	
X	18.8276	HA	0	0	55	180.0153		15.06239	-0.44631	X	3.7652
Y	0.4290	VA	91	41	50	91.69722	-1.697222			Y	0.4250
Z	-2.1960	SDx	15.069							Z	-1.3593
		HI	1.233								
		HT	-0.05								
	TBM 2	BS	**BM I**	m	S	DD	dA	Hd	Vd	**BM I**	
X	18.8276	HA	359	59	50	179.9972		15.06336	-0.447435	X	3.7642
Y	0.4290	VA	91	42	5	91.70139	-1.701389			Y	0.4297
Z	-2.1960	SDx	15.07							Z	-1.3614
		HI	1.232								
		HT	-0.05								
	TBM CT	BS	**Stbd Ant**	m	S	DD	dA	Hd	Vd	**Stbd Ant**	
X	5.123977	HA	161	13	25	161.2236		2.958503	0.249444	X	2.3229
Y	-0.000827	VA	85	10	50	85.18056	4.819444			Y	0.9514
Z	0.845	SDx	2.969							Z	1.9344
		HI	0.92								

		HT	0.08								

	BM CT	BS	**Stbd Ant**	m	S	DD	dA	Hd	Vd	**Stbd Ant**	
X	5.123977	HA	341	9	55	161.1653		2.956677	0.140223	X	2.3256
Y	-0.000827	VA	87	17	5	87.28472	2.715278			Y	0.9537
Z	0.845	SDx	2.96							Z	1.9362
		HI	1.031								
		HT	0.08								

	TBM CT	BS	**Port Ant**	m	S	DD	dA	Hd	Vd	**Port Ant**	
X	5.123977	HA	197	31	25	197.5236		2.943877	0.278278	X	2.3167
Y	-0.000827	VA	84	36	0	84.6	5.4			Y	-0.8872
Z	0.845	SDx	2.957							Z	1.9633
		HI	0.92								
		HT	0.08								

	BM CT	BS	**Port Ant**	m	S	DD	dA	Hd	Vd	**Port Ant**	
X	5.123977	HA	17	29	45	197.4958		2.943124	0.169485	X	2.3170
Y	-0.000827	VA	86	42	15	86.70417	3.295833			Y	-0.8856
Z	0.845	SDx	2.948							Z	1.9655
		HI	1.031								
		HT	0.08								

	BM C	BS	**IMU**	m	S	DD	dA	Hd	Vd	**IMU**	
X	0.0000	HA	359	35	35	359.5931		3.519377	-0.713627	X	3.5193
Y	0.0000	VA	101	27	45	101.4625	-11.4625			Y	-0.0250
Z	0.0000	SDx	3.591							Z	-1.1936
		HI	1.07								
		HT	1.55								

	BM C	BS	**IMU**	m	S	DD	dA	Hd	Vd	**IMU**	
X	0.0000	HA	359	37	30	359.625		3.519208	-0.709419	X	3.5191
Y	0.0000	VA	101	23	50	101.3972	-11.39722			Y	-0.0230
Z	0.0000	SDx	3.59							Z	-1.1944
		HI	1.065								
		HT	1.55								

	BM C	BS	**IMU**	m	S	DD	dA	Hd	Vd	**IMU**	
X	0.0000	HA	359	44	25	359.7403		3.508314	-0.722813	X	3.5083
Y	0.0000	VA	101	38	30	101.6417	-11.64167			Y	-0.0159
Z	0.0000	SDx	3.582							Z	-1.1748
		HI	1.147								
		HT	1.599								

	BM CT	BS	**TBM 1**	m	S	DD	dA	Hd	Vd	**TBM 1**	
X	5.123977	HA	180	0	10	0.002778		13.70743	-2.535711	X	18.8314
Y	-0.000827	VA	100	28	50	100.4806	-10.48056			Y	-0.0002
Z	0.845	SDx	13.94							Z	-2.2127
		HI	1.028								
		HT	1.55								
	BM CT	BS	**TBM 1**	m	S	DD	dA	Hd	Vd	**TBM 1**	
X	5.123977	HA	179	59	45	359.9958		13.70731	-2.536376	X	18.8313
Y	-0.000827	VA	100	29	0	100.4833	-10.48333			Y	-0.0018
Z	0.845	SDx	13.94							Z	-2.2104
		HI	1.031								
		HT	1.55								
	BM D	BS	**TBM 1**	m	S	DD	dA	Hd	Vd	**TBM 1**	
X	6.9065	HA	0	0	0	0		11.91516	-2.662444	X	18.8217
Y	0.0000	VA	257	24	15	257.4042	-12.59583			Y	0.0000
Z	0.3805	SDx	12.209							Z	-2.2020
		HI	1.165								
		HT	1.085								
	BM CT	BS	**TBM 2**	m	S	DD	dA	Hd	Vd	**TBM 2**	
X	5.123977	HA	181	47	50	1.797222		13.70934	-2.541907	X	18.8266
Y	-0.000827	VA	100	30	15	100.5042	-10.50417			Y	0.4291
Z	0.845	SDx	13.943							Z	-2.2159
		HI	1.031								
		HT	1.55								
	TBM1 Pier	BS	**TBM 2**	m	S	DD	dA	Hd	Vd	**TBM 2**	
X	18.8281	HA	90	0	0	90		0.43	0	X	18.8281
Y	-0.0007	VA	0	0	0	0	0			Y	0.4293
Z	-2.1960	SDx	0.43							Z	-2.1960
		HI	0								
		HT	0								
	BM CT	BS	**TBM 2**	m	S	DD	dA	Hd	Vd	**TBM 2**	
X	5.123977	HA	181	47	40	1.794444		13.71075	-2.539763	X	18.8280
Y	-0.000827	VA	100	29	40	100.4944	-10.49444			Y	0.4285
Z	0.845	SDx	13.944							Z	-2.2168
		HI	1.028								
		HT	1.55								
	BM C	BS	**TBM CT**	m	S	DD	dA	Hd	Vd	**TBM CT**	
X	0	HA	359	58	20	359.9722		5.117313	0.241326	X	5.1173

Y	0	VA	87	18	0	87.3	2.7			Y	-0.0025	
Z	0	SDx	5.123							Z	0.8483	
		HI	1.225									
		HT	0.618									
	BM H	BS	**PC**	m	S	DD	dA	Measured		**PC**		
X	3.2714	HA	N/A	N/A	N/A	N/A		0.089	N/A	X	3.3604	Direct Measurement
Y	0.4256	VA	N/A	N/A	N/A	N/A	N/A	-0.153		Y	0.2726	
Z	-1.3680	SDx	N/A					-0.351		Z	-1.7190	
		HI	N/A									
		HT	N/A									
	BM H	BS	**PC**	m	S	DD	dA	Measured		**PC**		
X	3.2714	HA	N/A	N/A	N/A	N/A		0.093	N/A	X	3.3644	Direct Measurement
Y	0.4256	VA	N/A	N/A	N/A	N/A	N/A	-0.154		Y	0.2716	
Z	-1.3680	SDx	N/A					-0.351		Z	-1.7190	
		HI	N/A									
		HT	N/A									
	BM H	BS	**PC**	m	S	DD	dA	Measured		**PC**		
X	3.2714	HA	N/A	N/A	N/A	N/A		0.099	N/A	X	3.3704	Direct Measurement
Y	0.4256	VA	N/A	N/A	N/A	N/A	N/A	-0.15		Y	0.2756	
Z	-1.3680	SDx	N/A					-0.354		Z	-1.7220	
		HI	N/A									
		HT	N/A									

Vertical

All offsets are in Theodolite Coordinate System

		FR						
SETUP 1								
BS	**BM C**		FS		**BM A**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.992		1.967333	Top	2.014		1.988333333	
Mid	1.967	0.025		Mid	1.988	0.026		
Bot	1.943	0.024		Bot	1.963	0.025		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM A				
	0	1.967333333	1.988333	-0.021				
SETUP 5								
BS	**BM C**		FS		**BM A**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.908		1.883	Top	1.928		1.902333333	
Mid	1.883	0.025		Mid	1.902	0.026		
Bot	1.858	0.025		Bot	1.877	0.025		
		DTI				DTI		
		0				1		
	BM C	HI	Rod	BM A			**BM A Ave**	**-0.02016667**
	0	1.883	1.902333	-0.019333			mm DIFF	-1.66666667
SETUP 1								
BS	**BM C**		FS		**BM B**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.992		1.967333	Top	2.046		2.021	
Mid	1.967	0.025		Mid	2.021	0.025		
Bot	1.943	0.024		Bot	1.996	0.025		
		DTI				DTI		
		1				0		
	BM C	HI	Rod	BM B				
	0	1.967333333	2.021	-0.053667				
SETUP 5								
BS	**BM C**		FS		**BM B**			
		TI	Ave (HI)			TI	Ave BM El	

Top	1.908		1.883	Top	1.961		1.935	
Mid	1.883	0.025		Mid	1.935	0.026		
Bot	1.858	0.025		Bot	1.909	0.026		
		DTI				DTI		
		0				0		
	BM C	HI	Rod	BM B			**BM B Ave**	**-0.05283333**
	0	1.883	1.935	-0.052			mm DIFF	-1.66666667
	BM C 0 BY DEFINITION							
SETUP 1								
BS	**BM C**		FS		**BM D**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.992		1.967333	Top	1.59		1.580666667	
Mid	1.967	0.025		Mid	1.581	0.009		
Bot	1.943	0.024		Bot	1.571	0.01		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM D				
	0	1.967333333	1.580667	0.386667				
SETUP 5								
BS	**BM C**		FS		**BM D**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.908		1.883	Top	1.502		1.494333333	
Mid	1.883	0.025		Mid	1.495	0.007		
Bot	1.858	0.025		Bot	1.486	0.009		
		DTI				DTI		
		0				2		
	BM C	HI	Rod	BM D			**BM D Ave**	**0.387666667**
	0	1.883	1.494333	0.388667			mm DIFF	-2
SETUP 1								
BS	**BM C**		FS		**BM E**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.992		1.967333	Top	0.372		0.354666667	
Mid	1.967	0.025		Mid	0.354	0.018		
Bot	1.943	0.024		Bot	0.338	0.016		

		DTI					DTI		
			1				2		
	BM C	HI		Rod	BM E				
	0		1.967333333	0.354667	1.612667				
SETUP 6									
BS	**BM D**			FS		**BM E**			
		TI		Ave (HI)			TI	Ave BM El	
Top	1.697			1.689	Top	0.481		0.463	
Mid	1.689		0.008		Mid	0.463	0.018		
Bot	1.681		0.008		Bot	0.445	0.018		
		DTI					DTI		
			0				5.55E-14		
	BM D	HI		Rod	BM E			**BM E Ave**	**1.612666833**
	0.386667		1.689	0.463	1.612667			mm DIFF	-0.00033333
SETUP 1									
BS	**BM C**			FS		**BM F**			
		TI		Ave (HI)			TI	Ave BM El	
Top	1.992			1.967333	Top	0.336		0.319666667	
Mid	1.967		0.025		Mid	0.319	0.017		
Bot	1.943		0.024		Bot	0.304	0.015		
		DTI					DTI		
			1				2		
	BM C	HI		Rod	BM F				
	0		1.967333333	0.319667	1.647667				
SETUP 5									
BS	**BM C**			FS		**BM F**			
		TI		Ave (HI)			TI	Ave BM El	
Top	1.908			1.883	Top	0.249		0.232666667	
Mid	1.883		0.025		Mid	0.233	0.016		
Bot	1.858		0.025		Bot	0.216	0.017		
		DTI					DTI		
			0				1		
	BM C	HI		Rod	BM F			**BM F Ave**	**1.649**
	0		1.883	0.232667	1.650333			mm DIFF	-2.66666667
SETUP 1									

BS	**BM C**		FS		**BM G**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.992		1.967333	Top	0.406		0.389333333	
Mid	1.967	0.025		Mid	0.389	0.017		
Bot	1.943	0.024		Bot	0.373	0.016		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM G				
	0	1.967333333	0.389333	1.578				
SETUP 6								
BS	**BM D**		FS		**BM G**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.697		1.689	Top	0.515		0.497666667	
Mid	1.689	0.008		Mid	0.497	0.018		
Bot	1.681	0.008		Bot	0.481	0.016		
		DTI				DTI		
		0				2		
	BM D	HI	Rod	BM G			**BM G Ave**	**1.578000167**
	0.386667	1.689	0.497667	1.578			mm DIFF	-0.00033333
SETUP 10								
BS	**BM C**		FS		**BM J**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.667		0.657	Top	1.764		1.755	
Mid	0.657	0.01		Mid	1.755	0.009		
Bot	0.647	0.01		Bot	1.746	0.009		
		DTI				DTI		
		0				2.22E-13		
	BM C	HI	Rod	BM J				
	0	0.657	1.755	-1.098				
SETUP 11								
BS	**BM C**		FS		**BM J**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.658		0.648333	Top	1.761		1.752	
Mid	0.649	0.009		Mid	1.752	0.009		
Bot	0.638	0.011		Bot	1.743	0.009		
		DTI				DTI		

			2				0		
	BM C	HI		Rod	BM J			**BM J Ave**	**-1.10083333**
	0		0.648333333	1.752	-1.103667			mm DIFF	5.666666667
SETUP 2									
BS	**BM C**			FS		**TBM 2**			
		TI		Ave (HI)			TI	Ave BM El	
Top	1.381			1.347333	Top	3.609		3.549666667	
Mid	1.348		0.033		Mid	3.55	0.059		
Bot	1.313		0.035		Bot	3.49	0.06		
		DTI					DTI		
			2				1		
	BM C	HI		Rod	TBM 2				
	0		1.347333333	3.549667	-2.202333				
BS	**BM C**			FS		**TBM 2**			NOTE
		TI		Ave (HI)			TI	Ave BM El	
Top	-			1.188	Top	-		3.395	
Mid	1.188	n/a			Mid	3.395	n/a		
Bot	-	n/a			Bot	-			
		DTI					DTI		
		n/a					n/a		
	BM C	HI		Rod	TBM 2			**TBM 2 Ave**	**-2.20466667**
	0		1.188	3.395	-2.207			mm DIFF	4.666666667
SETUP 2									
BS	**BM C**			FS		**BM CT**			
		TI		Ave (HI)			TI	Ave BM El	
Top	1.381			1.347333	Top	0.51		0.502	
Mid	1.348		0.033		Mid	0.502	0.008		
Bot	1.313		0.035		Bot	0.494	0.008		
		DTI					DTI		
			2				0		
	BM C	HI		Rod	BM CT				
	0		1.347333333	0.502	0.845333				
SETUP 7									
BS	**BM C**			FS		**BM CT**			

		TI		Ave (HI)			TI	Ave BM El	
Top	1.563			1.528	Top	0.693		0.683333333	
Mid	1.528		0.035		Mid	0.684	0.009		
Bot	1.493		0.035		Bot	0.673	0.011		
		DTI					DTI		
			0				2		
	BM C	HI		Rod	BM CT			**BM CT Ave**	**0.845**
	0		1.528	0.683333	0.844667			mm DIFF	0.666666667
SETUP 3									
BS	**BM C**			FS		**Stbd Ant**			
		TI		Ave (HI)			TI	Ave BM El	
Top	2.068			2.044333	Top	0.128		0.116	
Mid	2.045		0.023		Mid	0.116	0.012		
Bot	2.02		0.025		Bot	0.104	0.012		
		DTI					DTI		
			2				1.39E-14		
	BM C	HI		Rod	Stbd Ant				
	0		2.044333333	0.116	1.928333				
SETUP 4									
BS	**BM C**			FS		**Stbd Ant**			
		TI		Ave (HI)			TI	Ave BM El	
Top	2.067			2.043333	Top	0.126		0.114333333	
Mid	2.044		0.023		Mid	0.114	0.012		
Bot	2.019		0.025		Bot	0.103	0.011		
		DTI					DTI		
			2				1		
	BM C	HI		Rod	Stbd Ant			**Stbd Ant Ave**	**1.928666667**
	0		2.043333333	0.114333	1.929			mm DIFF	-0.66666667
SETUP 3									
BS	**BM C**			FS		**Port Ant**			
		TI		Ave (HI)			TI	Ave BM El	
Top	2.068			2.044333	Top	0.102		0.086666667	
Mid	2.045		0.023		Mid	0.086	0.016		
Bot	2.02		0.025		Bot	0.072	0.014		
		DTI					DTI		

		2				2		
	BM C	HI	Rod	Port Ant				
	0	2.044333333	0.086667	1.957667				
SETUP 4								
BS	**BM C**		FS		**Port Ant**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.067		2.043333	Top	0.101		0.085333333	
Mid	2.044	0.023		Mid	0.085	0.016		
Bot	2.019	0.025		Bot	0.07	0.015		
		DTI				DTI		
		2				1		
	BM C	HI	Rod	Port Ant			**Port Ant Ave**	**1.957833333**
	0	2.043333333	0.085333	1.958			mm DIFF	-0.33333333
SETUP 10								
BS	**BM C**		FS		**IMU**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.667		0.657	Top	1.849		1.841	
Mid	0.657	0.01		Mid	1.841	0.008		
Bot	0.647	0.01		Bot	1.833	0.008		
		DTI				DTI		
		0				0		
	BM C	HI	Rod	IMU				
	0	0.657	1.841	-1.184				
SETUP 11								
BS	**BM C**		FS		**IMU**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.658		0.648333	Top	1.839		1.830333333	
Mid	0.649	0.009		Mid	1.83	0.009		
Bot	0.638	0.011		Bot	1.822	0.008		
		DTI				DTI		
		2				1		
	BM C	HI	Rod	IMU			**IMU Ave**	**-1.183**
	0	0.648333333	1.830333	-1.182			mm DIFF	-2
SETUP 8								
BS	**TBM 2**		FS		**BM H**			NOTE

		TI		Ave (HI)			TI	Ave BM El	
Top	0.792			0.755667	Top	-0.032		-0.072	
Mid	0.755		0.037		Mid	-0.072	0.04		
Bot	0.72		0.035		Bot	-0.112	0.04		
		DTI					DTI		
			2				1.39E-14		
	TBM 2	HI		Rod	BM H				
	-2.204667		0.755666667	-0.072	-1.377				
SETUP 9									
BS	**TBM 2**			FS		**BM H**			NOTE
		TI		Ave (HI)			TI	Ave BM El	
Top	0.783			0.746333	Top	-0.041		-0.082	
Mid	0.746		0.037		Mid	-0.082	0.041		
Bot	0.71		0.036		Bot	-0.123	0.041		
		DTI					DTI		
			1				6.94E-15		
	TBM 2	HI		Rod	BM H			**BM H Ave**	**-1.37666667**
	-2.204667		0.746333333	-0.082	-1.376333			mm DIFF	-0.66666667
SETUP 8									
BS	**TBM 2**			FS		**BM I**			NOTE
		TI		Ave (HI)			TI	Ave BM El	
Top	0.792			0.755667	Top	-0.036		-0.075	
Mid	0.755		0.037		Mid	-0.075	0.039		
Bot	0.72		0.035		Bot	-0.114	0.039		
		DTI					DTI		
			2				6.94E-15		
	TBM 2	HI		Rod	BM I				
	-2.204667		0.755666667	-0.075	-1.374				
SETUP 9									
BS	**TBM 2**			FS		**BM I**			NOTE
		TI		Ave (HI)			TI	Ave BM El	
Top	0.783			0.746333	Top	-0.047		-0.085666667	
Mid	0.746		0.037		Mid	-0.086	0.039		
Bot	0.71		0.036		Bot	-0.124	0.038		
		DTI					DTI		
			1				1		

TBM 2	HI		Rod	BM I	**BM I Ave**	**-1.37333333**
-2.204667		0.746333333	-0.085667	-1.372667	mm DIFF	-1.33333333

1010 Launch Offsets Measurements

Jul-04

All offsets are in Theodolite Coordinate System

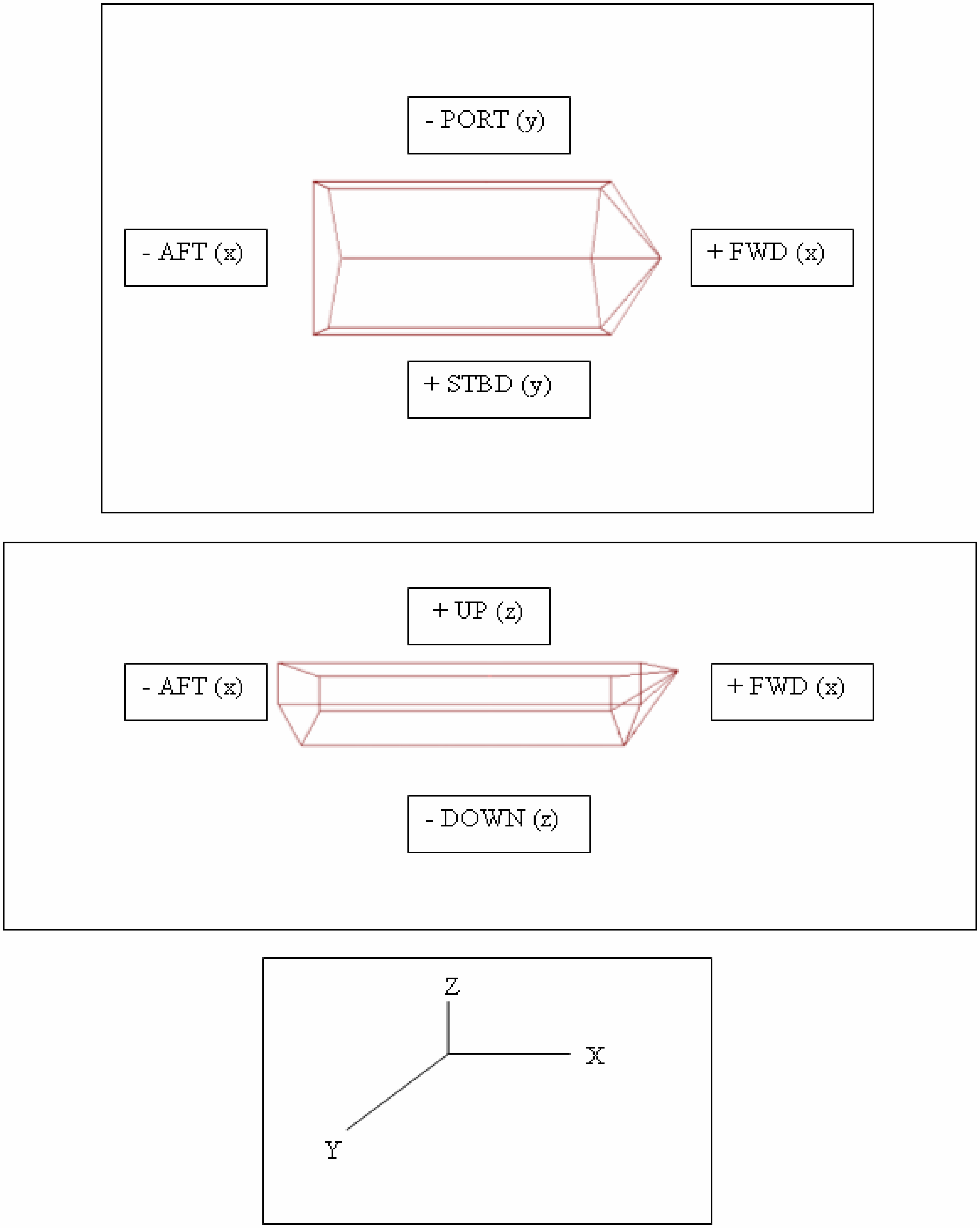
The Z plane means were taken using only the vertical level measurements.

BM A	88	165		133						
X	-0.0080	-0.0024						**Mean**	**-0.00523**	
Y	-1.0024	-1.0017							**-1.002038**	
Z	-0.0229	-0.0351	-0.021	-0.019333333					**-0.020167**	
BM B	95	172	13	143						
X	-0.006636	-0.000971						**Mean**	**-0.003804**	
Y	1.000078	0.999488							**0.999783**	
Z	-0.054751	-0.06738	-0.053666667	-0.052					**-0.052833**	
BM C										
X	**0**		**By Definition**							
Y	**0**									
Z	**0**									
BM D	3	39	137	200	235					
X	6.906514	6.917806	6.90609668	6.924299204	6.908486			**Mean**	**6.912961**	0.008066 ⇐ X Std De
Y	0	-0.001217	-9.25846E-05	2.19861E-06	-0.003272				**-0.001121**	0.001414 ⇐ Y Std De
Z	0.380484	0.339366	0.393190546	0.372414056	0.358922	0.386667	0.3886667		**0.387667**	
BM E	102	179	174	33						
X	1.66838	1.662692						**Mean**	**1.665536**	
Y	-0.892003	-0.892844							**-0.892424**	
Z	1.619989	1.601054	1.612667	1.612666667					**1.612667**	
BM F	18	109	186	43	163					
X	1.667546	1.67587	1.660831138					**Mean**	**1.668082**	0.007534 ⇐ X Std De
Y	-0.000827	-0.001997	-0.000826981						**-0.001217**	0.000676 ⇐ Y Std De
Z	1.643321	1.654747	1.63967874	1.647666667	1.650333				**1.649**	
BM G	116	193	53	184						
X	1.675333	1.660896						**Mean**	**1.668115**	
Y	0.955657	0.959932							**0.957794**	
Z	1.585729	1.566713	1.578	1.578000333					**1.578**	

BM H	60	221	242						
X	3.271201	3.270066	3.273074882			**Mean**	**3.271447**	0.001519	⇐ X Std De
Y	0.428992	0.422581	0.425221731				**0.425598**	0.003222	⇐ Y Std De
Z	-1.353679	-1.362658	-1.363947954	-1.377	-1.376333		**-1.376667**		
BM I	67	228	249	234	254				
X	3.7656	3.7652	3.764211686			**Mean**	**3.765006**	0.000723	⇐ X Std De
Y	0.4308	0.4250	0.429722538				**0.428505**	0.003105	⇐ Y Std De
Z	-1.3504	-1.3593	-1.361435445	-1.374	-1.372667		**-1.373333**		
BM J	67	228	249	274	294				
X	n/a	n/a	n/a	n/a	n/a	**Mean**			
Y	n/a	n/a	n/a	n/a	n/a				
Z	-1.3504	-1.3593	-1.361435445	-1.098	-1.103667		**-1.100833**		
BM CT	11	81	158						
X	5.117312	5.12892	5.1257			**Mean**	**5.123977**	0.005993	⇐ X Std De
Y	-0.002481	0	0				**-0.000827**	0.001432	⇐ Y Std De
Z	0.848326	0.847926	0.8586	0.845333333	0.844667		**0.845**		
TBM 1	46	144	207						
X	18.82167	18.83129	18.83141214			**Mean**	**18.82813**	0.005587	⇐ X Std De
Y	0	-0.001824	-0.000162426				**-0.000662**	0.001009	⇐ Y Std De
Z	-2.20196	-2.210376	-2.212711485	-2.196	-2.197		**-2.1965**		
TBM 2	53	151	214	63					
X	18.82813	18.82657	18.82800643			**Mean**	**18.82757**	0.000865	⇐ X Std De
Y	0.429338	0.429129	0.428509392				**0.428992**	0.000431	⇐ Y Std De
Z	-2.196	-2.215907	-2.216762747	-2.202333333	-2.207		**-2.204667**		
IMU	74	256	263						
X	3.5083	3.519289	3.519132539			**Mean**	**3.515566**	0.006313	⇐ X Std De
Y	-0.0159	0.024996	0.023032997				**0.010709**	0.023067	⇐ Y Std De
Z	-1.1748	-1.193627	-1.194419237	-1.184	-1.182		**-1.183**		
Port Ant	25	130	103	123					
X	2.316717	2.3170				**Mean**	**2.316862**		

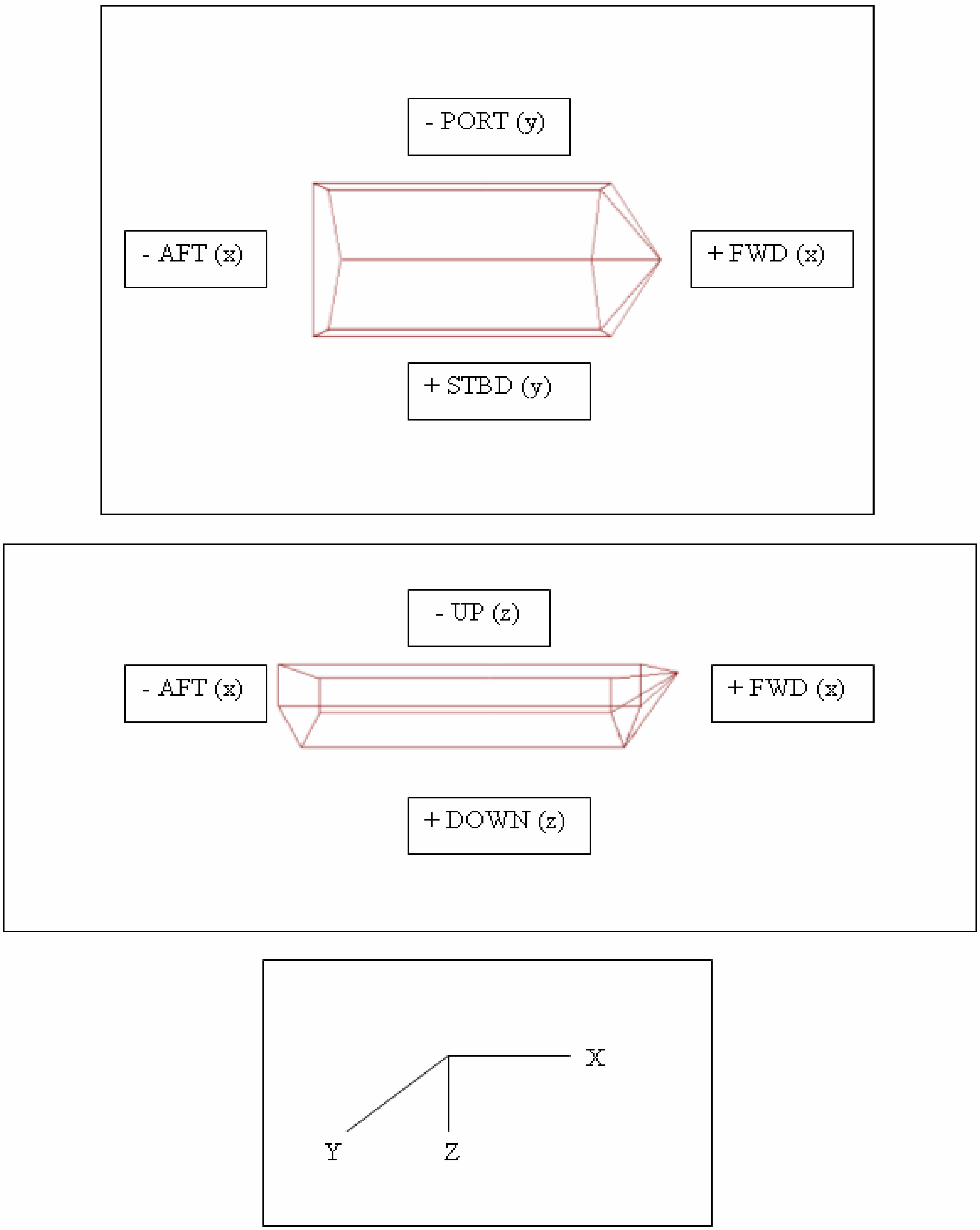
Y	-0.887225	-0.8856				**-0.886431**	
Z	1.963278	1.9655	1.957666667	1.958		**1.957833**	
Stbd Ant	32	123	93	113			
X	2.32292	2.32562			**Mean**	**2.32427**	
Y	0.951443	0.953705				**0.952574**	
Z	1.934444	1.936223	1.928333333	1.929		**1.928667**	
Phase Center of Ducer							
	270	277	284				
X	3.360447	3.364447	3.370447321		**Mean**	**3.365114**	0.005033 ⇐ X Std De
Y	0.272598	0.271598	0.275598369			**0.273265**	0.002082 ⇐ Y Std De
Z	-1.719	-1.719	-1.722	-1.729166667		**-1.729167**	

Theodolite Coordinate System



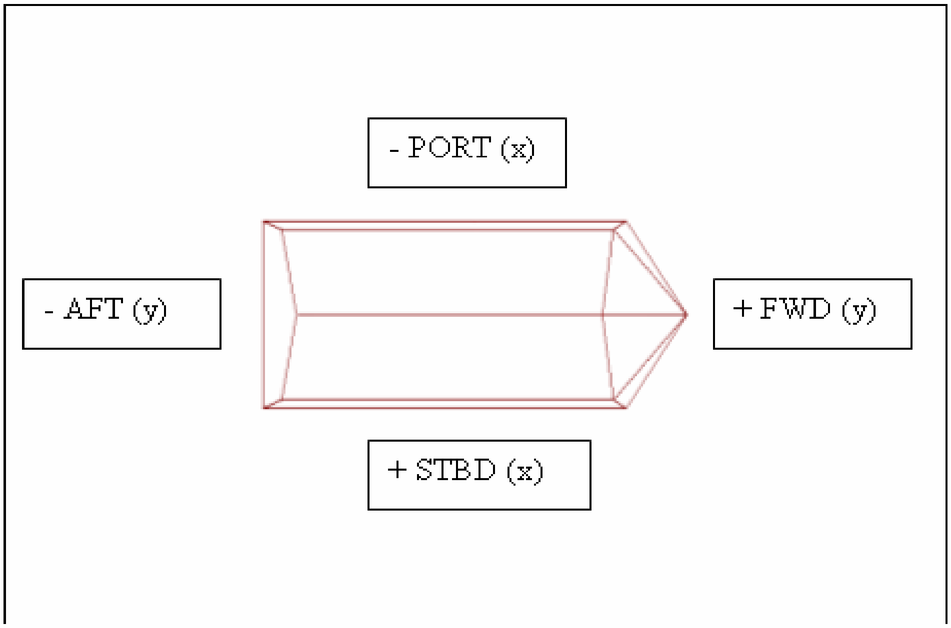
Benchmark C is the origin of the Theodolite Coordinate System

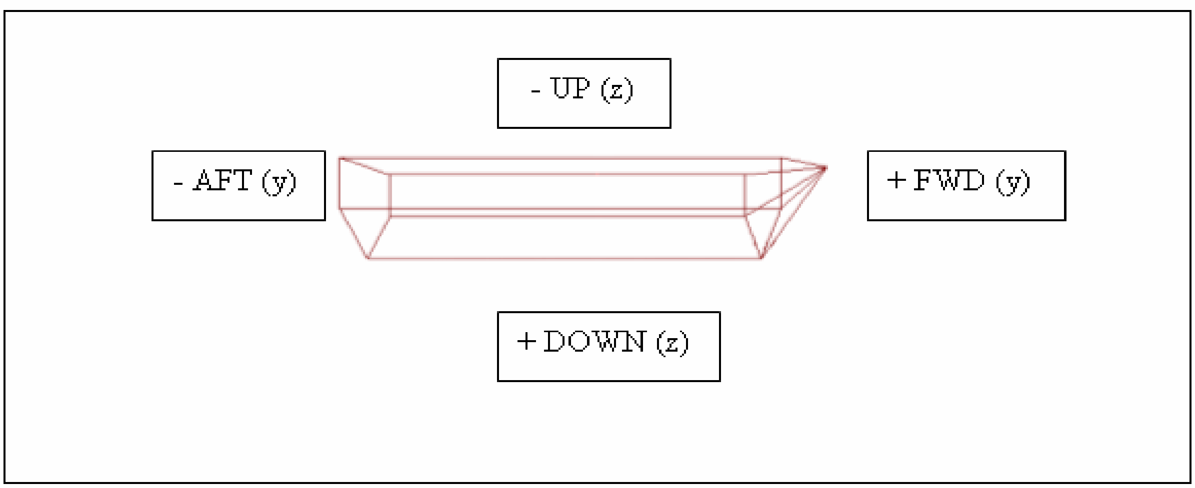
POS/MV Coordinate System

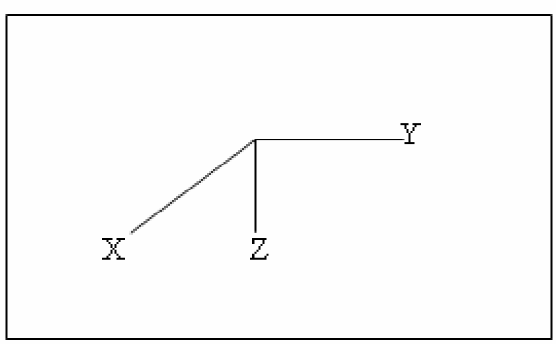


Top Center of IMU is origin of POS/MV Coordinate System

CARIS Coordinate System

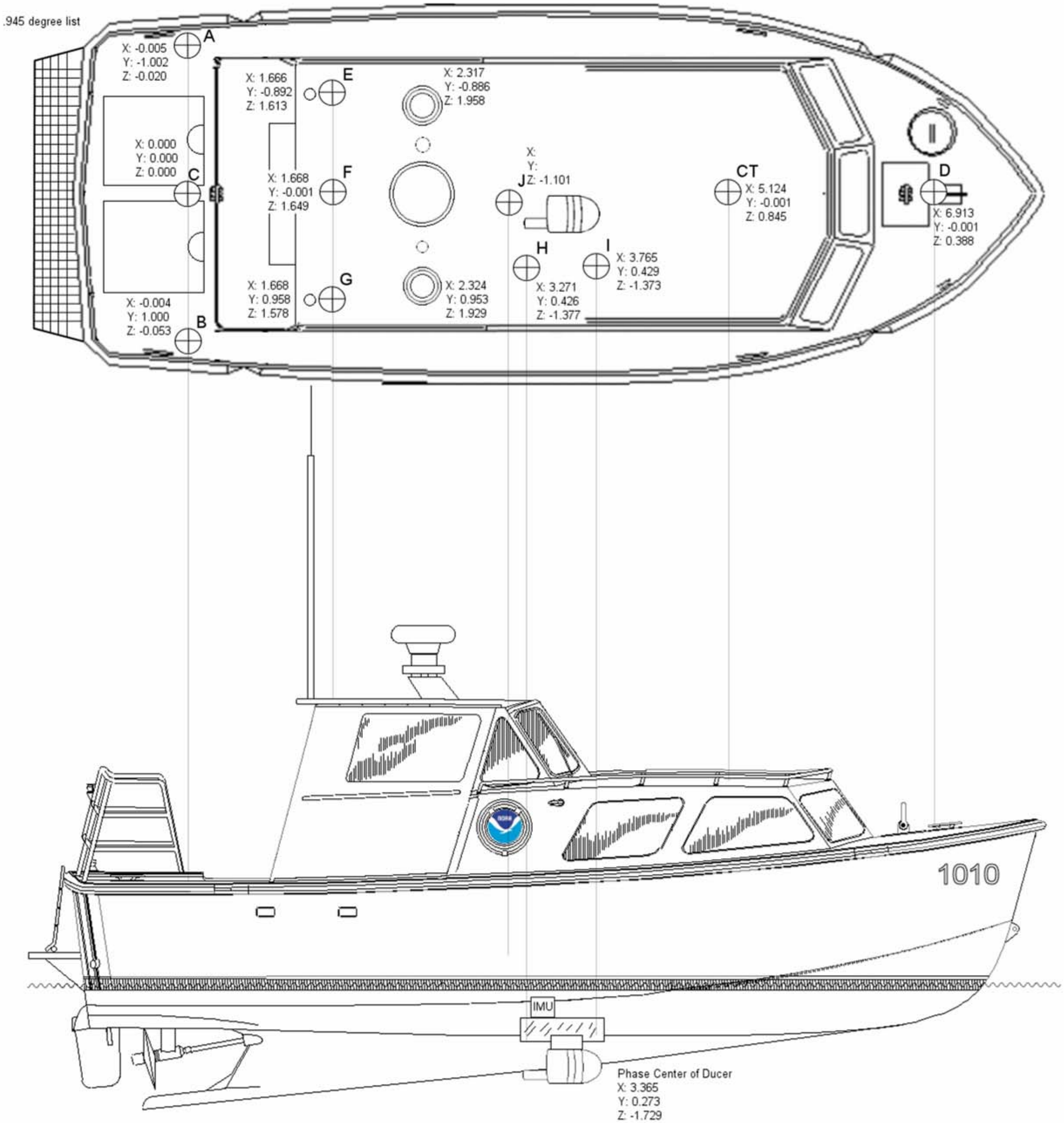


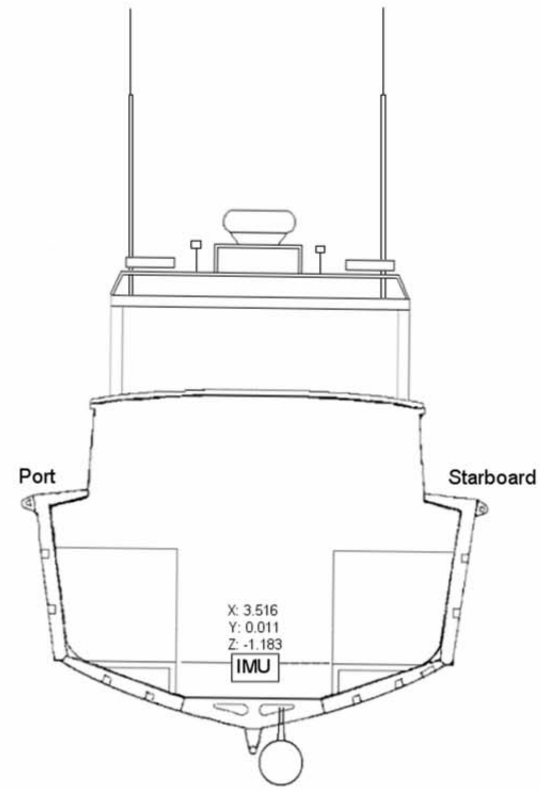




Top Center of IMU is origin of CARIS Coordinate System

1010 Vessel Diagram





1010 Offset Measurements

Sources

In general launches require two pieces of information in order to determine their lever arms for CARIS and the POS/MV. The first piece of information is the position of the physical offsets between the multibeam system components and the second is the position of the roll point.

Physical offset information was derived from values measured by ship's personnel with the assistance of Hydrographic Systems and Technology Personnel and Pacific Hydrographic Branch Personnel. The general procedure used is described in the *Measuring Launch Offsets SOP* document contained in Appendix VI-1 of the *2004 FAIRWEATHER Data Acquisition and Processing Report* (hereafter known as the DAPR). The resulting measurements are located in the offset sections of Appendix III.

The second source of information was from Appendix III of the RAINIER DAPR titled OPR_O112-RA-02. Information about the roll point, center of motion for a vessel, was needed for the 1010 HVF. Roll point values are calculated by conducting an inclination experiment. The FAIRWEATHER had no roll point information since the results of an inclination experiment were not released before or during the field season. For Launch 2123 the roll point was 0.574 m aft of the IMU on the centerline and at the waterline. Launch 2123 is very similar to Launch 1010 and its roll point approximation was used in Launch 1010's offset measurements.

Measurements

All measurements were taken after launch 1010 was "leveled" in accordance with the *Measuring Launch Offsets SOP* using Leveling Procedure Method A: Leveling to an Installed IMU. Most horizontal measurements were taken 3 times in order to determine a standard deviation. The average standard deviation for horizontal measurements was 4.3 mm. For launch 1010, since it was the first time the procedure was run, all horizontal control points do not have three measurements.

Vertical measurements were conducted in accordance with the procedures defined in the *Users Guide for the Installation of Bench marks and Leveling Requirements for Water Level Stations* dated October 1987. Vertical measurements were made with a Leica NA2 with a stadia of 100. The level specifications can be found in Appendix I of the DAPR. Each point was measured twice in accordance with the leveling procedure, and the runs between benchmarks were checked for closure. According to *Users Guide for the Installation of Bench marks and Leveling Requirements for Water Level Stations,* the maximum closure tolerance for a single third-order section, one setup, less than 0.1 km in length, is 2 mm. Three out of fifteen vertical measurements exceeded the specification ranging from 5.67 mm to 2.67 mm. These errors in closure were not found before the vessel was placed back in the water. There was not an opportunity to re-level the vessel.

With the exception of one set of measurements, horizontal measurements for lever arm distances were taken using a Nikon DTM 310. The Nikon specifications are located in Appendix I. In one instance, over a very short distance (< 0.4 m), the instrument could not be set up to calculate the difference in location. That offset distance was measured with steel tape, plumb bob and carpenter's squares.

Required Measurements

Pos/MV

Measurements required by the IMU are lever arm distances from the IMU, the multibeam transducer, the heave measurement location (roll point), and the primary GPS antenna to the chosen reference point. In the case of launch 1010 the reference point and the IMU are coincident. This simplifies installation. There is also a need for an antenna separation distance.

CARIS

Measurements required by CARIS are transducer to the reference point, IMU to the reference point and waterline to the reference point.

Calculations

The values for the required lever arms are listed in the 1010_Offsets and Measurements spreadsheet. The reference point and the IMU are identical.

As a requirement for the Total Propagated Error (TPE) model, the standard deviation for each position, in each axis, was stated to be 7 mm.

Pos/MV—IMU to Reference Point

IMU to the Reference Point is zero on all axes since the IMU is chosen to be the origin.

Pos/MV, CARIS—IMU (Reference Point) to Reson 8101

The location of the phase center of the Reson 8101 and the location of the IMU were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The lever arm distance between the phase center of the Reson 8101 and the IMU were then calculated. The measurements and calculations are listed in the 1010 Offsets Measurements spreadsheet in Appendix III.

Pos/MV—Antenna Separation

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated. The measurements and calculations are listed in the 1010 Offsets Measurements spreadsheet in Appendix III.

Pos/MV— IMU(Reference Point) to Primary (Port) antenna

The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The lever arm distance between the IMU and the port antenna were then calculated. The measurements and calculations are listed in the 1010 Offsets Measurements spreadsheet in Appendix III.

CARIS—IMU(Reference Point) to Waterline

The vertical distance between the top of the IMU to the waterline was measured by FAIRWEATHER personnel using a steel tape measuring from BM A to the waterline. With the knowledge of BM A's height above the IMU the waterline height above the IMU was calculated.   The measurements and calculations are listed in the 1010 Offsets Measurements spreadsheet in Appendix III.

Pos/MV—IMU (Reference Point) to Roll Point

The roll point was positioned differently on the three axes. On the longitudinal axis the distance was determined from the RAINIER DAPR described on page 1 of this document. The athwart ships axis for the roll point is the vessel centerline. Lastly, the height of the roll point was equivalent to the waterline. This waterline value was calculated in the same manner as the above paragraph, though the values are not identical as they were measured on different days. The measurements and calculations are listed in the 1010 Offsets Measurements spreadsheet in Appendix III.

Patch Test Acquisition Log __1010__________

(Vessel)

Page _1__ of _2__

Date: Sept. 1,2004	DN: 245	Local Area: Tongass Narrows/Blank Inlet		Wx:	
SV Cast #1 filename: 04245103.2	UTC time: 1032	Lat: 55/20/03.32	Lon: 131/38/05.92	Depth: 48	Ext Depth: 62.4
SV Cast #2 filename: 04245125.7	UTC time: 1257	Lat: 55/16/30.31	Lon: 131/39/39.7	Depth: 71.5	Ext Depth: 92.9

Personnel:
Abrams, Van Waes, Higgins

Other Comments:

ROLL LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
2	Roll1	113	7.1	
	Roll2	275	7.6	
	Roll3	117	5.5	
	Roll4	283	6.1	

PITCH LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
2	Pitch1	227	5.5	
	Pitch2	058	5.8	
	Pitch5	235	5.9	
	Pitch6	59	6.3	

HEADING LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	Heading5	222	4	Run parallel to wreck
	Heading6	222	4	“ “ “
	Heading7	42	6	“ “ “
	Heading8	40	6	“ “ “
	Heading9	114	4.7	Run perpendicular to wreck
	Heading11	121	4.7	“ “ “

HEADING LINES Continued

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	Heading14	295	7.6	Run perpendicular to wreck
	Heading15	288	6.9	“ “ “

Processing Patch Test **1010** **245/9-1-04**
(Vessel) *(Dn/Date)*

☐ HVF Hydrographic Vessel File created or updated with current offsets
Name: ____________________________ Date/Time: ________________________

X Data Converted → HDCS_Data in CARIS

X True Heave Applied

X Tide Applied Observed 9450460
Type (Zero, Observed, Verified)

X Zoned FA_Patch2004Corp.zdf
ZDF File

X SVP applied 04245103 applied to Heading and 04245125 applied to Pitch and Roll
File

X Lines merged

X Data cleaned to remove gross fliers

Compute Correctors – Order

1) Precise Timing 2) Pitch Bias 3) Roll Bias 3) Heading Bias

Do not Enter/Apply Correctors until all evaluations are complete and analyzed.

Patch Test Results/Correctors

Evaluator	Timing (sec)	Pitch (deg)	Roll (deg)	Hdg (deg)
Jess	0.01	-1.20	-0.39	-0.32
Kim	0.00	-0.65	-0.38	-0.35
Mark	0.00	-1.3	-0.39	-0.30
Lynn	0.00	-0.9	-0.35	-0.10
Final Values	0.00	-0.9	-0.38	-0.32

Final Values based on: Consensus

Patch Test Acquisition Log ____1010___

(Vessel)

Date: 10/19/04 **DN: 293** **Local Area: Rudyerd Bay** **Wx: Clear & Cold**

SV Cast #1 filename: 04293180	UTC time: 1805	Lat: 55/31.918	Lon: 130/47.152	Depth: 91.0	Ext Depth: 118.3
SV Cast #2 filename:	UTC time:	Lat:	Lon:	Depth:	Ext Depth:

Personnel: Wetzler, Keene, Kellner

Other Comments: Forgot to bring CTD on launch, so cast was done from the ship at anchor in the same area after acquisition.

TIME LATENCY LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	XTF Line Filename:
1	LATENCY1	NA		LATENCY3
	LATENCY2	NA		LATENCY4

ROLL LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	ROLL1	138	8	
	ROLL2	312	8	
	ROLL3	318	8	Run after latency lines to check roll stability.

PITCH LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	PITCH	24	8	
	PITCH2	200	8	

HEADING LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	HEADING1	154	8	Rock in outer beams to port.
	HEADING2	330	8	
	HEADING3	155	8	Attempt to run straighter line.
	HEADING4	333	8	Didn't see rock in outer beams.
	HEADING5	330	8	Good rock image.

Processing Patch Test __1010_ (Vessel) 293 10/19/04 (Dn/Date)

X Data Converted → HDCS_Data in CARIS

X Tide Applied ____Zero____
Type (Zero, Observed, Verified)

☐ Zoned ________
ZDF File

X SVP applied ____04293180____
File

X Lines merged

X Data cleaned to remove gross fliers

Compute Correctors – Order

1) Precise Timing 2) Pitch Bias 3) Roll Bias 3) Heading Bias

Do not Enter/Apply Correctors until all evaluations are complete and analyzed.

Patch Test Results/Correctors

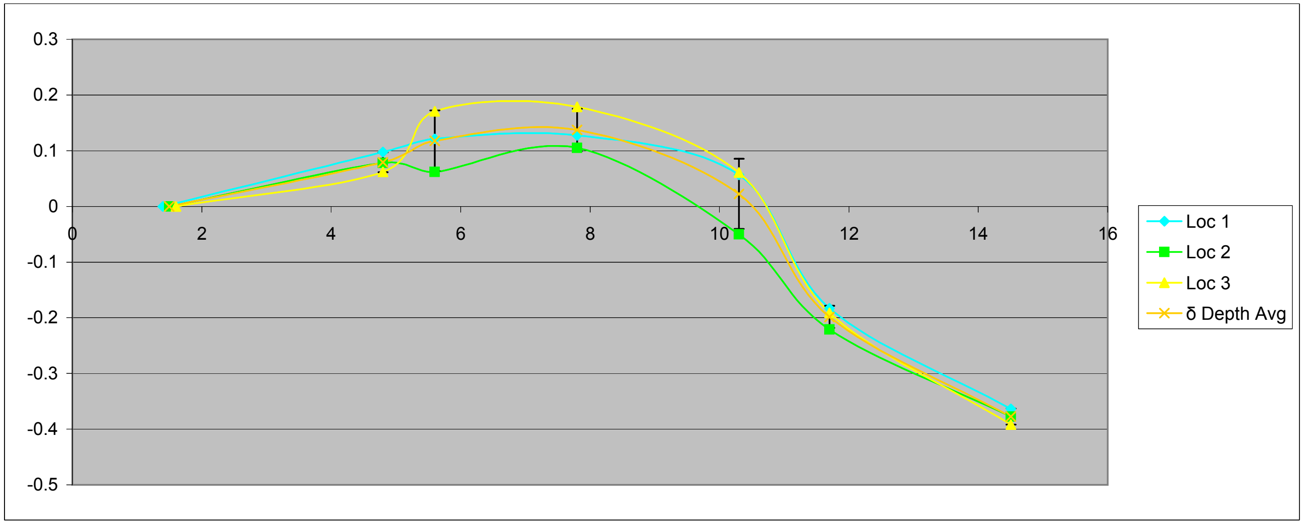
Evaluator	Timing (sec)	Pitch (deg)	Roll (deg)	Hdg (deg)
Keene/Wetzler/Kellner	0.0	-0.38	0.24	-0.30
Froelich	0.02	-0.44	0.27	-0.90
Abigail	0.01	-0.47	0.18	-0.09
Lynn				-0.30
Final Values	0.01 (ave)	-0.43 (ave)	0.23 (ave)	-0.30 (consensus)

Final Values based on ____________

☐ HVF Hydrographic Vessel File created or updated with current offsets
Name: ____________ Date: ____________

	Line	Speed	Depth	Delta Depth
Loc 1	DDSSM11	1.4	12.66266937	0
	DDSSM2	4.8	12.56513743	0.097531945
	DDSSM3	5.6	12.54164628	0.121023089
	DDSSM4	7.8	12.53501136	0.127658008
	DDSSM5	10.3	12.60566272	0.05700665
	DDSSM6	11.7	12.84574877	-0.183079397
	DDSSM10	14.5	13.02615407	-0.363484698
Loc 2	DDSSM12	1.5	12.03156266	0
	DDSSM2	4.8	11.9533921	0.078170561
	DDSSM3	5.6	11.96975088	0.061811781
	DDSSM4	7.8	11.92639686	0.105165797
	DDSSM5	10.3	12.082	-0.050437342
	DDSSM6	11.7	12.25242806	-0.220865399
	DDSSM10	14.5	12.40895522	-0.377392566
Loc 3	DDSSM13	1.6	15.72363089	0
	DDSSM2	4.8	15.66181636	0.061814534
	DDSSM3	5.6	15.55297121	0.170659682
	DDSSM4	7.8	15.5447398	0.178891096
	DDSSM5	10.3	15.6627099	0.060920994
	DDSSM6	11.7	15.91478884	-0.191157953
	DDSSM10	14.5	16.11541748	-0.391786584

	SpeedAvg	Delta Depth Avg
δ Depth Avg	1.5	0
	4.8	0.079172346
	5.6	0.117831517
	7.8	0.1372383
	10.3	0.022496767
	11.7	-0.198367583
	14.5	-0.377554616



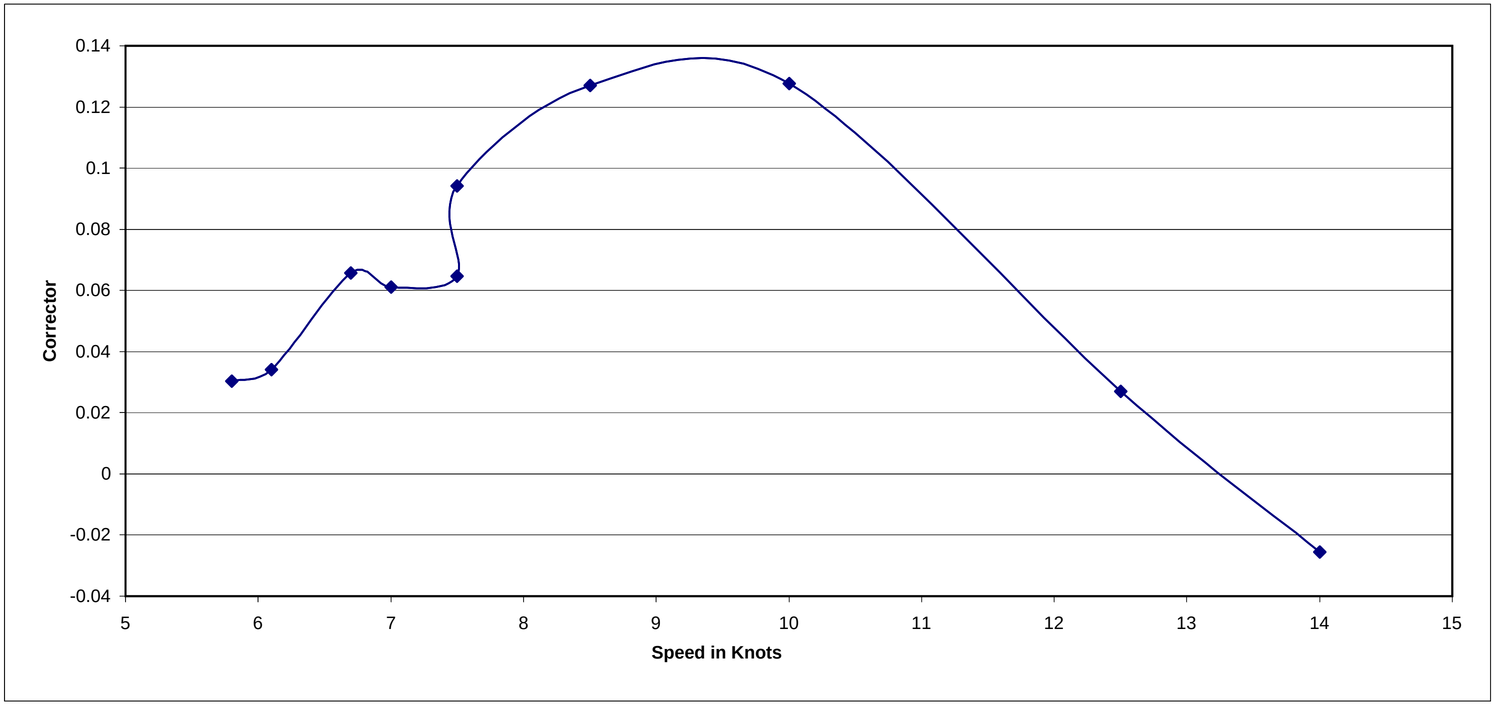
SETTLEMENT & SQUAT DATA COLLECTION FORM

Date	10/5/2004	DN	278	Wind	10 knots	Level S/N	10327 (Zeiss NI-2)
Launch	1010	Location	Ward Cove	Seas	0-2	Rod S/N	A
Average Depth	60 feet			Weather	rain	Measured By	ENS Higgins

Personnel Morgan, Heiner, Froelich, Higgins, Kellner

Comments measurements taken with trim tabs up and ducer up; launch measured with coxin and two personnel on board; rising tide; rain; visibility not ideal

RPM	Speed		Start Rest	1	2	3	4	5	6	7	8	9	10	End Rest	A Rest Average	B Speed Average	B-A Corrector
		Towards	0.570	0.580	0.600	0.610	0.590	0.570	0.630	0.590	0.580	0.575	0.600	0.560			
750	5.8	Away	0.555	0.580	0.590	0.585	0.580	0.575	0.610	0.580	0.570	0.565	0.570	0.540	0.55625	0.5865	0.03025
		Towards	0.545	0.550	0.570	0.565	0.570	0.570	0.565	0.575	0.570	0.555	0.540	0.530			
800	6	Away	0.535	0.540	0.530	0.580	0.565	0.565	0.540	0.580	0.585	0.565	0.550	0.500	0.5275	0.5615	0.034
		Towards	0.495	0.530	0.570	0.560	0.565	0.540	0.565	0.540	0.570	0.575	0.565	0.490			
900	6.7	Away	0.495	0.530	0.580	0.510	0.550	0.540	0.580	0.540	0.610	0.540	0.530	0.475	0.48875	0.5545	0.06575
		Towards	1.050	1.040	1.050	1.100	1.100	1.080	1.110	1.100	1.080	1.080	1.110	1.000			
1000	7	Away	1.010	1.050	1.060	1.040	1.080	1.060	1.040	1.030				0.980	1.01	1.07118	0.061176
		Towards	0.980	1.040	1.030	1.020	1.040	1.040	1.035	1.050	1.030	1.000	1.030	0.950			
1100	7.5	Away	0.945	1.010	1.010	0.990	0.975	1.000	1.020	1.000	1.005	1.020	1.025	0.940	0.95375	1.0185	0.06475
		Towards	0.930	1.020	1.000	0.995	1.010	0.990	0.985	1.010	0.990	1.000	1.000	0.905			
1200	7.5	Away	0.900	0.980	0.970	0.990	0.970	0.990	1.000	0.985	0.995	1.000	0.980	0.860	0.89875	0.993	0.09425
		Towards	0.860	0.980	0.975	0.965	0.950	0.970	0.980	0.970	0.980			0.840			
1400	8.5	Away	0.835	0.930	0.940	0.950	0.960	0.950	0.950					0.800	0.83375	0.96071	0.126964
		Towards	0.790	0.940	0.930	0.900	0.900	0.930	0.920	0.940	0.920	0.910	0.920	0.790			
1600	10	Away	0.790	0.910	0.910	0.900	0.905	0.870	0.900	0.880	0.910	0.850		0.750	0.78	0.90763	0.127632
		Towards	0.590	0.630	0.620	0.620	0.640	0.645	0.620	0.640	0.610	0.590	0.610	0.600			
1800	12.5	Away	0.590	0.540	0.660	0.610	0.590	0.590	0.610	0.630	0.625	0.600	0.610	0.570	0.5875	0.6145	0.027
		Towards	0.680	0.640	0.650	0.660	0.670	0.640	0.640	0.660	0.665	0.670		0.665			
2000	14	Away	0.665	0.630	0.620	0.590	0.580	0.640	0.600					0.640	0.6625	0.637	-0.0255



Speed	Corrector
5.8	0.03025
6.1	0.034
6.7	0.06575
7	0.06118
7.5	0.06475
7.5	0.09425
8.5	0.12696
10	0.12763
12.5	0.027
14	-0.0255

900 RPM with Ducer DOWN

RPM	Speed		Start Rest	1	2	3	4	5	6	7	8	9	10	End Rest	A Rest Average	B Speed Average	B-A Corrector
		Towards	0.440	0.480	0.470	0.450	0.490	0.500	0.470	0.465	0.480	0.485	0.490	0.420	0.430	0.478	0.048
900		Away	0.455	0.510	0.480	0.510	0.500	0.490	0.500	0.510	0.510	0.520	0.510	0.435	0.445	0.504	0.059

900 RPM with Ducer UP

		Towards	0.495	0.530	0.570	0.560	0.565	0.540	0.565	0.540	0.570	0.575	0.565	0.490	0.4925	0.558	0.0655
900	6.7	Away	0.495	0.530	0.580	0.510	0.550	0.540	0.580	0.540	0.610	0.540	0.530	0.475	0.485	0.551	0.066

NOAA POS/MV Calibration Report

Ship: Fairweather
Vessel: 1010
Date: 8/27/2004
Dn: 240

Personnel: Abrams, Wetzler, Sampadian

PCS Serial # 788

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.10d

POS Version (Use Menu View > Statistics) MV320 Ver3

GPS Receivers

Primary Receiver SGN 00160051

Secondary Receiver SGN 00120116

Calibration area

Location: Ketchikan, AK

Approximate Position:

	D	M	S
Lat	55	19	52
Lon	131	37	27

DGPS Beacon Station: Annette Island, AK

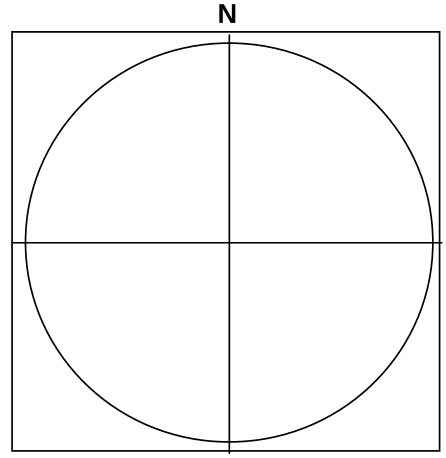
Frequency: 323 kHZ

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

N



HDOP:

VDOP:

Satelites in Use: 8

PDOP (Use View> GAMS Solution)

Note: Secondary GPS satellite constellation and number of satellites were exactly the same as the Primary GPS

POS/MV Configuration

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.839	Two Antenna Separation (m)
0.30	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0	X Component (m)
0	YComponent (m)
0	Z Component (m)

Configuration Notes: ____________________

____

____

POS/MV Calibration

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 14:25

End time: 14:25

Heading accuracy achieved for calibration: 0.237

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
1.841	Two Antenna Separation (m)	**0.004**	X Component (m)
0.300	Heading Calibration Threshold	**1.841**	YComponent (m)
0	Heading Correction	**0.03**	Z Component (m)

GAMS Status Online X

Save Settings X

Calibration Notes: ____________________

____

____

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: POSMV_Settings_082704.nvm

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

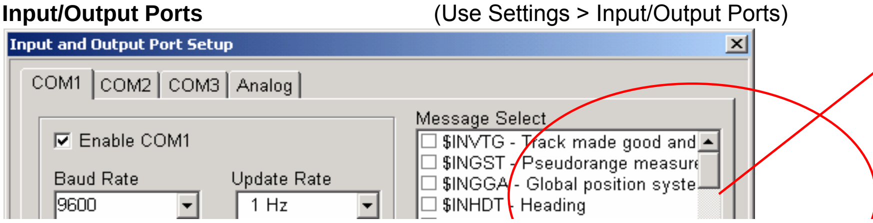
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

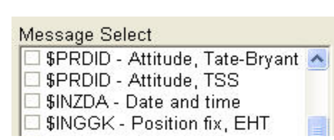
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

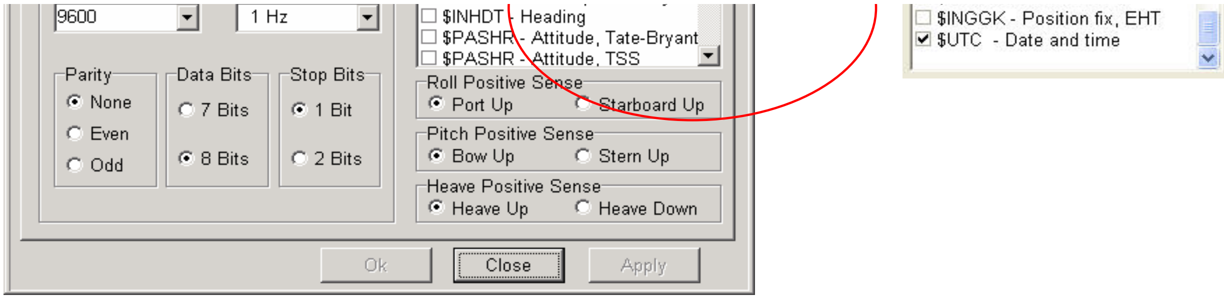
SETTINGS

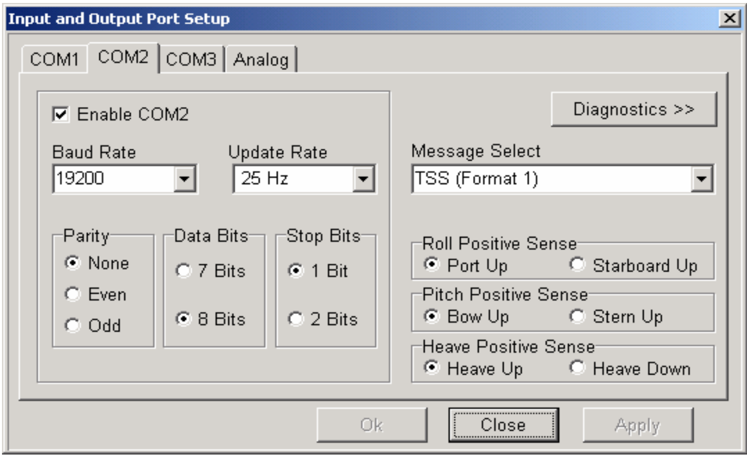
This is not the same as S220 or 1018

Input/Output Ports (Use Settings > Input/Output Ports)



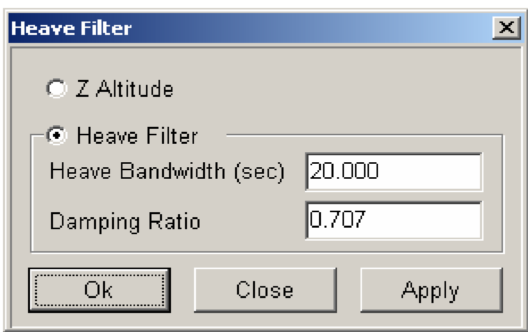




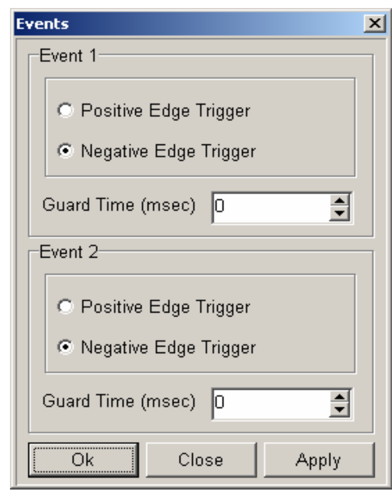


NOTE: COM3 and Analog are not used.

Heave Filter (Use Settings > Heave)

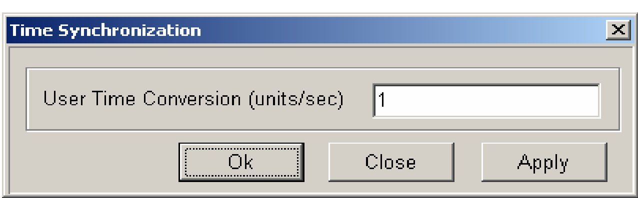


Events (Use Settings > Events)



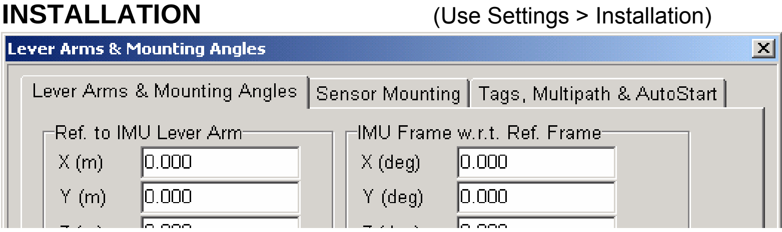
SETTINGS Continued

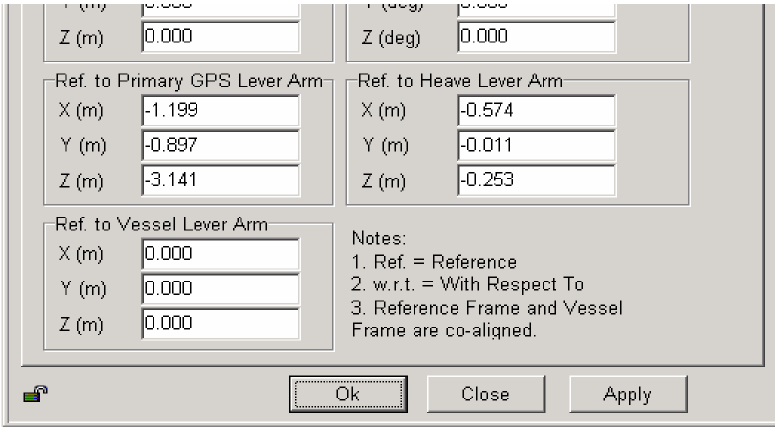
Time Sync (Use Settings > Time Sync)



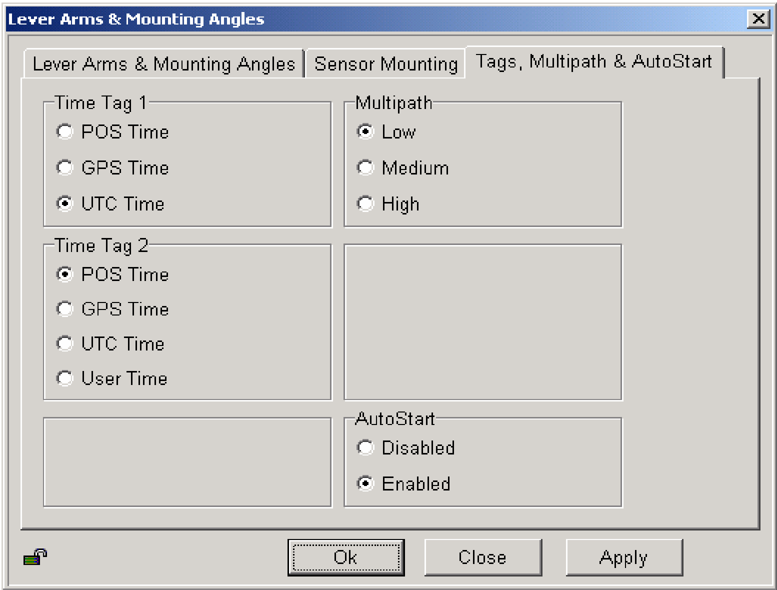
INSTALLATION

(Use Settings > Installation)

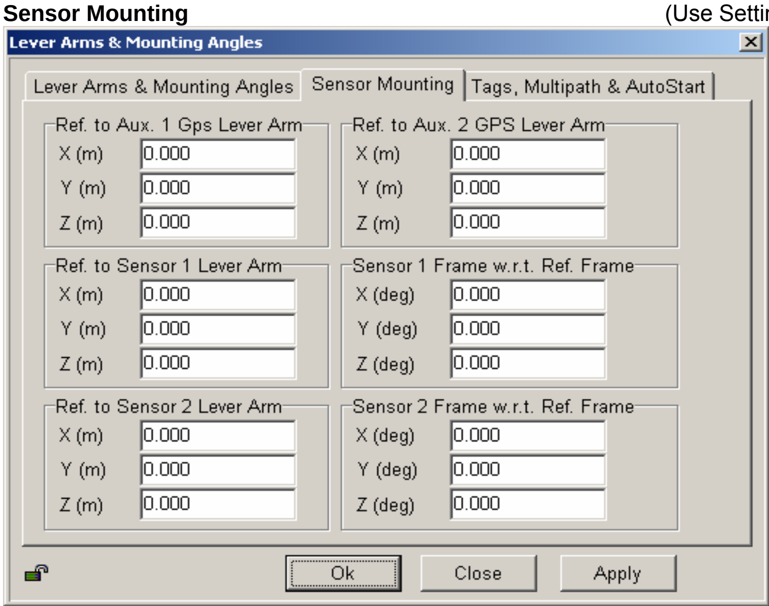




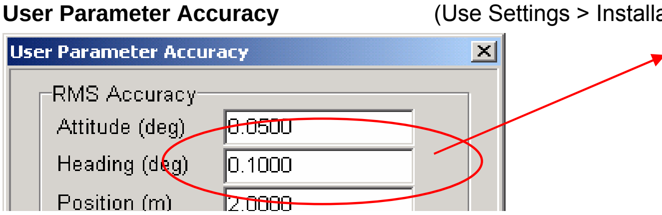
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



Sensor Mounting (Use Settings > Installation > Sensor Mounting)

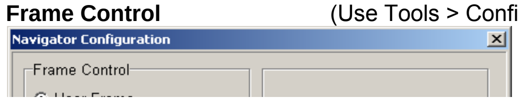


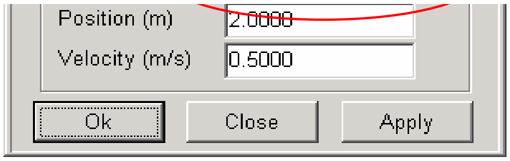
User Parameter Accuracy (Use Settings > Installation > User Accuracy)

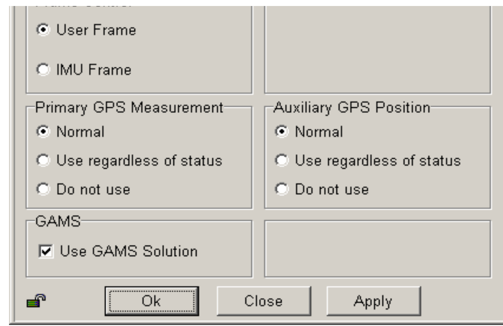


This is not the same as 1018

Frame Control (Use Tools > Config)



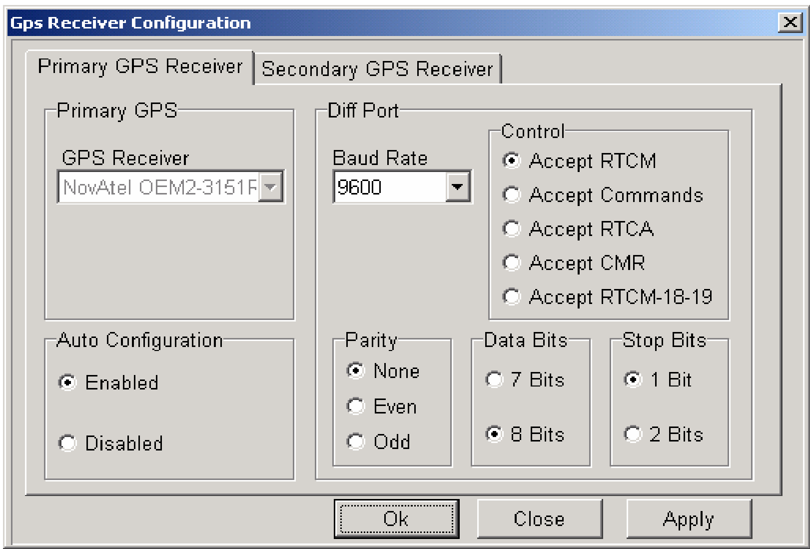




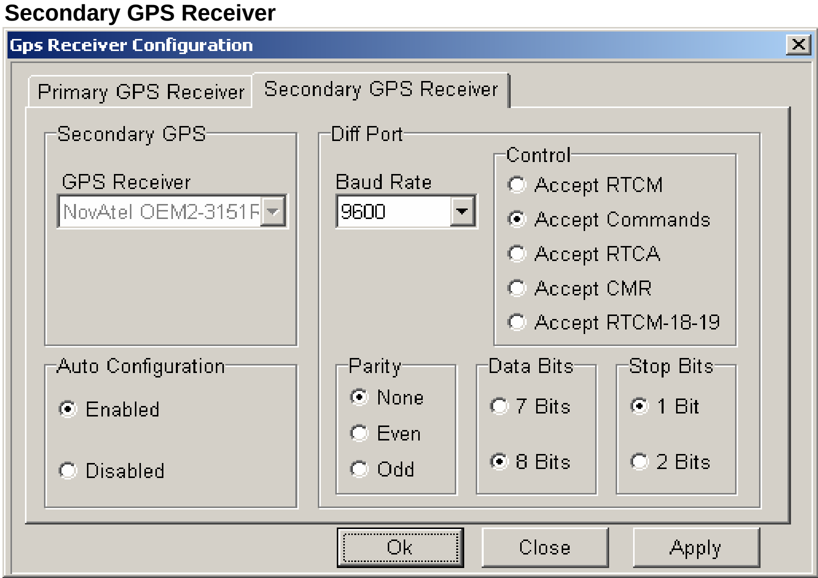
GPS Receiver Configuration

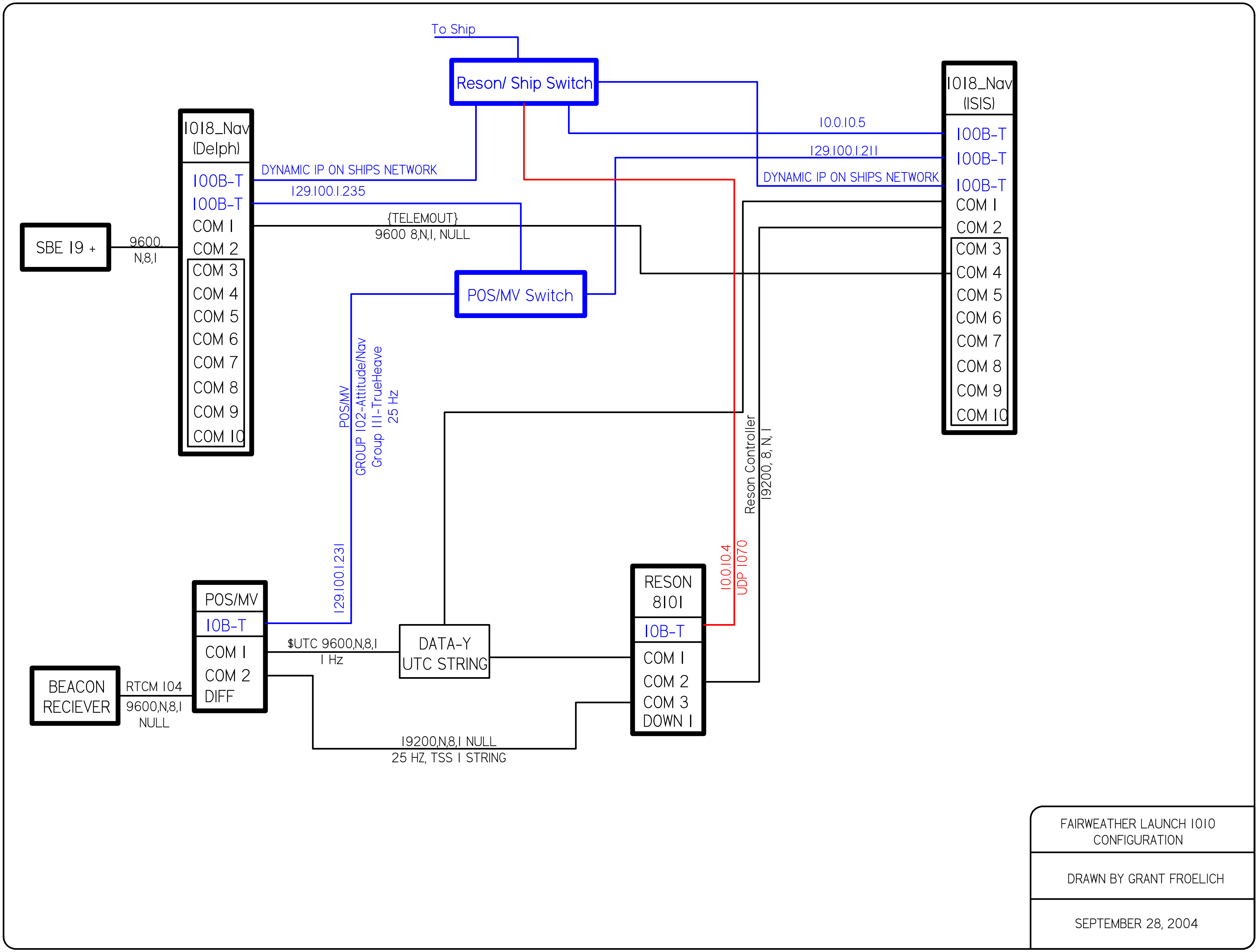
(Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver




To Ship
Reson/ Ship Switch
1018_Nav
(ISIS)
10.0.10.5
129.100.1.211
DYNAMIC IP ON SHIPS NETWORK
100B-T
100B-T
100B-T
COM 1
COM 2
COM 3
COM 4
COM 5
COM 6
COM 7
COM 8
COM 9
COM 10
1018_Nav
(Delph)
DYNAMIC IP ON SHIPS NETWORK
129.100.1.235
100B-T
100B-T
COM 1
COM 2
COM 3
COM 4
COM 5
COM 6
COM 7
COM 8
COM 9
COM 10
SBE 19 +
9600,
N,8,1
{TELEMOUT}
9600 8,N,1, NULL
POS/MV Switch
POS/MV
GROUP 102-Attitude/Nav
Group 111-TrueHeave
25 Hz
129.100.1.231
Reson Controller
19200, 8, N, 1
10.0.10.4
UDP 1070
POS/MV
10B-T
COM 1
COM 2
DIFF
BEACON
RECIEVER
RTCM 104
9600,N,8,1
NULL
$UTC 9600,N,8,1
1 Hz
DATA-Y
UTC STRING
RESON
8101
10B-T
COM 1
COM 2
COM 3
DOWN 1
19200,N,8,1 NULL
25 HZ, TSS 1 STRING
FAIRWEATHER LAUNCH 1010
CONFIGURATION
DRAWN BY GRANT FROELICH
SEPTEMBER 28, 2004

NOAA HYDROGRAPHIC SURVEY LAUNCH 1018
CALIBRATION REPORT 2004

Compiled by: SST Grant Froelich

Background:

NOAA Hydrographic Survey Launch (HSL) 1018 is a high speed, 29' aluminum Jensen survey launch. It is equipped with a Reson 8101 SWMB system mounted on a swing mount to the starboard of the keel and approximately centered fore and aft. The Reson 8101 operates at a frequency of 240 kHz and has a variable ping rate dependant upon depth. The maximum ping rate is user set to 20 Hz. The Reson 8101 has 101 1.5° x 1.5° beams and has an effective range of 120m depth. Multibeam data is collected in XTF format using TEI Isis Sonar v6.6. NOAA HSL 1018 is equipped with an Applanix Position and Orientation system for Marine Vessels (POS MV) 320 Version 3 consisting of a IMU-200 strap-down inertial measurement unit (IMU), a version 2.10d POS computer system (PCS) and two NovAtel GPS antennas. Differential correctors are supplied to the POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver. Sound velocity correctors are obtained by a SeaBird SeaCat SBE 19*plus* sound velocity profiler. NOAA HSL 1018 is also configured with Applanix TrueHeave[1] and "Precise Timing"[2]. Residual biases in sensor misalignment were assessed in CARIS HIPS & SIPS v5.4 (SP 1, HF's 1-7) calibration mode and applied to the HIPS Vessel File (HVF), 1018_8101.HVF. NOAA HSL 1018 is configured with a hydraulic A-frame on the aft quarter for deployment of heavy gear or towing side scan.

Location, Date, Personnel:

Patch Test

Multiple patch tests were attempted with NOAA HSL 1018 in several different locations at the beginning of the 2004 field season. Due to various different mis-

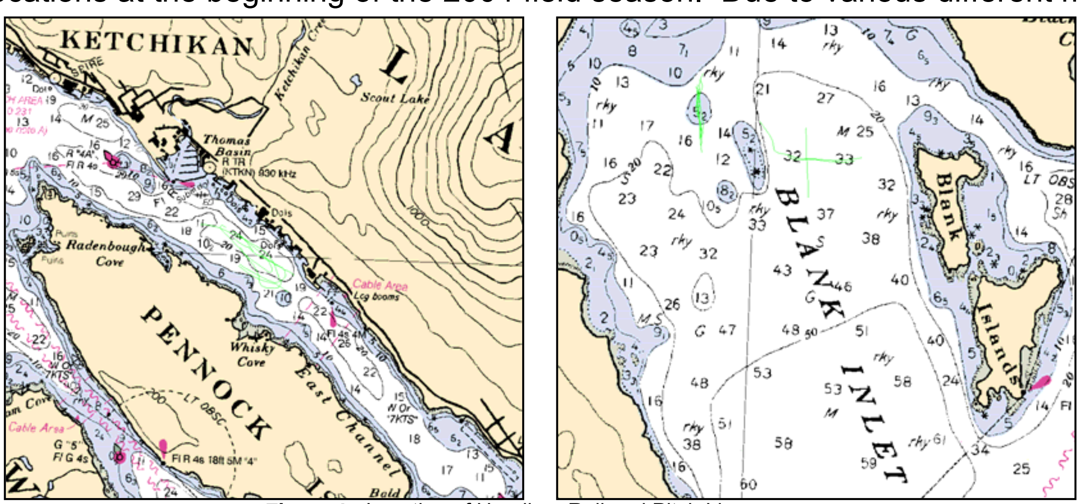


Figure 1. Location of Heading, Roll and Pitch Lines

[1] Applanix web site. http://www.applanix.com. June 2004

[2] Evans, Ben, LTJG, NOAA. Upgrading NOAA Multibeam Acquisition Systems to "Precise Timing". May 2004

entries and mis-configurations, none of these were accepted into the final 1018_8101.HVF. The patch test conducted in the vicinity of Ketchikan, AK in Tongass Narrows and Blank Inlet on September 1st (Dn245) was accepted and processed for residual biases. The heading bias patch was conducted over a wreck lying in an average depth of 42m with a least depth of 24m at 55°19'56.21"N, 131°37'52.09"W. The roll bias patch was conducted over a flat area in approximately 60m of water at location 55°16'50.70"N, 131°40'06.47"W. The pitch bias patch was conducted in the same area on a 10m shoal (see Figure 1). Sound velocity profiles were collected by NOAA HSL 1010, which was acquiring data in the same areas. NOAA HSL 1010's CTD and line was used for the dynamic draft determination after 1010 returned home due to mechanical malfunctions. The patch data was collected by SST Froelich, LT Wetzler, and PS Sampadian. The patch biases were processed by CST Morgan, SST Froelich, LT Wetzler, and PS Sampadian.

Dynamic Draft

Dynamic draft lines were collected at location 55°12'58.36"N, 131°43'24.71"W in approximately 10m of water on September 1st (Dn 245) (see Figure 2). The dynamic draft data was collected by SST Froelich and PS Sampadian. The dynamic draft data was processed using the Dynamic Draft Settlement and Squat Method (DDSSM) by LT Wetzler.

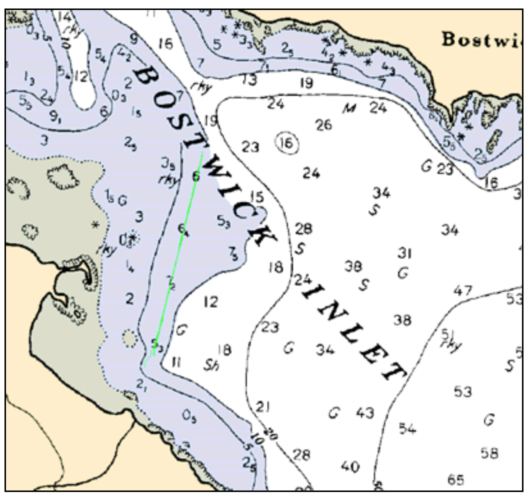


Figure 2. Location of Dynamic Draft

GAMS Calibration

POS MV GPS Azimuth Measurement Subsystem (GAMS) calibration occurred on September 1st (Dn245) in Ketchikan, Alaska. GAMS calibration was performed by SST Froelich, LT Wetzler and PS Sampadian.

Procedure:

All patch test and dynamic draft lines were "lightly" cleaned in CARIS swath mode to remove major data fliers. SVP and observed tides were applied.

Patch

SST Froelich reviewed the patch data twice due to large discrepancies between his initial values and the other reviewers' values. The values found in his second review were used in the consensus values.

Sensor Latency: One line from the dynamic draft or roll patch data was selected for latency biases. It was determined that either dynamic draft or roll data was suitable for sensor latency bias evaluation after examining previous patch test data. Those who chose to look at a dynamic draft line also looked at a roll line for comparison. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Froelich, LT Wetzler and PS Sampadian to determine the bias. Final values entered into 1018_8101.HVF were based on a consensus value between those involved.

Pitch: One pair of coincident lines was run over a shoal of 10m at the same speed in different directions. The lines were run at 7.5 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Froelich, LT Wetzler and PS Sampadian to determine the pitch bias. Final values entered into 1018_8101.HVF were based on a consensus value between those involved.

Roll: One pair of coincident lines was run over a flat area approximately 60m deep at the same speed in different directions. A single cross line was also run perpendicular to the roll lines as a quality check. The lines were run at 5.5 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Froelich, LT Wetzler and PS Sampadian to determine the roll bias. Final values entered into 1018_8101.HVF were based on a consensus value between those involved.

Heading: One pair of parallel lines offset by 130m was run in opposite directions at different speeds over a known target. The lines were run at 4.5 and 7.5 knots. The lines were reviewed in CARIS calibration mode independently by CST Morgan, SST Froelich, LT Wetzler and PS Sampadian to determine the heading bias. Final values entered into 1018_8101.HVF were based on a consensus value between those involved. Errors seen in heading bias may be attributed to the difference in acquisition speeds.

Patch Bias	Bias value
Sensor Latency	0.10 sec
Pitch	-0.70°
Roll	-0.38°
Heading	-0.66°

Table 1. Patch Test Bias Result

The patch test acquisition and processing logs for Dn#245 are located in Appendix III-1018-3.

Dynamic Draft
One line was run nine times in the same direction but at different speeds. Six lines were collected at speeds ranging from 4.7 knots to 14.3 knots at an average depth of 13m. At three points along the line, data was collected with the engine in idle. The lines were reviewed in CARIS by LT Wetzler and statistical comparisons between the speeds and δ draft were made using Microsoft Excel. The dynamic draft, settlement and squat spreadsheet, 1018_DDSSM.xls, is located in Appendix III-1018-4.

Speed (knots)	Delta Draft (m)
0.0	0.000
4.7	0.016
6.4	0.037
8.4	0.052
10.6	0.023
12.3	-0.043
14.3	-0.132

Table 2.Dynamic Draft Results

POS MV GAMS Calibration
The GAMS heading calibration threshold was initially set to 0.300°. There was difficulty in getting the POS MV to switch into Ready Offline mode to begin calibration. After relocating to an area with less traffic and smaller waves, the POS MV switched into Ready Offline mode. NOAA HSL 1018 was maneuvered in "figure 8's" to lower the heading accuracy as much as possible. The best heading accuracy value achieved during this process was 0.099°. The vessel steadied up on a constant heading and GAMS calibration was requested. The vessel maintained the constant heading until the calibration was complete. The POSMV settings were then saved to the file POSMV_ 09012004.nvm (see Table 3).

Component	Value
Baseline Vector X	-0.002 m
Baseline Vector Y	1.831 m
Baseline Vector Z	0.021 m
Two Antenna Separation	1.831 m
Heading Correction	0.000 °

Table 3. POS MV GAMS Calibration Results

The detailed POS/MV Calibration Report, 1018_POS_Calibration_090104.xls, is located in Appendix III-1018-5.

Recommendations:
These patch test, GAMS calibration, and dynamic draft results should be used from September 1st, 2004 (Dn 245) until such a time or event warrants a new calibration.

ADDENDUM 1
NOAA HYDROGRAPHIC SURVEY LAUNCH 1018
PATCH TEST REPORT NOVEMBER 2004
Compiled by: Verena Kellner

Background:
Residual biases for NOAA Hydrographic Survey Launch (HSL) 1018 were assessed in CARIS HIPS & SIPS v5.4 calibration mode and applied to the HIPS Vessel File (HVF), 1018_8101.HVF.

The RESON 8101 for launch 1018 was returned from RESON after repairs were made to the transducer circuit. A new patch test was conducted after the installation of the transducer onto HSL 1018, in order to update the biases in the current HVF.

Location, Date, Personnel:
The patch test was conducted on November 3rd, 2004 (DN 308) in Punchbowl Cove, off of Rudyerd Bay in Alaska. All data were acquired in the vicinity of 55°31'54"N, 130°47'00"W (See Figure 1). LT Wetzler, ENS Higgins, and AST Kellner acquired the patch data. The data was processed in CARIS 5.4 for residual biases by AST Kellner, AST Castle and ENS Higgins.

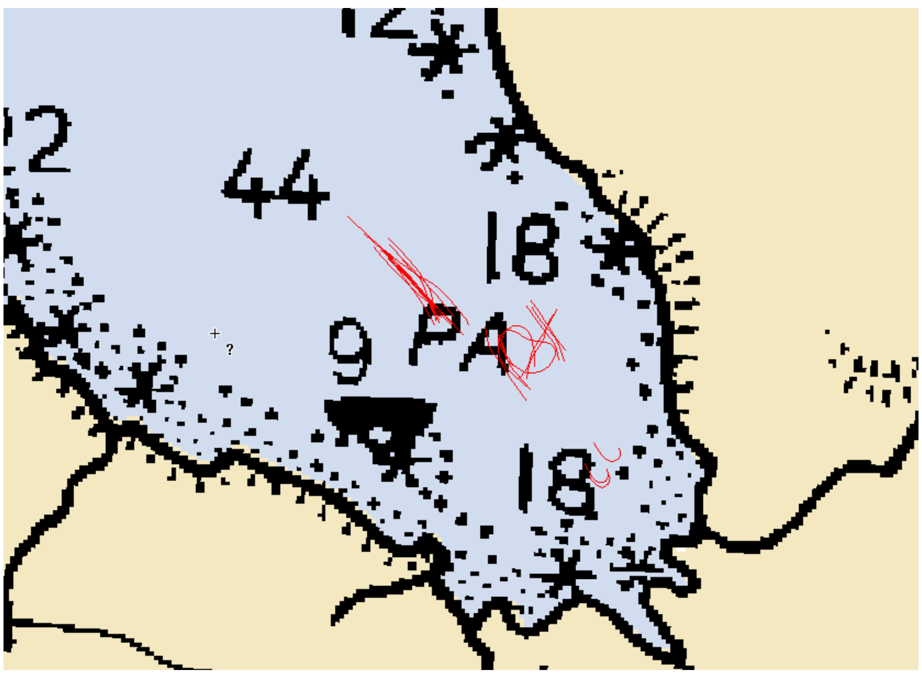


Figure 1: Location of Patch Test Lines in Punchbowl Cove

POS MV GPS Azimuth Measurement Subsystem (GAMS) calibration occurred on November 3rd (Dn308) in Punchbowl Cove, off of Rudyerd Bay in Alaska. GAMS calibration was performed by LT Wetzler, ENS Higgins and AST Kellner.

Dynamic Draft, Settlement & Squat data were not acquired at this time. Correctors from the September 3rd (DN 247) DDSSM data set should continue to be used in the HVF.

Equipment:

Hardware:

1 Reson 8101 Shallow Water Multibeam Echosounder
1 Applanix POS/MV Version 3.20 Strap-Down IMU
2 Novatel GPS Antennas
1 CSI wireless MBX-3S Automatic Differential GPS receiver
1 Seabird Seacat SBE 19*plus* sound velocity profiler

Software:

TEI Isis Sonar v6.6 w/ BathyPro Real Time Bathymetry
CARIS HIPS & SIPS v5.4 SP1, HF's1-12

Procedure:

Patch

All lines: All lines were "lightly" cleaned in CARIS Swath Editor to get rid of major data fliers. SVP and Zero Tides were applied.

Sensor Latency: Sensor latency data were acquired by turning the boat into its own wake while data was acquired, in order to generate roll in the outer beams. The lines were reviewed in CARIS calibration mode independently by SST Abrams, ENS Higgins, and LT Van Waes, in order to determine the bias. Final values entered into 1018_8101.HVF were based on an average value of the individual results. Roll Time (error Sensor Latency) was applied to Nav Time, Gyro Time, Pitch Time, Roll Time, and Heave Time errors in the 1018_8101.HVF.

Pitch: One pair of coincident lines was run over a known rock on a slope at the same speed in different directions. The lines were run at eight knots. The lines were reviewed in CARIS calibration mode independently by SST Abrams, ENS Higgins, and LT Van Waes in order to determine the pitch bias. Final values entered into 1018_8101.HVF were based on an average value of the individual results.

Roll: One pair of coincident lines was run over an area approximately 65m deep at the same speed in different directions. The lines were run at eight knots. The lines were reviewed in CARIS calibration mode independently by SST Abrams, ENS Higgins, and LT Van Waes in order to determine the roll bias. Final values entered into 1018_8101.HVF were based on an average value of the individual results.

Heading: Two parallel lines offset by approximately 100m were run in opposite directions at the same speed over a known rock. The lines were reviewed in CARIS calibration mode independently by SST Abrams, ENS Higgins, and LT

Van Waes, in order to determine the heading bias. Final values entered into 1018_8101.HVF were based on the FOO's evaluation of the data.

The patch test acquisition and processing logs for Dn308 are located in Appendix III-3.

The following table displays the results of this patch test, as well as the previous patch test, conducted in September.

PATCH BIAS	SEPTEMBER BIAS VALUE	NOVEMBER BIAS VALUE
SENSOR LATENCY	0.10 sec	0.00 sec
PITCH	-0.70°	-0.60°
ROLL	-0.38°	0.54°
HEADING	-0.66°	0.00°

Table 1 Patch test bias results

POS MV GAMS Calibration
The GAMS heading calibration threshold was initially set to 0.100°. NOAA HSL 1018 was maneuvered in "figure 8's" to lower the heading accuracy as much as possible. The best heading accuracy value achieved during this process was 0.098°. The vessel steadied up on a constant heading and GAMS calibration was requested. The vessel maintained the constant heading until the calibration was complete. The POSMV settings were then saved to the file POSMV_110304_2.nvm (see Table 2).

Component	Value
Baseline Vector X	-0.002 m
Baseline Vector Y	1.831 m
Baseline Vector Z	0.021 m
Two Antenna Separation	1.831 m
Heading Correction	0.000 °

Table 2. POS MV GAMS Calibration Results

The detailed POS/MV Calibration Report, 1018_POS_Calibration_DN308.xls, is located in Appendix III-5.

Recommendations:
These patch test calibration and GAMS calibration results should be used from November 3rd, 2004 (DN 308) until such a time or event warrants new calibration.

The DDSSM results from September 1st, 2004 (Dn 245) should continue to be used until such a time or event warrants a new test.

```
Vessel Name: 1018_8101.hvf
Vessel created: December 09, 2004


Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2004-218 00:00

      Transduer #1:
      -------------
      Pitch Offset:     -0.700
      Roll Offset:      0.380
      Azimuth Offset:   -0.660

      DeltaX:     0.302
      DeltaY:     -0.164
      DeltaZ:     0.550

      Manufacturer:      Reson
      Model:             sb8101
      Serial Number:     (null)

Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2004-308 00:00

      Transduer #1:
      -------------
      Pitch Offset:     -0.600
      Roll Offset:      0.540
      Azimuth Offset:   0.000

      DeltaX:     0.302
      DeltaY:     -0.164
      DeltaZ:     0.550

      Manufacturer:      Reson
      Model:             sb8101
      Serial Number:
```

```
Navigation Sensor:

      Time Stamp:  2004-218 00:00

      Comments (null)
      Latency 0.100
      DeltaX:     0.000
      DeltaY:     0.000
      DeltaZ:     0.000

      Manufacturer:      Applanix
      Model:             POS/MV v320
      Serial Number:     786
```

Time Stamp: 2004-308 00:00

Comments
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Gyro Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Latency 0.100

Time Stamp: 2004-308 00:00

Comments
Latency 0.000

Heave Sensor:

Time Stamp: 2004-218 00:00

Comments TrueHeave Enabled
Apply Yes
Latency 0.100
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Time Stamp: 2004-308 00:00

Comments TrueHeave Enabled
Apply Yes
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Pitch Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Apply Yes
Latency 0.100
Pitch offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Time Stamp: 2004-308 00:00

Comments
Apply Yes
Latency 0.000
Pitch offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Roll Sensor:

Time Stamp: 2004-218 00:00

Comments (null)
Apply Yes
Latency 0.100
Roll offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Time Stamp: 2004-308 00:00

Comments
Apply Yes
Latency 0.000
Roll offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 786

Draft Sensor:

Time Stamp: 2004-215 00:00

Apply Yes
Comments (null)
Entry 1) Draft: 0.000   Speed: 0.000
Entry 2) Draft: 0.016   Speed: 4.700
Entry 3) Draft: 0.037   Speed: 6.400
Entry 4) Draft: 0.052   Speed: 8.400
Entry 5) Draft: 0.023   Speed: 10.600
Entry 6) Draft: -0.043 Speed: 12.300
Entry 7) Draft: -0.132 Speed: 14.300

TPE

Time Stamp: 2004-218 00:00

Comments Not Finished
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.302
Y Head 1 -0.164
Z Head 1 0.550
Motion sensing unit to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000
Navigation antenna to the transducer 1
X Head 1 1.200
Y Head 1 0.937
Z Head 1 3.719
Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000'' of heave amplitude.
Measurement errors: 0.007
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.500
Surface sound speed measurement error: 0.500
Tide measurement error: 0.010
Tide zoning error: 0.000
Speed over ground measurement error: 0.030
Dynamic loading measurement error: 0.000

Static draft measurement error: 0.050
Delta draft measurement error: 0.010

Svp Sensor:

Time Stamp: 2004-218 00:00

Comments
Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.302
DeltaY: -0.164
DeltaZ: 0.550

WaterLine:

Time Stamp: 2004-218 00:00

Comments (null)
Apply Yes
WaterLine -0.340
WaterLineStdDev 0.000

Summary of Measurements

Measurement Coord. Sys.	IMU to RP* Caris	8101 to RP* Caris	IMU to 8101 Caris	Port Ant to 8101 Caris	RP* to Waterline Caris	IMU to Port Ant Caris	IMU to Port Ant Pos/Mv	IMU to Heave Caris	IMU to Heave Pos/Mv	Port Ant to Stbd Ant
x	0.000	0.302	0.302	1.200	n/a	-0.898	-1.101	0.015	-0.574	Scaler Distance 1.834
y	0.000	-0.164	-0.164	0.937	n/a	-1.101	-0.898	-0.574	0.015	
z	0.000	0.55	0.55	3.719	-0.34	-3.169	-3.169	-0.315	-0.315	

*RP is Reference Point

Vessel Offsets for 1018_8101 are derived from the Horizontal, Vertical & XYZ worksheets in this spreadsheet.

Calculations

Coord. Sys. **Theodolite**

8101 to RP*

IMU to 8101

IMU (m)	x	3.546
	y	-0.015
	z	-0.859
8101	x	3.382
(Phase Cntr)	y	0.287
(m)	z	-1.409

Port Ant to 8101

Port Ant (m)	x	2.445
	y	-0.913
	z	2.310
8101	x	3.382
(Phase Cntr)	y	0.287
(m)	z	-1.409

RP to Waterline

IMU (m)	x	3.546
	y	-0.015
	z	-0.859
BM A	x	-0.003
	y	-1.413
	z	0.299
BM A to IMU	x	n/a
	y	n/a
	z	1.158
BM B to Waterline (m) measured scalar dist		0.818

IMU to Port Ant

IMU (m)	x	3.546
	y	-0.015
	z	-0.859
Port Ant(m)	x	2.445
	y	-0.913
	z	2.310

IMU to Heave

IMU (m)	y	-0.015
x is n/a	z	-0.859
Heave Pt (m) (centerline)	y	0.000
BM B to Waterline (m) measured scalar dist		0.82
BM B x&y are n/a	z	0.276
BM C to Waterline (m) (Heave Pt)	z	-0.544
IMU to Hv Location - from RA DAPR	x	-0.574

Port Ant to Stbd Ant

Port Ant (m)	x	2.445
	y	-0.913
	z	2.31
Stbd Ant (m)	x	2.445
	y	0.921
	z	2.31

see
Coord. Sys. **Theodolite**

	IMU to 8101	Port Ant to 8101	RP to Waterline	IMU to Port Ant	IMU to Heave	Port Ant to Stbd Ant
x	-0.164	0.937	n/a	-1.101	-0.574	
y	0.302	1.200	n/a	-0.898	0.015	Scalar Distance 1.834
z	-0.550	-3.719	0.340	3.169	0.315	

	Coord. Sys. CARIS (IMU to 8101)	Coord. Sys. CARIS (Port Ant to 8101)	Coord. Sys. CARIS (RP to Waterline)	Coord. Sys. Pos/Mv (IMU to Port Ant)	Coord. Sys. Pos/Mv (IMU to Heave)
x	0.302	1.200	n/a	-1.101	-0.574
y	-0.164	0.937	n/a	-0.898	0.015
z	0.550	3.719	-0.340	-3.169	-0.315

see Description tab

Horizontal

All offsets are in Theodolite Coordinate System

	BM C	BS	**BM A**	D	m	S	DD	dA	Hd	Vd	**BM A**	
X	0		HA	269	55	40	269.9278		1.412249	-1.000956	X	-0.0018
Y	0		VA	125	19	40	125.3278	-35.32778			Y	-1.4122
Z	0		SDx	1.731							Z	0.2940
			HI	1.385								
			HT	0.09								
	BM L	BS	**BM A**	D	m	S	DD	dA	Hd	Vd	**BM A**	
X	4.8802		HA	196	5	30	196.0917		5.084436	-0.720982	X	-0.0050
Y	-0.00318		VA	98	4	15	98.07083	-8.070833			Y	-1.4125
Z	1.192667		SDx	5.1353							Z	0.3037
			HI	1.431								
			HT	1.599								
	BM F	BS	**BM A**	D	m	S	DD	dA	Hd	Vd	**BM A**	
X	1.8269		HA	217	38	5	217.6347		2.310529	-1.824927	X	-0.0029
Y	-0.0020		VA	128	18	10	128.3028	-38.30278			Y	-1.4129
Z	2.0543		SDx	2.9443							Z	0.3004
			HI	1.673								
			HT	1.602								
	BM C	BS	**BM B**	D	m	S	DD	dA	Hd	Vd	**BM B**	
X	0		HA	90	6	50	90.11389		1.408507	-1.02162	X	-0.0028
Y	0		VA	125	57	15	125.9542	-35.95417			Y	1.4085
Z	0		SDx	1.74							Z	0.2734
			HI	1.385								
			HT	0.09								
	BM F	BS	**BM B**	D	m	S	DD	dA	Hd	Vd	**BM B**	
X	1.8269		HA	142	17	30	142.2917		2.30385	-1.847291	X	0.0042
Y	-0.0020		VA	128	43	25	128.7236	-38.72361			Y	1.4071
Z	2.0543		SDx	2.953							Z	0.2780
			HI	1.673								
			HT	1.602								
	BM L	BS	**BM B**	D	m	S	DD	dA	Hd	Vd	**BM B**	
X	4.8802		HA	163	48	50	163.8139		5.07525	-0.745425	X	0.0061
Y	-0.00318		VA	98	21	20	98.35556	-8.355556			Y	1.4116
Z	1.192667		SDx	5.1297							Z	0.2792
			HI	1.431								

			HT	1.599									
	BM D	BS	**BM C**	D	m	S	DD	dA	Hd	Vd	**BM C**		
X	6.970125		HA	180	0	0	180		6.971795	-0.940903	X	-0.0017	Modified D so C is 0
Y	-0.002655		VA	97	41	10	97.68611	-7.686111			Y	-0.0027	
Z	0.695667		SDx	7.035							Z	0.0108	
			HI	1.451									
			HT	1.195									
	BM F	BS	**BM C**	D	m	S	DD	dA	Hd	Vd	**BM C**		
X	1.8244		HA	180	4	0	180.0667		1.824376	-2.121032	X	0.0000	Modified F so C is 0
Y	0.0021		VA	139	18	0	139.3	-49.3			Y	0.0000	
Z	2.0500		SDx	2.7977							Z	0.0000	
			HI	1.673									
			HT	1.602									
		BS	**BM C**	D	m	S	DD	dA	Hd	Vd	**BM C**		
X	0		HA	0	0	0	0		0	0	X	0.0000	
Y	0		VA	0	0	0	0	90			Y	0.0000	
Z	0		SDx	0							Z	0.0000	
			HI	0									
J			HT	0									
	BM C	BS	**BM D**	D	m	S	DD	dA	Hd	Vd	**BM D**		
X	0		HA	0	0	0	0		6.971868	0.503147	X	6.9719	
Y	0		VA	85	52	20	85.87222	4.127778			Y	0.0000	
Z	0		SDx	6.99							Z	0.6901	
			HI	1.385									
			HT	1.198									
		BS	**BM D**	D	m	S	DD	dA	Hd	Vd	**BM D**		
X	0		HA	0	0	0	0		0	0	X	6.9718	
Y	0		VA	0	0	0	0	90			Y	0.0000	IN BM D BS BM C
Z	0		SDx	0							Z	0.6849	
			HI	0									
			HT	0									
	BM F	BS	**BM D**	D	m	S	DD	dA	Hd	Vd	**BM D**		
X	1.8269		HA	359	58	20	359.9722		5.142666	-1.428201	X	6.9695	
Y	-0.0020		VA	105	31	15	105.5208	-15.52083			Y	-0.0045	
Z	2.0543		SDx	5.3373							Z	0.6971	
			HI	1.673									
			HT	1.602									

	BM L	BS	**BM D**	D	m	S	DD	dA	Hd	Vd	**BM D**	
X	4.8802		HA	359	59	50	359.9972		2.085613	-1.839614	X	6.9658
Y	-0.00318		VA	131	24	50	131.4139	-41.41389			Y	-0.0033
Z	1.192667		SDx	2.781							Z	0.7021
			HI	1.431								
			HT	0.082								

	BM C	BS	**BM E**	D	m	S	DD	dA	Hd	Vd	**BM E**	
X	0		HA	334	42	5	334.7014		2.016759	1.426038	X	1.8233
Y	0		VA	54	44	10	54.73611	35.26389			Y	-0.8618
Z	0		SDx	2.47							Z	2.0160
			HI	1.385								
			HT	0.795								

	BM D	BS	**BM E**	D	m	S	DD	dA	Hd	Vd	**BM E**	
X	6.970125		HA	189	28	15	189.4708		5.214703	0.66789	X	1.8265
Y	-0.002655		VA	82	42	5	82.70139	7.298611			Y	-0.8607
Z	0.695667		SDx	5.2573							Z	2.0166
			HI	1.451								
			HT	0.798								

	BM L	BS	**BM E**	D	m	S	DD	dA	Hd	Vd	**BM E**	
X	4.8802		HA	195	42	25	195.7069		3.171173	0.192337	X	1.8274
Y	-0.00318		VA	86	31	45	86.52917	3.470833			Y	-0.8617
Z	1.192667		SDx	3.177							Z	2.0220
			HI	1.431								
			HT	0.794								

	BM C	BS	**BM F**	D	m	S	DD	dA	Hd	Vd	**BM F**	
X	0		HA	359	48	40	359.8111		1.823512	1.461634	X	1.8235
Y	0		VA	51	17	10	51.28611	38.71389			Y	-0.0060
Z	0		SDx	2.337							Z	2.0516
			HI	1.385								
			HT	0.795								

	BM D	BS	**BM F**	D	m	S	DD	dA	Hd	Vd	**BM F**	
X	6.970125		HA	180	1	10	180.0194		5.139289	0.704122	X	1.8308
Y	-0.002655		VA	82	11	55	82.19861	7.801389			Y	-0.0044
Z	0.695667		SDx	5.1873							Z	2.0528
			HI	1.451								
			HT	0.798								

	BM L	BS	**BM F**	D	m	S	DD	dA	Hd	Vd	**BM F**	
X	4.8802		HA	179	56	15	179.9375		3.051481	0.228177	X	1.8287
Y	-0.00318		VA	85	43	25	85.72361	4.276389			Y	0.0001
Z	1.192667		SDx	3.06							Z	2.0578
			HI	1.431								
			HT	0.794								

	BM C	BS	**BM G**	D	m	S	DD	dA	Hd	Vd	**BM G**	
X	0		HA	26	44	30	26.74167		2.041987	1.405606	X	1.8236
Y	0		VA	55	27	30	55.45833	34.54167			Y	0.9188
Z	0		SDx	2.479							Z	1.9956
			HI	1.385								
			HT	0.795								
	BM D	BS	**BM G**	D	m	S	DD	dA	Hd	Vd	**BM G**	
X	6.970125		HA	169	49	30	169.825		5.221683	0.647696	X	1.8306
Y	-0.002655		VA	82	55	45	82.92917	7.070833			Y	0.9198
Z	0.695667		SDx	5.2617							Z	1.9964
			HI	1.451								
			HT	0.798								
	BM L	BS	**BM G**	D	m	S	DD	dA	Hd	Vd	**BM G**	
X	4.8802		HA	163	11	15	163.1875		3.185444	0.170427	X	1.8309
Y	-0.00318		VA	86	56	15	86.9375	3.0625			Y	0.9182
Z	1.192667		SDx	3.19							Z	2.0001
			HI	1.431								
			HT	0.794								

	TBM	BS	**BM H**	D	m	S	DD	dA	Hd	Vd	**BM H**	
X	10.0263		HA	179	55	15	179.9208		6.721906	0.035522	X	3.3044
Y	0.4245		VA	89	41	50	89.69722	0.302778			Y	0.4337
Z	-1.8654		SDx	6.722							Z	-1.0239
			HI	0.756								
			HT	-0.05								
	TBM	BS	**BM H**	D	m	S	DD	dA	Hd	Vd	**BM H**	
X	10.0263		HA	179	57	40	179.9611		6.726626	-0.031633	X	3.2996
Y	0.4245		VA	90	16	10	90.26944	-0.269444			Y	0.4290
Z	-1.8654		SDx	6.7267							Z	-1.0231
			HI	0.824								
			HT	-0.05								
	TBM	BS	**BM H**	D	m	S	DD	dA	Hd	Vd	**BM H**	

X	10.0263		HA	179	57	20	179.9556		6.724154	-0.044336	X	3.3021
Y	0.4245		VA	90	22	40	90.37778	-0.377778			Y	0.4297
Z	-1.8654		SDx	6.7243							Z	-1.0098
			HI	0.85								
			HT	-0.05								
	TBM	BS	**BM I**	D	m	S	DD	dA	Hd	Vd	**BM I**	
X	10.0263		HA	179	57	50	179.9639		6.189202	0.034807	X	3.8371
Y	0.4245		VA	89	40	40	89.67778	0.322222			Y	0.4284
Z	-1.8654		SDx	6.1893							Z	-1.0246
			HI	0.756								
			HT	-0.05								
	TBM	BS	**BM I**	D	m	S	DD	dA	Hd	Vd	**BM I**	
X	10.0263		HA	180	1	50	180.0306		6.186227	-0.030142	X	3.8400
Y	0.4245		VA	90	16	45	90.27917	-0.279167			Y	0.4212
Z	-1.8654		SDx	6.1863							Z	-1.0216
			HI	0.824								
			HT	-0.05								
	TBM	BS	**BM I**	D	m	S	DD	dA	Hd	Vd	**BM I**	
X	10.0263		HA	180	0	0	180		6.187145	-0.043795	X	3.8391
Y	0.4245		VA	90	24	20	90.40556	-0.405556			Y	0.4245
Z	-1.8654		SDx	6.1873							Z	-1.0092
			HI	0.85								
			HT	-0.05								
	BM C	BS	**BM J**	D	m	S	DD	dA	Hd	Vd	**BM J**	
X	0		HA	0	5	40	0.094444		3.28806	-0.990463	X	3.2881
Y	0		VA	106	45	50	106.7639	-16.76389			Y	0.0054
Z	0		SDx	3.434							Z	-0.8005
			HI	1.385								
			HT	1.195								
	BM C	BS	**BM J**	D	m	S	DD	dA	Hd	Vd	**BM J**	
X	0		HA	0	3	45	0.0625		3.291776	-0.936134	X	3.2918
Y	0		VA	105	52	30	105.875	-15.875			Y	0.0036
Z	0		SDx	3.4223							Z	-0.7991
			HI	1.372								
			HT	1.235								
	BM C	BS	**BM J**	D	m	S	DD	dA	Hd	Vd	**BM J**	
X	0		HA	0	2	15	0.0375		3.291552	-0.928486	X	3.2916

Y	0		VA	105	45	10	105.7528	-15.75278			Y	0.0022
Z	0		SDx	3.42							Z	-0.8065
			HI	1.36								
			HT	1.238								
	BM C	BS	**BM K**	D	m	S	DD	dA	Hd	Vd	**BM K**	
X	0		HA	2	19	25	2.323611		3.293853	-0.992034	X	3.2911
Y	0		VA	106	45	40	106.7611	-16.76111			Y	0.1335
Z	0		SDx	3.44							Z	-0.8020
			HI	1.385								
			HT	1.195								
	BM C	BS	**BM K**	D	m	S	DD	dA	Hd	Vd	**BM K**	
X	0		HA	2	19	55	2.331944		3.294948	-0.938504	X	3.2922
Y	0		VA	105	53	55	105.8986	-15.89861			Y	0.1341
Z	0		SDx	3.426							Z	-0.8015
			HI	1.372								
			HT	1.235								
	BM C	BS	**BM K**	D	m	S	DD	dA	Hd	Vd	**BM K**	
X	0		HA	2	21	0	2.35		3.293653	-0.92951	X	3.2909
Y	0		VA	105	45	35	105.7597	-15.75972			Y	0.1351
Z	0		SDx	3.4223							Z	-0.8075
			HI	1.36								
			HT	1.238								
	BM C	BS	**BM L**	D	m	S	DD	dA	Hd	Vd	**BM L**	
X	0		HA	359	58	35	359.9764		4.884186	-0.13311	X	4.8842
Y	0		VA	91	33	40	91.56111	-1.561111			Y	-0.0020
Z	0		SDx	4.886							Z	1.1899
			HI	1.385								
			HT	0.062								
	BM D	BS	**BM L**	D	m	S	DD	dA	Hd	Vd	**BM L**	
X	6.970125		HA	180	2	45	180.0458		2.089829	0.115163	X	4.8803
Y	-0.002655		VA	86	50	45	86.84583	3.154167			Y	-0.0043
Z	0.695667		SDx	2.093							Z	1.1938
			HI	1.451								
			HT	1.068								
	BM F	BS	**BM L**	D	m	S	DD	dA	Hd	Vd	**BM L**	
X	1.8269		HA	0	3	10	0.052778		3.052617	-0.926082	X	4.8795
Y	-0.0020		VA	106	52	35	106.8764	-16.87639			Y	0.0008

Z	2.0543		SDx	3.19							Z	1.1993
			HI	1.673								
			HT	1.602								
	BM D	BS	**PORT ANT**	D	m	S	DD	dA	Hd	Vd	**PORT ANT**	
X	0		HA	339	28	10	339.4694		2.610523	1.726867	X	2.4447
Y	0		VA	56	30	55	56.51528	33.48472			Y	-0.9155
Z	0		SDx	3.13							Z	2.3219
			HI	1.385								
			HT	0.79								
	BM D	BS	**PORT ANT**	D	m	S	DD	dA	Hd	Vd	**PORT ANT**	
X	6.970125		HA	191	21	30	191.3583		4.613315	0.970543	X	2.4472
Y	-0.002655		VA	78	7	10	78.11944	11.88056			Y	-0.9112
Z	0.695667		SDx	4.7143							Z	2.3222
			HI	1.451								
			HT	0.795								
	BM L	BS	**PORT ANT**	D	m	S	DD	dA	Hd	Vd	**PORT ANT**	
X	4.8802		HA	200	29	30	200.4917		2.600669	-0.216924	X	2.4441
Y	-0.00318		VA	94	46	5	94.76806	-4.768056			Y	-0.9136
Z	1.192667		SDx	2.6097							Z	2.3247
			HI	1.431								
			HT	0.082								
	BM C	BS	**STBD ANT**	D	m	S	DD	dA	Hd	Vd	**STBD ANT**	
X	0		HA	20	41	20	20.68889		2.60875	1.709557	X	2.4405
Y	0		VA	56	45	45	56.7625	33.2375			Y	0.9217
Z	0		SDx	3.119							Z	2.3046
			HI	1.385								
			HT	0.79								
	BM D	BS	**STBD ANT**	D	m	S	DD	dA	Hd	Vd	**STBD ANT**	
X	6.970125		HA	168	29	0	168.4833		4.617073	0.951015	X	2.4460
Y	-0.002655		VA	78	21	40	78.36111	11.63889			Y	0.9192
Z	0.695667		SDx	4.714							Z	2.3027
			HI	1.451								
			HT	0.795								
	BM L	BS	**STBD ANT**	D	m	S	DD	dA	Hd	Vd	**STBD ANT**	
X	4.884186		HA	159	15	20	159.2556		2.605607	-0.236301	X	2.4475
Y	-0.002013		VA	95	10	55	95.18194	-5.181944			Y	0.9209
Z	1.18989		SDx	2.6163							Z	2.3026

			HI	1.431								
			HT	0.082								
	BM H	BS	**PHASE CENT**	D	m	S	DIRECT MEASUREMENT				**PHASE CENT**	
X	3.302044		HA	N/A	N/A	N/A	0.08				X	3.3820
Y	0.430807		VA	N/A	N/A	N/A	-0.143				Y	0.2878
Z	-1.0485		SDx	N/A			-0.36				Z	-1.4085
			HI	N/A								
			HT	N/A								
	BM H	BS	**PHASE CENT**	D	m	S	DIRECT MEASUREMENT				**PHASE CENT**	
X	3.302044		HA	N/A	N/A	N/A	0.08				X	3.3820
Y	0.430807		VA	N/A	N/A	N/A	-0.145				Y	0.2858
Z	-1.0485		SDx	N/A			-0.36				Z	-1.4085
			HI	N/A								
			HT	N/A								
	BM H	BS	**PHASE CENT**	D	m	S	DIRECT MEASUREMENT				**PHASE CENT**	
X	3.302044		HA	N/A	N/A	N/A	0.08				X	3.3820
Y	0.430807		VA	N/A	N/A	N/A	-0.143				Y	0.2878
Z	-1.0485		SDx	N/A			-0.36				Z	-1.4085
			HI	N/A								
			HT	N/A								
	BM C	BS	**IMU**	D	m	S	DD	dA	Hd	Vd	**IMU**	
X	0		HA	359	45	30	359.7583		3.545118	-1.038158	X	3.5451
Y	0		VA	106	19	20	106.3222	-16.32222			Y	-0.0150
Z	0		SDx	3.694							Z	-0.8482
			HI	1.385								
			HT	1.195								
	BM C	BS	**IMU**	D	m	S	DD	dA	Hd	Vd	**IMU**	
X	0		HA	359	45	55	359.7653		3.5471	-0.98379	X	3.5471
Y	0		VA	105	30	5	105.5014	-15.50139			Y	-0.0145
Z	0		SDx	3.681							Z	-0.8468
			HI	1.372								
			HT	1.235								
	BM C	BS	**IMU**	D	m	S	DD	dA	Hd	Vd	**IMU**	
X	0		HA	359	44	30	359.7417		3.545481	-0.975756	X	3.5454
Y	0		VA	105	23	15	105.3875	-15.3875			Y	-0.0160
Z	0		SDx	3.6773							Z	-0.8538
			HI	1.36								

			HT	1.238									
	BM D	BS	**TBM**	D	m	S	DD	dA	Hd	Vd	**TBM**		
X	6.970125		HA	7	55	30	7.925		3.082642	-2.405777	X	10.0233	
Y	-0.002655		VA	127	58	10	127.9694	-37.96944			Y	0.4224	
Z	0.695667		SDx	3.9103							Z	-1.8641	
			HI	1.451									
			HT	1.605									
	BM L	BS	**TBM**	D	m	S	DD	dA	Hd	Vd	**TBM**		
X	4.8802		HA	4	45	40	4.761111		5.161378	-2.88509	X	10.0238	
Y	-0.00318		VA	119	12	15	119.2042	-29.20417			Y	0.4252	
Z	1.192667		SDx	5.913							Z	-1.8664	
			HI	1.431									
			HT	1.605									
	BM F	BS	**TBM**	D	m	S	DD	dA	Hd	Vd	**TBM**		
X	1.8269		HA	2	59	5	2.984722		8.215994	-4.000061	X	10.0317	
Y	-0.0020		VA	115	57	35	115.9597	-25.95972			Y	0.4258	
Z	2.0543		SDx	9.138							Z	-1.8657	
			HI	1.673									
			HT	1.593									

Vertical

All offsets are in Theodolite Coordinate System

		FR						
SETUP 1								
BS	**BM C**		FS		**BM A**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	2.409		2.383	
Mid	2.681	0.023		Mid	2.383	0.026		
Bot	2.657	0.024		Bot	2.357	0.026		
		DTI				DTI		
		1				0		
	BM C	HI	Rod	BM A				
	0	2.680667	2.383	0.297667				
SETUP 2								
BS	**BM C**		FS		**BM A**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	2.409		2.383667	
Mid	2.685	0.023		Mid	2.384	0.025		
Bot	2.661	0.024		Bot	2.358	0.026		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM A			**BM A AVE**	**0.299333**
	0	2.684667	2.383667	0.301			mm DIFF	-3.333333
SETUP 1								
BS	**BM C**		FS		**BM B**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	2.431		2.406333	
Mid	2.681	0.023		Mid	2.406	0.025		
Bot	2.657	0.024		Bot	2.382	0.024		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM B				
	0	2.680667	2.406333	0.274333				
SETUP 2								
BS	**BM C**		FS		**BM B**			
		TI	Ave (HI)			TI	Ave BM El	

Top	2.708		2.684667	Top	2.432		2.407667		
Mid	2.685	0.023		Mid	2.408	0.024			
Bot	2.661	0.024		Bot	2.383	0.025			
		DTI				DTI			
		1				1			
	BM C	HI	Rod	BM B			**BM B AVE**	**0.275667**	
	0	2.684667	2.407667	0.277			mm DIFF	-2.666667	
SETUP 1									
BS	**BM C**		FS		**BM C**				
		TI	Ave (HI)			TI	Ave BM El		
Top	2.704		2.680667	Top	2.409		2.383		
Mid	2.681	0.023		Mid	2.383	0.026			
Bot	2.657	0.024		Bot	2.357	0.026			
		DTI				DTI			
		1				0			
	BM C	HI	Rod	BM C					
	0	2.680667	2.383	0.297667					
SETUP 2									
BS	**BM C**		FS		**BM C**				0 BY DEFINITION
		TI	Ave (HI)			TI	Ave BM El		
Top	2.708		2.684667	Top	2.409		2.383667		
Mid	2.685	0.023		Mid	2.384	0.025			
Bot	2.661	0.024		Bot	2.358	0.026			
		DTI				DTI			
		1				1			
	BM C	HI	Rod	BM C					
	0	2.684667	2.383667	0.301			mm DIFF	-0.003333	
SETUP 1									
BS	**BM C**		FS		**BM D**				
		TI	Ave (HI)			TI	Ave BM El		
Top	2.704		2.680667	Top	1.997		1.986667		
Mid	2.681	0.023		Mid	1.986	0.011			
Bot	2.657	0.024		Bot	1.977	0.009			
		DTI				DTI			
		1				2	??		

	BM C	HI	Rod	BM D				
	0	2.680667	1.986667	0.694				
SETUP 2								
BS	**BM C**		FS		**BM D**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	1.997		1.987333	
Mid	2.685	0.023		Mid	1.987	0.01		
Bot	2.661	0.024		Bot	1.978	0.009		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM D			**BM D AVE**	**0.695667**
	0	2.684667	1.987333	0.697333			mm DIFF	-3.333333
SETUP 1								
BS	**BM C**		FS		**BM E**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	0.68		0.664333	
Mid	2.681	0.023		Mid	0.664	0.016		
Bot	2.657	0.024		Bot	0.649	0.015		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM E				
	0	2.680667	0.664333	2.016333				
SETUP 2								
BS	**BM C**		FS		**BM E**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	0.679		0.663667	
Mid	2.685	0.023		Mid	0.663	0.016		
Bot	2.661	0.024		Bot	0.649	0.014		
		DTI				DTI		
		1				2		
	BM C	HI	Rod	BM E			**BM E AVE**	**2.018667**
	0	2.684667	0.663667	2.021			mm DIFF	-4.666667
SETUP 1								
BS	**BM C**		FS		**BM F**			
		TI	Ave (HI)			TI	Ave BM El	

Top	2.704		2.680667	Top	0.643		0.628	
Mid	2.681	0.023		Mid	0.628	0.015		
Bot	2.657	0.024		Bot	0.613	0.015		
		DTI				DTI		
		1				0		
	BM C	HI	Rod	BM F				
	0	2.680667	0.628	2.052667				
SETUP 2								
BS	**BM C**		FS		**BM F**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	0.643		0.628667	
Mid	2.685	0.023		Mid	0.629	0.014		
Bot	2.661	0.024		Bot	0.614	0.015		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM F			**BM F AVE**	**2.054333**
	0	2.684667	0.628667	2.056			mm DIFF	-3.333333
SETUP 1								
BS	**BM C**		FS		**BM G**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	0.699		0.684	
Mid	2.681	0.023		Mid	0.684	0.015		
Bot	2.657	0.024		Bot	0.669	0.015		
		DTI				DTI		
		1				1.11E-13		
	BM C	HI	Rod	BM G				
	0	2.680667	0.684	1.996667				
SETUP 2								
BS	**BM C**		FS		**BM G**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	0.699		0.684667	
Mid	2.685	0.023		Mid	0.685	0.014		
Bot	2.661	0.024		Bot	0.67	0.015		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	BM G			**BM G AVE**	**1.998333**

	0	2.684667	0.684667	2			mm DIFF	-3.333333
SETUP 5								
BS	**TBM**		FS		**BM H**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.506		0.492	Top	-0.058		-0.072333	
Mid	0.492	0.014		Mid	-0.072	0.014		
Bot	0.478	0.014		Bot	-0.087	0.015		
		DTI				DTI		
		0				1		
	TBM	HI	Rod	BM H				
	-1.612667	0.492	-0.072333	-1.048333				
SETUP 6								
BS	**TBM**		FS		**BM H**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.403		0.418	Top	-0.131		-0.146	
Mid	0.418	-0.015		Mid	-0.146	0.015		
Bot	0.433	-0.015		Bot	-0.161	0.015		
		DTI				DTI		
		5.55E-14				2.78E-14		
	TBM	HI	Rod	BM H			**BM H AVE**	**-1.0485**
	-1.612667	0.418	-0.146	-1.048667			mm DIFF	0.333333
SETUP 5								
BS	**TBM**		FS		**BM I**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.506		0.492	Top	-0.06		-0.073667	
Mid	0.492	0.014		Mid	-0.074	0.014		
Bot	0.478	0.014		Bot	-0.087	0.013		
		DTI				DTI		
		0				1		
	TBM	HI	Rod	BM I				
	-1.612667	0.492	-0.073667	-1.047				
SETUP 6								
BS	**TBM**		FS		**BM I**			
		TI	Ave (HI)			TI	Ave BM El	
Top	0.403		0.418	Top	-0.134		-0.147333	

Mid	0.418	-0.015		Mid	-0.147	0.013		
Bot	0.433	-0.015		Bot	-0.161	0.014		
		DTI				DTI		
		5.55E-14				1		
	TBM	HI	Rod	BM I			**BM I AVE**	**-1.047167**
	-1.612667	0.418	-0.147333	-1.047333			mm DIFF	0.333333
SETUP 7								
BS	**BM C**		FS		**BM J**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.068		1.06	Top	1.88		1.871	
Mid	1.06	0.008		Mid	1.871	0.009		
Bot	1.052	0.008		Bot	1.862	0.009		
		DTI				DTI		
		0				0		
	BM C	HI	Rod	BM J				
	0	1.06	1.871	-0.811				
SETUP 8								
BS	**BM C**		FS		**BM J**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.058		1.049	Top	1.865		1.857333	
Mid	1.049	0.009		Mid	1.857	0.008		
Bot	1.04	0.009		Bot	1.85	0.007		
		DTI				DTI		
		2.22E-13				1		
	BM C	HI	Rod	BM J			**BM J AVE**	**-0.809667**
	0	1.049	1.857333	-0.808333			mm DIFF	-2.666667
SETUP 7								
BS	**BM C**		FS		**BM K**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.068		1.06	Top	1.88		1.871	
Mid	1.06	0.008		Mid	1.871	0.009		
Bot	1.052	0.008		Bot	1.862	0.009		
		DTI				DTI		
		0				0		
	BM C	HI	Rod	BM K				

	0	1.06	1.871	-0.811				
SETUP 8								
BS	**BM C**		FS		**BM K**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.058		1.049	Top	1.868		1.859667	
Mid	1.049	0.009		Mid	1.86	0.008		
Bot	1.04	0.009		Bot	1.851	0.009		
		DTI				DTI		
		2.22E-13				1		
	BM C	HI	Rod	BM K			**BM K AVE**	**-0.810833**
	0	1.049	1.859667	-0.810667			mm DIFF	-0.333333
SETUP 3								
BS	**BM C**		FS		**BM L**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.852		1.817333	Top	0.633		0.623667	
Mid	1.818	0.034		Mid	0.624	0.009		
Bot	1.782	0.036		Bot	0.614	0.01		
		DTI				DTI		
		2				1		
	BM C	HI	Rod	BM L				
	0	1.817333	0.623667	1.193667				
SETUP 4								
BS	**BM C**		FS		**BM L**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.851		1.817	Top	0.635		0.625333	
Mid	1.817	0.034		Mid	0.625	0.01		
Bot	1.783	0.034		Bot	0.616	0.009		
		DTI				DTI		
		0				1		
	BM C	HI	Rod	BM L			**BM L AVE**	**1.192667**
	0	1.817	0.625333	1.191667			mm DIFF	2
SETUP 1								
BS	**BM C**		FS		**P ANT**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	0.377		0.364	

Mid	2.681	0.023		Mid	0.364	0.013		
Bot	2.657	0.024		Bot	0.351	0.013		
		DTI				DTI		
		1				0		
	BM C	HI	Rod	P ANT				
	0	2.680667	0.364	2.316667				
SETUP 2								
BS	**BM C**		FS		**P ANT**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	0.394		0.382	
Mid	2.685	0.023		Mid	0.382	0.012		
Bot	2.661	0.024		Bot	0.37	0.012		
		DTI				DTI		
		1				0		
	BM C	HI	Rod	P ANT			**P ANT AVI**	**2.309667**
	0	2.684667	0.382	2.302667			mm DIFF	14
SETUP 1								
BS	**BM C**		FS		**S ANT**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.704		2.680667	Top	0.394		0.381667	
Mid	2.681	0.023		Mid	0.382	0.012		
Bot	2.657	0.024		Bot	0.369	0.013		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	S ANT				
	0	2.680667	0.381667	2.299				
SETUP 2								
BS	**BM C**		FS		**S ANT**			
		TI	Ave (HI)			TI	Ave BM El	
Top	2.708		2.684667	Top	0.376		0.363333	
Mid	2.685	0.023		Mid	0.363	0.013		
Bot	2.661	0.024		Bot	0.351	0.012		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	S ANT			**S ANT AVI**	**2.310167**
	0	2.684667	0.363333	2.321333			mm DIFF	-22.33333

SETUP 7									
BS	**BM C**		FS		**IMU**				
		TI	Ave (HI)			TI	Ave BM El		
Top	1.068		1.06	Top	1.928		1.918		
Mid	1.06	0.008		Mid	1.918	0.01			
Bot	1.052	0.008		Bot	1.908	0.01			
		DTI				DTI			
		0				0			
	BM C	HI	Rod	IMU					
	0	1.06	1.918	-0.858					
SETUP 8									
BS	**BM C**		FS		**IMU**				
		TI	Ave (HI)			TI	Ave BM El		
Top	1.058		1.049	Top	1.918		1.908667		
Mid	1.049	0.009		Mid	1.909	0.009			
Bot	1.04	0.009		Bot	1.899	0.01			
		DTI				DTI			
		2.22E-13				1			
	BM C	HI	Rod	IMU			**IMU AVE**	**-0.858833**	
	0	1.049	1.908667	-0.859667			mm DIFF	1.666667	
SETUP 1									
BS	**BM C**		FS		**PC**				
		TI	Ave (HI)			TI	Ave BM El		
Top	2.704		2.680667	Top	2.409		2.383		
Mid	2.681	0.023		Mid	2.383	0.026			
Bot	2.657	0.024		Bot	2.357	0.026			
		DTI				DTI			
		1				0			
	BM C	HI	Rod	PC					
	0	2.680667	2.383	0.297667					MEASURED
SETUP 2									
BS	**BM C**		FS		**PC**				
		TI	Ave (HI)			TI	Ave BM El		
Top	2.708		2.684667	Top	2.409		2.383667		
Mid	2.685	0.023		Mid	2.384	0.025			

Bot	2.661	0.024		Bot	2.358	0.026		
		DTI				DTI		
		1				1		
	BM C	HI	Rod	PC			**PC AVE**	**0.299333**
	0	2.684667	2.383667	0.301			mm DIFF	-3.333333
SETUP 3								
BS	**BM C**		FS		**TEMP BM**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.852		1.817333	Top	3.448		3.429667	
Mid	1.818	0.034		Mid	3.429	0.019		
Bot	1.782	0.036		Bot	3.412	0.017		
		DTI				DTI		
		2				2		
	BM C	HI	Rod	TEMP BM				
	0	1.817333	3.429667	-1.612333				
SETUP 4								
BS	**BM C**		FS		**TEMP BM**			
		TI	Ave (HI)			TI	Ave BM El	
Top	1.851		1.817	Top	3.449		3.43	
Mid	1.817	0.034		Mid	3.43	0.019		
Bot	1.783	0.034		Bot	3.411	0.019		
		DTI				DTI		
		0				4.44E-13		
	BM C	HI	Rod	TEMP BM			**TEMP BM**	**-1.612667**
	0	1.817	3.43	-1.613			mm DIFF	0.666667

1018 Launch Offset Measurements

Jul-04

All offsets are in Theodolite Coordinate System

The Z plane means were taken using only the vertical level measurements.

BM A

X	-0.00178	-0.005025	-0.002888			Mean	**-0.003231**	0.001649	⇐ X Std Dev
Y	-1.412248	-1.412458	-1.41291				**-1.412539**	0.000338	⇐ Y Std Dev
Z	0.294044	0.303685	0.300406	0.299333			**0.299333**		

BM B

X	-0.0028	0.00421	0.006127			Mean	**0.002512**	0.004699	⇐ X Std Dev
Y	1.408504	1.407088	1.411589				**1.40906**	0.002301	⇐ Y Std Dev
Z	0.27338	0.278042	0.279241	0.275667			**0.275667**		

BM C

X	**0**	**By Definition**
Y	**0**	
Z	**0**	

BM D

X	6.971868	6.971768	6.9671	6.9698		Mean	**6.970125**	0.002251	⇐ X Std Dev
Y	0	0	-0.0085	-0.0021			**-0.002655**	0.004025	⇐ Y Std Dev
Z	0.690147	0.684947	0.6944	0.6993	0.695667		**0.695667**		

BM E

X	1.823338	1.826502	1.827443			Mean	**1.825761**	0.002151	⇐ X Std Dev
Y	-0.861834	-0.860711	-0.86167				**-0.861405**	0.000607	⇐ Y Std Dev
Z	2.016038	2.016557	2.022004	2.018667			**2.018667**		

BM F

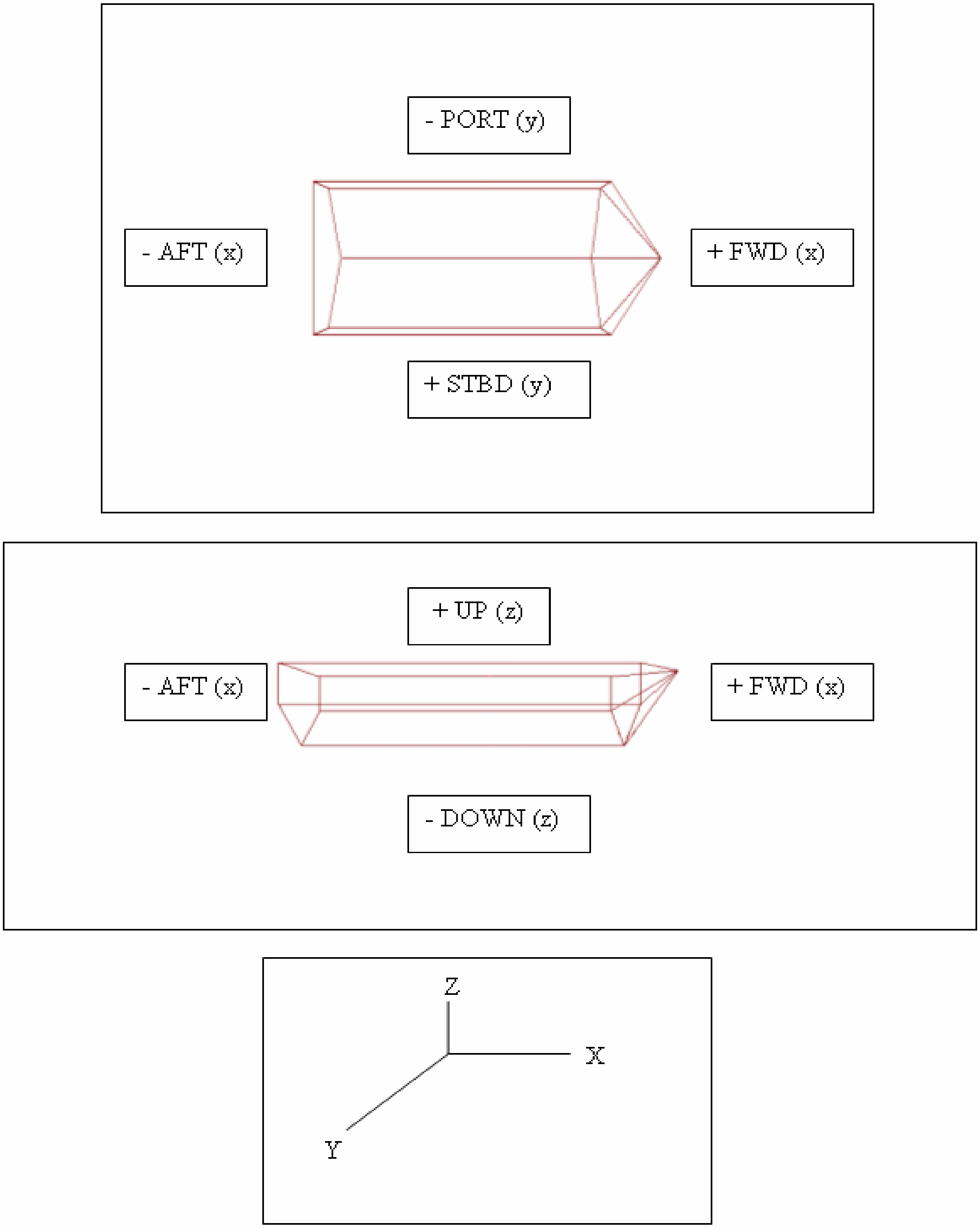
X	1.823502	1.830837	1.828721	1.824402		Mean	**1.826865**	0.003493	⇐ X Std Dev
Y	-0.006012	-0.004399	0.000149	0.002088			**-0.002043**	0.003794	⇐ Y Std Dev
Z	2.051634	2.052789	2.057844	2.050034	2.054333		**2.054333**		

BM G

X	1.823585	1.830565	1.830913		Mean	**1.828354**	0.004134	⇐ X Std Dev
Y	0.91883	0.919783	0.91818			**0.918931**	0.000806	⇐ Y Std Dev
Z	1.995606	1.996363	2.000093	1.998333		**1.998333**		
BM H								
X	3.30437	3.299646	3.302118		Mean	**3.302044**	0.002363	⇐ X Std Dev
Y	0.433739	0.429017	0.429667			**0.430807**	0.002559	⇐ Y Std Dev
Z	-1.023898	-1.023054	-1.009757	-1.0485		**-1.0485**		
BM I								
X	3.8371	3.840044	3.839125		Mean	**3.838746**	0.001523	⇐ X Std Dev
Y	0.4284	0.421152	0.424451			**0.424652**	0.003604	⇐ Y Std Dev
Z	-1.0246	-1.021562	-1.009215	-1.047167		**-1.047167**		
BM J								
X	3.288056	3.291774	3.291551		Mean	**3.29046**	0.002086	⇐ X Std Dev
Y	0.00542	0.003591	0.002154			**0.003722**	0.001637	⇐ Y Std Dev
Z	-0.800463	-0.799134	-0.806486	-0.809667		**-0.809667**		
BM K								
X	3.291145	3.29222	3.290883		Mean	**3.291416**	0.000708	⇐ X Std Dev
Y	0.133544	0.134068	0.135052			**0.134221**	0.000765	⇐ Y Std Dev
Z	-0.802034	-0.801504	-0.80751	-0.810833		**-0.810833**		
BM L								
X	4.884186	4.880297	4.876118		Mean	**4.8802**	0.004035	⇐ X Std Dev
Y	-0.002013	-0.004326	-0.0032			**-0.00318**	0.001157	⇐ Y Std Dev
Z	1.18989	1.193829	1.196552	1.192667		**1.192667**		
S ANT								
X	2.440518	2.446009	2.447502		Mean	**2.444676**	0.003678	⇐ X Std Dev
Y	0.921654	0.919158	0.920894			**0.920569**	0.00128	⇐ Y Std Dev
Z	2.304557	2.302682	2.302589	2.310167		**2.310167**		
P ANT								
X	2.444717	2.447164	2.444094		Mean	**2.445325**	0.001623	⇐ X Std Dev

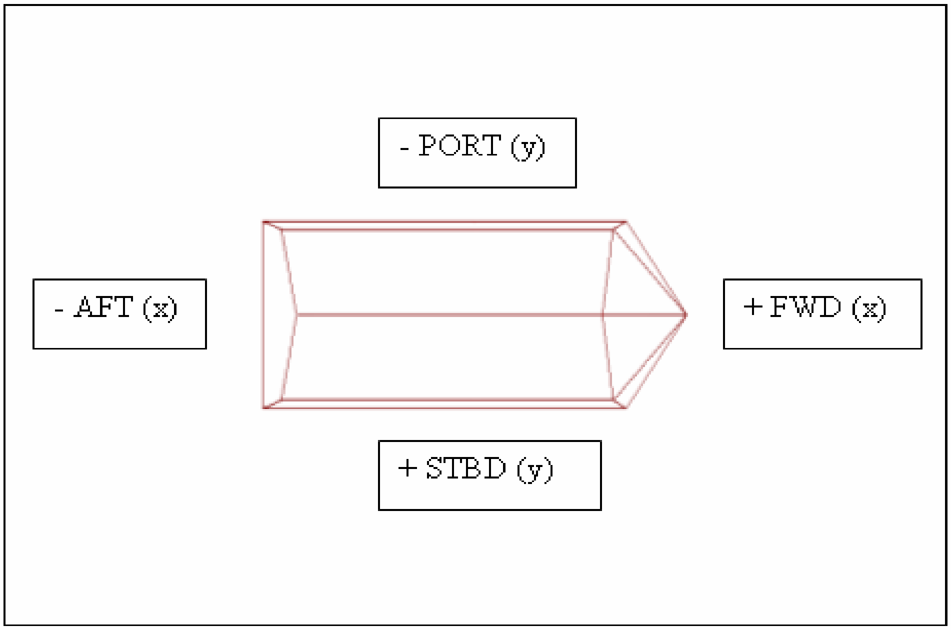
Y	-0.915528	-0.911221	-0.913599			**-0.913449**	0.002157	⇐ Y Std Dev
Z	2.321867	2.322209	2.324743	2.309667		**2.309667**		
IMU								
X	3.545087	3.54707	3.545445		**Mean**	**3.545867**	0.001057	⇐ X Std Dev
Y	-0.014953	-0.014531	-0.015986			**-0.015157**	0.000748	⇐ Y Std Dev
Z	-0.848158	-0.84679	-0.853756	-0.858833		**-0.858833**		
TBM Theo								
X	10.02333	10.02377	10.03171		**Mean**	**10.02627**	0.00472	⇐ X Std Dev
Y	0.42237	0.425222	0.425761			**0.424451**	0.001822	⇐ Y Std Dev
Z	-1.864111	-1.866423	-1.865728	-1.86542		**-1.86542**		
Phase Center								
X	3.382044	3.382044	3.382044		**Mean**	**3.382044**	0	⇐ X Std Dev
Y	0.287807	0.285807	0.287807			**0.287141**	0.001155	⇐ Y Std Dev
Z	-1.4085	-1.4085	-1.4085	-1.4085		**-1.4085**		

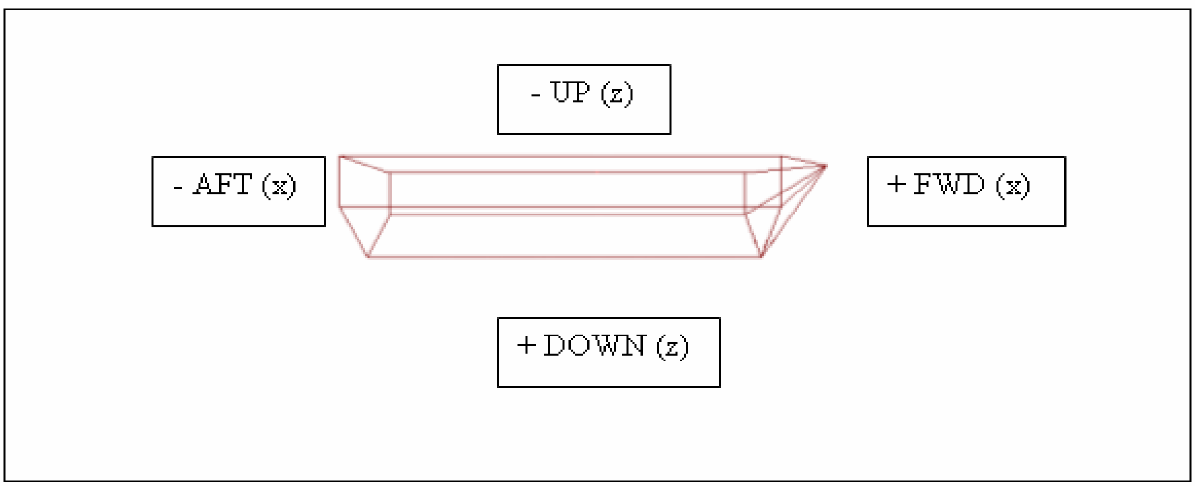
Theodolite Coordinate System

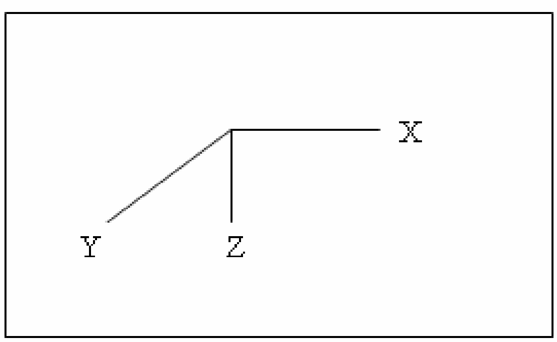


Benchmark C is the origin of the Theodolite Coordinate System

POS/MV Coordinate System

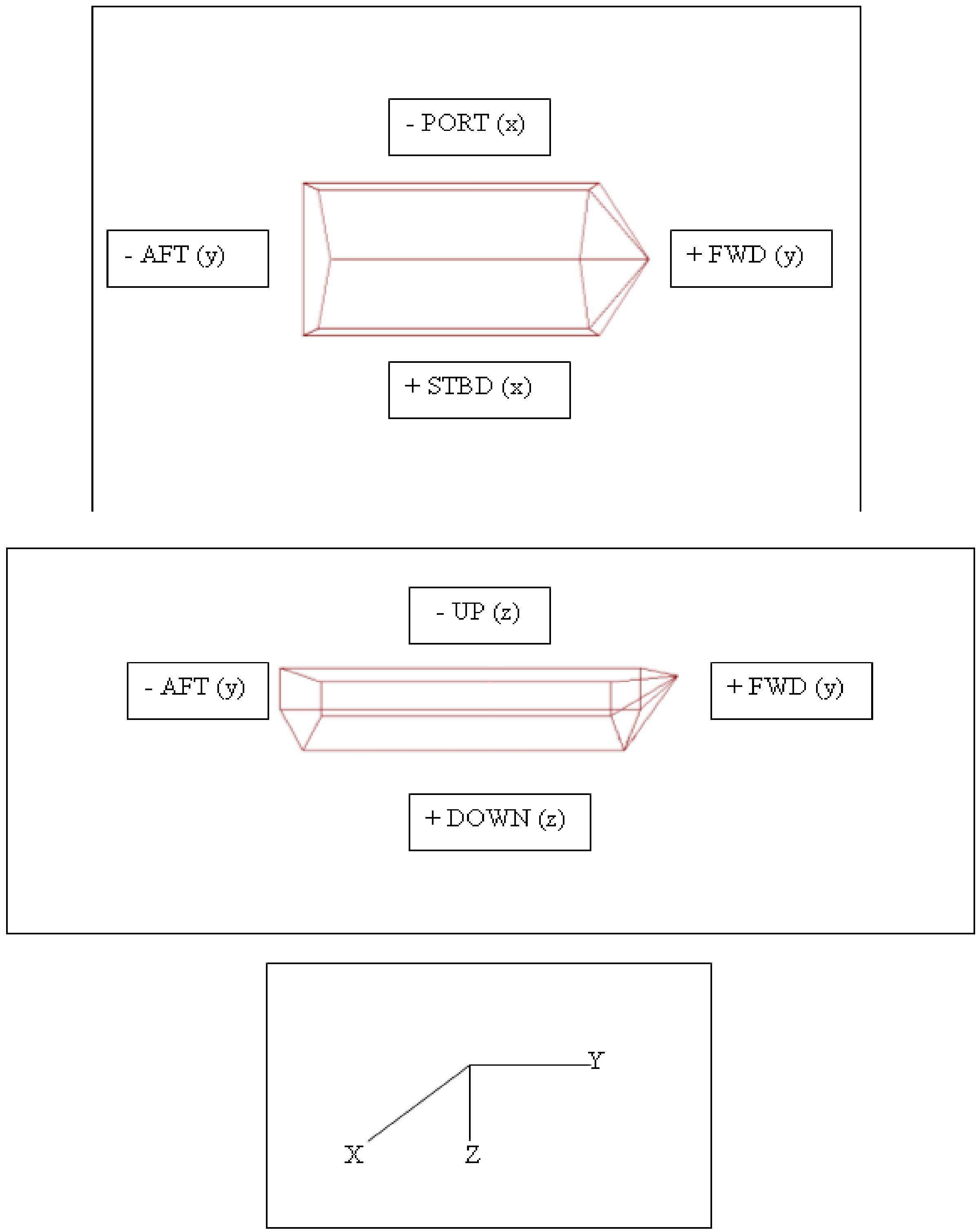






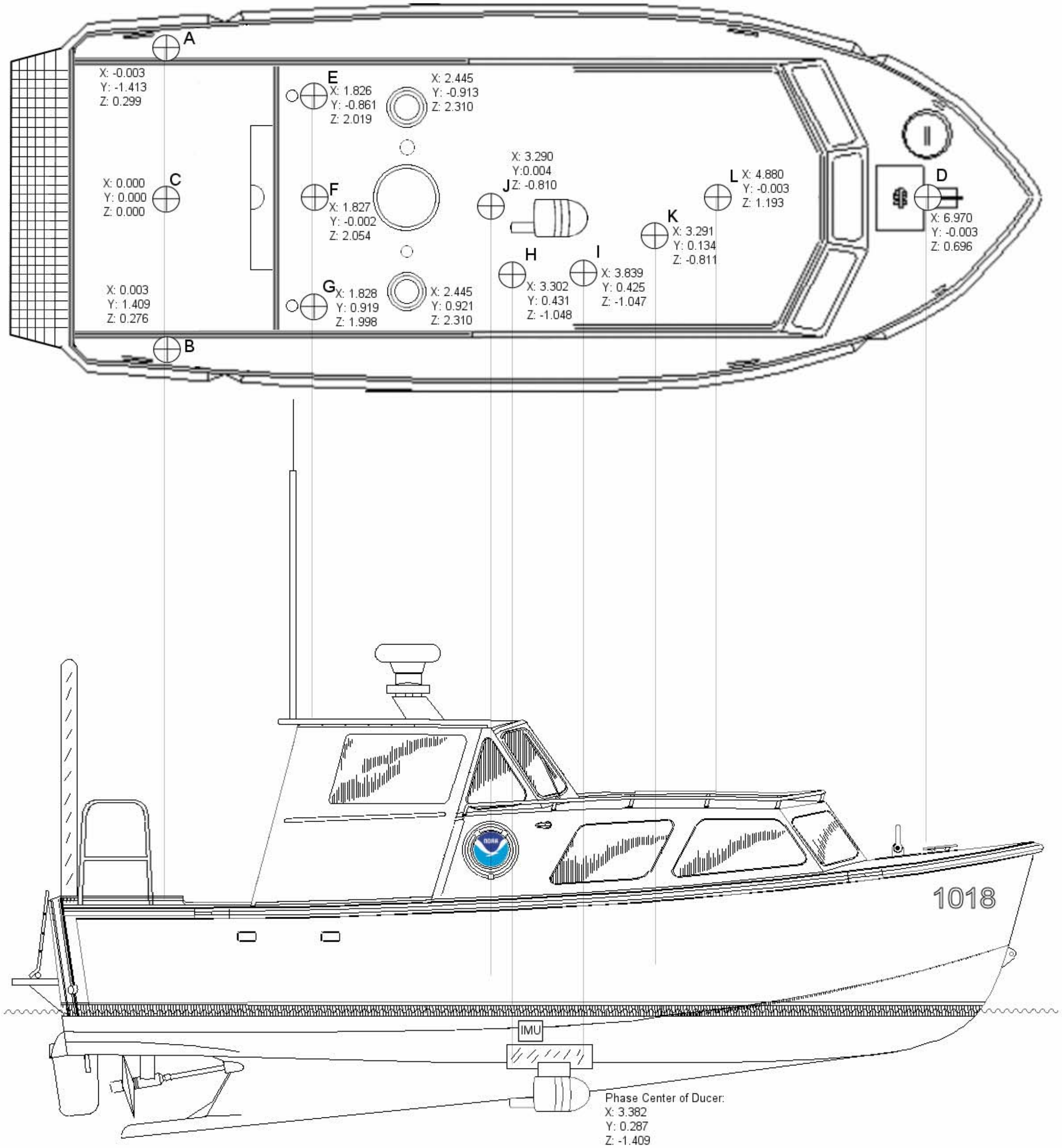
Top Center of IMU is origin of POS/MV Coordinate System

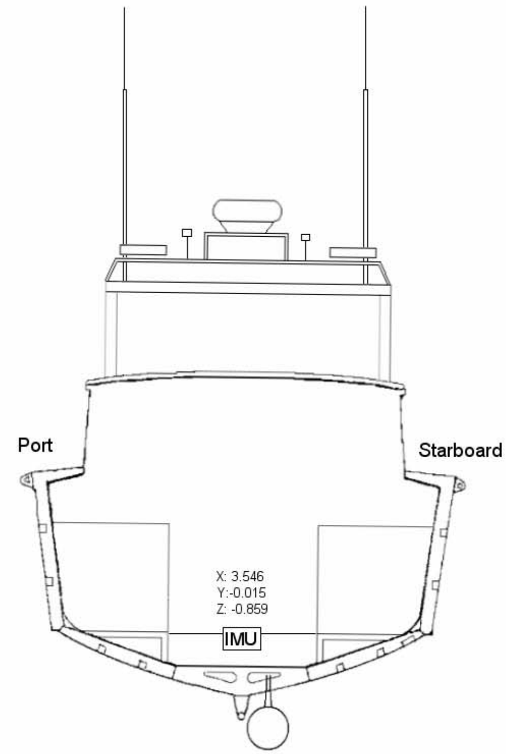
CARIS Coordinate System



Top Center of IMU is origin of CARIS Coordinate System

1018 Vessel Diagram





1018 Offset Measurements

Sources

In general launches require two pieces of information in order to determine their lever arms for CARIS and the POS/MV. The first piece of information is the position of the physical offsets between the multibeam system components and the second is the position of the roll point.

Physical offset information was derived from values measured by ship's personnel with the assistance of Hydrographic Systems and Technology Personnel and Pacific Hydrographic Branch Personnel. The general procedure used is described in the *Measuring Launch Offsets SOP* document contained in Appendix VI-1 of the *2004 FAIRWEATHER Data Acquisition and Processing Report* (hereafter known as the DAPR). The resulting measurements are located in the Appendix III.

The second source of information was from Appendix III of the RAINIER DAPR titled OPR_O112-RA-02. Information about the roll point, center of motion for a vessel, was needed for the 1018 HVF. Roll point values are calculated by conducting an inclination experiment. The FAIRWEATHER had no roll point information since the results of an inclination experiment were not released before or during the field season. For Launch 2123 the heave measurement location (roll point) was 0.574 m aft of the IMU on the centerline and at the waterline. Launch 2123 is very similar to Launch 1018 and its heave measurement location was used in Launch 1018's offset measurements.

Measurements

All measurements were taken after launch 1018 was "leveled" in accordance with the *Measuring Launch Offsets SOP* using Leveling Procedure Method A: Leveling to an Installed IMU. All horizontal measurements were taken 3 times in order to determine a standard deviation. The average standard deviation for horizontal measurements was 2.2 mm.

Vertical measurements were conducted in accordance with the procedures defined in the *Users Guide for the Installation of Bench marks and Leveling Requirements for Water Level Stations* dated October 1987. Vertical measurements were made with a Leica NA2 with a stadia of 100. The level specifications can be found in Appendix I of the DAPR. Each point was measured twice in accordance with the leveling procedure, and the runs between benchmarks were checked for closure. According to *Users Guide for the Installation of Bench marks and Leveling Requirements for Water Level Stations*, the maximum closure tolerance for a single third-order section, one setup, less than 0.1 km in length, is 2 mm. 10 out of 17 vertical measurements exceeded the specification ranging from 4.67 mm to 2.67 mm. These errors in closure, a function of training, were not found before the vessel was placed back in the water. There was not an opportunity to re-level the vessel.

With the exception of one set of measurements, horizontal measurements for lever arm distances were taken using a Sokkia Set 5F. The Sokkia specifications are located in Total Station section of Appendix I. In one instance, over a very short distance (< 0.4 m), the instrument could not be set up to calculate the difference in location. That offset distance was measured with steel tape, plumb bob and carpenter's squares.

Required Measurements

Pos/MV

Measurements required by the IMU are lever arm distances from the IMU, the multibeam transducer, the heave measurement location (roll point), and the primary GPS antenna to the chosen reference point. In the case of launch 1018 the reference point and the IMU are coincident. This simplifies installation. There is also a need for an antenna separation distance.

CARIS

Measurements required by CARIS are transducer to the reference point, IMU to the reference point and waterline to the reference point.

Calculations

The values for the required lever arms are listed in the 1018_Offsets and Measurements spreadsheet. The reference point and the IMU are identical.

As a requirement for the TPE, the standard deviation for each position, in each axis, was stated to be 7 mm.

Pos/MV—IMU to Reference Point

IMU to the Reference Point is zero on all axes since the IMU is chosen to be the origin.

Pos/MV, CARIS—IMU (Reference Point) to Reson 8101

The location of the phase center of the Reson 8101 and the location of the IMU were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The lever arm distance between the phase center of the Reson 8101 and the IMU were then calculated. The measurements and calculations are listed in the 1018 Offsets Measurements spreadsheet in Appendix III.

Pos/MV—Antenna Separation

The location of the phase center of the port and starboard POS/MV antennas were measured by NOAA personnel with respect to the SRF. The scalar distance between the phase centers was then calculated. The measurements and calculations are listed in the 1018 Offsets Measurements spreadsheet in Appendix III.

IMU(Reference Point) to Primary (Port) antenna —Pos/MV

The location of the IMU and the location of the port antenna were measured by NOAA personnel with respect to the Ship Reference Frame (SRF). The lever arm distance between the IMU and the port antenna were then calculated. The measurements and calculations are listed in the 1018 Offsets Measurements spreadsheet in Appendix III.

CARIS—IMU(Reference Point) to Waterline

The vertical distance between the top of the IMU to the waterline was measured by FAIRWEATHER personnel using a steel tape measuring from BM A to the waterline. With the knowledge of BM A's height above the IMU the waterline height above the IMU can be calculated.   The measurements and calculations are listed in the 1018 Offsets Measurements spreadsheet in Appendix III.

Pos/MV—IMU (Reference Point) to Heave

The heave measurement location was positioned differently on the three axes. On the longitudinal axis the distance was determined from the RAINIER DAPR described on paged 1 of this document. The athwart ships axis for the heave measurement location is the vessel centerline. Lastly the height of the heave measurement location was equivalent to the waterline. This waterline value was calculated in the same manner as the above paragraph, though the values are not identical as they were measured on different days. The measurements and calculations are listed in the 1018 Offsets Measurements spreadsheet in Appendix III.

Patch Test Acquisition Log __1018________

(Vessel)

Date: Sept. 1,2004 **DN: 245** **Local Area: Tongass Narrows/Blank Inlet** **Wx: Sunny**

SV Cast #1 filename: 04245103.2	UTC time: 1032	Lat: 55/20/03.32	Lon: 131/38/05.92	Depth: 48	Ext Depth: 62.4
SV Cast #2 filename: 04245125.7	UTC time: 1257	Lat: 55/16/30.31	Lon: 131/39/39.7	Depth: 71.5	Ext Depth: 92.9

Personnel: **Walker, Froelich, Wetzler, Sampadian**
Other Comments: **Use 1010 SVP casts**

ROLL LINES

SV Cast:	**XTF Line Filename:**	**Hdg:**	**Speed (knots):**	**Remarks:**
2	245-2046 (Roll1)	142	5.5	
	245-2052 (Roll2)	252	5.5	
	245-2131 (Roll3)	175	6.8	XL

PITCH LINES

SV Cast:	**XTF Line Filename:**	**Hdg:**	**Speed (knots):**	**Remarks:**
2	245-2059 (Pitch1)	190	7.4	Do Not Use (Logs in water)
	245-2102 (Pitch2)	355	8.0	
	245-2105 (Pitch3)	175	7.5	Do Not Use
	245-2111 (Pitch4)	155	7.5	
	245-2120 (Pitch5)	165	7.0	
	245-2124 (Pitch6)	365	7.5	

HEADING LINES

SV Cast:	**XTF Line Filename:**	**Hdg:**	**Speed (knots):**	**Remarks:**
1	245-1913 (Yaw1)	153	5	Test line- Do not use
	245-1923 (Yaw2)	115	4.9	Perpendicular over wreck
	245-1929 (Yaw3)	295	7.7	“ “ “

Processing Patch Test   1018   245/9-1-04

(Vessel)   (Dn/Date)

X Data Converted → HDCS_Data in CARIS

X True Heave Applied

X Tide Applied   9450460.tid   Observed
Type (Zero, Observed, Verified)

Zoned   ______________
ZDF File

X SVP applied   1010_245.svp
File

X Lines merged

X Data cleaned to remove gross fliers

Compute Correctors – Order

1) Precise Timing   2) Pitch Bias   3) Roll Bias   3) Heading Bias

Do not Enter/Apply Correctors until all evaluations are complete and analyzed.

Patch Test Results/Correctors

Evaluator	Timing (sec)	Pitch (deg)	Roll (deg)	Hdg (deg)
Grant	0.00	0.93	0.43	-0.30
Kim	0.10	-0.70	0.37	-0.54
Mark	0.10	-0.80	0.38	-0.70
Lynn	0.10	-0.54	0.39	-0.66
Grant #2	0.10	-0.72	0.38	-0.68
Final Values	0.10	-0.70	0.38	-0.66

Final Values based on: Consensus

☐ HVF Hydrographic Vessel File created or updated with current offsets
Name: ______________________ Date: ____________________

Patch Test Acquisition Log __1018__________

(Vessel)

Date: Nov. 3 ,2004 **DN: 308** **Local Area: Punchbowl Cove, Rudyerd Bay** **Wx: Rainy**

SV Cast #1 filename: 04308220.5ex	UTC time: 2205	Lat: 55/31/54	Lon: 130/47/00	Depth: 84.7	Ext Depth: 110.1
SV Cast #2 filename:	UTC time:	Lat:	Lon:	Depth:	Ext Depth:

Personnel: Wetzler, Kellner, Higgins
Other Comments:

ROLL LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
	Roll1_1018_308		8	
	Roll2		8	
	Roll3		8	
	Roll4		8	
	Roll5		14	Coming on too line quickly
	Roll6		14	
	Roll7		14	
	Roll8		14	
	Roll9		14	
	Roll10		14	
	Roll11		14	

PITCH LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
2205	Pitch1_1018_308		8	
	Pitch2_1018_308		8	

HEADING LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
2205	Heading1_1018_308		8	
	Heading2_1018_308		8	
	Heading3_1018_308		8	
	Heading4_1018_308		8	
	Heading5_1018_308		8	
	Heading6_1018_308		8	
	Circle_Test		7	

NAV Latency

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
2205	Latency1_1018_308			
	Latency2_1018_308			
	Latency3_1018_308			

Processing Patch Test **1018** **308/11-3-04**

(Vessel) *(Dn/Date)*

X Data Converted → HDCS_Data in CARIS

X True Heave Applied

X Tide Applied Zero Tide
Type (Zero, Observed, Verified)

Zoned
ZDF File

X SVP applied 04308220.5ex
File

X Lines merged

X Data cleaned to remove gross fliers

Compute Correctors – Order

1) Precise Timing 2) Pitch Bias 3) Roll Bias 3) Heading Bias

Do not Enter/Apply Correctors until all evaluations are complete and analyzed.

Patch Test Results/Correctors

Evaluator	Timing (sec)	Pitch (deg)	Roll (deg)	Hdg (deg)
Abigail	0.01	-0.60	0.52	0.12
Jess	0.00	-0.62	0.56	-0.9
Mark Van Waes	0.00	-0.60	0.51	-0.6
Final Values	0.00	-0.60	0.54	0
Final Values based on	Average	Average	Average	FOO

X HVF Hydrographic Vessel File created or updated with current offsets
Name: Mark Wetzler Date: Dn 310

Location 1

Speed	Delta Depth
3.2	0
4.7	0.016255
6.4	0.037244
8.4	0.052051
10.6	0.02324
12.3	-0.0435
14.3	-0.13204

Location 2

Speed	DD2
0	0
4	-0.02113
6	-0.01012
8	0.009358
10	-0.03981
12	-0.11947
14	-0.16339

Location 3

Speed	DD3
0.9	0
4	-0.16615
6	-0.12654
8	-0.11113
10	-0.10011
12	-0.09211
14	-0.08562

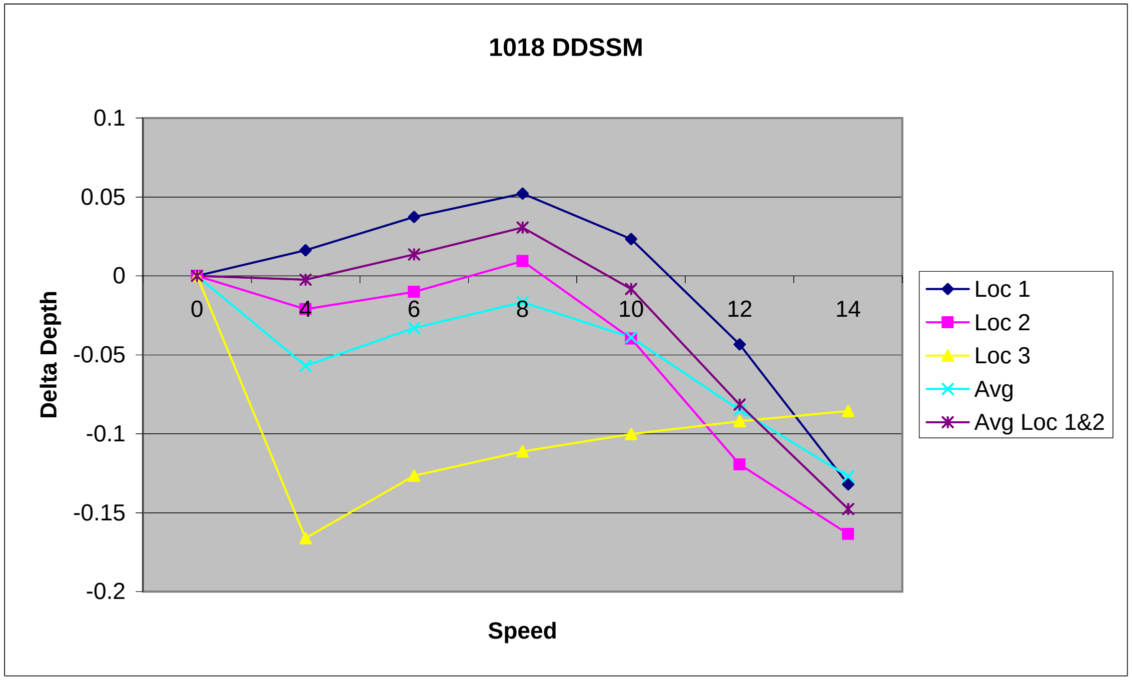
Average

0	0
4	-0.05701
6	-0.03314
8	-0.01657
10	-0.03889
12	-0.08502
14	-0.12702

Average Loc 1 & 2

0	0
4	-0.00244
6	0.013562
8	0.030704
10	-0.00828
12	-0.08148
14	-0.14772

The DDSSM values at location 1 were used in the HVF, the values at this location better represent the motion of launch 1018. Location 3 was completely disregarded after analyzing the data in that area in subset mode in CARIS Hips.



NOAA POS/MV Calibration Report

Ship: Fairweather **Vessel:** 1018

Date: 9/1/2004 **Dn:** 245

Personnel: Froelich, Wetzler, Sampadian

PCS Serial # 786

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.10d

POS Version (Use Menu View > Statistics) MV320 Ver3

GPS Receivers

Primary Receiver SGN 99330009

Secondary Receiver SGN 98370085

Calibration area

Location: Ketchikan, AK

Approximate Position:

	D	M	S
Lat	55	19	46
Lon	131	37	27

DGPS Beacon Station: Annette Island, AK

Frequency: 323 kHZ

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

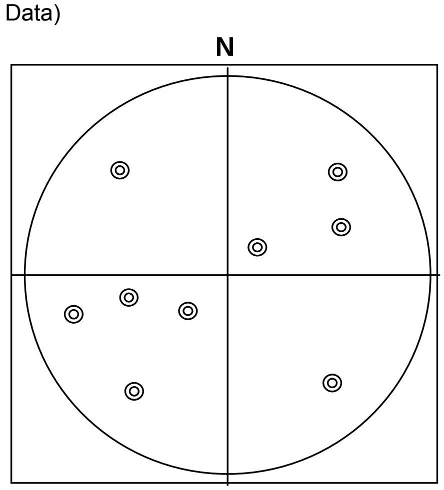
HDOP: 0.873

VDOP: 1.033

Sattelites in Use: 9

1,4,11,13,16,20,23,25,30

PDOP 1.352 (Use View> GAMS Solution)



Note: Secondary GPS satellite constellation and number of satellites were exactly the same as the Primary GPS

POS/MV Configuration

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration		Baseline Vector	
1.834	Two Antenna Separation (m)	**0**	X Component (m)
0.30	Heading Calibration Threshold	**0**	YComponent (m)
0	Heading Correction	**0**	Z Component (m)

Configuration Notes: GAMS needed re-calibration because the leverarm for IMU to Port Antenna was incorrect

POS/MV Calibration

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 10:18

End time: 10:20

Heading accuracy achieved for calibration: 0.099

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
1.831	Two Antenna Separation (m)	**-0.002**	X Component (m)
0.300	Heading Calibration Threshold	**1.831**	YComponent (m)
0	Heading Correction	**0.021**	Z Component (m)

GAMS Status Online X

Save Settings X

Calibration Notes: Took over an hour to get fixed OTF solution and GAMS Ready Offline

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: POSMV_09012004.nvm

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

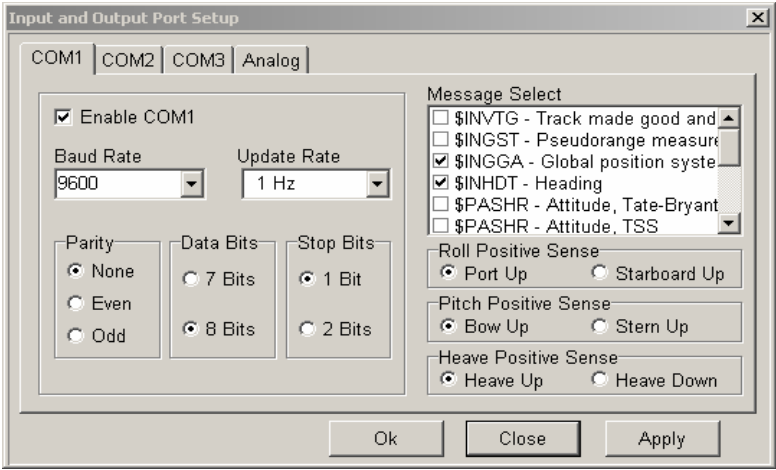
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

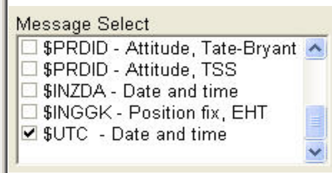
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

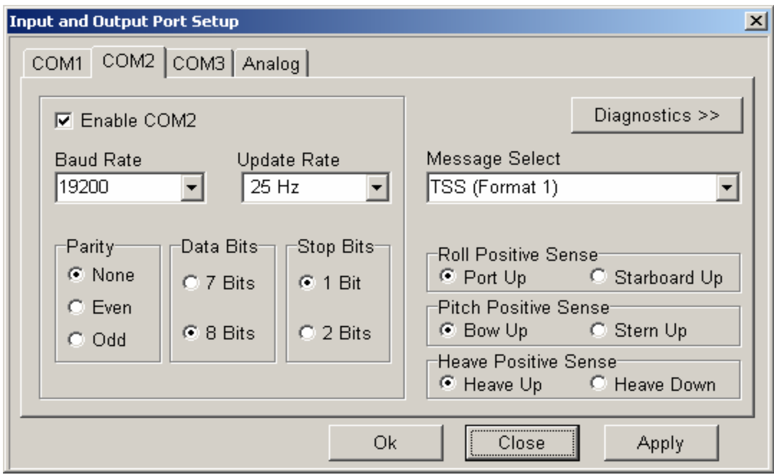
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS

Input/Output Ports (Use Settings > Input/Output Ports)

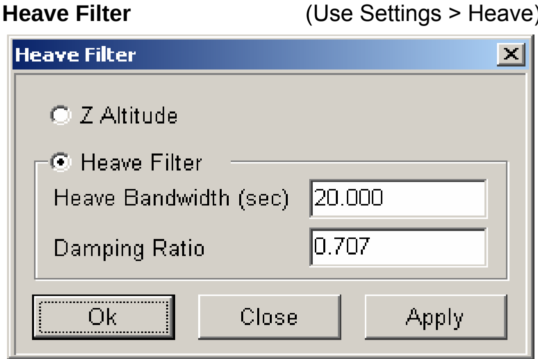




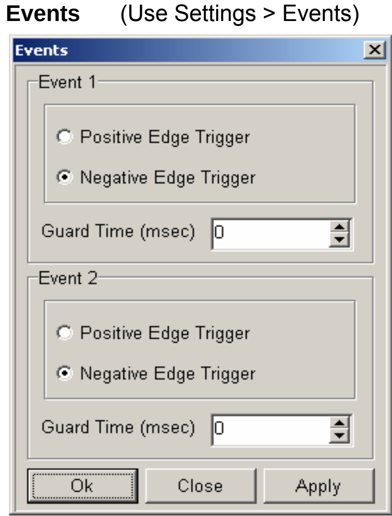


NOTE: COM3 and Analog are not used.

Heave Filter (Use Settings > Heave)

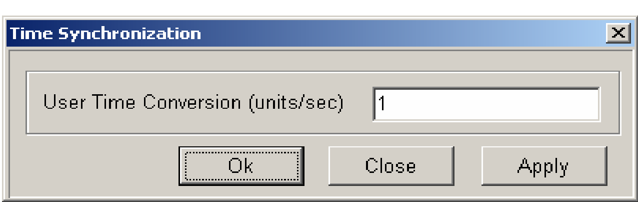


Events (Use Settings > Events)

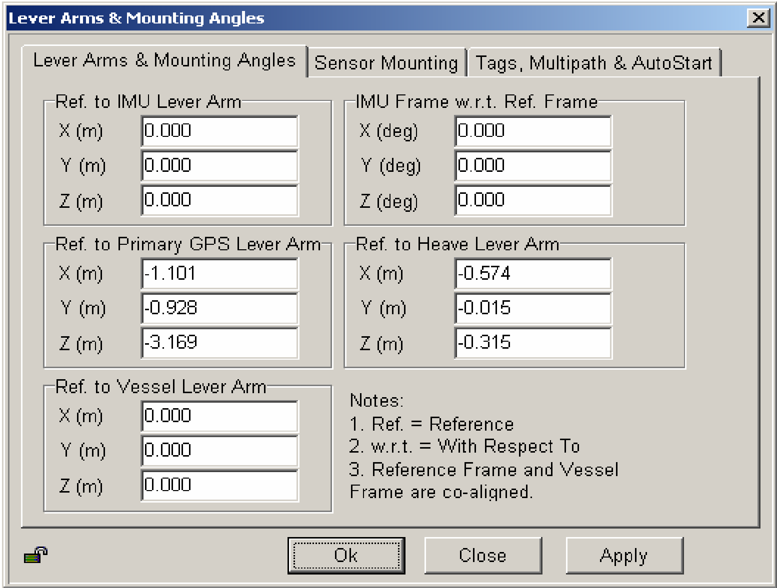


SETTINGS Continued

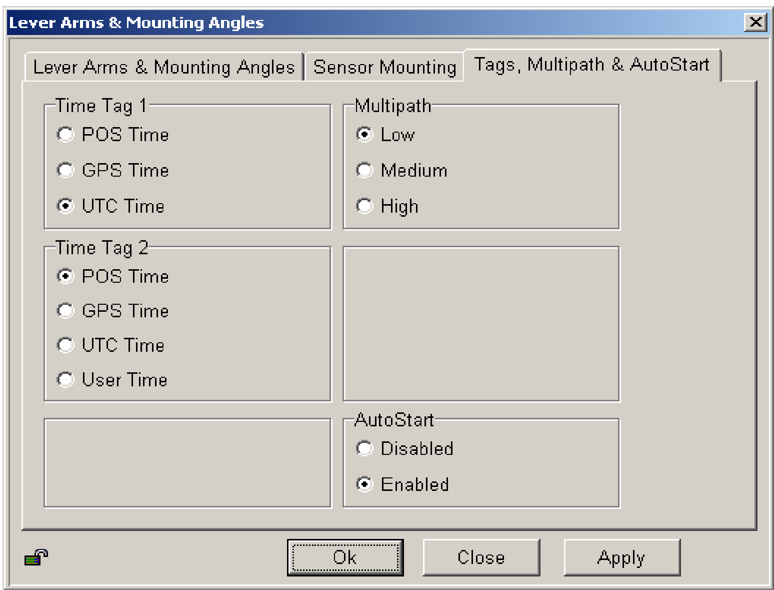
Time Sync (Use Settings > Time Sync)



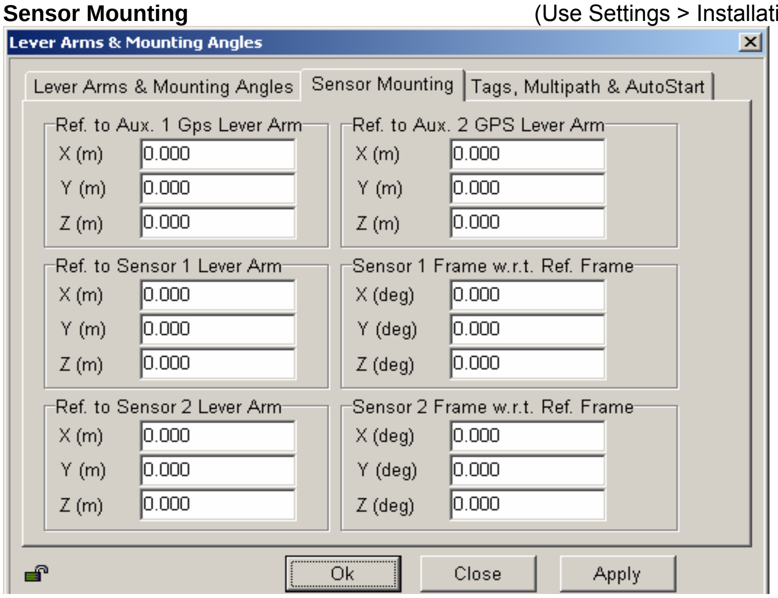
INSTALLATION (Use Settings > Installation)

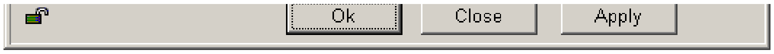


Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)

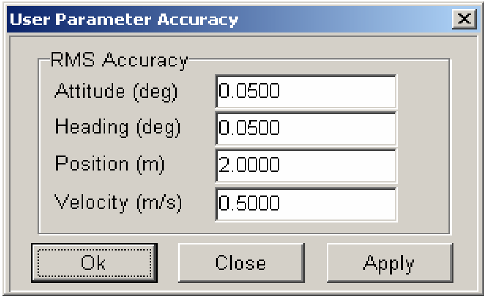


Sensor Mounting (Use Settings > Installation > Sensor Mounting)

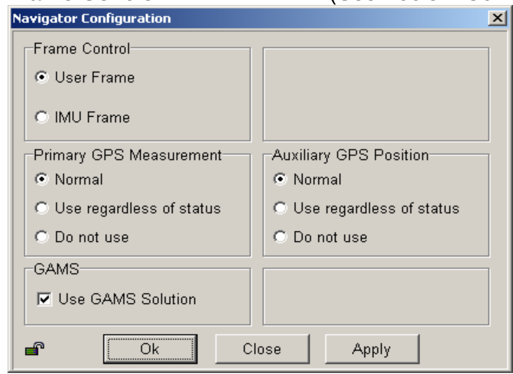




User Parameter Accuracy (Use Settings > Installation > User Accuracy)



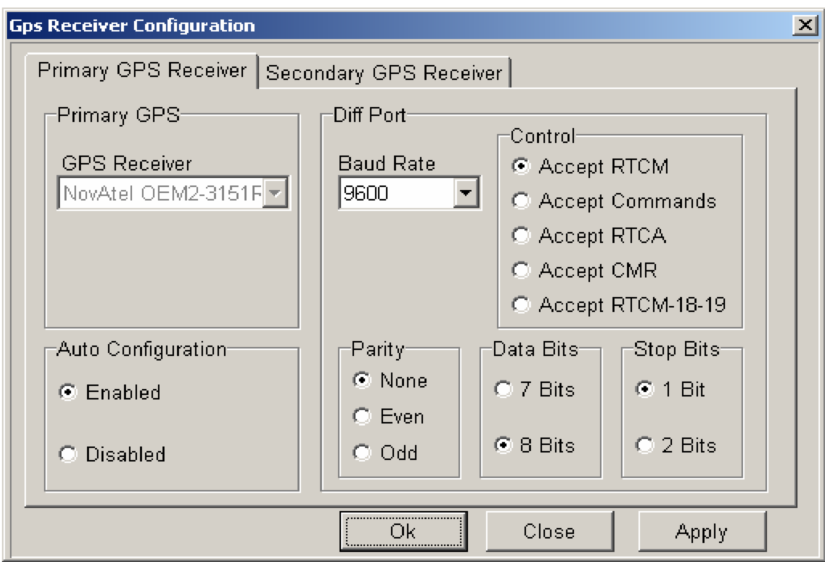
Frame Control (Use Tools > Config)



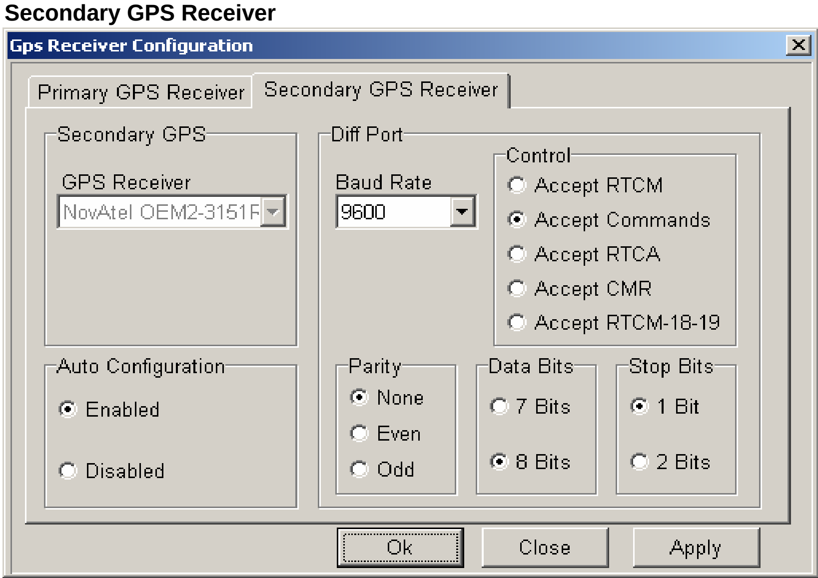
GPS Receiver Configuration

(Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver



NOAA POS/MV Calibration Report

Ship: Fairweather **Vessel:** 1018
Date: 11/3/2004 **Dn:** 308

Personnel: Wetzler, Kellner, Higgins

PCS Serial # 786 **IMU Serial #** 323

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.1

POS Version (Use Menu View > Statistics) MV320 V3

GPS Receivers

Primary Receiver SGN99330009

Secondary Receiver SGN98370085

Calibration area

Location: Punchbowl Cove, Rudyerd Bay, AK

Approximate Position:

	D	M	S
Lat	55	32	25
Lon	130	47	52

DGPS Beacon Station: Annette Island

Frequency: 323 KHz

Satellite Constellation

(Use View> GPS Data)

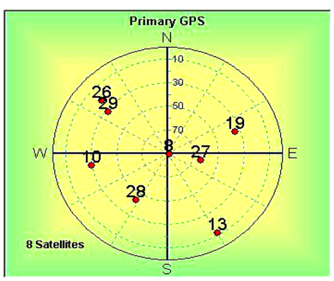
Primary GPS

Primary and secondary GPS satellite configurations are identical.

HDOP 1.01

VDOP 1.033

N



Sattelites in use: 8

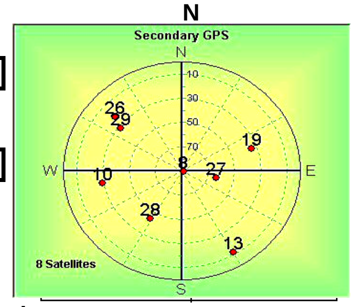
L1 SNR > **45**

Secondary GPS

HDOP 1.01

VDOP 1.033

N



Sattelites in use: 8

L1 SNR : **45**

PDOP 1.352 (Use View> GAMS Solution)

POS/MV Configuration

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.83	Two Antenna Separation (m)
0.3	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0	X Component (m)
0	YComponent (m)
0	Z Component (m)

Configuration Notes:

POS/MV Calibration

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 1056

End time: 1058

Heading accuracy achieved for calibration: 0.098

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
1.83	Two Antenna Separation (m)	**-0.002**	X Component (m)
0.3	Heading Calibration Threshold	**1.831**	YComponent (m)
0	Heading Correction	**0.021**	Z Component (m)

GAMS Status Online X

Save Settings X

Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: 110304_2.nvm

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

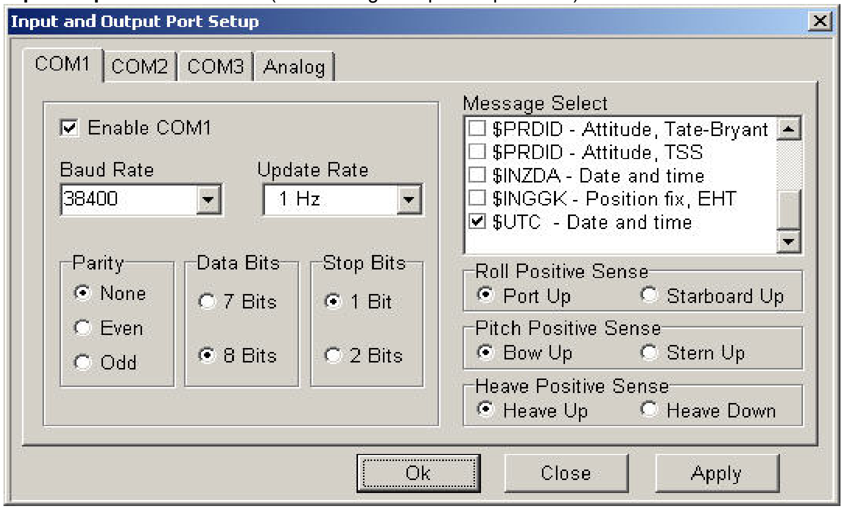
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

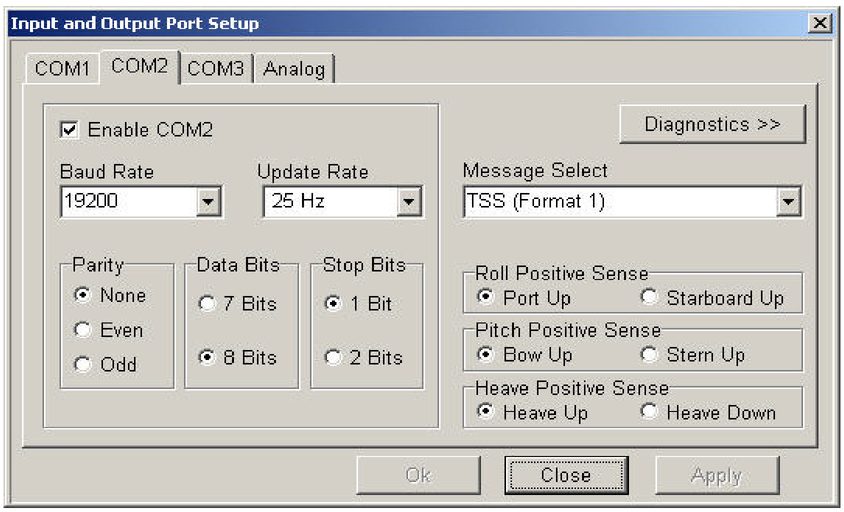
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS

Input/Output Ports (Use Settings > Input/Output Ports)



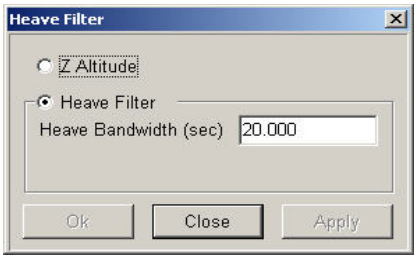
Note: In COM1, only the UTC string is selected

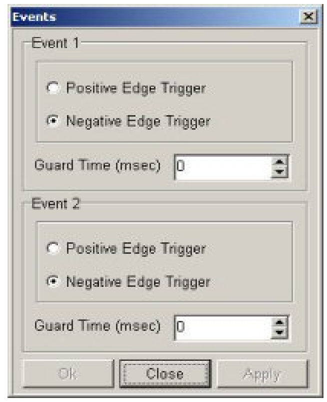


Note: COM3 and Analog are not used

SETTINGS Continued

Heave Filter (Use Settings > Heave)

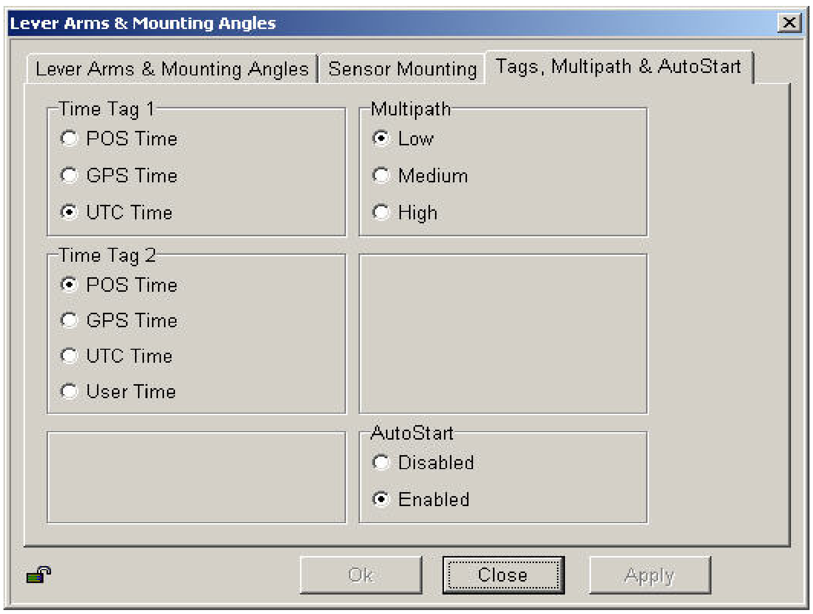




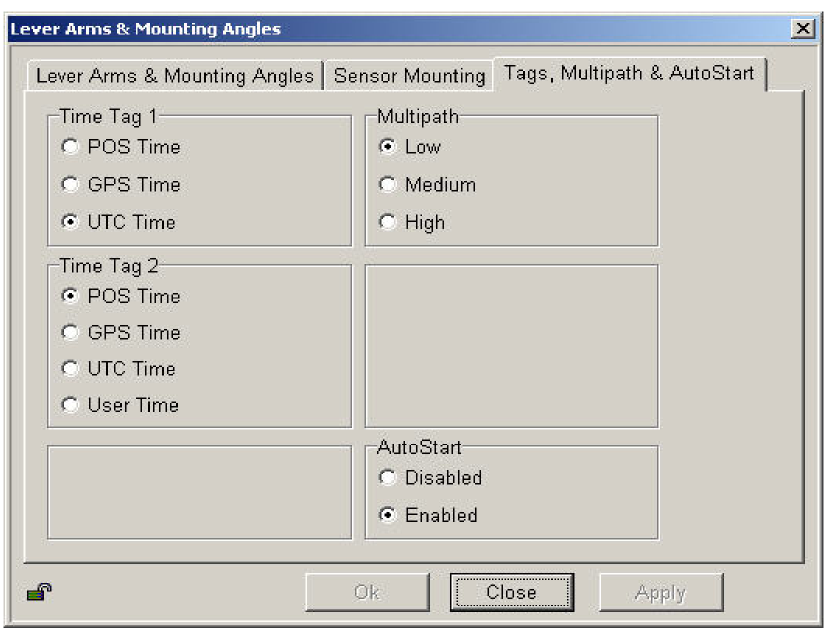
Time Sync (Use Settings > Time Sync)

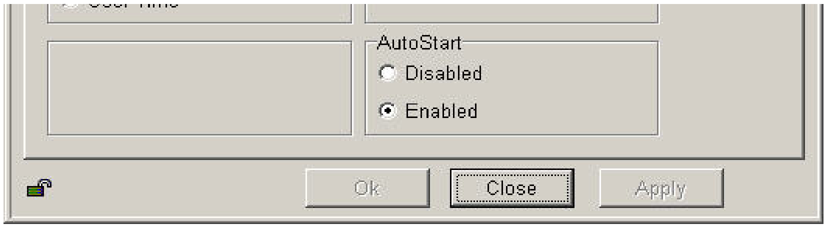
1	User Time Conversion (Units/Sec.)

INSTALLATION (Use Settings > Installation)

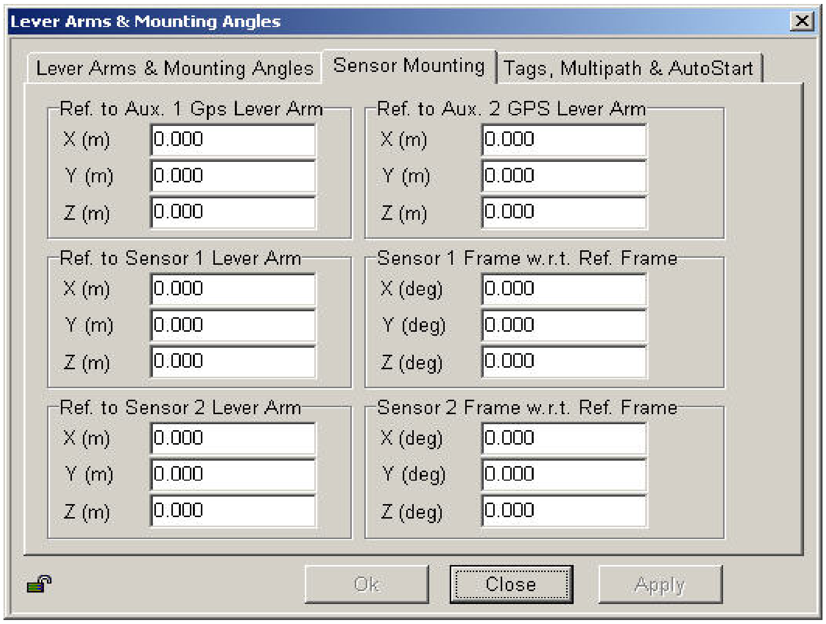


Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)

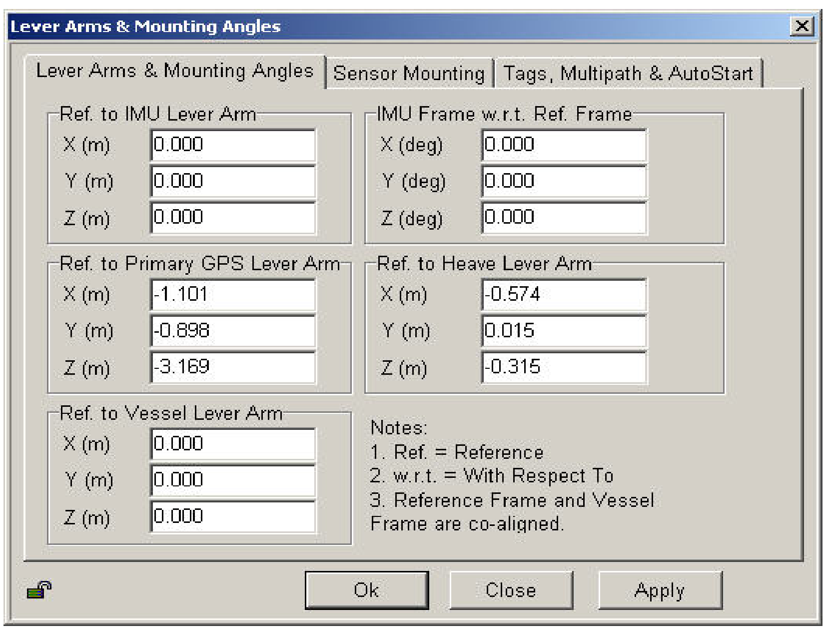




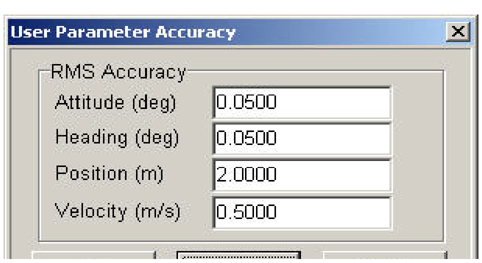
Sensor Mounting (Use Settings > Installation > Sensor Mounting)

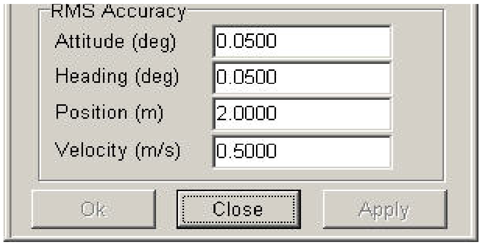


Lever Arms & Mounting Angles (Use Settings > Installation > Lever Arms & Mounting Angles)



User Parameter Accuracy (Use Settings > Installation > User Accuracy)





Frame Control (Use Tools > Config)

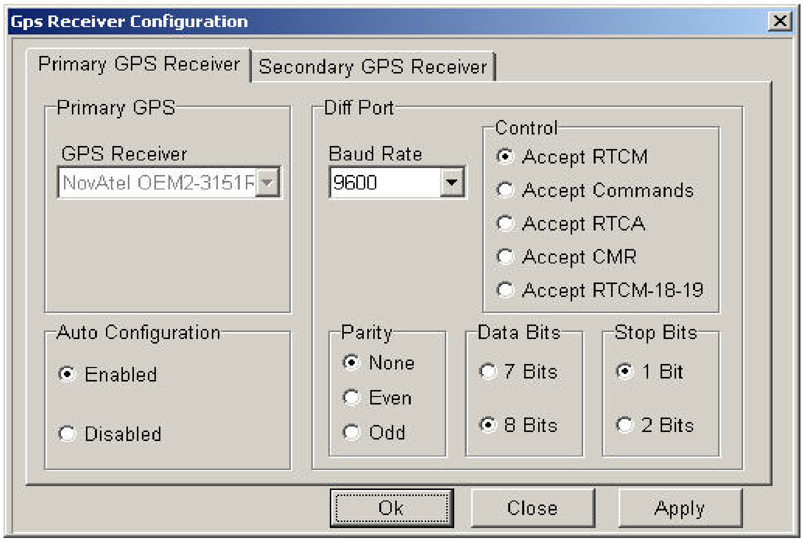
X	User Frame	Primary GPS Measurement	Normal
	IMU Frame	Auxiliary GPS Measurement	Normal

X **Use GAMS enabled**

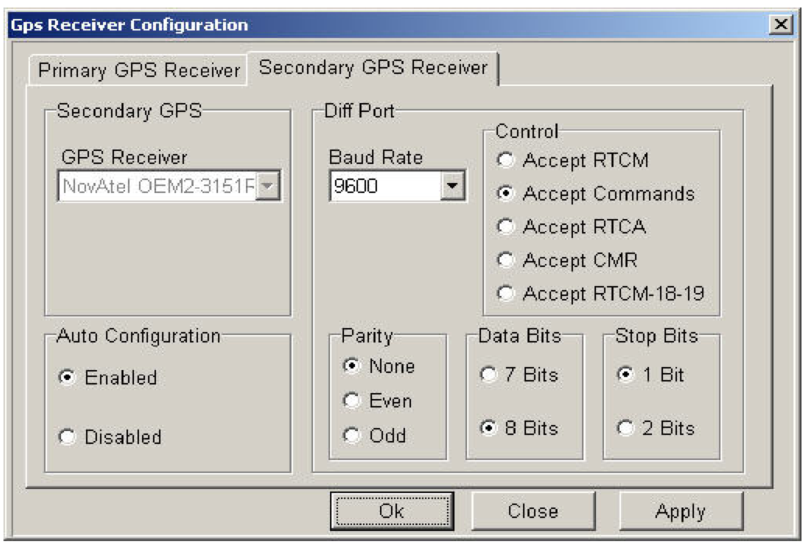
GPS Receiver Configuration

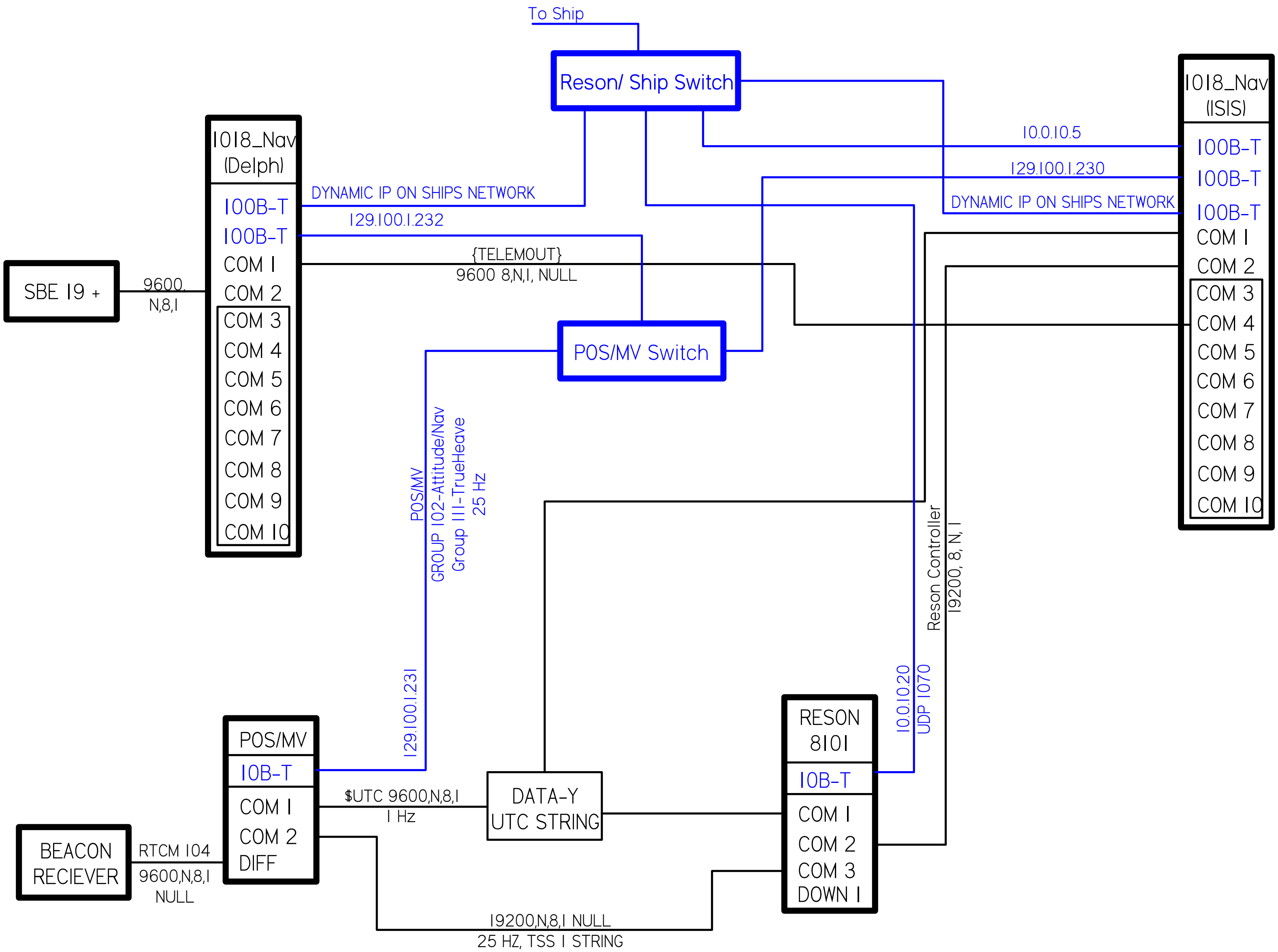
(Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver





FAIRWEATHER LAUNCH 1018 CONFIGURATION

DRAWN BY GRANT FROELICH

SEPTEMBER 28, 2004

NOAA SHIP FAIRWEATHER (S220)
RESON 8111ER CALIBRATION REPORT 2004[1]

SST Jessica Abrams

Background:
NOAA Ship FAIRWEATHER (S220) is a 231' hydrographic survey vessel. It is equipped with a Reson 8111 MWMB system mounted in the hull of the vessel starboard of the centerline. The Reson 8111ER operates at a frequency of 100 kHz and has a variable ping rate dependant upon depth. The maximum ping rate is user set to 35 Hz. The Reson 8111ER has 101 1.5° across-track x 1.5°, 3.0°, 4.5°, or 6.0° (operator selected) along-track beams and has an technical depth range of 3m to 1200m. Multibeam data is collected in XTF format using TEI Isis Sonar v6.6. Sound velocity correctors are acquired with a SeaBird SeaCat SBE 19*plus* sound velocity profiler. FAIRWEATHER (S220) is equipped with an Applanix Position and Orientation System for Marine Vessels (POS/MV) 320 version 3. The POS/MV components include an IMU-200 strap down inertial measurement unit (IMU), a version 2.10d POS Computer System (PCS) and two NovAtel GPS antennas. Differential correctors are supplied to the POS/MV by a CSI Wireless MBX-3S Automatic Differential GPS receiver. FAIRWEATHER (S220) is equipped with Applanix TrueHeave[1] and "Precise Timing"[2]. Residual biases were assessed in CARIS HIPS & SIPS v5.4 calibration mode and applied to the HIPS Vessel File (HVF), S220_8111.HVF.

Location, Date, Personnel:
Patch Test
Multiple patch tests of the Reson 8111ER were attempted with FAIRWEATHER (S220) in several different locations in the 2004 field season. Because of various technical issues and incorrect configurations, only one of these was used in the final S220_8111.HVF. The patch test done on September 16th (Dn 260) in Sumner Strait off Point Saint Albans, AK was accepted and processed for residual biases. The pitch and heading bias patch lines were run over a 16 fathom shoal at 56°03'44.60"N, 133°55'24.75"W. The roll and precise timing bias patch lines were run over a flat area at location 56°01'53.25"N. 133°57'33.95"W with an approximate depth of 75m. See Figure 1 for patch test area.

GAMS Calibration
A POS/MV GPS Azimuth Measurement Subsystem (GAMS) calibration was conducted on September 16th (Dn 260) in Affleck Canal, AK. The GAMS calibration was performed by LT Wetzler and PS Sampadian.

---

[1] Applanix web site. http://www.applanix.com. June 2004
[2] Evans, Ben, LTJG, NOAA. Upgrading NOAA Multibeam Acquisition Systems to "Precise Timing". May 2004

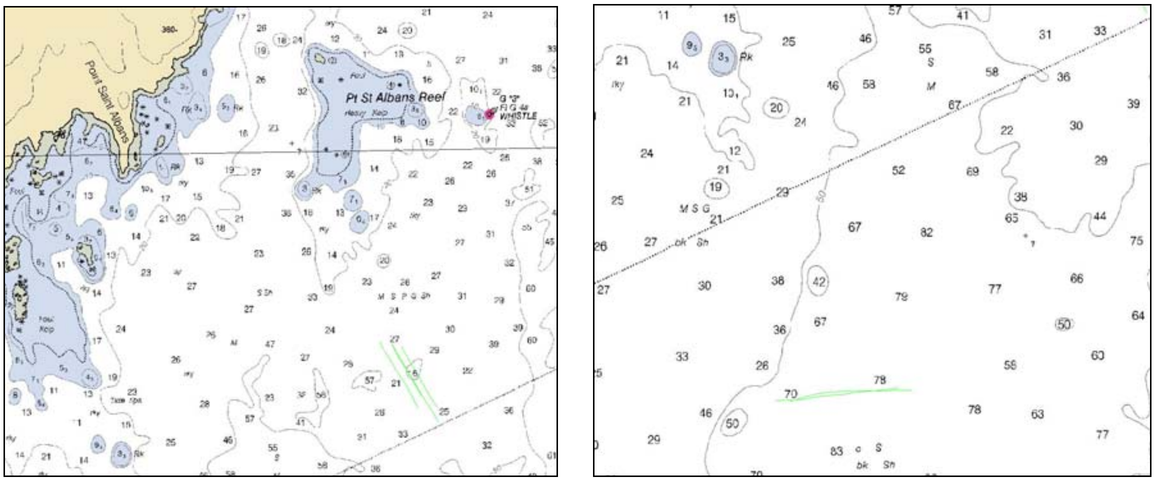


Figure 1: Location of heading, pitch, roll and precise timing bias patch lines.

Dynamic Draft

A Dynamic Draft, Settlement and Squat Method (DDSSM) test was conducted on July 3, 2004 off Port Angeles, WA, but changes in POS/MV configuration since that test have rendered the results unusable. The DDSSM calibration will be done again at a later date. Until those results are available, no values for dynamic draft will be included in S220_8111.HVF.

Equipment:

1 Reson 8111ER Medium Water Multibeam Echosounder
1 Applanix POS/MV Version 3.20 Strap-Down IMU
2 Novatel GPS Antennas
1 CSI wireless MBX-3S Automatic Differential GPS receiver
1 Seabird Seacat SBE 19*plus* sound velocity profiler
TEI Isis Sonar v6.6 w/ BathyPro Real Time Bathymetry
CARIS HIPS & SIPS v5.4 SP1, HF's1-7

Procedure:

Patch

All lines: All lines were "lightly" cleaned in CARIS swath mode to get rid of major data fliers. SVP and observed tides were applied. The patch data were processed and examined for bias independently by SST Froelich, SST Abrams, LT Wetzler, CST Morgan, and PS Sampadian. All patch lines were examined for biases and latency in CARIS HIPS & SIPS Calibration mode in the order listed below. The patch test results are located in Table 1.

Sensor Latency: One line from the roll patch data was chosen for latency biases. Final values entered into S220_8111.HVF were based on an average value. Roll time error was applied to Nav time, Gyro time and Pitch time errors in the S220_8111.HVF.

Pitch: One pair of coincident lines was run over a 16 fathom shoal at the same speed in different directions. The lines were run at 6 knots. Final values entered into S220_8111.HVF were based on a consensus value.

Roll: One pair of coincident lines was run over a flat area approximately 60m deep at the same speed in different directions. The lines were run at 7 to 8 knots. Final values entered into S220_8111.HVF were based on a consensus value.

Heading: One pair of parallel lines offset by 170m was run in opposite directions at the same speed over a known target. The lines were run at 6 to 7 knots. Final values entered into S220_8111.HVF were based on a consensus value.

Patch Bias	Bias value
Sensor Latency	0.11 sec
Pitch	0.20°
Roll	0.00°
Heading	-0.80°

Table 1. Patch test bias results

The patch test acquisition and processing logs for Dn#260 are located in Appendix III-S220-3.

POS/MV GAMS Calibration

The CSI wireless MBX-3S Automatic Differential GPS receiver was set to the DGPS Beacon station Biorka (305 kHz) The GAMS heading calibration threshold was set initially to 0.70°, though a heading accuracy of 0.468° was achieved before GAMS calibration was requested. A GAMS was then requested and the ship maintained a constant speed and heading until the calibration was complete. The resulting POS/MV settings were saved to the file S220_091604_SN846.nvm (see Table 2).

Component	Value
Baseline Vector X	-0.032 m
Baseline Vector Y	4.067 m
Baseline Vector Z	0.017 m
Two Antenna Separation	4.067 m
Heading Correction	0.000 °

Table 2. POS MV GAMS Calibration Results

The detailed POS/MV Calibration Report, 1010_POS_Calibration_091604.xls, is located in Appendix III-S220-5.

Recommendations:

The patch test calibration results should be used from September 16, 2004 (Dn 260) and should be used until such time as a new calibration is necessary.

No DDSSM results are presently available and so no values should be entered into S220_8111.HVF until a new test is conducted and accepted.

The POS/MV GAMS calibration results should be used from September 16th (Dn 260) and should be used until such time as a new calibration is necessary.

[1] The format and much of the content of this document was adapted directly from **NOAA Hydrographic Survey Launch 1010 Calibration Report 2004**, by SST Grant Froelich

Vessel Name: S220_8111.hvf
Vessel created: October 29, 2004

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2003-365 00:00

Transduer #1:

Pitch Offset: 0.200
Roll Offset: 0.000
Azimuth Offset: -0.800

DeltaX: 2.868
DeltaY: 8.252
DeltaZ: 4.753

Manufacturer: Reson
Model: sb8111
Serial Number: (null)

Navigation Sensor:

Time Stamp: 2003-365 00:00

Comments (null)
Latency 0.110
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 846

Gyro Sensor:

Time Stamp: 2003-365 00:00

Comments (null)
Latency 0.110

Heave Sensor:

Time Stamp: 2003-365 00:00

Comments TrueHeave Enabled
Apply Yes
Latency 0.110
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 846

Pitch Sensor:

Time Stamp: 2003-365 00:00

Comments (null)
Apply Yes
Latency 0.110
Pitch offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 846

Roll Sensor:

Time Stamp: 2003-365 00:00

Comments (null)
Apply Yes
Latency 0.110
Roll offset: 0.000

Manufacturer: Applanix
Model: POS/MV v320
Serial Number: 846

Draft Sensor:

Time Stamp: 2003-365 00:00

Apply Yes
Comments (null)

TPE

Time Stamp: 2003-365 00:00

Comments Not Finished
Offsets

Motion sensing unit to the transducer 1
X Head 1 2.868
Y Head 1 8.252
Z Head 1 4.753
Motion sensing unit to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000
Navigation antenna to the transducer 1

X Head 1 2.993
Y Head 1 19.145
Z Head 1 16.253
Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000'' of heave amplitude.
Measurement errors: 0.003
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.500
Surface sound speed measurement error: 0.500
Tide measurement error: 0.010
Tide zoning error: 0.000
Speed over ground measurement error: 0.030
Dynamic loading measurement error: 0.030
Static draft measurement error: 0.050
Delta draft measurement error: 0.010

Svp Sensor:

Time Stamp: 2003-365 00:00

Comments (null)
Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 2.868
DeltaY: 8.252

DeltaZ: 4.753

WaterLine:

Time Stamp: 2003-365 00:00

Comments (null)
Apply Yes
WaterLine 0.074
WaterLineStdDev 0.000

S220 - 8111															
Measurement	**IMU to 8111 (MRU to Trans)**				**Port Ant to 8111 (Nav to Trans)**				**Waterline to RP***				**Port Ant to Stbd Ant**		
Coord. Sys.			Caris				Caris				Caris				
x			2.868				2.993				n/a		Scaler Distance		4.064
y			8.252				19.145				n/a				
z			4.753				16.253				0.074				
	*Top of IMU is RP (Reference Pt)														
Vessel Offsets for S220_8111 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf															

Calculations

Coord. Sys.	**IMU to 8111**				**Port Ant to 8111**				**Waterline to RP***				**Port Ant to Stbd Ant**		
Westlake	IMU	easting	0.000		Port	easting	-35.739		IMU Base to baseline at Keel				Port	easting	-35.739
	Base	northing	0.000		Ant	northing	-0.409		(ft)	elevation	12.856		Ant	northing	-0.409
	(ft/m)	elevation	0.000		(ft)	elevation	-38.283		IMU Base to baseline at Keel				(ft)	elevation	-38.283
									(m)	elevation	3.919				
	8111	easting	27.072		8111	easting	27.072						Stbd	easting	-35.866
	(ft)	northing	9.410		(ft)	northing	9.410		Waterline to Keel				Ant	northing	12.925
		elevation	15.042			elevation	15.042		(ft)	elevation	13.167		(ft)	elevation	-38.209
									Waterline to Keel						
	8111	easting	8.252		Port Ant to 8111				(m)	elevation	4.013				
	(m)	northing	2.868		(ft)	easting	62.811								
		elevation	4.585			northing	9.819		Top of IMU to Base of IMU						
						elevation	53.325		(m)	elevation	0.168				
	Base of IMU to Top of IMU								Top of IMU to Keel						
	(m)	elevation	-0.168						(m)	elevation	4.087				
	Top of IMU to 8111				Port Ant to 8111				Waterline to IMU						
	(m)	easting	8.252		(m)	easting	19.145		(m)	easting	N/A				
		northing	2.868			northing	2.993			northing	N/A		**Port Ant to Stbd Ant**		
		elevation	4.753			elevation	16.253			elevation	0.074				
													Scalar Distance (ft)		13.335
	Coord Sys.	CARIS			Coord Sys.	CARIS			Coord. Sys.	CARIS					
		x	2.868			x	2.993			x	N/A		Scalar Distance (m)		4.064
		y	8.252			y	19.145			y	N/A				
		z	4.753			z	16.253			z	0.074				
									see Description Tab						

IMU to Port Ant				IMU to Heave		
Caris		Pos/Mv		Caris		Pos/Mv
-0.125		-10.893		1.866		-7.028
-10.893		-0.125		-7.028		1.866
-11.501		-11.501		-2.085		-2.085

IMU to Port Ant

IMU	easting	0.000
Base	northing	0.000
(ft/m)	elevation	0.000
Port	easting	-35.739
Ant	northing	-0.409
(ft)	elevation	-38.283
Port	easting	-10.893
Ant	northing	-0.125
(m)	elevation	-11.669
Base of IMU to Top of IMU		
(m)	elevation	-0.168
Top of IMU to Port Ant		
(m)	easting	-10.893
	northing	-0.125
	elevation	-11.501
Coord Sys.	Pos/Mv	
	x	-10.893
	y	-0.125
	z	-11.501

IMU to Heave

IMU to Bulkhd (Frame) 52		
(ft)	easting	11.638
(m)	easting	3.547
Frame 0 (FP) to Frame 52		
(m)	easting	27.737
IMU to Frame 0 (FP)		
(m)	easting	24.19
Heave Pt* to Frame 0 (FP)		
(ft)	easting	102.42
(m)	easting	31.218
IMU to Centerline		
(ft)	northing	6.122
(m)	northing	1.866
Heave Pt* to Centerline		
(m)	northing	0
Coord. Sys.	Pos/Mv	
	x	-7.028
	y	1.866
	z	-2.085

see Description Tab

IMU Base to baseline at Keel		
(ft)	elevation	12.856
(m)	elevation	3.919
Top of IMU to Base of IMU		
(m)	elevation	0.168
Top of IMU to Keel		
(m)	elevation	4.087
Center of Gravity above baseline		
(ft)	elevation	16.37
Mean Metacentric height		
(ft)	elevation	3.88
Heave Pt* to baseline at Keel		
(ft)	elevation	20.25
(m)	elevation	6.172
Top of IMU to Heave Pt*		
(m)	easting	-7.028
	northing	1.866
	elevation	-2.085

(*Heave Pt is Metacenter)
(FP is Forward Perpendicular)

S220 - 8160

Measurement	IMU to 8160 (MRU to Trans)			Port Ant to 8160 (Nav to Trans)			Waterline to RP*			Port Ant to Stbd Ant		
Coord. Sys.			Caris			Caris			Caris			
x			0.493			0.618			n/a	Scaler Distance		4.064
y			7.665			18.559			n/a			
z			4.727			16.227			0.074			

*Top of IMU is RP (Reference Pt)

Vessel Offsets for S220_8160 are derived from Westlake-Survey-Report-NOAA-Fairweather-09-23-03.pdf

Derivisions

Coord. Sys.	IMU to 8160			Port Ant to 8160			Waterline to RP			Port Ant to Stbd Ant		
Westlake	IMU	easting	0.000	Port	easting	-35.739	IMU Base to baseline at Keel			Port	easting	-35.739
	Base	northing	0.000	Ant	northing	-0.409	(ft)	elevation	12.856	Ant	northing	-0.409
	(ft/m)	elevation	0.000	(ft)	elevation	-38.283	IMU Base to baseline at Keel			(ft)	elevation	-38.283
							(m)	elevation	3.919			
	8160	easting	25.149	8160	easting	25.149				Stbd	easting	-35.866
	(ft)	northing	1.619	(ft)	northing	1.619	Waterline to Keel			Ant	northing	12.925
		elevation	14.956		elevation	14.956	(ft)	elevation	13.167	(ft)	elevation	-38.209
							Waterline to Keel					
	8160	easting	7.665	Port Ant to 8160			(m)	elevation	4.013			
	(m)	northing	0.493	(ft)	easting	60.888						
		elevation	4.559		northing	2.028	Top of IMU to Base of IMU					
					elevation	53.239	(m)	elevation	0.168			
	Base of IMU to Top of IMU						Top of IMU to Keel					
	(m)	elevation	-0.168				(m)	elevation	4.087			
	Top of IMU to 8160			Port Ant to 8160			Waterline to IMU					
	(m)	easting	7.665	(m)	easting	18.559	(m)	easting	N/A			
		northing	0.493		northing	0.618		northing	N/A	Port Ant to Stbd Ant		
		elevation	4.727		elevation	16.227		elevation	0.074			
										Scalar Distance (ft)		13.335
	Coord Sys	Caris		Coord Sys	Caris		Coord. Sys.	CARIS				
		x	0.493		x	0.618		x	N/A	Scalar Distance (m)		4.064
		y	7.665		y	18.559		y	N/A			
		z	4.727		z	16.227		z	0.074			

see Description Tab

IMU to Port Ant				IMU to Heave		
Caris		Pos/Mv		Caris		Pos/Mv
-0.125		-10.893		1.866		-7.028
-10.893		-0.125		-7.028		1.866
-11.501		-11.501		-2.085		-2.085

IMU to Port Ant				IMU to Heave					
IMU	easting	0.000		IMU to Bulkhd (Frame) 52			IMU Base to baseline at Keel		
Base	northing	0.000		(ft)	easting	11.638	(ft)	elevation	12.856
(ft/m)	elevation	0.000		(m)	easting	3.547	(m)	elevation	3.919
Port	easting	-35.739		Frame 0 (FP) to Frame 52			Top of IMU to Base of IMU		
Ant	northing	-0.409		(m)	easting	27.737	(m)	elevation	0.168
(ft)	elevation	-38.283					Top of IMU to Keel		
				IMU to Frame 0 (FP)			(m)	elevation	4.087
Port	easting	-10.893		(m)	easting	24.19			
Ant	northing	-0.125					Center of Gravity above baseline		
(m)	elevation	-11.669		Heave Pt* to Frame 0 (FP)			(ft)	elevation	16.37
				(ft)	easting	102.42	Mean Metacentric height		
Base of IMU to Top of IMU				(m)	easting	31.218	(ft)	elevation	3.88
(m)	elevation	-0.168							
				IMU to Centerline			Heave Pt* to baseline at Keel		
Top of IMU to Port Ant				(ft)	northing	6.122	(ft)	elevation	20.25
(m)	easting	-10.893		(m)	northing	1.866	(m)	elevation	6.172
	northing	-0.125							
	elevation	-11.501		Heave Pt* to Centerline			Top of IMU to Heave Pt*		
				(m)	northing	0	(m)	easting	-7.028
Coord Sys.	Pos/Mv							northing	1.866
	x	-10.893		Coord. Sys.	Pos/Mv			elevation	-2.085
	y	-0.125			x	-7.028			
	z	-11.501			y	1.866	(*Heave Pt is Metacenter)		
					z	-2.085	(FP is Forward Perpendicular)		
				see Description Tab					

S220 Offset Measurements

Sources

Offset values for the ship were derived from three sources. A static offset survey, an inclination experiment, and values measured or approximated by ship's personnel.

On September 23, 2003 an offset survey of the NOAA Ship FAIRWEATHER was conducted by:

Westlake Consultants, Incorporated
15115 SW Sequoia Parkway, Suite 150
Tigard, Oregon 97224
Phone (503) 684-0652

These values relate the physical positions of one sensor to the next with the base plate of the IMU being the point of origin. All dimensions in the document are given in feet and decimal feet. The Westlake document is located in the Data Acquisition and Processing Report (DAPR) appendices.

On July 16, 2004 an inclination experiment was conducted at MOC-P by:

Art Anderson Associates
202 Pacific Avenue
Bremerton, WA 98337-1932

The importance of the inclination experiment document is the calculation of the location of the Heave Measurement location (Roll Point) of the vessel. The Roll Point is the point of least nausea and is used by the IMU for the calculation of heave and the relative movement between sensors with respect to an earth reference frame. The value of the Heave Measurement location is used in the POS/MV, but is not used in CARIS directly.

Required Measurements

Pos/MV
Measurements required by the IMU are lever arm distances from the IMU, the multibeam transducer, the heave measurement location (roll point), and the primary GPS antenna to the chosen reference point. In the case of the FAIRWEATHER the reference point and the IMU are coincident. This simplifies installation. There is also a need for an antenna separation distance.

CARIS
Measurements required by CARIS are transducer to the reference point, IMU to the reference point and waterline to the reference point.

Calculations

The values for the required lever arms are listed in the S220_Offsets and Measurements spreadsheet. The reference point and the IMU are identical. Difference in documentation between Westlake and FA calculations are based off of measuring up from the IMU base (Westlake's origin) and the top of the IMU. The top center of the IMU for the POS/MV is the defined origin for the POS/MV and the origin that is being used on all FAIRWEATHER vessels. The distance from the base plate to the top of the IMU is 0.168 m, a value measured by ship's complement. Conversions factor from feet to meters is 0.3048 m/ft.

As a requirement for the TPE, the standard deviation for each position is 3 mm. This value is based upon a conversation with Elaine McDonald of Westlake and is followed up by an Email documenting that fact. The email is located at the end of this document.

Pos/MV—IMU to Reference Point

IMU to the Reference Point is zero on all axes since the IMU is chosen to be the origin.

Pos/MV, CARIS—IMU (Reference Point) to Reson 8111, and Reson 8160

The lever arms between the IMU and phase center of the 8111 and the 8160 transducers are taken from the Westlake report with the addition of the 0.168 m offset included for the height of the IMU.

Pos/MV—Antenna Separation

From the Westlake survey it was determined that the vector for antenna separation was 4.064 m.

Pos/MV— IMU(Reference Point) to Primary (Port) antenna

This information comes directly from the Westlake survey.

CARIS—IMU(Reference Point) to Waterline

The height of the IMU above the keel comes from the Westlake survey as 3.919 m + 0.168 m for the IMU height for a total of 4.087 m above the keel. The draft used for the FAIRWEATHER (based on repeated observations) was 13' 2" (4.013 m). Differencing the value of IMU to keel and waterline to keel gives a value of 0.074 m. Since the waterline is below the reference point (IMU) the value is positive.

Pos/MV—IMU (Reference Point) to Heave Measurement Location (Roll Point)

Key points on the IMU, from the Westlake survey, are its location with respect to the ship's reference frame. It is 4.087 m (3.919 m to base line + 0.168 m for IMU height above base plate) above the keel, 1.866 m port of centerline and 3.547 m forward of frame 52. This information is needed to reference the IMU to the ship's Heave Measurement Location (Heave Point).

From the Art Anderson inclination experiment the position of the metacenter was used as the position of the ship's Heave Point. (There may be a better way to determine the Heave Point, but this decision was based upon available information). The metacenter is defined by the center of buoyancy. As a vessel inclines through small angles, the center of buoyancy moves through the arc of a circle whose center is at the metacenter.

Important numbers and information determined from the Art Anderson report are the location of the metacenter and how it is positioned with respect to the vessel. The longitudinal location of the metacenter is defined as 102.42 feet (31.217 m) aft of the forward perpendicular. The height of the metacenter is 20.25 feet (6.172 m) above the keel. There is an assumption of the metacenter being on the centerline of the vessel. Similar values for the RAINIER's metacenter are 32.52 m aft of the forward perpendicular and 5.2 m above the keel. The difference in the height of the metacenter can be attributed to the difference between the FA's and RA's average draft which is 13.12 feet as opposed to approximately 14.5 feet respectively.

Referencing the metacenter (Heave Point, HP) to the IMU information requires information about the frame spacing of the vessel. From the Westlake survey, the IMU is located 3.547 m forward of frame 52. From Inclination document, the HP is 31.217 m aft of the forward perpendicular. From engineering drawings of the ship frame spacing is approximately 21 inches. The calculation for the longitudinal location of the HP with respect to frame zero, the Forward Perpendicular (FP) is as follows:

52 (frame) * 21 (inches/frame)/12(inches/ft)*.3048(m/ft)-3.547 m = 24.190 m from frame 0.

31.217 m (HP aft of FP) – 24.190 m (IMU aft of FP) = 7.027 m (HP aft of IMU)

The calculation for the vertical separation between the IMU and the HP is based on the height of the metacenter being 6.172m and the height of the IMU being 4.087 m above the keel. Differencing yields the metacenter being 2.085 m above the IMU.

The calculation for the athwartship separation is based upon the assumption that the HP is on the centerline and the knowledge that the IMU is 1.866 m to port of the centerline.

IMU to Heave

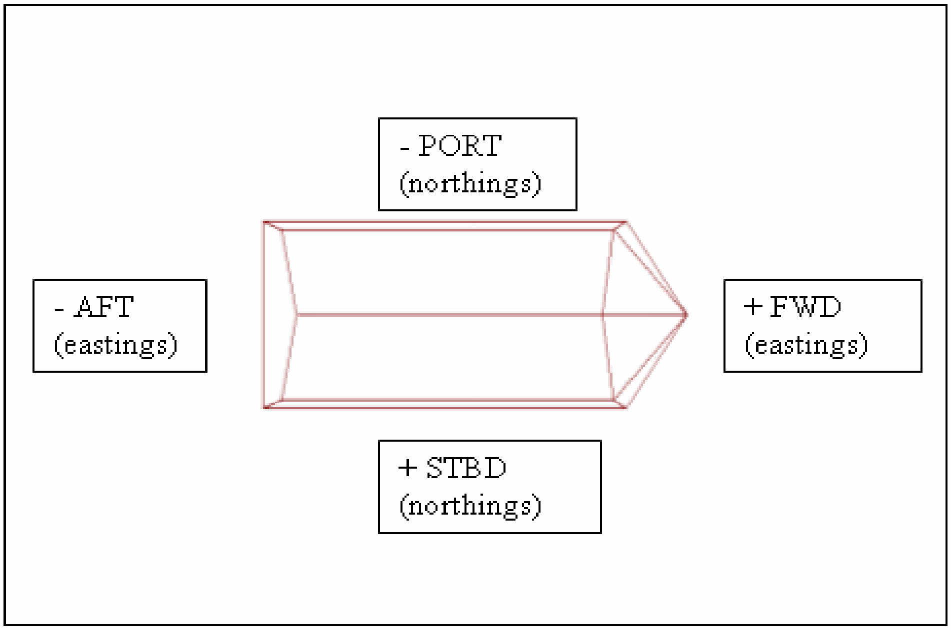
From pg 3 of the Westlake Survey

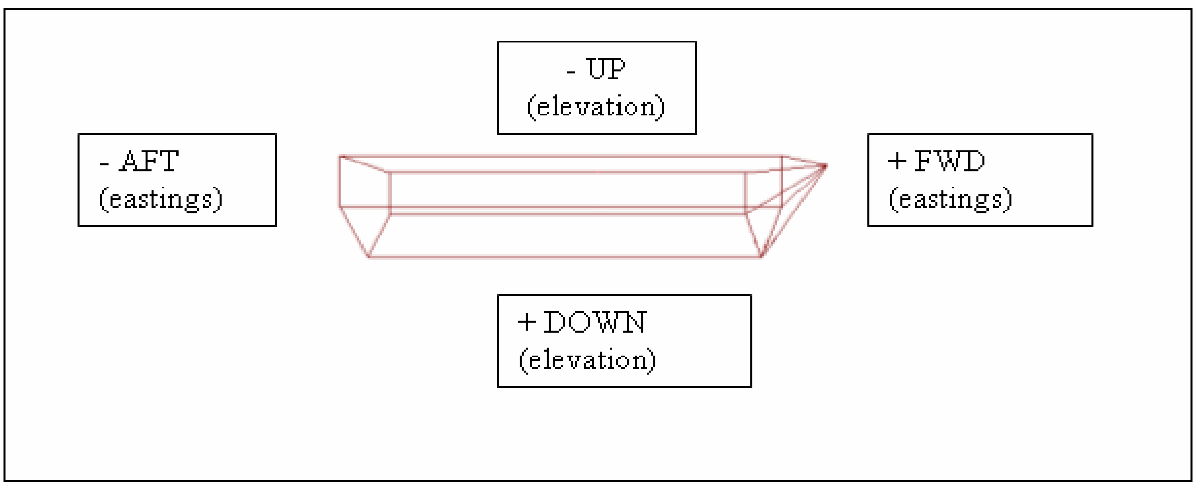
SUMMARY

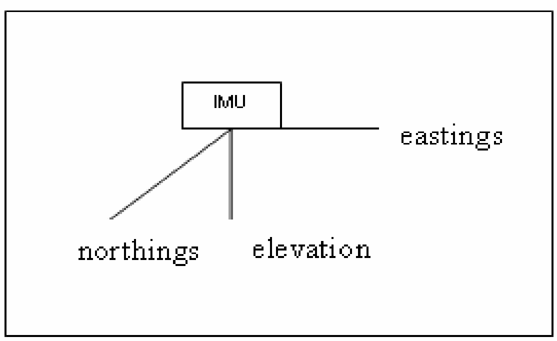
- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.

  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

WESTLAKE Coordinate System

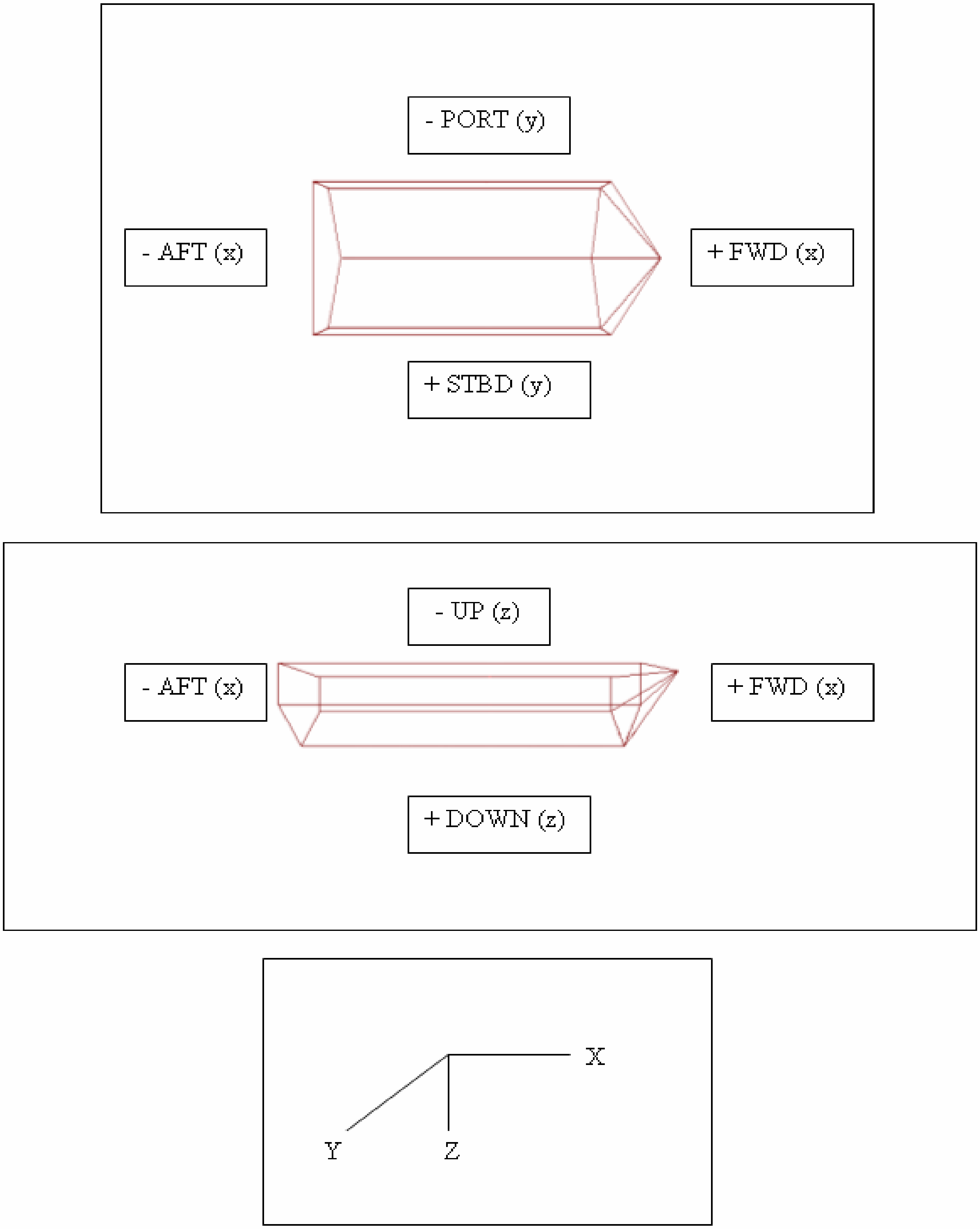






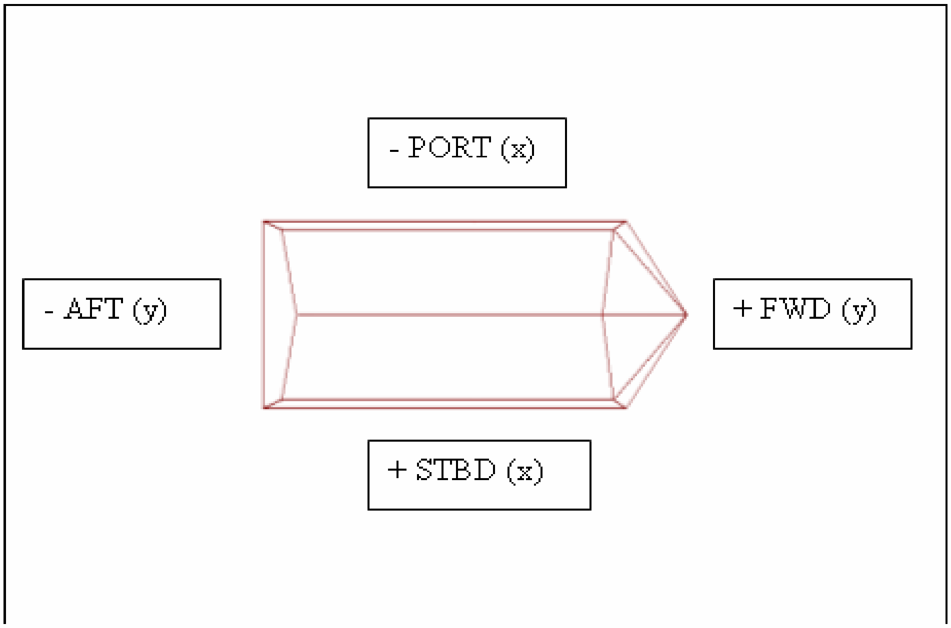
Bottom Center of IMU is origin of Westlake Coordinate System

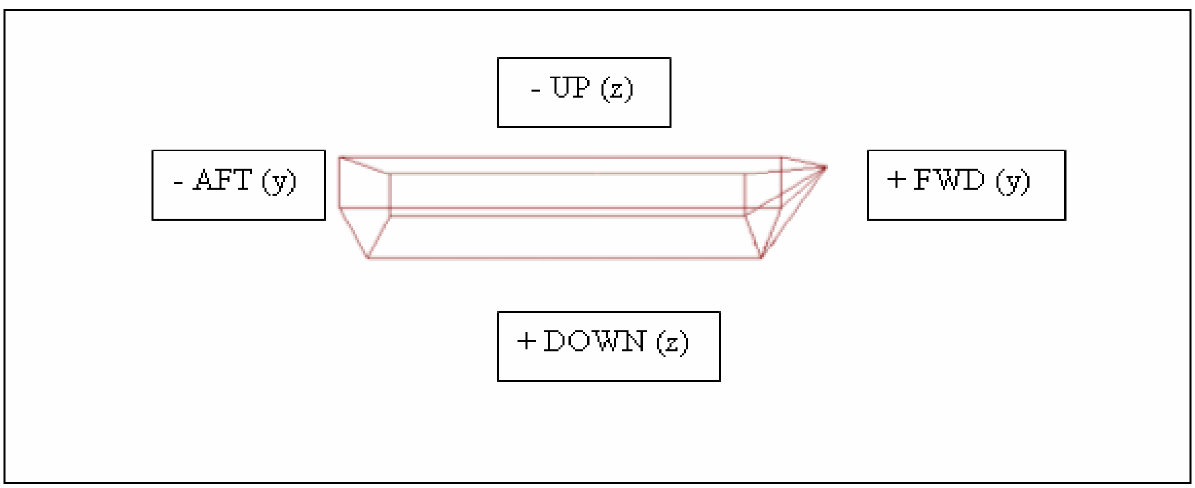
POS/MV Coordinate System

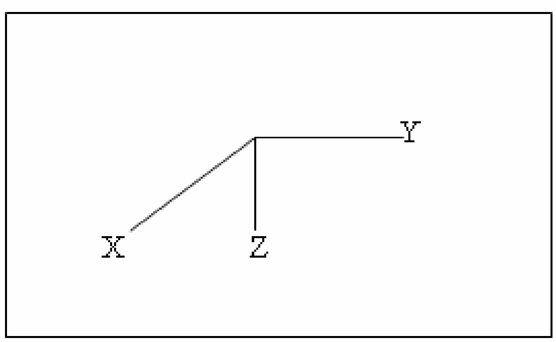


Top Center of IMU is origin of POS/MV Coordinate System

CARIS Coordinate System







Top Center of IMU is origin of CARIS Coordinate System

STABILITY TEST: **NOAA Ship FAIRWEATHER (16 Jul 2004)**

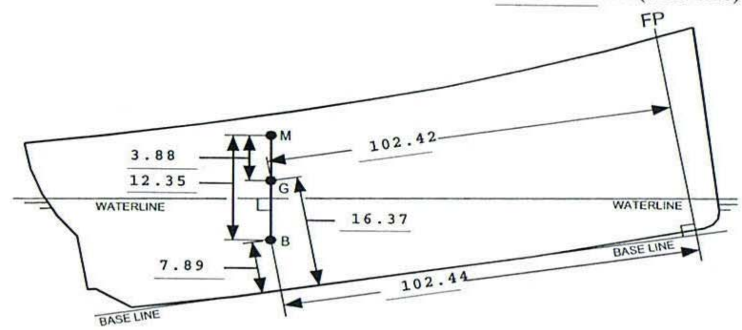
SHIP AT TIME OF STABILITY TEST--CONDITION 0

		FROM HYDROSTATIC CURVES	FROM INDEPENDENT CALCULATION
Corrected diaplacement		tons	1638.79 tons
Mean virtual metacentric height obtained from plot of inclining moments versus tangents of angles of heel $\frac{\text{moment}}{\text{displacement x tangent}}$	= 5987.252 / 1638.790	feet	3.65 feet
Correction for free surface	= 374.0 / 1638.790	feet	0.23 feet
Mean metacentric height G.M. =		feet	3.88 feet
Transverse metacenter above base line corresponding to draft at LCF (corrected for hog or sag)		feet	
Transverse metacenter above base line corrected for trim, and hog or sag		feet	
C.G. above base line		feet	16.37 feet (from figure)
			16.36 feet (from GHS)
Longitudinal metacenter above C.G.		feet	
Moment to alter trim 1 foot, (Long GM x Δ) / L		ft-tons	
Trim by stern		feet	
Trimming lever = (Trim x moment to trim) / displacement		feet	
Longitudinal center of buoyancy (LCB) from origin		feet	
C.G. from origin		feet	102.44 feet (from figure)
			102.42 feet (from GHS)

Period of complete roll ____ seconds

Apparent radius of gyration of vessel $\alpha = \frac{T\,GM}{1.108}$ ____ feet

Rolling constant $C = \frac{T\,GM}{B}$ ____



Definitions and Basis for Dimensions/Locations

Northings

Northings (Port - Starboard) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are starboard of the IMU.
Negative values are port of the IMU.
Calculated values are in italics.

Eastings

Eastings (Stern to Bow) are with reference to the IMU Foundation Plate centerline scribe.
Positive values are forward of the IMU.
Negative values are aft of the IMU.
Calculated values are in italics.

Elevations

Elevations are with reference to the IMU Foundation Plate centerline scribe = 0 elevation.
Positive values are below the IMU (toward the keel).
Negative values are toward the topside.

Dimensions

All dimensions are in feet and decimal feet. All dimensions provided are "offsets" to IMU centerline.

Ship's Centerline Data

At project initiation, control was established to define the ship's centerline
as a plane running from a point on the centerline of the keel at the stern through a
point on the centerline of the keel near the bow, to a point on the bow splitting the bow chock.

IMU Referenced Data - Procedure

All data was originally referenced to the ship's geometry.
Following location of the IMU, data was transformed to the IMU as point of origin for
Northings, Eastings, and Elevation. All dimensions provided with reference to the IMU are "offsets."

Ship's Centerline - Control Measurements

(Prior to location of IMU and referencing of data to IMU as point of origin (0,0,0)

Defined by measurements at the keel centerline

	longitude	transverse	elevation
near the bow	1190.674	1000.000	135.8672
at the stern (point of origin)	1000.000	1000.000	100.0000
along the keel (approx 180' forward)	1180.121	1000.000	116.6810

Ship's Baseline

Defined by measurements on the keel

	longitude	transverse	elevation
at the stern (point of origin)	1000.000	1000.000	100.0000
and approx. 129' forward of stern	1129.120	999.985	100.0022

IMU Foundation Plate

	EASTING	NORTHING	ELEVATION
Horizontal alignment per scribed lines on IMU foundation plate		0.001	
		0.000	
Scribed lines - intersection/centerline of IMU plate	0.000	0.000	0.000
Elevation checks near four corners of IMU Foundation plate *			
** elevation check adjusted for target that created 10 mm offset =.03281 feet*			0.001
			-0.001
			0.000
			-0.001

SUMMARY

- IMU foundation plate is level to within +/-0.001 feet.
- IMU foundation plate is located 12.856 feet above baseline established at the keel.
- IMU is parallel to ship's centerline to within +/- 0.001 feet.
  Location of scribed centerline intersection is 6.122 feet port of ship's centerline.
- IMU foundation plate centerline is located 11.638' feet forward of bulkhead 52.

Granite Block

	EASTING	NORTHING	ELEVATION	
Horizontal alignment per scribed lines				
		1.584		
		1.583		
Scribed lines - intersection/centerline of granite block				
	-0.003	**1.583**		
				Deviation from level
Elevation checks near four corners of granite block				
** elevation check adjusted for target that created 10 mm offset = 0.03281 feet*			**-0.217**	-0.001
			-0.217	-0.001
			-0.216	0.001
			-0.215	0.001

SUMMARY

- Granite block is level to within +/-0.001 foot
  of average elevation = -0.21632 feet
- Granite block is parallel to ship's centerline to within 0.001 foot
  Location is 4.54 feet to port of ship's centerline and 1.583 feet starboard of IMU.
- Granite block is aligned with IMU to within 0.003 feet longitudinally.

Array Acoustical Centers - Referenced to IMU

	EASTING	NORTHING	ELEVATION
PORT ARRAY (81-60)	***25.149***	***1.619***	***14.956***

Explanation of Calculations

Acoustic center is defined as the center of the transmitter array with the elevation = 83 mm below mounting face of array.

Easting

Center of array is defined by the foundation plate bolt centerlines (1/2 distance between bolts)

27.008	Forward edge of foundation as measured
- 0.104	Forward edge of foundation to centerline of forward bolt hole
- 1.755	Distance from bolt hole centerline to center of array
25.149	feet forward of IMU

Northing

Center of array is defined as the mid-point between the bolt holes on the foundation.

1.369	Port edge of foundation as measured
+ 0.078	Port edge of foundation to centerline of bolt hole - per Cascade General
+ 0.172	Distance from bolt hole centerline to array center
1.619	feet starboard of IMU

Elevation

Per Reson drawing 2148M011_001 the elevation is 83 mm below array mounting surface

14.679	Array foundation elevation as measured.
0.005	Isolation "shim" added between foundation and array
0.272	83 mm below array mounting surface to acoustical center
14.956	feet below IMU

Array Acoustical Centers - Referenced to IMU

	EASTING	NORTHING	ELEVATION
STARBOARD ARRAY (81-11)	*27.072*	9.41	*15.042*

Explanation of Calculations

Acoustic center is defined as midpoint of the transmitter array in the longitudinal and transverse axes. The elevation is defined as the center of the receiving array.

Easting

Center of array is defined as 0.235' aft of the forward bolt centerlines on transmitter array foundation

28.563	Forward edge of foundation fixture plate as measured (receiving plate forward edge)
27.349	Forward edge of transmitter array foundation as calculated
- 0.042	Forward edge of foundation to centerline of forward bolt hole - per design
- 0.235	Distance from bolt hole centerline to center of array - per design
27.072	feet forward of IMU

Northing

Center of array is defined as the mid-point between the bolt holes on the transmitter array foundation.

9.410	Centerline of array foundation as measured on scribe - aft section of fixture plate
9.410	feet starboard of IMU

Elevation

Elevation is 0.401 feet above receiver array mounting surface

16.085	Mounting foundation fixture plate as measured.
15.447	Receiver foundation elevation - as calculated
+ 0.005	Isolation "shim" added between foundation and array
- 0.410	Design distance from mounting surface of array to acoustic center
15.042	feet below IMU

Longitudinal Array Foundation - Port Side

	EASTING	NORTHING	ELEVATION	
Horizontal alignment *measured* at port edge of array foundation				
		1.369		
		1.369		
Forward edge of array foundation - *measured*				
	27.008			
Horizontal alignment - *calculated* to array centerline				
Foundation edge is 0.25 feet port of		***1.619***		
array centerline		***1.619***		
				deviation from
Elevation checks near four corners of array foundation				level (average)
			14.680	0.001
			14.681	0.002
			14.678	-0.001
			14.677	-0.002

SUMMARY

- Port longitudinal array foundation average elevation is 14.679 feet.
  Variation in elevation is +0.002 to -0.002 feet.
- Port longitudinal array foundation is parallel to ship's centerline and 1.369 feet starboard of IMU.
  Calculated array centerline is 1.619 feet starboard of IMU

Longitudinal Array Foundation - Starboard Side

	EASTING	NORTHING	ELEVATION	deviation from
Horizontal alignment *measured* on fixture plate scribe -				*parallel*
Design location is 3.292 feet		**9.410**		0.002
starboard of ship centerline		**9.406**		-0.002
Forward edge of array foundation fixture plate - *measured*				
	28.563			
				deviation from
Elevation checks near four corners of array foundation "fixture plate"				*average*
			16.085	0.000
			16.085	0.000
			16.084	0.000
			16.085	0.000
Calculated locations of longitudinal and transverse array foundations				
Forward edge				
Receiver (transverse)	**28.563**			
Transmitter (longitudinal)	***27.349***			
difference = 1.214				

NOTE: *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'*
On Receiver array foundation distance from forward edge to center of forward holes = 0.076'

			ELEVATION
Calculated elevation of longitudinal and transverse array foundations			
Receiver/Transverse Foundation			***15.446***
Transmitter/Longitudinal Foundation			***15.709***
difference = 0.263			

SUMMARY

- Starboard longitudinal array foundation (measured at fixture plate) average elevation is 16.085 feet.
  Deviation from level (average elevation) is less than 0.001 feet.
- Starboard longitudinal array foundation averages 9.408 feet starboard of IMU.
  Variation from parallel is from -0.002 feet to +0.002 feet from average.
- Starboard longitudinal array foundation forward edge is 28.563 feet forward of IMU.

Transverse Array Foundation - Port Side

	EASTING	NORTHING	ELEVATION	
Forward Edge - Transverse array foundation - *measured*				
	28.343			
	28.338			
Port edge - Transverse array - *measured*				
		-0.181		
Centerline of array - *calculated*				
Foundation forward edge minus	***28.093***			
0.25 feet to array centerline	***28.088***			
Port edge of foundation plus 1.806 feet to calculated array centerline		***1.624***		
				deviation from
Elevation checks near four corners of array foundation				level
			14.679	0.002
0.861 feet below baseline with 0.965			**14.675**	-0.001
foot offset = 98.180 feet average			**14.675**	-0.001
elevation			**14.677**	0.001

SUMMARY

- Transverse array foundation average measured elevation is 14.677 feet
  below IMU (0.006 feet above design location).
  Deviation from level (average elevation) is 0.003 to -0.001 feet
- Transverse array foundation centerline (calculated) averages 28.090 feet forward of IMU.
  Variation from parallel to ship's centerline is from -0.003 to 0.003 feet (from average).
- Transverse array centerline is calculated to be 1.624 feet starboard of IMU.

Transverse Array Foundation - Starboard Side

NOTE: Direct Measurements were not taken to the transverse array because a single "fixture plate" covered bo
transmitter and receiver foundations. The data provided here is primarily *"calculated".*

	EASTING	NORTHING	ELEVATION
Forward edge - as measured on fixture plate			
Receiver - (transverse)	**28.563**		
as measured			
Transmitter (longitudinal)	***27.349***		
difference = 1.214			

NOTE: *On Transmitter array foundation - from forward edge to center of forward holes = 0.042'*
On Receiver array foundation distance from forward edge to center of forward holes = 0.076'

	EASTING	NORTHING	ELEVATION
Horizontal Alignment		**9.406**	
centerline scribe on fixture plate			
as measured - forward portion of plate			
(near receiver array)			
Average of measurements on fixture plate		***9.408***	
Elevation of longitudinal and transverse array foundations			
Receiver/Transducer Transverse Foundation			***15.446***
Transmitter/Longitudinal Foundation			***15.709***
difference = 0.263			

Based on measured elevations averaging 16.085 feet across fixture plate

SUMMARY

- Transverse array foundation is calculated to be 15.446 feet below IMU - calculated from measured elevation of 16.085 feet. Deviation in elevation measurements across the array fixture plate is less than 0.001 fe
- Transverse array foundation forward edge (measured) is 28.563 feet forward of IMU.
- Transverse array centerline is measured to be 9.406 feet starboard of IMU.

Variation from parallel of the fixture plate across entire starboard array is ± 0.002 feet (from average).

Antennae

	EASTING	NORTHING	ELEVATION
Stbd POS MV Antenna -Location	-35.866	12.925	-38.209
Port POS MV Antenna - Location	-35.739	-0.409	-38.283
Foundation Plate Stack Antenna Alignment		7.677	
Foundation Plate Stack Antenna Alignment		7.677	
Port GYRO Foundation Plate Alignment		2.411	
Port GYRO Foundation Plate Alignment		2.411	
Stbd GYRO Foundation Plate Alignment		3.866	
Stbd GYRO Foundation Plate Alignment		3.867	

SUMMARY

- Foundation plate stack antenna alignment is parallel to ship's centerline.
- Port GYRO Foundation Plate is aligned parallel to ship's centerline.
- Starboard GYRO Foundation Plate is aligned parallel to ship's centerline.

Email regarding Standard Deviation of Westlake Survey

Subject: Precision of Measurements - NOAA Fairweather (1109-11 and 12)
Date: Thu, 12 Aug 2004 12:06:45 -0700
From: "Elaine McDonald" <emcdonald@westlakeconsultants.com>
To: <mark.wetzler@noaa.gov>
CC: "Derek Colclough" <dcolclough@westlakeconsultants.com>,
"Mike Hargrave" <mhargrave@westlakeconsultants.com>,
"Judi Haney" <jhaney@westlakeconsultants.com>,

Greetings Mark -

As promised I am writing to document our conversation of late yesterday afternoon regarding the reliability of measurements on the NOAA Fairweather.

We discussed your question here at Westlake and possible interpretations.

We believe the you can comfortably use plus/minus 3 mm as the standard error of any given distance between 2 measured/located points on the vessel. We are confident that given the same circumstances, were we to repeat the measurements, our inter-point distances would be within plus/minus 3 mm of data reported (standard error).

If the measurements were taken from a single instrument set up within a fairly close range the distance would be reliable to nearly plus/minus 1 mm. However, we had to take many measurements from a number of setups around, on, and inside the vessel, and we then tied all of these measurements to a common coordinate system. Consequently, it is not realistic to expect a 1 mm error.

As we discussed yesterday, there are many other factors that will impact the location of each point and, consequently, the distance between two or more points. Temperature, sun light, deformation of the vessel when it is in and out of the water, movement of the drydock, settlement, definition of the actual point to be measured relative to the identified structure etc. all impact the reliability or repeatability of measurements.

Nonetheless we appear to be in agreement that the 3 mm value will work in your software without introducing significant, additional variability.

If you have questions or require additional information, please give me a call - or email.

Best wishes,

Elaine for Derek Colclough, Director, Industrial Measurement Division

Elaine McDonald
Director of Marketing
Westlake Consultants, Inc.
15115 SW Sequoia Parkway (150)
Tigard, Oregon 97224

phone 503-684-0652
fax 503-624-0157
toll-free 800-523-8750
email emcdonald@westlakeconsultants.com

We invite you to visit our website www.westlakeconsultants.com

Patch Test Acquisition Log __S-220__________

(Vessel)

Page _1__ of _1__

Date: Sept. 16,2004 **DN: 260** **Local Area: Cape Decision** **Wx:**

SV Cast #1 filename: 04260225	UTC time: 2257	Lat: 56/02.595	Lon: 133/56.249	Depth: 130.8	Ext Depth: 170
SV Cast #2 filename:	UTC time:	Lat:	Lon:	Depth:	Ext Depth:

Personnel: **FA Personnel**
Other Comments:

ROLL LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	Roll_8_W		8	
	Roll_8_E		8	

PITCH LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	Pitch_6_330	330	6	
	Pitch_6_155	155	6	

HEADING LINES

SV Cast:	XTF Line Filename:	Hdg:	Speed (knots):	Remarks:
1	Heading_6_330	330	6	
	Heading_6_155	155	6	

Processing Patch Test **S220** **260/9-16-04**
(Vessel) *(Dn/Date)*

☐ HVF Hydrographic Vessel File created or updated with current offsets
Name: ________________________ Date/Time: ____________________

X Data Converted → HDCS_Data in CARIS

X True Heave Applied

X Tide Applied ______________ Zerotide.tid ______________________________
Type (Zero, Observed, Verified)

☐ Zoned ____
ZDF File

X SVP applied 04260225, Back timed cast to 1200__________________________
File

X Lines merged

X Data cleaned to remove gross fliers

Compute Correctors – Order

1) Precise Timing 2) Pitch Bias 3) Roll Bias 3) Heading Bias

Do not Enter/Apply Correctors until all evaluations are complete and analyzed.

Patch Test Results/Correctors

Evaluator	Timing (sec)	Pitch (deg)	Roll (deg)	Hdg (deg)
Grant	0.09	0.17	0.03	-1.30
Jess	0.13	-0.64	-0.03	-0.42
Mark	0.11	0.3	0.03	-0.6
Lynn	0.12	0.5	0.02	-1.10
Kim	0.10	0.2	0.00	-0.65
Final Values	0.11	0.2	0.00	-0.80

Final Values based on: AVG Consensus Consensus Consensus

NOAA POS/MV Calibration Report

Ship: Fairweather **Vessel:** S220

Date: 9/16/2004 **Dn:** 260

Personnel: Wetzler, Sampadian

PCS Serial # 846

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.10d

POS Version (Use Menu View > Statistics) MV320 Ver3 SN846 HW1.3 SW02.10d

GPS Receivers

Primary Receiver SGN 98490013

Secondary Receiver CGN 96200099

Calibration area

Location: Affleck Canal, AK

Approximate Position:

	D	M	S
Lat	56	4	30
Lon	134	3	27

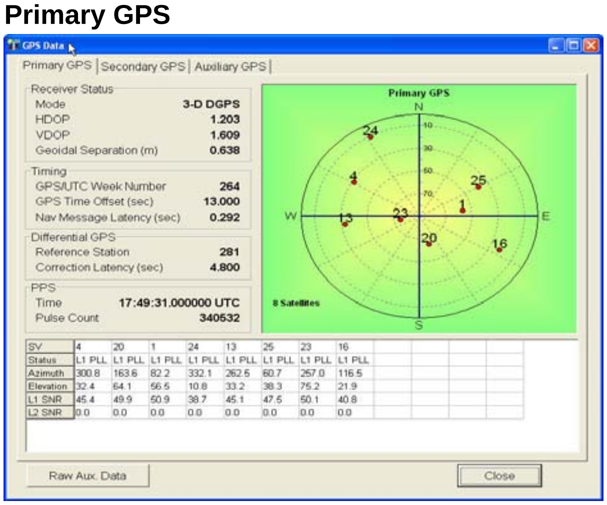
DGPS Beacon Station: Biorka

Frequency: 305 kHZ

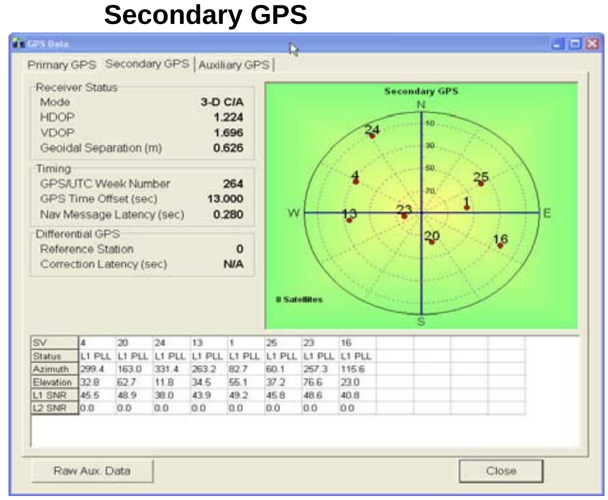
Satellite Constellation

(Use View> GPS Data)

Primary GPS



Secondary GPS



PDOP 2.480 (Use View> GAMS Solution)

POS/MV Configuration

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration		Baseline Vector	
4.065	Two Antenna Separation (m)	**0**	X Component (m)
0.70	Heading Calibration Threshold	**0**	YComponent (m)
0	Heading Correction	**0**	Z Component (m)

Configuration Notes: GAMS needed re-calibration because the antenna cables were reversed; the Port antenna is now the primary antenna. The heading calibration threshold was set high because of possible time constraints but we were able to achieve a heading accuracy of 0.468 before requesting CAL.

POS/MV Calibration

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 17:50

End time: 17:53

Heading accuracy achieved for calibration: 0.468

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
4.067	Two Antenna Separation (m)	**-0.032**	X Component (m)
0.500	Heading Calibration Threshold	**4.067**	YComponent (m)
0	Heading Correction	**0.017**	Z Component (m)

GAMS Status Online X

Save Settings X

Calibration Notes: After shutdown and restart the calibration appears to be good and no drift in heading. However, the GAMS solution was slow to FIX. Once fixed, the Heading accuracy is around 0.013 deg on average.

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: S220_091604_SN846.nvm

General Notes:

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

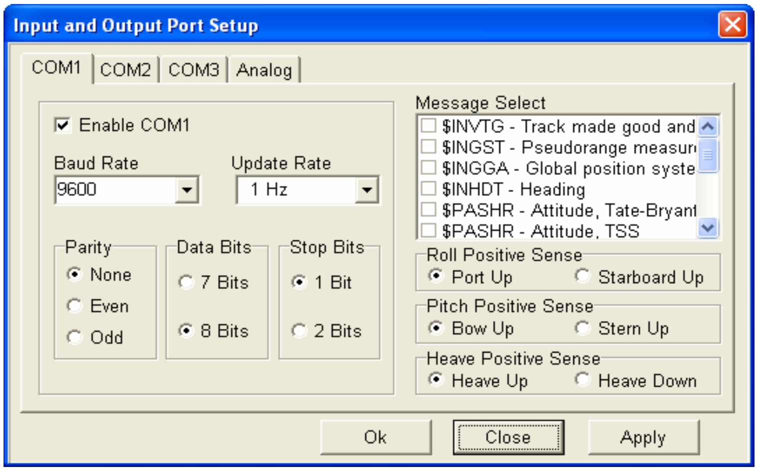
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

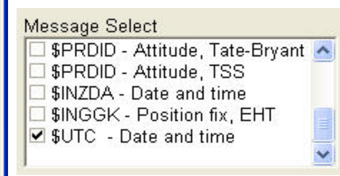
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

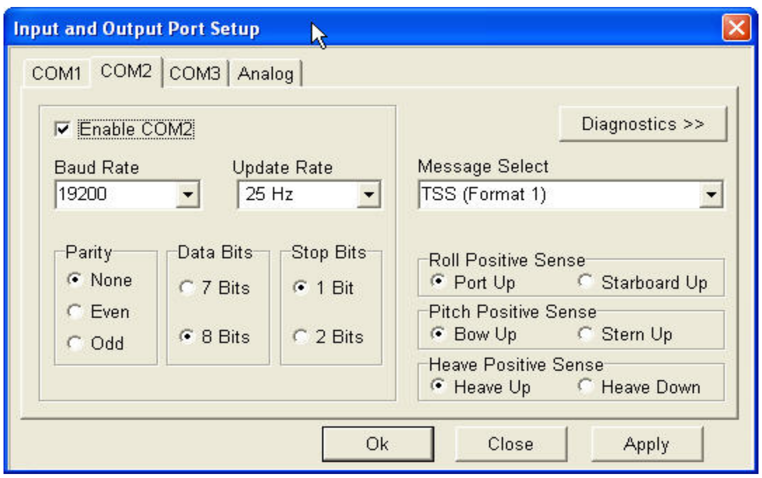
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS

Input/Output Ports (Use Settings > Input/Output Ports)

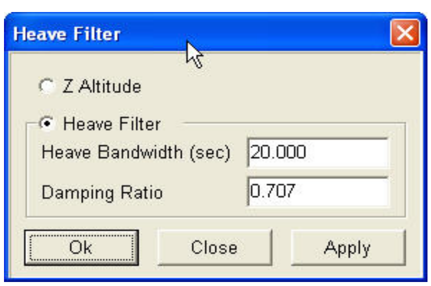




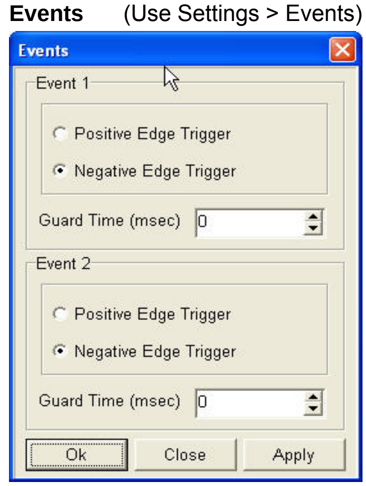


NOTE: COM3 and Analog are not used.

Heave Filter (Use Settings > Heave)

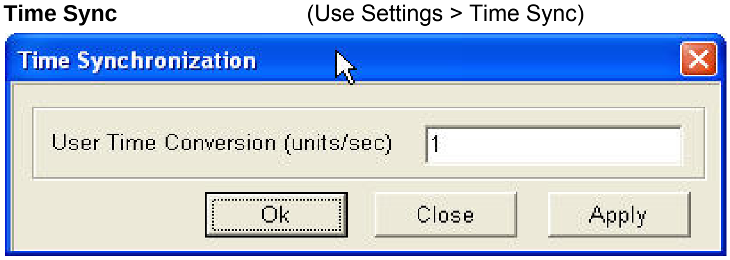


Events (Use Settings > Events)

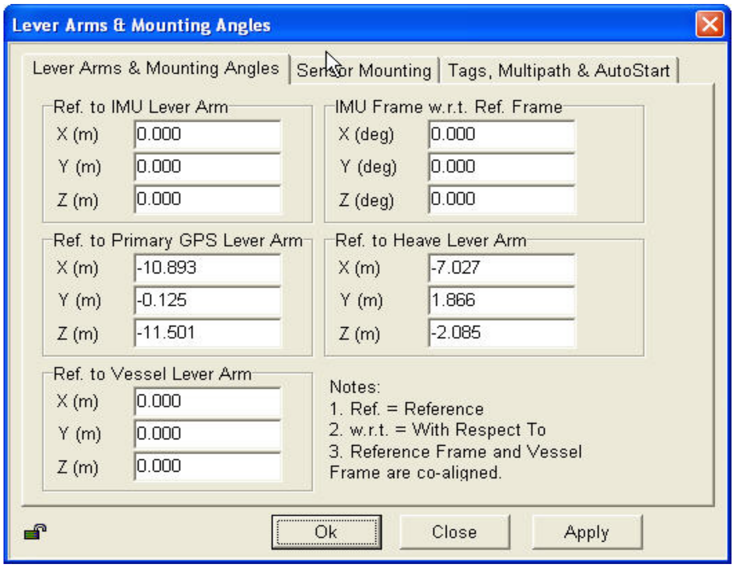


SETTINGS Continued

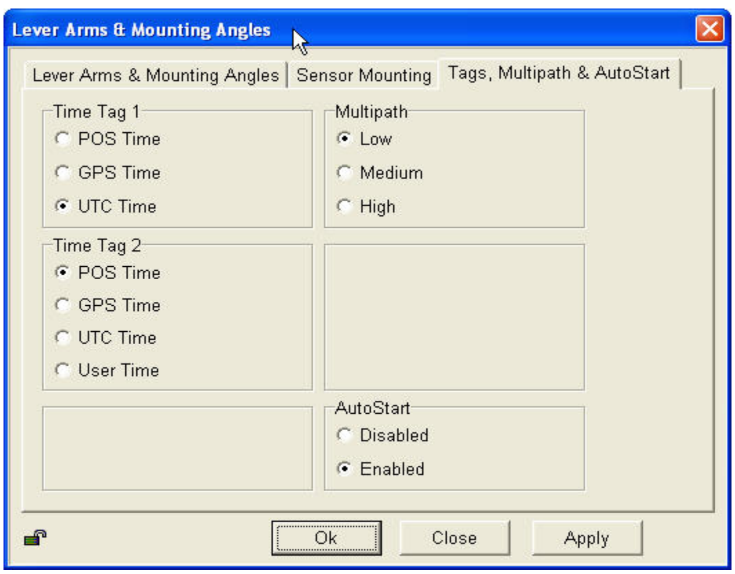
Time Sync (Use Settings > Time Sync)



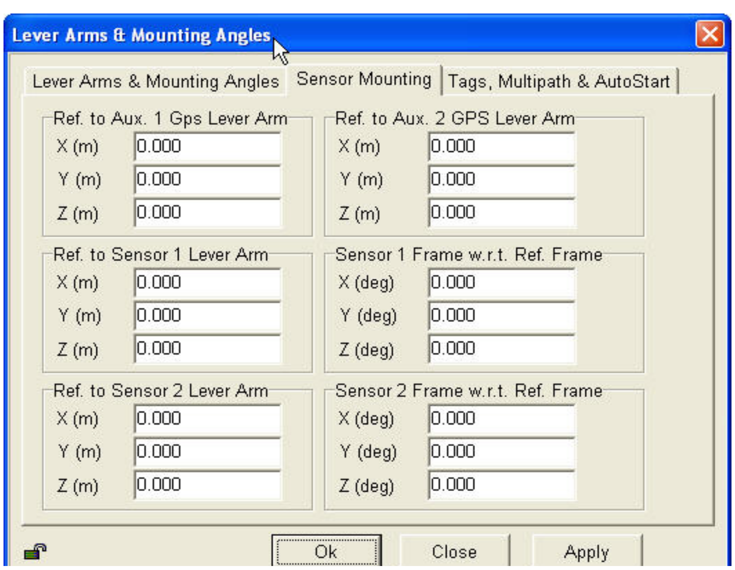
INSTALLATION (Use Settings > Installation)



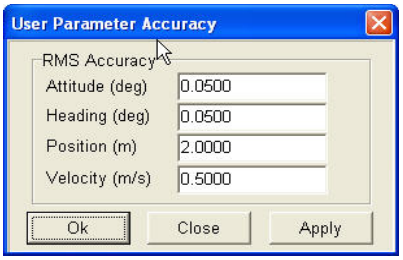
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



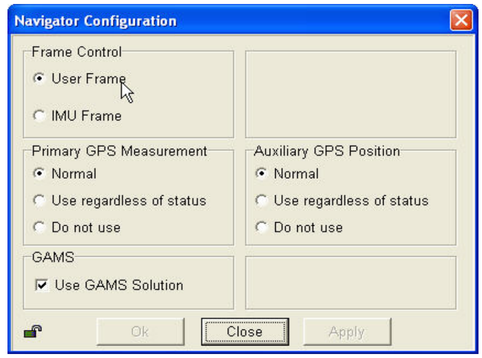
Sensor Mounting (Use Settings > Installation > Sensor Mounting)



User Parameter Accuracy (Use Settings > Installation > User Accuracy)



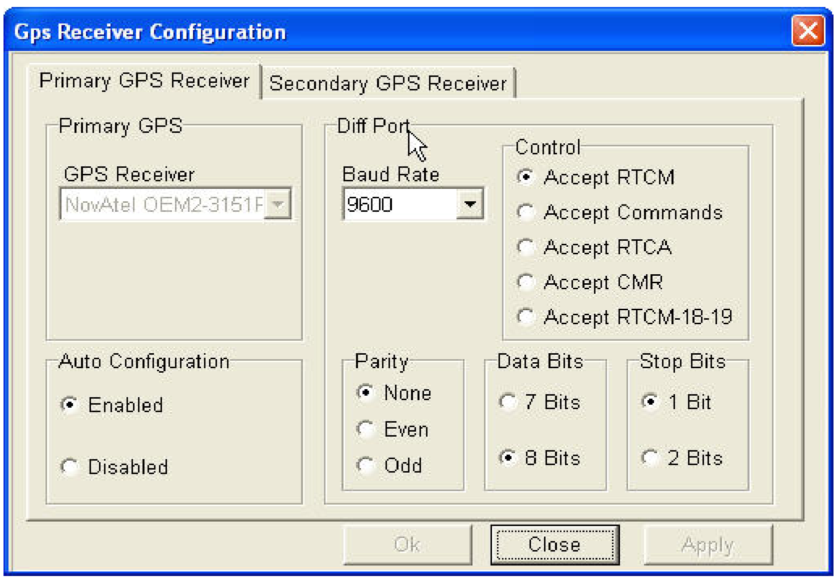
Frame Control (Use Tools > Config)



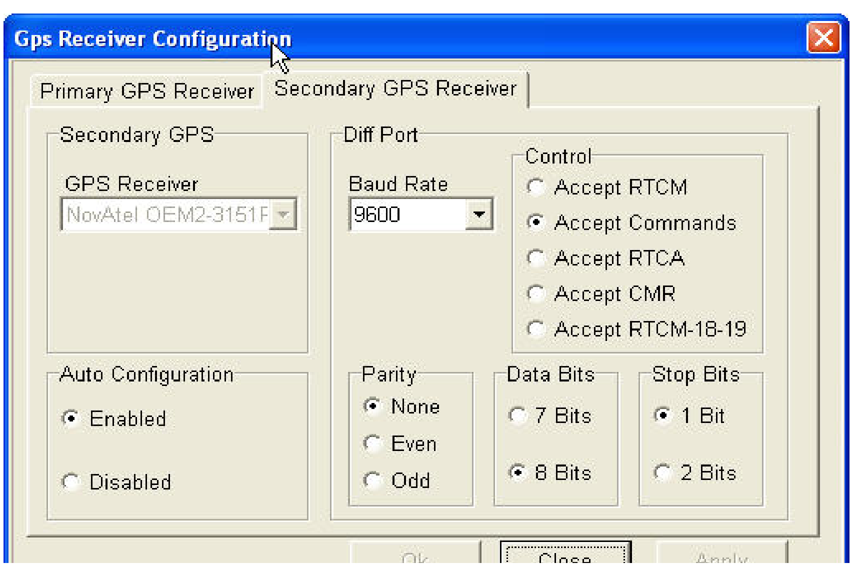
GPS Receiver Configuration

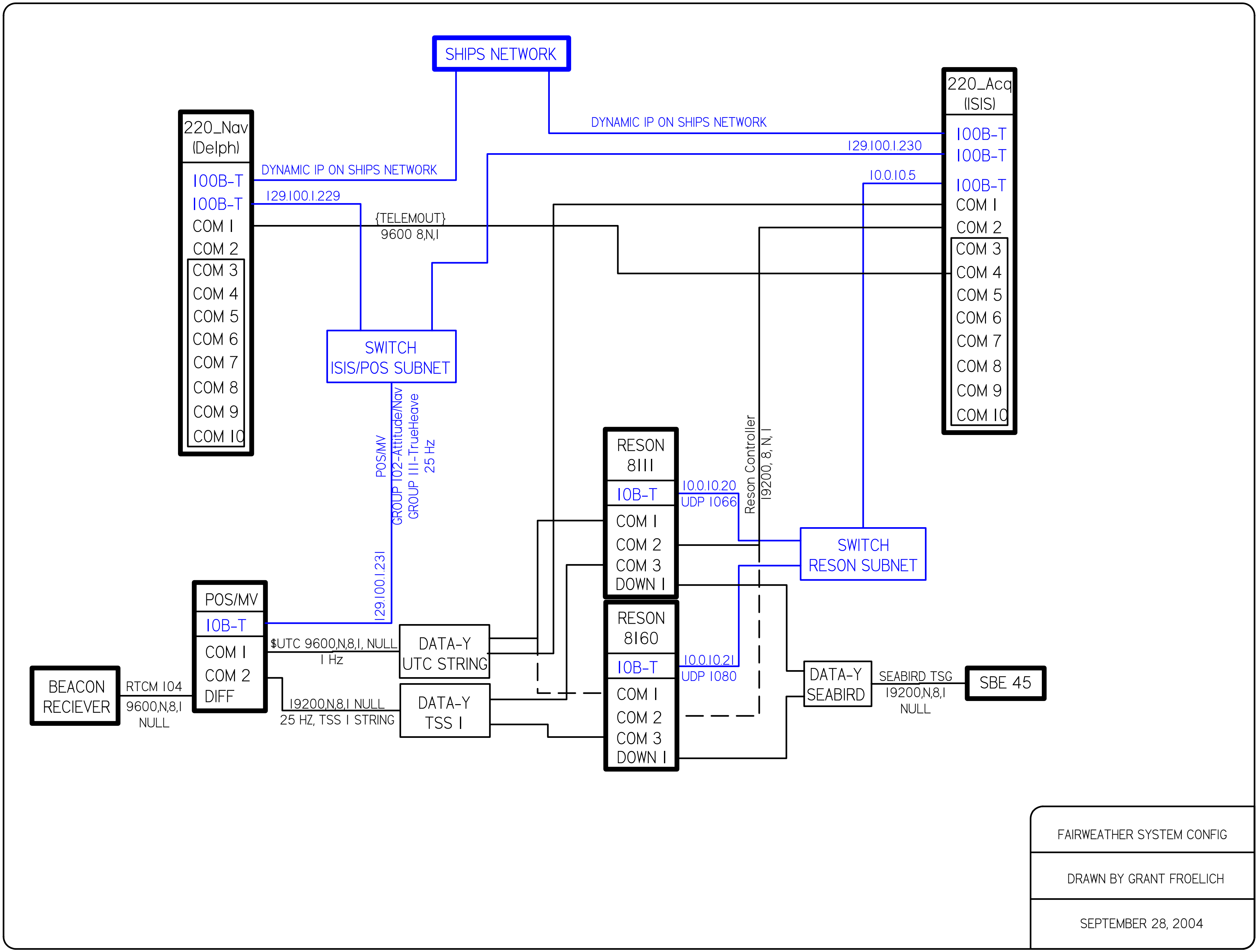
(Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver




SHIPS NETWORK
220_Nav (Delph)
100B-T
100B-T
COM 1
COM 2
COM 3
COM 4
COM 5
COM 6
COM 7
COM 8
COM 9
COM 10
DYNAMIC IP ON SHIPS NETWORK
129.100.1.229
{TELEMOUT}
9600 8,N,1
220_Acq (ISIS)
100B-T
100B-T
100B-T
COM 1
COM 2
COM 3
COM 4
COM 5
COM 6
COM 7
COM 8
COM 9
COM 10
DYNAMIC IP ON SHIPS NETWORK
129.100.1.230
10.0.10.5
SWITCH
ISIS/POS SUBNET
POS/MV
GROUP 102-Attitude/Nav
GROUP 111-TrueHeave
25 Hz
129.100.1.231
RESON 8111
10B-T
COM 1
COM 2
COM 3
DOWN 1
10.0.10.20
UDP 1066
Reson Controller
19200, 8, N, 1
SWITCH
RESON SUBNET
RESON 8160
10B-T
COM 1
COM 2
COM 3
DOWN 1
10.0.10.21
UDP 1080
POS/MV
10B-T
COM 1
COM 2
DIFF
BEACON RECIEVER
RTCM 104
9600,N,8,1
NULL
$UTC 9600,N,8,1, NULL
1 Hz
DATA-Y
UTC STRING
19200,N,8,1 NULL
25 HZ, TSS 1 STRING
DATA-Y
TSS 1
DATA-Y
SEABIRD
SEABIRD TSG
19200,N,8,1
NULL
SBE 45
FAIRWEATHER SYSTEM CONFIG
DRAWN BY GRANT FROELICH
SEPTEMBER 28, 2004

Appendix IV

Total Propagated Error (TPE)

TPE Values

	FAIRWEATHER SURVEY	*Doc. No .* REP-6XX	*DAPR Appendix IV*	*Process Owner* Grant Froliech
	Documents Title **FA_TPE_Values_2004**	*Last update* Jan 12, 2004	*Version* *2.1*	*Approval Date*

	Vessel	**FAIRWEATHER-S220**	**FAIRWEATHER-S220**	**1010**	**1018**
	Sonar System	**Reson 8111**	**Reson 8160**	**Reson 8101**	**Reson 8101**
	Positioning System	**POS/MV Model 320 V3**	**POS/MV Model 320 V3**	**POS/MV Model 320 V3**	**POS/MV Model 320 V3**
StdDev	Gyro (deg)	0.02	0.02	0.02	0.02
68% CI	Heave% Amp	5	5	5	5
	Heave (m)	0.05	0.05	0.05	0.05
	Roll (deg)	0.02	0.02	0.02	0.02
	Pitch (deg)	0.02	0.02	0.02	0.02
	Pos. Navigation (m)	0.5	0.5	0.5	0.5
	Timing Trans (s)	0.001	0.001	0.001	0.001
	Nav Timing (s)	0.001	0.001	0.001	0.001
	Gyro Timing (s)	0.001	0.001	0.001	0.001
	Heave Timing (s)	0.001	0.001	0.001	0.001
	Pitch Timing (s)	0.001	0.001	0.001	0.001
	Roll Timing (s)	0.001	0.001	0.001	0.001
	SV Meas (m/s)	0.5	0.5	0.5	0.5
	Surface SV (m/s)	0.5	0.1	0.5	0.5
	Tide Meas (m)	0.01	0.01	0.01	0.01
	Tide Zoning (m)	0	0	0	0
	Offset X (m)	0.003	0.003	0.007	0.007
	Offset Y (m)	0.003	0.003	0.007	0.007
	Offset Z (m)	0.003	0.003	0.007	0.007
	Vessel Speed (m/s)	0.03	0.03	0.03	0.03
	Loading	0.03	0.03	0	0
	Draft (m)	0.05	0.05	0.05	0.05
	DeltaDraft (m)	0.01	0.01	0.04	0.01
	MRU alignStdev gyro	unknown	unknown	unknown	unknown
	MRU align roll/pitch	unknown	unknown	unknown	unknown

	Vessel	**FAIRWEATHER-S220**	**FAIRWEATHER-S220**	**1010**	**1018**
	Sonar System	**Reson 8111**	**Reson 8160**	**Reson 8101**	**Reson 8101**
	Positioning System	**POS/MV Model 320**	**POS/MV Model 320**	**POS/MV Model 320**	**POS/MV Model 320**
Offsets	MRU to Trans X	2.868	0.493	0.262	0.272
	MRU to Trans Y	8.252	7.665	-0.151	-0.164
	MRU to Trans Z	4.753	4.559	0.546	0.55
	Nav to Trans X	2.993	0.618	1.159	1.2
	Nav to Trans Y	19.145	18.558	1.048	0.937
	Nav to Trans Z	16.253	16.060	3.687	3.719
	Trans Roll	0.00	0.00	0.00	0.00

Vessel Offsets

See

Appendix VI-1
Wetzler, M., (2004) Measuring Launch Offsets Standard Operating Procedure, NOAA Ship FAIRWEATHER Launches.

For 1010, see
Appendix III-1010-2
1010_Offsets & Measurements.xls

For 1018 see
Appendix III-1018-2
1018_Offsets & Measurements.xls

For S220, see
Appendix III-S220-2
S220_Offsets & Measurements.xls
Report of Sonar Array installation on NOAA FAIRWEATHER, Westlake Consultants, Inc September 23, 2003, 11 pages
S220_Stability_Test.jpg

1010

- **Automatic Vertical Compensator**
  - System : Liquid-electric detection
  - Working range : ±3'
- **Optical plummet**
  - Image : Erect
  - Magnification : 3×
  - Field of view : 5°
  - Focusing range : 0.5m～∞
- **Clamps/tangent screws** : Coaxial dual speed tangents
- **Sensitivity of level vials**
  - Plate level vial : 30"/2mm
  - Circular level vial : 10'/2mm
- **Tribrach** : Detachable
- **Dimensions and weight**
  - Main body : 5.5kg (12lbs) including BC-6 battery pack
  - Case : About 3.5kg (7.6lbs)
- **Operating temperature range**: −20°C～50°C/−4°F～+122°F

1018

SET5F Specifications

Telescope		**Fully transiting, coaxial EDM**
Length		165mm (6.5in)
Objective aperture		45mm (1.8in)
Magnification, image		30x, Erect
Resolving power		3.0"
Field of view		1°30'(26m/1,000m)
Minimum focus		1.3m (4.3ft.)
Reticle illumination		Bright or Dim, selectable
Angle measurement		**Incremental encoder, diametrical detection**
Display resolution	H&V	1"/ 0.2 mgon/ 0.005 mil, 5"/1 mgon/ 0.02 mil
Angle unit	H&V	Degree/Gon/Mil
Accuracy	H&V	5" (1.5 mgon/ 0.02 mil) according to DIN18723
Dual-axis compensator		Liquid dual-axis tilt sensor, range: ±3' (±55 mgon)
Display mode	H	Clockwise/ Counterclockwise, Repetition, Oset, Hold available
	V	Zenith 0°/ Horizontal 0°/ Horizontal 0°±90°/ Slope%
Distance measurement		**Electro-optical with modulated infrared LED.**
Measuring range (slope distance)		A: Average conditions; slight haze, visibility about 20km(12 miles), sunny periods, weak scintillation. G: Good conditions; no haze, visibility about 40km (25 miles), overcast, no scintillation. Maximum ranges are achieved with Sokkia CP/AP prisms.
With CP01 compact prism		A: 1.3m (4.3ft.) to 700m (2,300ft.)
With one AP01 prism		A: 1.3m (4.3ft.) to 1,200m (3,900ft.), G: 1,500m (4,900ft.)
With three AP01 prism		A: 1.3m (4.3ft.) to 1,600m (5,200ft.), G: 2,000m (6,500ft.)
Distance unit		Meters or feet, selectable
Accuracy (Fine measurement)		±(3+2ppmxD)mm D=measuring range, unit=mm
Measuring unit and time (slope distance)	Fine	0.001 m Every 3.2 seconds (initial 4.7 seconds)
	Rapid	0.001 m 1.7 seconds
	Tracking	0.01 m Every 0.3 seconds (initial 1.4 seconds)
	Average	0.0001 m (average of 2 to 9 times measurement)
Atmospheric correction		Key-in the temperature and pressure, or -499 to +499ppm.
Prism constant		-99 to 0mm (1 mm steps)
Refraction & Earth-curvature correction		On/off selectable (K=0.142)
General		
Display		LCD dot matrix display (20 characters x 4 lines) on both faces with back light.
Keyboard		5 keys on both faces, free assignment of functions.
Resume function		On/off selectable
Sensitivity of levels		Plate level: 40"/2mm, Circular level: 10'/2mm (in tribrach)
Optical plummet		Image: erect, Magnification: 3x, Minimum focus: 0.5m (1.6ft.)
Interface		Asynchronous serial, RS-232C compatible, baud rate 1200/ 9600bps
2-way communication		Provided
Data storage		3,000-point data memory
Operating temperature		-20°C to +50°C (-4°F to +122°F)
Tilting/Trunnion axis height		236mm (9.3in) from tribrach bottom, 193mm (7.6in) from tribrach dish.
Size with handle and battery		W150 x D165 x H353mm, W5.9 x D6.5 x H13.9in.
Weight with handle and battery		5.4kg (11.9lbs)
Weight of parts		BDC25 battery: 240g (8.5oz.), Handle: 100g (3.5oz.), Tribrach: 740g (1.6 lbs), Case:2.4kg (5.3lbs)
Power supplies		
Battery level display		4 steps with warning message.
Automatic power cut-off		On/off selectable (30 minutes after the last operation)
Power source		BDC25 rechargeable battery, Ni-Cd 6V, 2 supplied as standard.
Working duration at 25°C (77°F) w/one BDC25 battery		Distance & angle measurement: about 5 hours, about 600 points (Fine & single measurement with 30 seconds intervals). Angle measurement only: about 9 hours.
Charging time		CDC27/31: about 80 minutes, CDC31A: about 90 minutes

Attitude Data

POS MV™ 320

Performance

	RTK	DGPS
Position (m)	0.02 - 0.10	0.5 - 4.0
Velocity (m/s)	0.03	0.03
Roll and Pitch	0.01û	0.02û
True Heading	4m baseline: 0.01, 2m baseline: 0.02û	
Heave	5% of heave amplitude or 5cm	

For full POS/MV Specifications, see posmv v320 specs.pdf located in Appendix I.

Latency Uncertainty Estimates
Precise Timing and Transducer Timing

For information on upgrading NOAA Multibeam Acquisition Systems to “Precise Timing.”
See Precise Timing Setup.doc authored by Evans, B., (2004) and located in Appendix VI-1

Below is an email concerning latency, Riley, J., (2004) CARIS 5.4 Email, 2 pages.

Subject:
Re: CARIS 5.4
Date:
Thu, 22 Apr 2004 10:28:54 -0400
From:
"Jack Riley" <Jack.Riley@noaa.gov>
To:
"Shyla Allen" <shyla.allen@noaa.gov>, "Jeffrey Ferguson" <Jeffrey.Ferguson@noaa.gov>
CC:
"Marc S Moser" <Marc.S.Moser@noaa.gov>, "Ada Otter" <Ada.Otter@noaa.gov>, "Toshihiko Uozumi" <Toshihiko.Uozumi@noaa.gov>,
"Crescent Moegling" <Crescent.Moegling@noaa.gov>, "Ashley S Harris" <ashley.s.harris@noaa.gov>, "Shep Smith" <Shep.Smith@noaa.gov>,
"Edward J Van Den Ameele" <Edward.J.Vandenameele@noaa.gov>, "Kim Sampadian" <Kim.Sampadian@noaa.gov>
References:
1 , 2 , 3 , 4

Hello Shyla. Here's a short response to your first ?...will revisit other ?s when I get more time...

(1) For an initial implementation, I think it is safe to assume that the multibeam echosounder equipment keeps track of any internal latency and either compensates reported transmit time or includes this latency value in the datagram for use in processing software. The Reson Seabat series of multibeam sonars use this latter approach, and the HIPS converter applies the latency value to correct the transmit timestamps. I expect the precision of the clock in the multibeam system is pretty tight--barring finding any docs on this value, you can treat it as being zero and move on. So, the stdev of the transducer timestamp can be confined to the accuracy estimate of the data connection from the sonar (e.g., serial or Ethernet data transmit time stdev) and the stdev of the DAQ computer clock (e.g., NT+ based computer w/o specialized h/w ~10 ms (0.010 sec); so-called "precise timing" solution available in POS+Seabat+Isis config ~1 ms (0.001 sec)).

----- Original Message -----
From: Shyla Allen
To: Jeffrey Ferguson
Cc: Marc S Moser ; Ada Otter ; Toshihiko Uozumi ; Crescent Moegling ; Jack Riley ; Ashley S Harris ; Shep Smith ; Edward J Van Den Ameele ; Kim Sampadian
Sent: Wednesday, April 21, 2004 9:27 PM
Subject: Re: CARIS 5.4

Hello All,
You might want to grab a cup or two of coffee before you start on this one....

I have attached an error estimate spreadsheet of TPE values for the RAINIER which includes references for all the entries. I was hoping that somebody could help me with the following questions concerning TPE values:

(1) Where can find information about the stdev of the transducer time stamp. I can find no literature on line nor is it mentioned in the specifications sheets for the 8101,8125 or 1180. The data rate varies dependent on the ping rate but, I have a feeling that this would not affect the internal time stamping of the transducer.

(2) Can somebody clarify the difference between loading and draft? I can't think of a test for loading that wouldn't affect the static draft. CARIS defines the following:

a. Waterline- height of the waterline below the RP

b. Loading-vertical changes during the survey because of fuel consumption. (CARIS does not define the units, assuming meter).

c. Draft-the stdev of the vessel static draft

Which leads me to the following statements:

a.The waterline measurement error is based on how accurately you can read the waterline (direct measurement).

b.The expected change in the waterline due to fuel consumption of the course of a day (averaged over the course of the day).

c. Static draft error is the based on the accuracy that measure the true vertical distance between the transducer and the assumed waterline (direct measurement).

In which case I have the following questions:

b. Is the loading value the average vertical changes or is it the measurement accuracy (in the case of a 1" total change the measurement is known to be accurate within +/-0.5")?

c.If the loading value is the measurement accuracy isn't that essential the static draft error?

What is a draft latency? Is this referring to real time draft measurements from a draft well?

```
<DraftSensor>
  <TimeStamp value="2002-001 00:00:00">
   <Latency value="0.000000"/>
   <ApplyFlag value="Yes"/>
   <DraftEntries>
```

What is a waterline latency? Is the StdDev Waterline the "Delta Draft" entry?

```
  <WaterlineHeight>
  <TimeStamp value="2002-001 01:00:00">
   <Latency value="0.000000"/>
   <WaterLine value="0.000000"/>
   <ApplyFlag value="Yes"/>
   <StdDev Waterline="0.000000"/>
  </TimeStamp>
 </WaterlineHeight>
```

Scary you can almost see the wheel turning in my head.....

Any and all help will be greatly appreciated!

-Shyla

Below is email regarding a discussion on latency, originally from Rainier 2004 Error Estimates

Subject:
Re: CARIS 5.4
Date:
Wed, 14 Apr 2004 12:59:23 -0400
From:
"Jack Riley" <Jack.Riley@noaa.gov>
To:
"Shyla Allen" <shyla.allen@noaa.gov>
References:
1 , 2 , 3

Hello Shyla--got your phone msg too.
The paper that Rob is referring to is the "Multibeam System Calibration using Stochastic Optimization" paper I wrote for CHC2000. It was about automating the patch test analysis procedure, and focused on estimating the system biases (e.g., positional, angular, and temporal offsets)--not the random error/precision/uncertainty of the sensor measurements.
Timing precision for the various sensors can be estimated from statistics computed from "workbench" measurements using a known [high-precision] reference clock, or from known resolution/precision values associated with the data logging system (hardware, OS/software). We haven't done the former...but EED could help us do something like this in the future. For the latter option, we're talking about PC-based data acquisition using NT+ OSs, incorporated with optional time controllers (e.g., the so-called Precise Timing setup for POS/Reson/Isis systems that Ben et al just got RA going with), over serial or Ethernet connection using (optional) data broadcasters/hubs/switches.
Practically speaking, NT+ OSs nominally have a timing precision of 10 ms (i.e. 0.010 seconds). The jury is still out on the RA precise timing setup--perhaps it's better than 1 ms (0.001 sec)?

Below is 2nd Discussion of Latency, originally from Rainier 2004 Error Estimates

SeaBird 19plus

The full specifications for the Fairweather SeaBird 19Plus CTDs are located in Appendix I.

	Temperature (°C)	Conductivity (S/m)	Strain Gauge Pressure
Measurement Range	-5 to +35	0 to 9	0 to full scale range: 20 / 100 / 350 / 1000 / 2000 / 3500 / 7000 meters
Initial Accuracy	0.005	0.0005	0.1% of full scale range
Typical Stability (per month)	0.0002	0.0003	0.004% of full scale range
Resolution	0.0001	0.00005 (most oceanic waters; resolves 0.4 ppm in salinity) 0.00007 (high salinity waters; resolves 0.4 ppm in salinity) 0.00001 (fresh waters; resolves 0.1 ppm in salinity)	0.002% of full scale range
Sensor Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	+1 to +32	0 to 9; physical calibration over range 1.4 to 6 S/m, plus zero conductivity (air)	Ambient pressure to full scale range in 5 steps
Memory	8 Mbyte non-volatile FLASH memory		
Data Storage	<u>Recorded Parameter</u> — <u>Bytes/sample</u> temperature + conductivity — 6 (3 each) strain-gauge pressure — 5 each external voltage — 2 date and time (Moored mode only) — 4		
Real-Time Clock	32,768 Hz TCXO accurate to ±1 minute/year		
Internal Batteries	Nine alkaline D-cells - 60 hours continuous CTD operation (profiling mode, with no auxiliary sensors). Optional Ni-Cad battery pack - 24 hours continuous CTD operation / charge (profiling mode, with no auxiliary sensors).		
External Power Supply	9 - 28 VDC		
Power Requirements	*Sampling:* 65 mA *SBE 5M pump:* 95 mA (continuous duty, profiling mode); 0.148 amp-seconds per 0.5 second pulse (pulsed duty, moored mode) *Quiescent:* 30 μA Actual sampling (non-quiescent) time in Moored mode is 3.0 seconds/sample (if configured with no delays and 1 measurement per sample).		
Auxiliary Voltage Sensors	Auxiliary power out: up to 500 mA at 10.5 - 11 VDC A/D resolution: 14 bits Input range: 0 - 5 VDC		
Housing Materials	600 meter (1950 ft) - acetal copolymer (plastic) 7000 meter (22,900 ft) - 3AL-2.5V titanium		
Weight	With plastic housing: 7.3 kg (16 lbs) With titanium housing: 13.7 kg (30 lbs)		

MEMO

Date: 5 May 2004
From: Brian Calder
To: Shyla Allen, Jeff Fergusson (and others as required)
Topic: CARIS "draft" uncertainty and sound speed from CTDs.

Uncertainty in Speed of Sound Determination from CTDs

I have done a little more digging on the topic of sound speed determination from CTD measurements, and have tried to quantify a figure for uncertainty based on the Chen-Millero-Li equations [1] for sound speed, the Fofonoff-Millard equations for salinity from conductivity, pressure and temperature [2], and the values in the SeaBird SBE19 manuals for the base uncertainties of the actual measurements (conductivity, temperature and pressure). The SeaBird manual describes the values presented as 'accuracy', which normally means a bias from the true value, and not the precision of the measurements

(the topic of interest here). Assuming that they really mean 'precision', they list errors of 0.01 °C, 0.001 S/m and either 0.25% FSD or 0.02% FSD for pressure for a strain gauge or digiquartz pressure sensor (respectively). I have assumed that the 300 psia pressure scale is the maximum likely to be used for hydrographic work (300 psia is about the gauge pressure at 200 m), and therefore the likely maximum error is 5.2 kPa for a strain gauge or 420 Pa for a digiquartz gauge. I have also assumed that these are RMS values, and therefore equivalent to standard deviations.

The manual also indicates increases of error with time as the calibration drifts. These amount to 0.01 °C/6 mo., and 0.001 S/m/mo.; there is no indicated drift for pressure calibration. Therefore, I also built a scenario for the system being 12 months out of calibration to examine the effect towards the end of a field season.

I built code to compute the salinity and sound speed given the raw measurements, and then embedded this into a Monte Carlo scheme to generate pseudo-random samples of these estimates. I chose ranges of [1,6] S/m, [5,35] °C and $[0, 2.5\times10^6]$ Pa, which cover likely ranges of the variables down to approximately 250 m, in steps of 1 S/m, 5 °C and 10^5 Pa (approx. 10 m). For each set of mean values (1092 in all), the code generated 500 pseudo-samples according to the uncertainties in the base measurements outlined above, and then computed the mean and standard deviation of the derived sound speed to summarise the expected variability.

For the uncertainties at calibration, estimates of approx. 0.013-0.043 m/s and 0.014-0.046 m/s (for digiquartz and strain gauge, respectively) were found (at one standard deviation); for the 12-month scenario, estimates of approx. 0.069-0.21 m/s and 0.068-0.22 m/s were found (with the same conditions). Uncertainties decreased with increasing temperature and salinity, but seemed mostly unaffected by pressure changes.

Hence, it appears that the type of pressure sensor is not a major influence, and that we might expect the CTD to provide sound speed estimates with standard deviations approx. 0.25 m/s in practice. However, the equations used in determination of the salinity and sound speed are generated from numerical fits to laboratory data and hence have uncertainties of their own. Chen & Millero [1] indicate that the standard deviation of the fit is approx. 0.19 m/s, and hence we should expect a somewhat higher standard deviation that indicated from the Monte Carlo analysis if we were to refer the sound speed values to an absolute reference. Chen & Millero also point out that their sound speed determinations only agree with Del Grosso & Mader's [3] values to within approx. 0.5 m/s over the range of inputs, even under laboratory conditions, and therefore it is probably unreasonable of us to expect that a field method is going to be much better than probably unreasonable of us to expect that a field method is going to be much better than this in practice.

Therefore, I would suggest that an uncertainty estimate of 0.5 m/s (at one standard deviation) is reasonable for the types of CTD that are currently in use with the fleet. This might be a little pessimistic, but it is in the correct ballpark sans further information.

References

[1] Chen, C.-T., and F. Millero, "Speed of Sound in Seawater at High Pressures", J. Acoust. Soc. Am., 62(5), pp.1129-1135, 1977.

[2] Fofonoff, N. P., "Physical Properties of Seawater: A New Salinity Scale and Equation of State for Water", J. Geophys. Res. 90(C2), pp. 3332-3342, 1985.

[3] Del Grosso, V. A., and C. W. Mader, "Speed of Sound in Seawater Samples", J. Acoust. Soc. Am., 52, pp. 961-974, 1972.

SeaBird 45
Surface Sound Velocity (8160)

For full SeaBird 45 specifications, see SBE45 specs.pdf located in Appendix I.

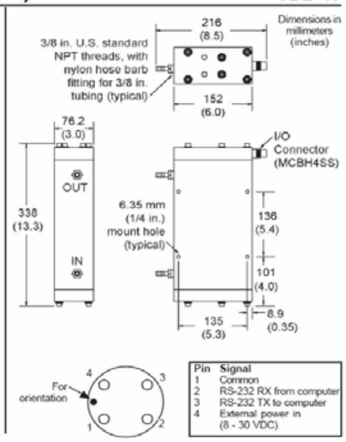
MicroTSG (Thermosalinograph)

SBE 45

SPECIFICATIONS

Measurement Range	
Conductivity:	0-7 S/m (0-70 mS/cm)
*Temperature *:*	-5 to 35 °C
Initial Accuracy	
Conductivity:	0.0003 S/m (0.003 mS/cm)
*Temperature *:*	0.002 °C
Salinity:	0.005 PSU, typical
Typical Stability *(per month)*	
Conductivity:	0.0003 S/m (0.003 mS/cm)
*Temperature *:*	0.0002 °C
Salinity:	0.003 PSU, typical
Resolution	
Conductivity:	0.00001 S/m (0.0001 mS/cm)
*Temperature *:*	0.0001 °C
Salinity:	0.0002 PSU, typical
Calibration Range	
Conductivity:	0-6 S/m (60 mS/cm); physical calibration 2.6-6 S/m (26-60 mS/cm), plus zero conductivity (air)
*Temperature *:*	+1 to +32 °C
Time Resolution	1 second
Clock Stability	13 seconds/month
Input Power	8-30 VDC
Acquisition Current	34 mA at 8 VDC; 30 mA at 12-30 VDC
Quiescent Current	10 microamps
Acquisition Rate	1 Hz maximum
Operating Pressure	34.5 decibars (50 psi) maximum
Flow Rate	10 to 30 ml/sec (0.16 to 0.48 gal/min)
Materials	PVC housing
Weight	4.6 kg (10.2 lbs)

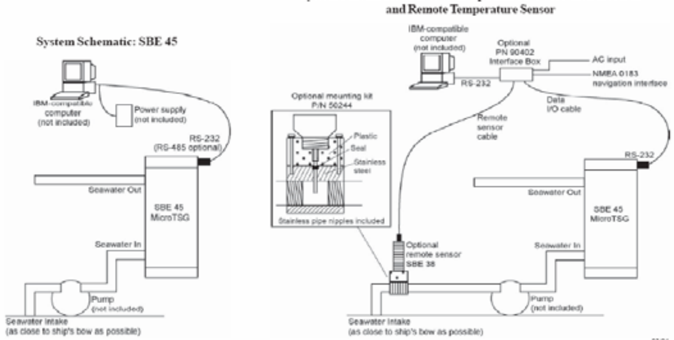
* For specifications for optional SBE 38 remote temperature sensor, see SBE 38 datasheet.



Pin	Signal
1	Common
2	RS-232 RX from computer
3	RS-232 TX to computer
4	External power in (8 - 30 VDC)

System Schematic: SBE 45 with Optional PN 90402 Interface Box and Remote Temperature Sensor

System Schematic: SBE 45



SBE Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
E-mail: seabird@seabird.com
Telephone: (425) 643-9866
Fax: (425) 643-9954

Subject: Re: SBE45 Std Dev
Date: Mon, 28 Jun 2004 11:31:09 -0400
From: Brian Calder <brc@ccom.unh.edu>
Organization: Center for Coastal and Ocean Mapping & Joint Hydrographic Center
To: Grant Froelich <grant.froelich@noaa.gov>

Hi Grant,

Congratulations on the move to Fairweather; I understand it should be a very nice ship to sail in once it gets going.

I've looked into the SBE45 with the same method that I used for the SBE19, and it appears to me to be significantly better in theory. The initial and drift accuracies are about 3-10 times better than the SBE19, and therefore, we should expect a somewhat better performance both initially and over time. Assuming that the system software is tuned to the more limited range of temperature, conductivity and pressure implied by this system configuration, then the system probably also does better in matching the various defining equations that can be used to predict sound speed from the base measurements.

I have doubts, however, about whether the accuracies are realistic --- the drift amounts to about 2 lsd per month, implying that you can really tell that well what's going on. This might be possible, but I've never used one of these, so I don't know whether it's probable.

There's also the question of what's going to happen over time --- I'm assuming that the TSG isn't going to be removed and recalibrated every so often? Therefore the measurement budget will probably have to be inflated each year as the system ages.

All that aside, the numbers indicate about 0.01 m/s at initial calibration, fading to about 0.12 m/s (max) after 12 months, and about 0.10 m/s per year thereafter. I really don't know whether it will continue to degrade over time, or whether it will eventually settle to a particular level of accuracy and stay there.

So I think I'd say that the probable accuracy over the first year would be something on the order of 0.10-0.25 m/s (1sd), conservatively, and might get worse over time unless the TSG is removed and recalibrated every so often.

Hope that helps,
Brian.

Brian Calder (brc@ccom.unh.edu) 1-603-862-0526 (Fax 1-603-862-0839)
Center for Coastal and Ocean Mapping & Joint Hydrographic Center
Chase Ocean Engineering Lab, University of New Hampshire, Durham NH 03824

Tide Zoning from CO-OPS
(Subject to change survey to survey)

From THOMAS JEFFERSON Survey
*TJ Zoning error used because no FAIRWEATHER projects zoning error has been supplied

Tide Error Break Down:

This is how we determine the tidal error estimates for a particular area.

Using a 30 day station with zoning – Typical scenario

Confidence Interval = b +1.96 * s (estimates maximum error)

b = systematic errors/biases
s = random errors at one standard deviation

For water levels there are 3 major categories of error sources. The following shows maximum errors for each category:

1) Measurement – error associated with measuring water levels in the dynamic environment and relating the measurement to a station datum.
   - **a.** Calibration <0.01 meters **Systematic Error**
   - b. Dynamic Effects (waves, currents,) <0.05 meters **Systematic Error**
   - c. Processing to Datum **Random Errors**
     - i. Leveling <0.01 meters
     - ii. Staff/gauge <0.03 meters (not applicable with acoustic gauges, only pressure gauges)
     - iii. Processing <0.03 meters

2) Tidal Datum – Error associated with estimating tidal datums using less than 19-year periods.
   - a. 30-day station East and West coast - <0.08 Gulf of Mexico < .10 meters **Systematic Error**

3) Tidal Zoning – Errors associated with extrapolating the tide observed at certain station locations to discrete zones, using time and range correctors.

   Typical estimate is 0.20 meters **Random Error**

(This value will be negligible ~0 when zoning direct off of a subordinate gauge. – no time and range correctors)

Typical Observed Tide Measurement
(Subject to change per project)

From PS Shyla Allen

RSS (Root Sum Square) rounded up to 0.01, observed tide measurements are not fully available during acquisition, therefore the value at 0.01 is a conservative estimate.

Station	Date	Time	WL	**Sigma**	I	F	R	T	
9451600	5/10/2002	0:00	0.791	0.004	0	0	0	0	**rss**
9451600	5/10/2002	0:06	0.745	0.008	0	0	0	0	**0.003332**
9451600	5/10/2002	0:12	0.702	0.008	0	0	0	0	
9451600	5/10/2002	0:18	0.642	0.009	0	0	0	0	
9451600	5/10/2002	0:24	0.608	0.006	0	0	0	0	
9451600	5/10/2002	0:30	0.57	0.006	0	0	0	0	
9451600	5/10/2002	0:36	0.533	0.008	0	0	0	0	
9451600	5/10/2002	0:42	0.505	0.007	0	0	0	0	
9451600	5/10/2002	0:48	0.478	0.008	0	0	0	0	
9451600	5/10/2002	0:54	0.448	0.007	0	0	0	0	
9451600	5/10/2002	1:00	0.42	0.008	0	0	0	0	
9451600	5/10/2002	1:06	0.397	0.005	0	0	0	0	
9451600	5/10/2002	1:12	0.367	0.004	0	0	0	0	
9451600	5/10/2002	1:18	0.347	0.006	0	0	0	0	
9451600	5/10/2002	1:24	0.331	0.003	0	0	0	0	
9451600	5/10/2002	1:30	0.315	0.006	0	0	0	0	
9451600	5/10/2002	1:36	0.297	0.003	0	0	0	0	
9451600	5/10/2002	1:42	0.288	0.004	0	0	0	0	
9451600	5/10/2002	1:48	0.28	0.002	0	0	0	0	
9451600	5/10/2002	1:54	0.27	0.004	0	0	0	0	
9451600	5/10/2002	2:00	0.26	0	0	0	0		
9451600	5/10/2002	2:06	0.26	0	0	0	0		
9451600	5/10/2002	2:12	0.267	0	0	0	0		
9451600	5/10/2002	2:18	0.283	0	0	0	0		
9451600	5/10/2002	2:24	0.281	0	0	0	0		
9451600	5/10/2002	2:30	0.297	0	0	0	0		
9451600	5/10/2002	2:36	0.32	0	0	0	0		
9451600	5/10/2002	2:42	0.337	0	0	0	0		
9451600	5/10/2002	2:48	0.35	0	0	0	0		
9451600	5/10/2002	2:54	0.375	0	0	0	0		
9451600	5/10/2002	3:00	0.401	0.003	0	0	0	0	
9451600	5/10/2002	3:06	0.433	0.005	0	0	0	0	
9451600	5/10/2002	3:12	0.466	0.004	0	0	0	0	
9451600	5/10/2002	3:18	0.503	0.005	0	0	0	0	
9451600	5/10/2002	3:24	0.541	0.005	0	0	0	0	
9451600	5/10/2002	3:30	0.585	0.006	0	0	0	0	
9451600	5/10/2002	3:36	0.63	0.007	0	0	0	0	
9451600	5/10/2002	3:42	0.672	0.008	0	0	0	0	
9451600	5/10/2002	3:48	0.714	0.007	0	0	0	0	
9451600	5/10/2002	3:54	0.768	0.006	0	0	0	0	
9451600	5/10/2002	4:00	0.806	0.006	0	0	0	0	
9451600	5/10/2002	4:06	0.859	0.006	0	0	0	0	
9451600	5/10/2002	4:12	0.906	0.007	0	0	0	0	
9451600	5/10/2002	4:18	0.958	0.008	0	0	0	0	
9451600	5/10/2002	4:24	1.007	0.008	0	0	0	0	
9451600	5/10/2002	4:30	1.05	0.008	0	0	0	0	
9451600	5/10/2002	4:36	1.111	0.01	0	0	0	0	
9451600	5/10/2002	4:42	1.16	0.008	0	0	0	0	
9451600	5/10/2002	4:48	1.228	0.008	0	0	0	0	
9451600	5/10/2002	4:54	1.288	0.008	0	0	0	0	
9451600	5/10/2002	5:00	1.348	0.009	0	0	0	0	

Vessel Loading
Standard Deviation Based on Various Loading Conditions

See Loading_worksheet.xls located in Appendix IV - 3

UNIVERSITY OF NEW HAMPSHIRE

Center for Coastal and Ocean Mapping/Joint Hydrographic Center
Chase Ocean Engineering Lab
24 Colovos Road
Durham, New Hampshire 03824-3525
PHONE: (603) 862-3433
FAX: (603) 862-0839
www.ccom.unh.edu

MEMO

Date: 5 May 2004
From: Brian Calder
To: Shyla Allen, Jeff Fergusson (and others as required)
Topic: CARIS "draft" uncertainty and sound speed from CTDs.

Uncertainty in "draft" v's waterline

I have now heard from Bill Lamey and Wing Wong at CARIS on the issue of "draft" uncertainty in HIPS 5.4 HVF files, with respect to the "waterline" section of the HVF. They confirmed that this is an issue with the difference in specification between the CHS error model and HIPS's mode of describing offsets. That is, the CHS model uses the draft of the sensor below the waterline in order to do vertical corrections, and assumes that it is measured directly (with some uncertainty: the "draft" section in the CHS error model); HIPS measures the waterline w.r.t. the RP, and the offset of the transducer w.r.t. the RP, and then computes the vertical offset by subtraction. Therefore, it should have an uncertainty for the waterline measurement, and combine that with the uncertainty of the transducer vertical offset to determine the uncertainty of the draft correction that is being applied. However, they have not included an uncertainty for the waterline measurement, and use only the "draft" uncertainty for this element of the computation.

I suggested to them that it might be appropriate to make a nomenclature change, call the slot "waterline uncertainty" and compute the uncertainty appropriately. The alternative is to instruct the user to make the appropriate calculations and set the "draft" uncertainty to the quadratic sum of the transducer Z-offset and the waterline measurement uncertainty when the model is set up in HVF form. After some consideration they opined that the latter option was better for them.

Therefore, when entering the "draft" uncertainty, you should include your uncertainty of waterline determination, and the uncertainty of transducer offset w.r.t. the RP.

Dynamic Draft

Hull 1010

See 1010/DDSSM section of Appendix III-1010-4.

Std Dev
0.04

Hull 1018

See 1018/DDSSM section of Appendix III-1018-4.

Std Dev not utilized due to problems with the DDSSM data.

Total Propagated Error

This section defines the values for calculating Total Propagated Error (TPE). TPE is derived from a combination of all individual error sources. The TPE Configuration section of the vessel file contains the following errors (among others):

- nav/gyro/heave/pitch/roll/tide errors
- latency error estimate
- sensor offset error estimates.

These errors are combined with individual sonar model characteristics in the DeviceModels.xml file to calculate horizontal and vertical uncertainty values for every sounding along a track line when TPE is applied (see "Total Propagated Error" on page 7-20).

1. Expand the TPE section by clicking + icon.
2. Type data (as needed) in the Offsets section:
   - *MRU to Transducer*: The physical 3D offset from the motion recording unit to transducer 1 on the vessel. All units in metres.
   - *MRU to Transducer2*: The physical 3D offset from the motion recording unit to transducer 2 on the vessel. All units in metres.
   - *Navigation To Transducer*: The physical 3D offset from the navigation sensor to transducer 1 on the vessel. All units in metres.
   - *Navigation To Transducer2*: The physical 3D offset from the navigation sensor to transducer 2 on the vessel. All units in metres.
   - *Transducer Roll*: The mounting roll offset for transducer 1 in degrees.
   - *Transducer Roll 2*: The mounting roll offset for transducer 2 in degrees.
3. Type data (as needed) in the Standard Deviation section:
   - *Gyro*: The measurement standard deviation of the heading data in degrees.
   - *Heave % Amplitude*: An additional heave standard deviation component that is the percentage of the instantaneous heave.
   - *Heave*: The measurement for standard deviation of the heave data in metres. Most heave manufacturers quote heave error as being determined from StaticHeave or PercentageOfHeave depending on which value is larger.
   - *Roll*: The measurement standard deviation of the roll data in degrees.
   - *Pitch*: The measurement standard deviation of the pitch data in degrees.

- *Navigation*: The standard deviation associated with the measurement of positions for the vessel in metres. This is usually the error of the GPS sensor being used.
- *Timing Transducer*: Standard deviation in transducer time stamp measurement.
- *Navigation Timing*: Standard deviation in navigation time stamp measurement.
- *Gyro Timing*: Standard deviation in gyro time stamp measurement.
- *Heave Timing*: Standard deviation in heave time stamp measurement.
- *Pitch Timing*: Standard deviation in pitch time stamp measurement.
- *Roll Timing*: Standard deviation in roll time stamp measurement.
- *Sound Velocity Measured*: The standard deviation in the measurement of Sound Velocity readings in metres/second.
- *Surface*: The standard deviation in the measurement of Surface Sound velocity in metres/second.
- *Tide Measured*: The standard deviation in the measured tide values in metres.
- *Tide Zoning*: The standard deviation in the tide values associated with zoning in metres.
- *Offset X*: Standard deviation for the X measured offset on the vessel in metres.
- *Offset Y*: Standard deviation for the Y measured offset on the vessel in metres.
- *Offset Z*: Standard deviation for Z measured offset on the vessel in metres.
- *Vessel Speed*: The standard deviation for the vessel speed measurements in metres/second.
- *Loading*: Vertical changes during the survey because of fuel consumption, etc.
- *Draft*: The standard deviation in the vessel draft measurements in metres.
- *Delta Draft*: The standard deviation in the dynamic vessel draft measurements in metres.

See 8101_CARIS_Device_Model_xml.doc located in Appendix IV - 2
See 8111_CARIS_Device_Model_xml.doc located in Appendix IV - 2
DeviceModels.xml, the Device Model used by the Fairweather while processing in CARIS during the 2004 season, is located in Appendix IV - 2.

DeviceModel.XML Explanantion from Bill Lamey HIPS/SIPS Program Manager 08/05/2004

```
<SonarModel label="Simrad EM300" key="em300">
<Max_Num_Beams value="135"/>                    /* Maximum number of beams on device */
  <Operating_Frequency_1 value="30.0"/>         /* Operating frequency 1 (or prime freq.), kHz */
  <Operating_Frequency_2 value="0.0"/>          /* Operating frequency 2 (or zero), kHz */
  <Max_Angle value="75.0"/>                     /* Maximum angle away from nadir, deg. */
  <Beam_Width_Across value="1.0"/>              /* Beam widths, degrees */
  <Beam_Width_Along value="1.0"/>               /* Beam widths, degrees */
  <Steering_Angle value="0.0"/>                 /* Angle beyond which beams are steered, deg. */
  <Range_Sampling_Frequency value="5000.0"/>    /* Range sampling frequency, Hz */
  <Range_Sampling_Distance value="0.15"/>       /* Range sampling distance, m */
<Min_Pulse_Length value="5.0"/>                 /* Minimum pulse length, ms. */
  <Rates>
   <Repitition value="10"/>                     /* Maximum rep. rate, pings/second */
   <Bathy value="10"/>                          /* Rate of bathymetry packets per second */
   <Attitude value="200"/>                      /* Packets of attitude information per datagram */
   <Imagery value="1"/>                         /* Packets of imagery per datagram */
  </Density>
  <DeviceProperties>
   <Multibeam value="Yes"/>                     /* Device is a multi-beam (else single-beam). Note that MB not= MBES since e.g. K5K has multiple beams. */
   <SideScan value="No"/>                       /* Device is a true side-scan sonar */
   <Towed value="No"/>                          /* Device is towed/tethered or is being towed */
   <Calibrated value="Yes"/>                    /* Device backscatter is calibrated in dB */
   <DualFrequency value="No"/>                  /* Device uses two operating frequencies */
   <HasAccuracy value="No"/>                    /* Accuracy information for device is available through device module calls */
   <Steered value="Yes"/>                       /* Device has steered beams */
   <Splithead value="No"/>                      /* Device is physically in two halves (typically one on either side of the ship) */
   <Bathymetric value="Yes"/>                   /* Device can generate bathymetry information */
   <Imagery value="Yes"/>                       /* Device can generate imagery (backscatter) */
   <Attitude value="Yes"/>                      /* Device can generate attitude datastream */
  </DeviceProperties>
 </SonarModel>
```

Email: CARIS Device Model
Date: 07/22/2004
From:K.Wing Wong (CARIS)

The range sampling distance is specified in terms of metres.
It is used to compute the Range measurement error (equation 3.20 in the 1995 Rob Hare/CHS report). The code that we received from UNH has this value hardcoded for a number of devices. In our implementation we have moved those defaults into the devicemodel XML file, so that the user can change them.

The range sampling frequency is specified in Hz, and was originally intended for use in computing errors due to beam angle measurements. This value is not actually being used in the computation, I think due to the fact that its validity was not certain.

Email correspondence, originally from Rainier 2004 Error Estimates, 2 pages.

Thu May 06 19:12:51 2004
To: Shyla Allen <shyla.allen@noaa.gov>
Subject: Re: CARIS draft uncertainty and CTD sound speed determination

I wouldn't get too attached to the numbers suggested: they are, at best, rough predictions of likely uncertainty. I made a bunch of assumptions in developing the test, particularly the assumption that the numbers given by SeaBird were for random uncertainty (a.k.a. precision or variance), and not for systematic uncertainty (a.k.a. bias or accuracy). This may not be the case (in which case, they certainly should give a random uncertainty estimate too). However, I think the values are in the right ball-park, even if they're not quite in the slips (cricket ref., not baseball), and given the model errors suggested by the authorities, I don't see a field method being better than about 0.5m/s (1sd), as I said. I think Rob's flying low with 0.25m/s.

> 1) XYZ offset measurements on the launches. Besides the offset
> measurements that were conducted this year for the launches there is no
> documentation of procedures used to measure the offset.

I think it's probably safe to assume that the procedures haven't changed a whole heap in the last couple of years, although the physical tapes might have done.

> Even if I get the documentation from this year I can not assess the sum of the
> variance in the measurements since there is only one measurement.

You don't strictly need to have more than one measurement to work out the variance: you can predict it based on your knowledge of the likely accuracy of the tape measurement itself. That is, say that you know that the tape is graduated in mm marks. Then you know that, blunders notwithstanding, the measurement can be read to within about +/- 0.5mm with care. Assuming that the folks doing the measuring are careful to make sure that things are plumb before they measure and that they take care to avoid parallax error, then you can assume that every measurement should have (say 95%) uncertainty of 0.5mm. You then need to look at the way that the measurements are combined, and accumulate the measurement uncertainties with the data; for example, if you add or subtract two numbers, then you add the variances; if you measure more than once and average the results, then the variance goes down as 1/N for N independent measurements.

So given the measurements that you have from the latest survey and the methods used, you should be able to come up with an estimate of the uncertainty of the offset predictions. Having multiple measurements would be nice, of course, since you could use this as a way of testing your predictions, but if you can't get them, then you might just have to go with the estimates.

You might want to try to find a copy of "Measurement Uncertainty: Methods and Applications", R. H. Dieck (the one we have is 3rd ed., ISBN

Methods and Applications", R. H. Dieck (the one we have is 3rd ed., ISBN 1-55617-795-X), which has a relatively informal but clear introduction to the estimation and combination of error sources (and is quite amusing too: "pride" is defined in the glossary as "The human factor most to blame for estimating systematic uncertainty too low"; "bad data" is defined as "Data that disprove 'my' theory or thesis".) Amazon's list price is $66.

> 2) XYZ offset measurements on the RAINIER. OTF ambiguity resolution was
> conducted in 98 or 99 but, the ship can not seem to locate any
> documentation about this survey.

I'm not sure that I understand what you mean: did they take an antenna to each position? If not, then this would only tell you about the vertical component (as you suggest below).

[Draft and Waterline]

Same answer as above: you can estimate it, even if you don't have repeated measurements to check it with (although that's better, of course).

I spoke, earlier today, with the inestimable Dr. Huff on exactly this matter, and he recalled that the RAINIER was hauled out and accurately measured (with an EDM) when the Elac system was installed, but that you have to bear in mind that the ship might flex a little when put back into the water --- his guess is not more than 1%, though (and Lloyd's guesses are usually good within 5-10% of their magnitude). He agreed with your idea of a sight tube being installed, although he was much more enthusiastic about linking an automatic system into the transducer well in order to do the measurement directly. If I'm understanding his idea correctly, I'm seeing something like a standard tide-gauge installed at the transducer void and leveled into the ship's coordinate frame just like you would when installing on shore; you'ld then blank the data stream except when the GPS indicates the ship has stopped, the only difficulty being to make sure that the time reference of the systems doesn't get too far out of step. His guess for static draft changes on RAINIER is about 1m, which could be significant in some areas where the ship's system might be used.

He also suggested that loading of the launches shouldn't be much more than about 3cm (I guess that's where TJ's numbers came from), and I think I agree. Your suggestion of waterline marks would allow this to be confirmed over a period of time.

Hope that helps,
Brian.
--

Brian Calder (brc@ccom.unh.edu) 1-603-862-0526 (Fax 1-603-862-0839)
Center for Coastal and Ocean Mapping & Joint Hydrographic Center
Chase Ocean Engineering Lab, University of New Hampshire, Durham NH 03824

Vessel Loading
Standard Deviation Based on Various Loading Conditions

1010

Vessel Loading Std Dev Worksheet

DN	Reading From	Draft Reading Beginning	Draft Reading End	Draft Change
254	BM A	0.875	0.825	-0.050
254	BM B	0.875	0.825	-0.050

Std. Dev 0.000

1018

Vessel Loading Std Dev Worksheet

DN	Reading From	Draft Reading Beginning	Draft Reading End	Draft Change
253	BM A	0.795	0.770	-0.025
253	BM B	0.825	0.815	-0.010

Std. Dev 0.011

S220

Vessel Loading Std Dev Worksheet

DN	Draft Reading Beginning	Draft Reading End	Draft Change

Std. Dev #DIV/0!

Draft readings should be taken by same person for morning and afternoon readings
Only enter values into the non-colored cells. Colored cells are locked.

- <SonarModel label="Reson SeaBat 8101" key="sb8101">
<Max_Num_Beams value="101" />
<Operating_Frequency_1 value="240.0" />
<Operating_Frequency_2 value="0.0" />
<Max_Angle value="75.0" />
<Beam_Width_Across value="1.5" />
<Beam_Width_Along value="1.5" />
<Steering_Angle value="60.0" />
<Range_Sampling_Frequency value="10000.0" />
<Range_Sampling_Distance value="0.05" />
<Min_Pulse_Length value="0.15" />
- <Rates>
<Repitition value="30" />
<Bathy value="30" />
<Attitude value="0" />
<Imagery value="30" />
</Rates>
- <Density>
<Bathy value="1" />
<Attitude value="0" />
<Imagery value="1" />
</Density>
- <DeviceProperties>
<Multibeam value="Yes" />
<SideScan value="No" />
<Towed value="No" />
<Calibrated value="No" />
<DualFrequency value="No" />
<HasAccuracy value="No" />
<Steered value="Yes" />
<Splithead value="No" />
<Bathymetric value="Yes" />
<Imagery value="Yes" />
<Attitude value="Yes" />
</DeviceProperties>
</SonarModel>

```
<SonarModel label="Reson SeaBat 8111" key="sb8111">
    <Max_Num_Beams value="101"/>
    <Operating_Frequency_1 value="100.0"/>
    <Operating_Frequency_2 value="0.0"/>
    <Max_Angle value="75.0"/>
    <Beam_Width_Across value="1.5"/>
    <Beam_Width_Along value="1.5"/>
    <Steering_Angle value="361.0"/>
    <Range_Sampling_Frequency value="80000.0"/>
    <Range_Sampling_Distance value="0.037"/>
    <Min_Pulse_Length value="0.15"/>
    <Rates>
      <Repitition value="35"/>
      <Bathy value="35"/>
      <Attitude value="0"/>
      <Imagery value="35"/>
    </Rates>
    <Density>
      <Bathy value="1"/>
      <Attitude value="0"/>
      <Imagery value="1"/>
    </Density>
    <DeviceProperties>
      <Multibeam value="Yes"/>
      <SideScan value="No"/>
      <Towed value="No"/>
      <Calibrated value="No"/>
      <DualFrequency value="No"/>
      <HasAccuracy value="No"/>
      <Steered value="No"/>
      <Splithead value="No"/>
      <Bathymetric value="Yes"/>
      <Imagery value="Yes"/>
      <Attitude value="Yes"/>
    </DeviceProperties>
  </SonarModel>
```

Appendix V

Additional Calibration Reports

Control
CTD
Leadlines
Total Stations

Header File for Station: Kukkamaki 2004 Level 100056

Station Name:	kukkamaki
Station State:	ak
Chief of Party:	Mark Wetzler
Instr Person:	abrams
Rod Person:	wetzler
Level SN:	100056
Level Make/Mod:	NI 2
Level Stadia:	333
Rod SN:	559587
Rod Make:	Leica
Rod Increment:	Full
Survey Order:	3rd Order
Weather:	Cloudy

Benchmark for Station: 111-1111

---

1 - (a) Staff Stop
2 - T.P.
3 - (a) ETG
4 - AQUA-old
5 - AQUA-new
6 - TBM #1
7 - TBM #2

Raw Data File for Station: 111-1111

			BACKSIGHT						FORESIGHT					
S	C	R	BM	TOP	MID	BOT	C	R	BM	TOP	MID	BOT	DATE	TIME
001	0	1	Kukkamaki	1444	1429	1415	0	1	Kukkamaki	1449	1433	1418	08/20/04	05:15
002	0	1	Kukkamaki	1452	1423	1392	0	1	Kukkamaki	1480	1419	1359	08/20/04	05:16
001	0	1	Kukkamaki	1449	1433	1418	0	1	Kukkamaki	1444	1429	1415	08/20/04	05:17
002	0	1	Kukkamaki	1452	1423	1392	0	1	Kukkamaki	1480	1419	1359	08/20/04	05:17

S	C	R	BM	TOP	MID	BOT	C	R	BM	TOP	MID	BOT	DATE	TIME
001	0	1	(a) Staff S	0150	0100	0050	0	1	TBM #1	0150	0100	0050	08/27/04	00:06
002	0	1	TBM #1	0150	0100	0050	0	1	(a) Staff S	0150	0100	0050	08/27/04	00:07

Benchmark: Kukkamaki — Station Name: kukkamaki, ak
To: Kukkamaki — Number: 111-1111
Date: 08/20/04 — Time: 05:15 UTC — Order: 3rd Order

Set up number	B.S. reading	Mean	Thread int.	Sum of int.	F.S. reading	Mean	Thread int.	Sum of int.
			FOREWARD RUN					
	1444		15		1449		16	
001	1429	1.42933		29	1433	1.43333		31
	1415		14		1418		15	
	-----	--------		----	-----	--------		----
	4288	1.42933		29	4300	1.43333		31
		-1.43333						

		-0.00400						
			BACKWARD RUN					
	1452		29		1480		61	
002	1423	1.42233		60	1419	1.41933		121
	1392		31		1359		60	
	-----	--------		----	-----	--------		----
	4267	1.42233		60	4258	1.41933		121
		-1.41933						

		0.00300						

Forward Run	-0.0040 m	Backward Run	0.0030 m
Mean Elevation	-0.0035 m	Distance	0.0200 Km
Error	-0.3600 mm/m	Allowable Error	0.0500 mm/m

Stadia: 333 Rod: Full Level: NI 2 SN: 100056 Weather: Cloudy
Chief: Mark Wetzl Instrument Person: abrams Rod Person: wetzler

Pacific Regional Section, Seattle, WA.

Benchmark: Kukkamaki Station Name: kukkamaki, ak
To: Kukkamaki Number: 111-1111
Date: 08/20/04 Time: 05:17 UTC Order: 3rd Order

Set up number	B.S. reading	Mean	Thread int.	Sum of int.	F.S. reading	Mean	Thread int.	Sum of int.
			FOREWARD RUN					
	1449		16		1444		15	
001	1433	1.43333		31	1429	1.42933		29
	1418		15		1415		14	
	-----	--------		----	-----	--------		----
	4300	1.43333		31	4288	1.42933		29
		-1.42933						

		0.00400						
			BACKWARD RUN					
	1452		29		1480		61	
002	1423	1.42233		60	1419	1.41933		121
	1392		31		1359		60	
	-----	--------		----	-----	--------		----
	4267	1.42233		60	4258	1.41933		121
		-1.41933						

		0.00300						

Forward Run	0.0040 m	Backward Run	0.0030 m
Mean Elevation	0.0035 m	Distance	0.0200 Km
Error	0.0400 mm/m	Allowable Error	0.0500 mm/m

Stadia: 333 Rod: Full Level: NI 2 SN: 100056 Weather: Cloudy

Chief: Mark Wetzl Instrument Person: abrams Rod Person: wetzler

Pacific Regional Section, Seattle, WA.

SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface

Serial Number: 19P36026-4585

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

CALIBRATION SHEETS

Calibration Manual Generation Date: 10 June 2004

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 04-May-04

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.144238e-003
a1 = 2.800401e-004
a2 = -1.599101e-006
a3 = 2.064399e-007

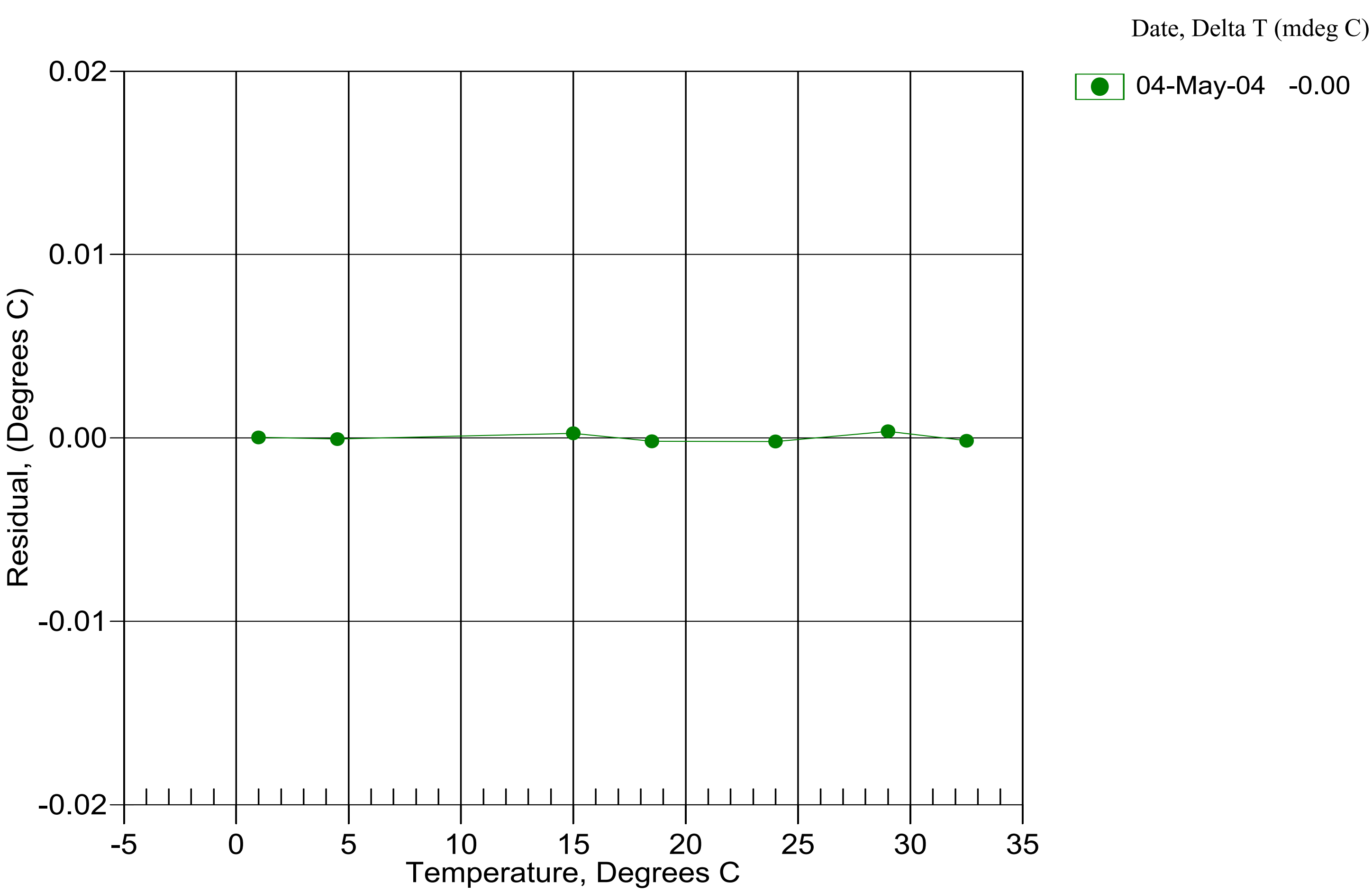
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	686550.960	1.0000	0.0000
4.5000	613874.183	4.4999	-0.0001
14.9999	430359.044	15.0001	0.0002
18.5000	380275.871	18.4998	-0.0002
24.0000	311679.154	23.9998	-0.0002
29.0000	258970.010	29.0004	0.0004
32.5000	226924.233	32.4998	-0.0002

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 04-May-04

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.029557e+000
h = 1.489816e-001
i = -1.752308e-004
j = 3.475449e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

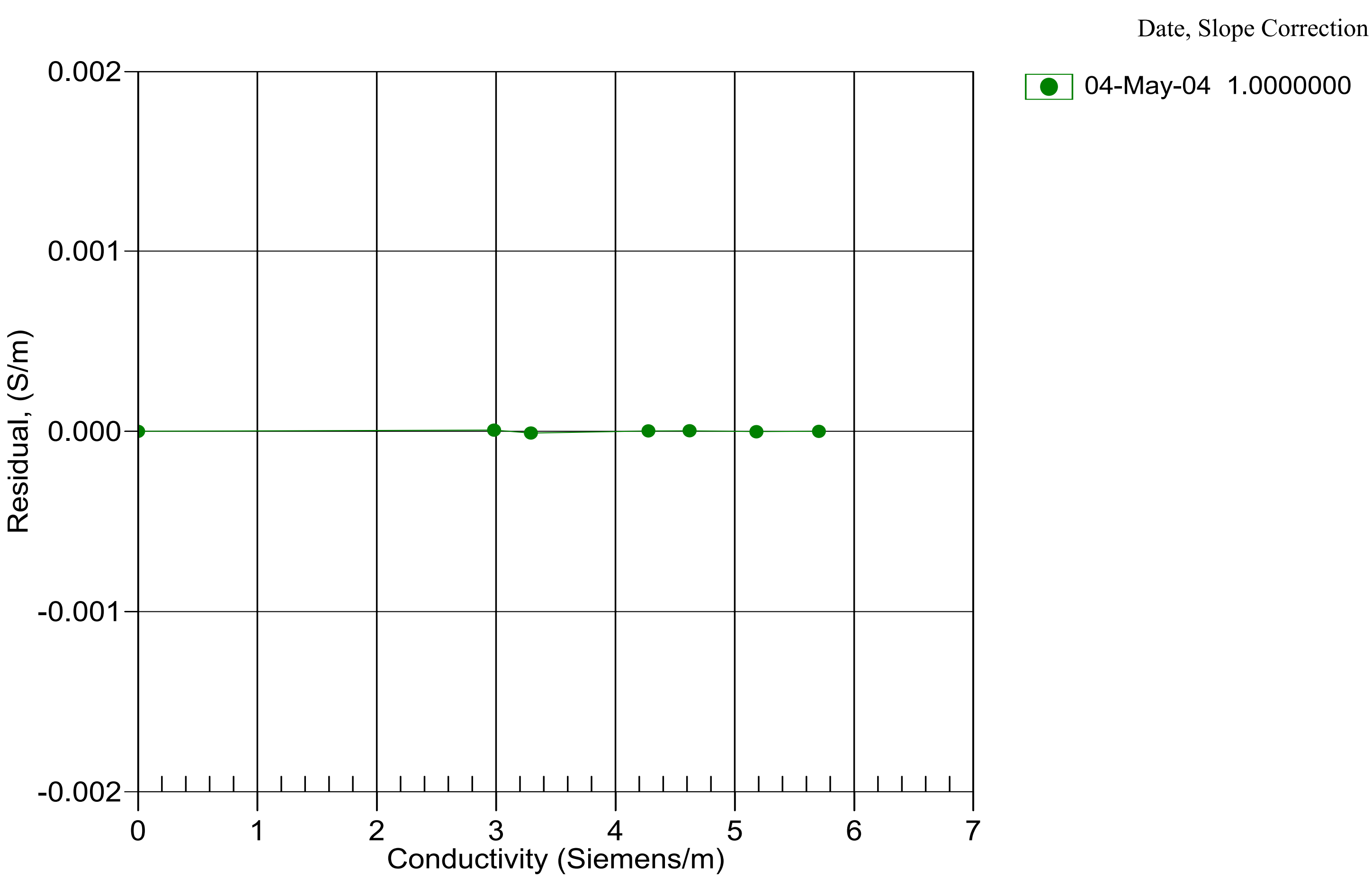
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2630.76	-0.0000	-0.00000
1.0000	34.9275	2.98456	5190.28	2.9846	0.00001
4.5000	34.9074	3.29247	5385.00	3.2925	-0.00001
14.9999	34.8640	4.27683	5964.35	4.2768	0.00000
18.5000	34.8548	4.62292	6154.85	4.6229	0.00000
24.0000	34.8449	5.18241	6450.64	5.1824	-0.00000
29.0000	34.8401	5.70578	6715.25	5.7058	-0.00000

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \epsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ϵ = CPcor;

Residual = instrument conductivity - bath conductivity



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4585
CALIBRATION DATE: 01-Apr-04

SBE19plus PRESSURE CALIBRATION DATA
5076 psia S/N 5433

COEFFICIENTS:

PA0 =	4.122797e-001	PTCA0 =	5.087085e+005
PA1 =	1.543137e-002	PTCA1 =	-1.554920e+000
PA2 =	-6.621421e-010	PTCA2 =	1.198843e-001
PTEMPA0 =	-6.648085e+001	PTCB0 =	2.398063e+001
PTEMPA1 =	5.248301e+001	PTCB1 =	-2.075000e-003
PTEMPA2 =	-5.831752e-001	PTCB2 =	0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.80	509647.0	1.7	14.63	-0.00
1115.04	581024.0	1.7	1114.57	-0.01
2115.20	646306.0	1.7	2114.67	-0.01
3115.31	711973.0	1.7	3114.97	-0.01
4115.38	778014.0	1.7	4115.20	-0.00
5115.49	844434.0	1.7	5115.34	-0.00
4115.36	778050.0	1.7	4115.76	0.01
3115.28	712023.0	1.7	3115.75	0.01
2115.13	646357.0	1.7	2115.47	0.01
1114.96	581071.0	1.7	1115.30	0.01
14.79	509677.0	1.7	15.07	0.01

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1.93	509715.97
29.00	1.86	509691.60
24.00	1.76	509665.49
18.50	1.65	509649.81
15.00	1.58	509644.82
4.50	1.37	509632.18
1.00	1.30	509635.66

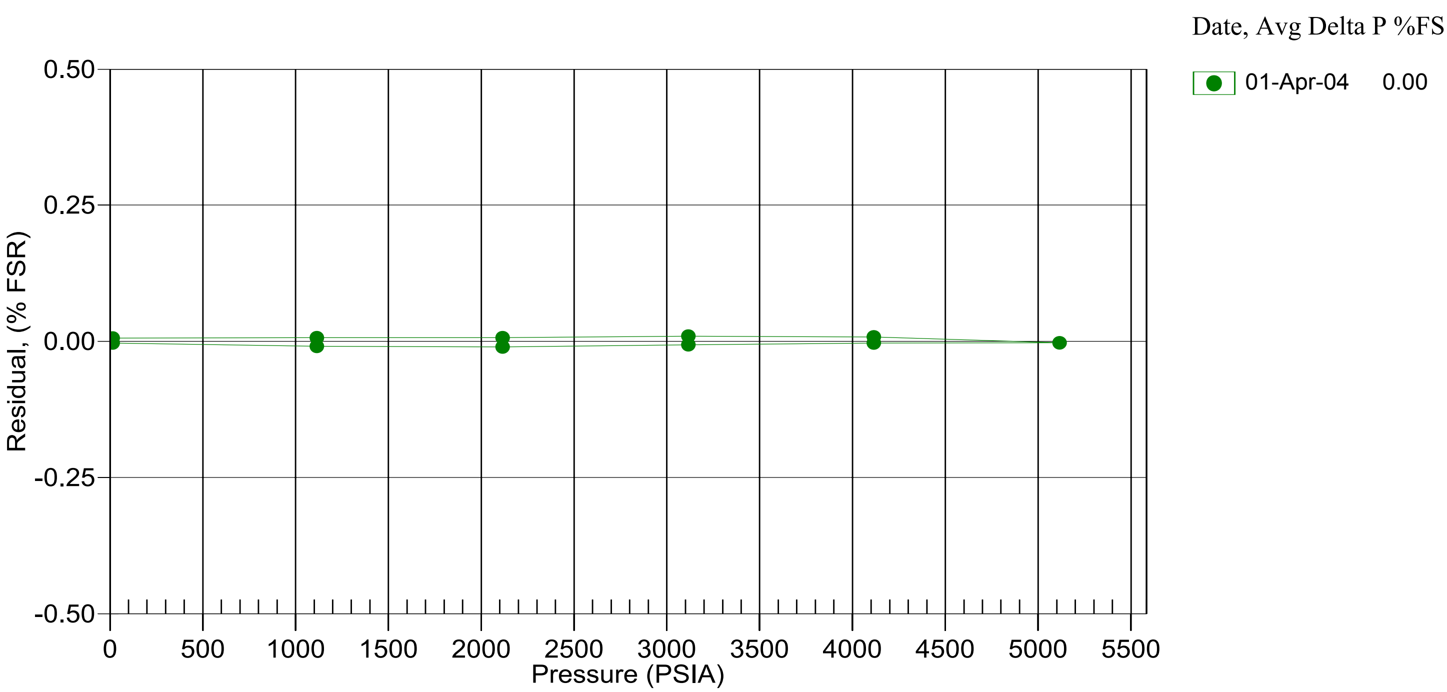
TEMP(ITS90)	SPAN(mV)
-5.00	23.99
35.00	23.91

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2$

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel: (425) 643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0647

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	8.015	VDC	Current	7.73	mA
Vin 9V voltage across C2:	8.014	VDC	Current	7.4	mA
Vin 6V voltage across C2:	5.888	VDC	Current	7.61	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 121 mA

PRESSURE TEST CERTIFICATES

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **3/8/2004** Description **SBE-19 SeaCat Profiler**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **19**
Serial Number: **4585**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **5433**
Sensor Rating: **5000**

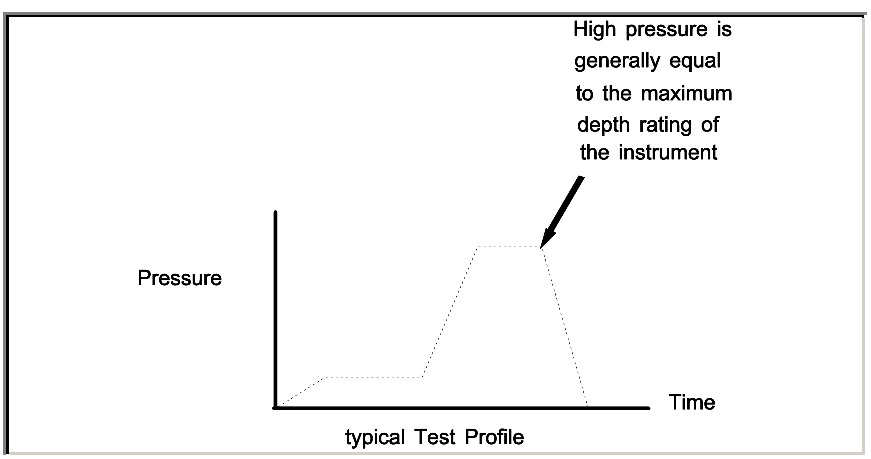
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **5000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: ML



Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com
Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **4/15/2004** Description **SBE-5M Mini-Submersible Pump**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **5M**
Serial Number: **0647**

Pressure Sensor Information:

Sensor Type: **None**
Sensor Serial Number: **None**
Sensor Rating: **0**

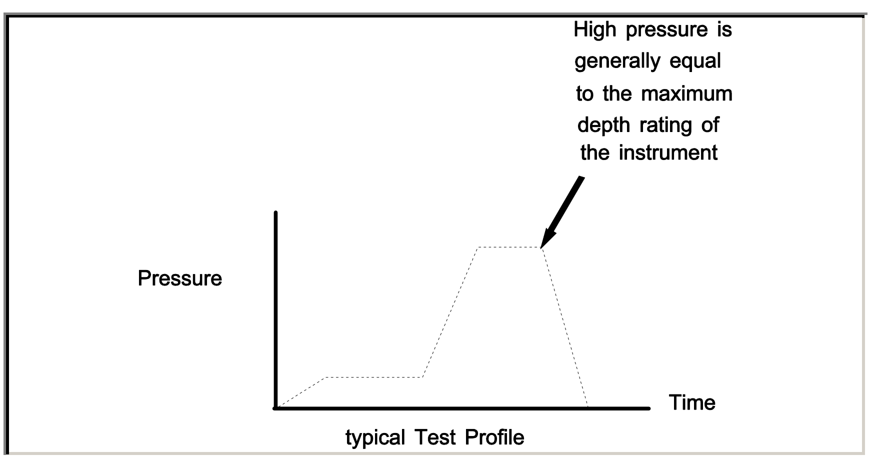
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **10000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: DF



SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface

Serial Number: 19P36026-4616

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

CALIBRATION SHEETS

Calibration Manual Generation Date: 10 June 2004

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 13-May-04

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.266766e-003
a1 = 2.586384e-004
a2 = 4.388350e-007
a3 = 1.305821e-007

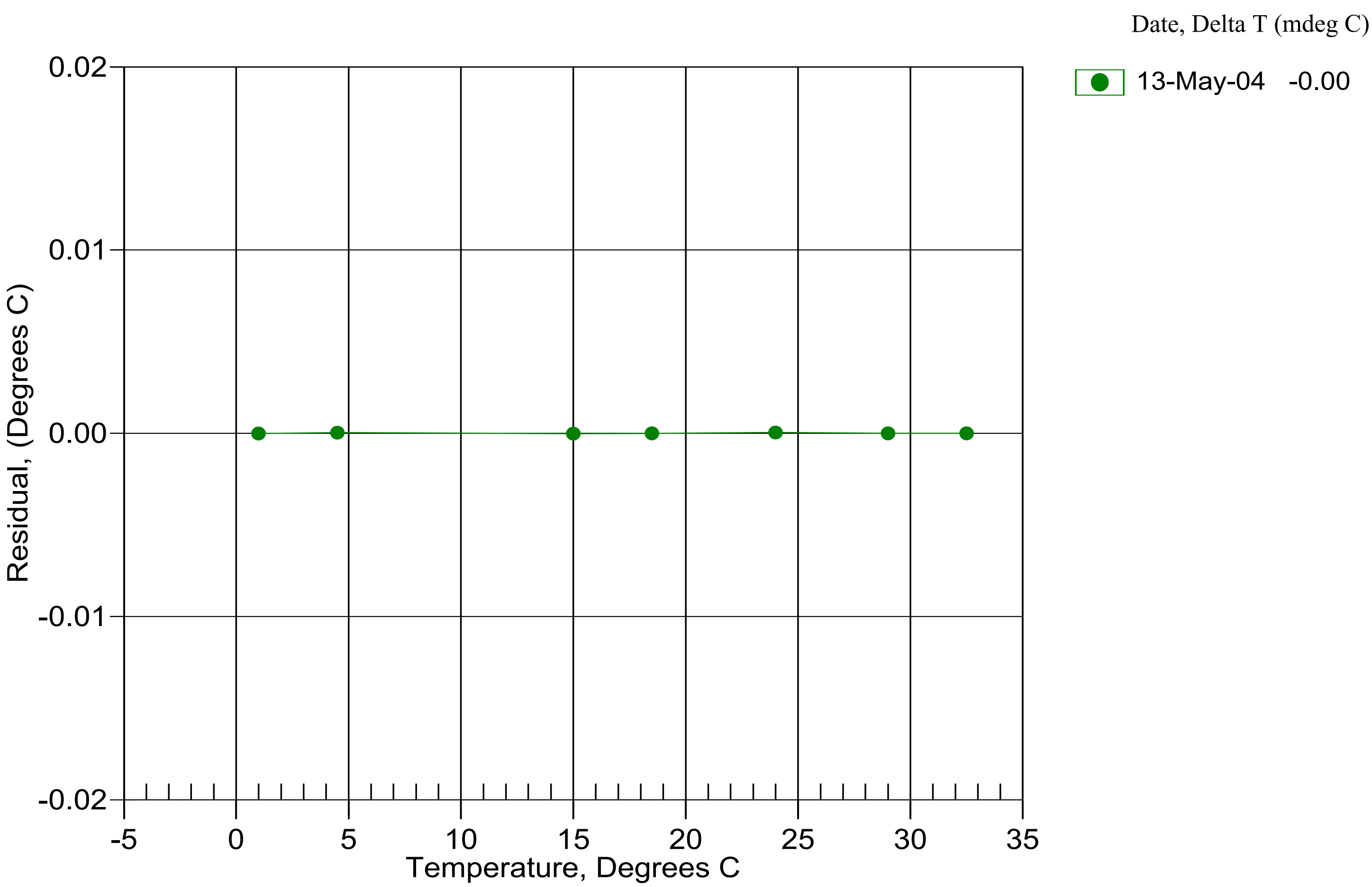
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	622316.325	1.0000	-0.0000
4.5000	552525.400	4.5000	0.0000
14.9999	379349.198	14.9999	-0.0000
18.5000	332862.233	18.5000	-0.0000
24.0000	269768.692	24.0000	0.0000
29.0000	221758.685	29.0000	-0.0000
32.5000	192768.010	32.5000	-0.0000

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 13-May-04

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.045285e+000
h = 1.453177e-001
i = -2.826921e-004
j = 4.105207e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

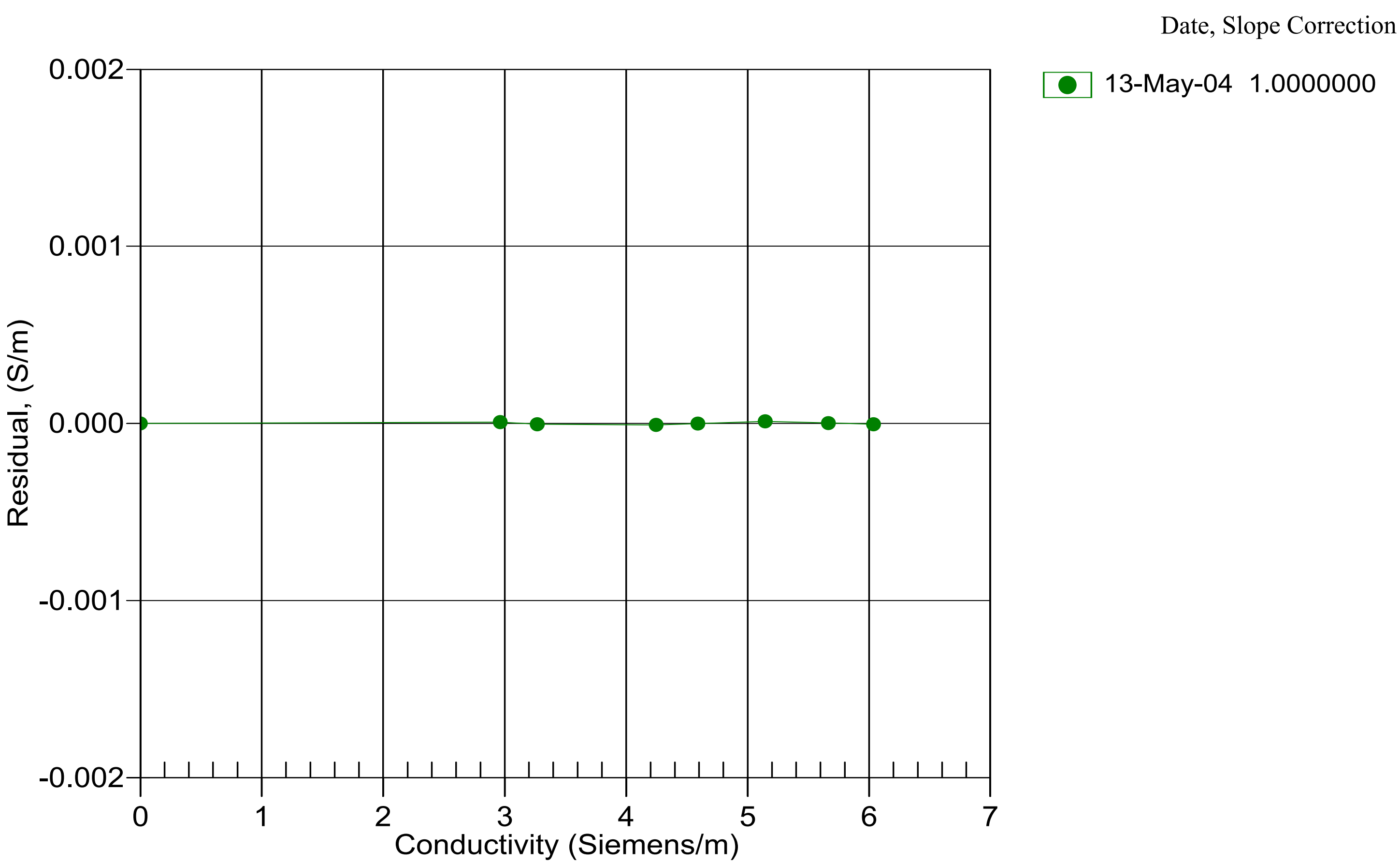
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2686.28	-0.0000	-0.00000
1.0000	34.6538	2.96340	5258.57	2.9634	0.00001
4.5000	34.6339	3.26921	5454.90	3.2692	-0.00000
14.9999	34.5909	4.24687	6039.19	4.2469	-0.00001
18.5000	34.5816	4.59058	6231.35	4.5906	-0.00000
24.0000	34.5717	5.14625	6529.76	5.1463	0.00001
29.0000	34.5668	5.66603	6796.72	5.6660	0.00000
32.5000	34.5648	6.03707	6980.85	6.0371	-0.00000

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4616
CALIBRATION DATE: 07-Jun-04

SBE19plus PRESSURE CALIBRATION DATA
1450 psia S/N 4616

COEFFICIENTS:

```
PA0 =     7.363594e-001        PTCA0 =  5.204318e+005
PA1 =     4.421346e-003        PTCA1 =  1.310369e+001
PA2 =    -9.233915e-012        PTCA2 = -2.500431e-001
PTEMPA0 = -7.610142e+001       PTCB0 =  2.473825e+001
PTEMPA1 =  4.912463e+001       PTCB1 =  5.000000e-005
PTEMPA2 = -2.225885e-001       PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.59	523741.0	2.0	14.63	0.00
314.74	591615.0	2.0	314.66	-0.00
614.74	659504.0	2.0	614.68	-0.00
914.74	727427.0	2.0	914.76	0.00
1214.92	795374.0	2.0	1214.86	-0.00
1514.98	863345.0	2.0	1514.98	0.00
1214.91	795385.0	2.0	1214.91	-0.00
914.73	727440.0	2.0	914.82	0.01
614.72	659521.0	2.0	614.75	0.00
314.71	591629.0	2.0	314.72	0.00
14.59	523730.0	2.0	14.58	-0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.23	523837.35
29.00	2.16	523836.54
24.00	2.06	523829.25
18.50	1.94	523822.29
15.00	1.87	523816.16
4.50	1.65	523736.70
1.00	1.58	523670.18

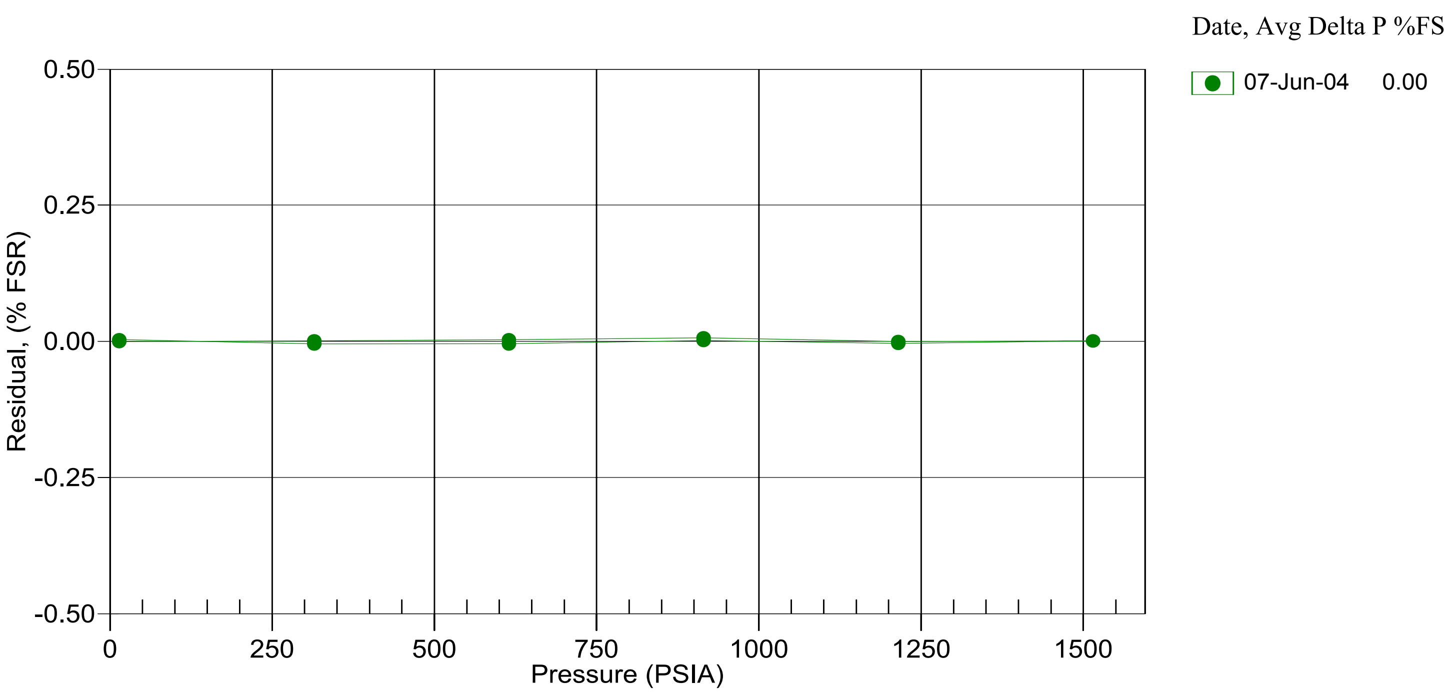
TEMP(ITS90)	SPAN(mV)
-5.00	24.74
35.00	24.74

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

x = pressure output - $PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2$

pressure (psia) = $PA0 + PA1 * n + PA2 * n^2$



Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel: (425) 643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0651

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.929	VDC	Current	9.29	mA
Vin 9V voltage across C2:	7.928	VDC	Current	8.8	mA
Vin 6V voltage across C2:	5.885	VDC	Current	7.99	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 120 mA

PRESSURE TEST CERTIFICATES

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **5/17/2004** Description **SBE-19 SeaCat Profiler**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **19**
Serial Number: **4616**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **5512**
Sensor Rating: **1450**

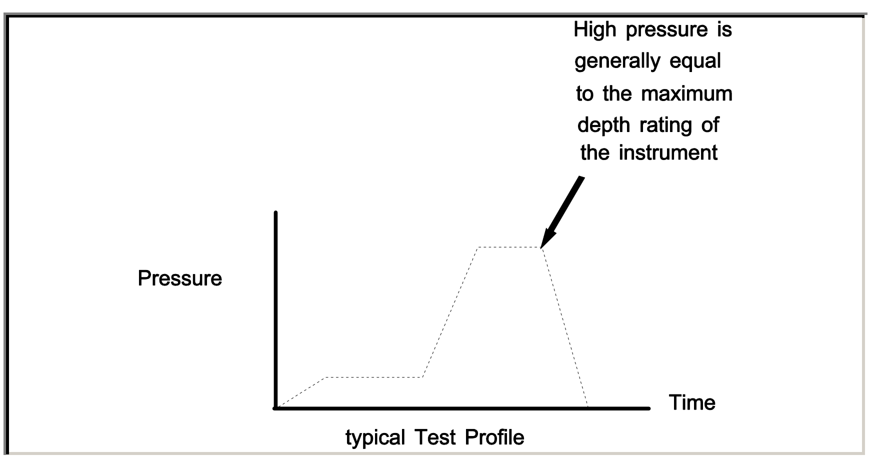
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **900** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PC



Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **4/15/2004** Description **SBE-5M Mini-Submersible Pump**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **5M**
Serial Number: **0651**

Pressure Sensor Information:

Sensor Type: **None**
Sensor Serial Number: **None**
Sensor Rating: **0**

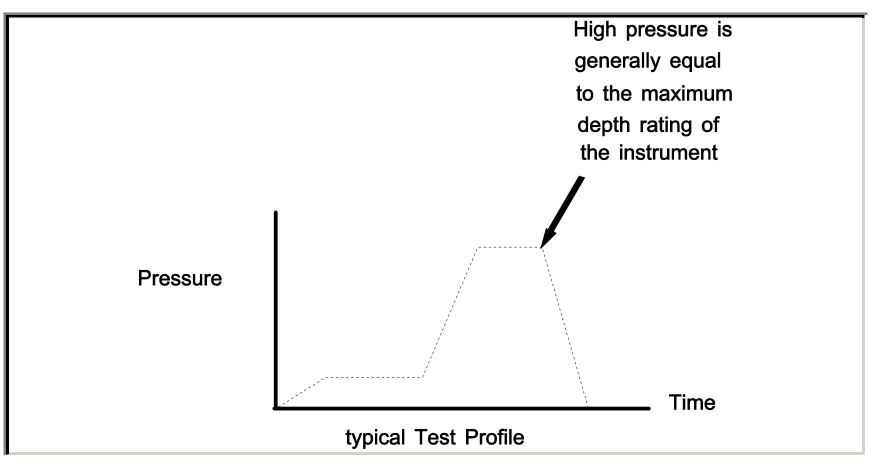
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **10000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: DF



SBE 19plus
SEACAT PROFILER

Conductivity, Temperature, and Pressure Recorder with RS-232 Interface

Serial Number: 19P36026-4617

Sea-Bird Electronics, Inc.
1808 136th Place NE
Bellevue, Washington 98005 USA
Tel: 425/643-9866
Fax:425/643-9954

CALIBRATION SHEETS

Calibration Manual Generation Date: 10 June 2004

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 11-May-04

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.291823e-003
a1 = 2.526379e-004
a2 = 1.450684e-006
a3 = 9.186631e-008

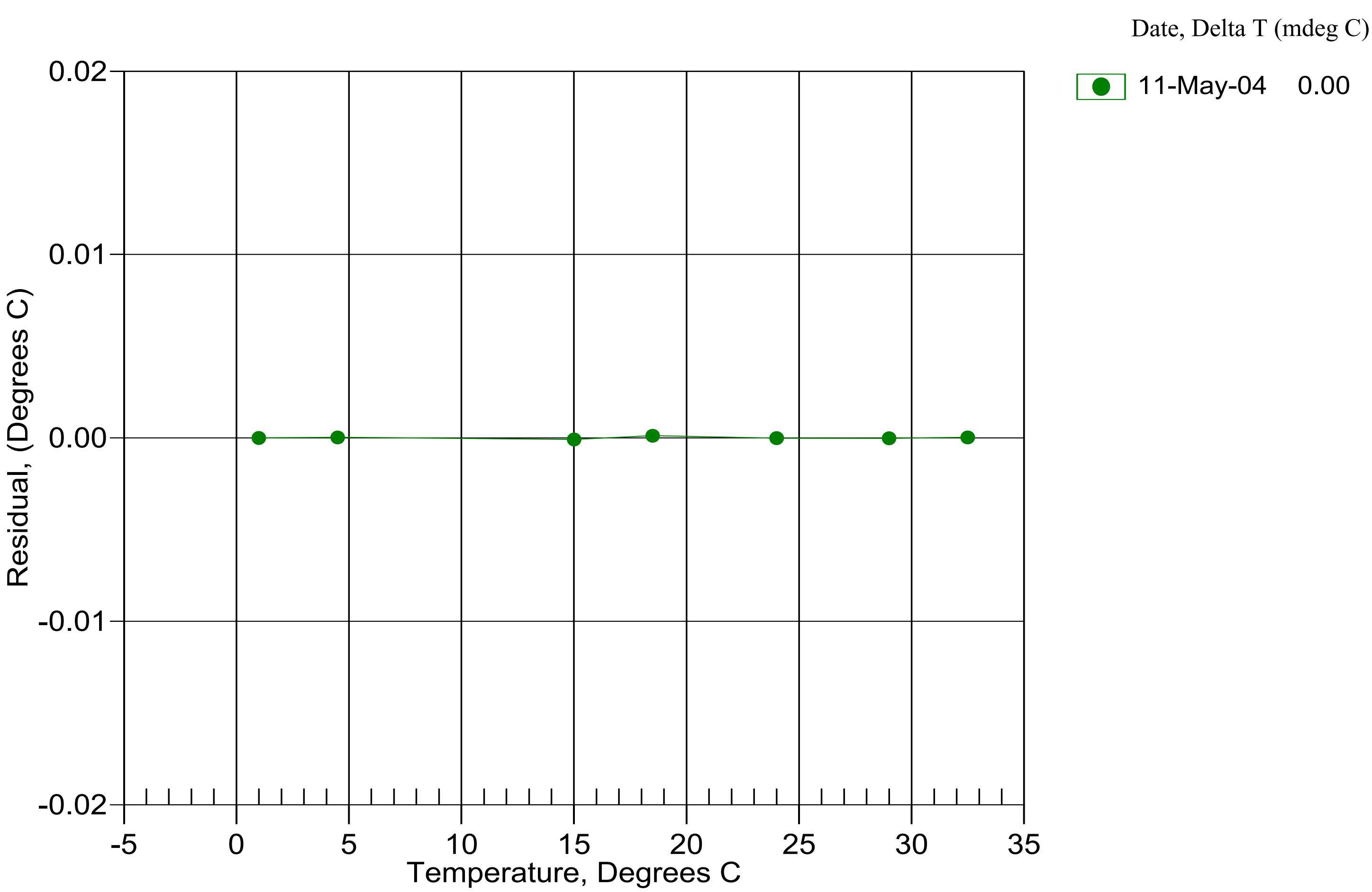
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	585601.879	1.0000	-0.0000
4.5000	518753.727	4.5000	0.0000
15.0000	354111.031	14.9999	-0.0001
18.5000	310185.358	18.5001	0.0001
24.0000	250731.238	24.0000	-0.0000
29.0000	205598.150	29.0000	-0.0000
32.5000	178383.838	32.5000	0.0000

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 11-May-04

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.988625e-001
h = 1.277874e-001
i = -2.759004e-004
j = 3.510651e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

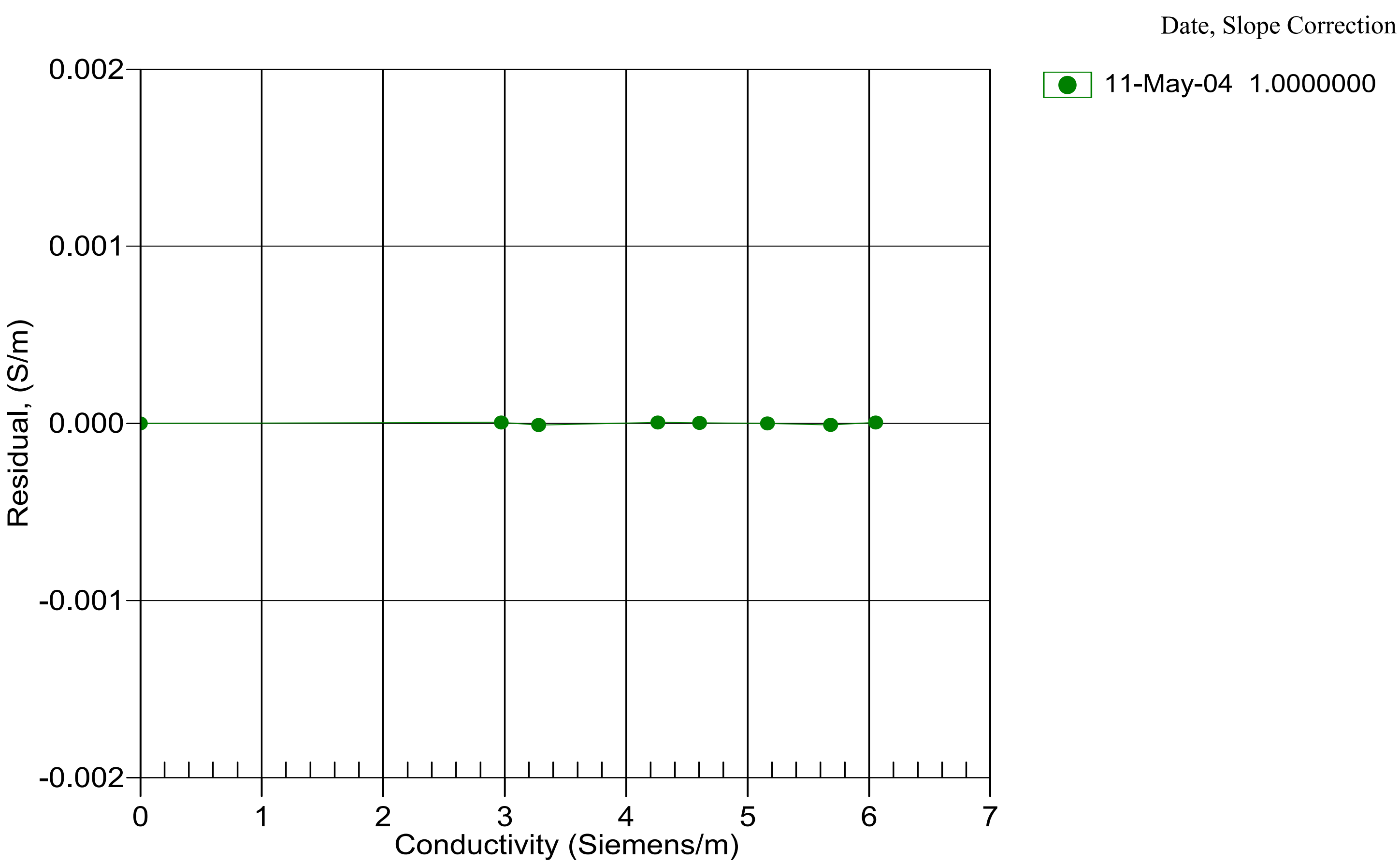
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2801.28	0.0000	0.00000
1.0000	34.7750	2.97277	5584.71	2.9728	0.00001
4.5000	34.7554	3.27954	5795.80	3.2795	-0.00001
15.0000	34.7123	4.26020	6423.47	4.2602	0.00001
18.5000	34.7032	4.60498	6629.74	4.6050	0.00000
24.0000	34.6934	5.16236	6949.94	5.1624	-0.00000
29.0000	34.6883	5.68371	7236.26	5.6837	-0.00001
32.5000	34.6861	6.05585	7433.69	6.0559	0.00001

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4617
CALIBRATION DATE: 07-Jun-04

SBE19plus PRESSURE CALIBRATION DATA
1450 psia S/N 5513

COEFFICIENTS:

PA0 =	-4.963912e-001	PTCA0 =	5.191864e+005
PA1 =	4.431500e-003	PTCA1 =	-1.113324e+001
PA2 =	-1.012479e-011	PTCA2 =	2.771534e-001
PTEMPA0 =	-7.905883e+001	PTCB0 =	2.460838e+001
PTEMPA1 =	4.950230e+001	PTCB1 =	6.750000e-004
PTEMPA2 =	-4.960344e-001	PTCB2 =	0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.59	522490.0	2.1	14.63	0.00
314.74	590250.0	2.1	314.67	-0.00
614.74	658027.0	2.1	614.70	-0.00
914.74	725829.0	2.1	914.75	0.00
1214.92	793664.0	2.1	1214.84	-0.01
1514.98	861531.0	2.1	1514.99	0.00
1214.91	793681.0	2.1	1214.92	0.00
914.73	725845.0	2.1	914.82	0.01
614.72	658042.0	2.1	614.77	0.00
314.71	590257.0	2.1	314.70	-0.00
14.59	522481.0	2.1	14.59	-0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.31	522573.13
29.00	2.23	522565.54
24.00	2.13	522556.16
18.50	2.01	522538.38
15.00	1.94	522540.34
4.50	1.72	522594.40
1.00	1.64	522650.56

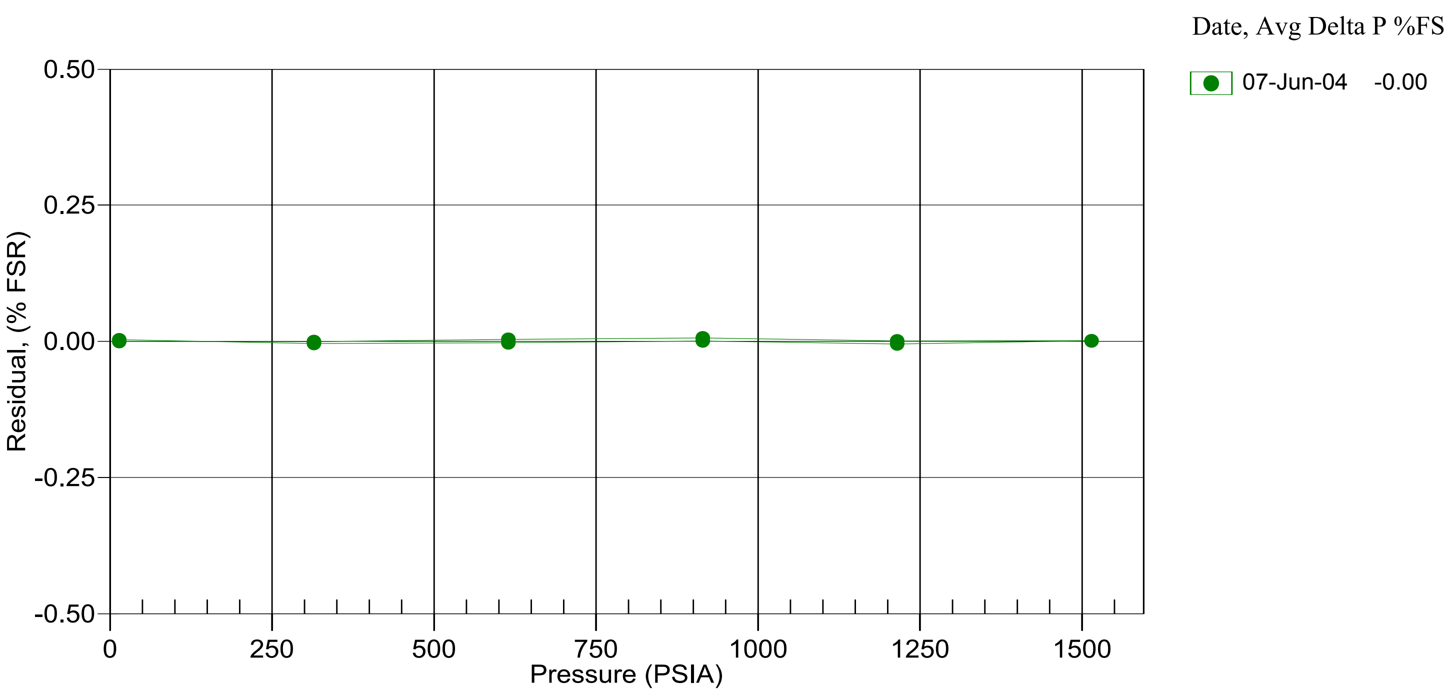
TEMP(ITS90)	SPAN(mV)
-5.00	24.61
35.00	24.63

y = thermistor output; t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2

x = pressure output - PTCA0 - PTCA1 * t - PTCA2 * t^2

n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2

pressure (psia) = PA0 + PA1 * n + PA2 * n^2



Sea-Bird Electronics, Inc. FAX: (425) 643-9954
1808 136th Place NE, Bellevue, Washington 98005 USA Tel: (425) 643-9866
Website: http://www.seabird.com Email: seabird@seabird.com

SBE 5M MINI SUBMERSIBLE PUMP CONFIGURATION SHEET

Serial Number: 0649

Job Number: 36026

Customer: NOAA/PMC

Delivery Date: 6/14/2004

Single Connector Housing with Titanium screws

Pressure Case: 10,500 meters (titanium)

Maxon Motor Type:

P/N 90337, Motor PN 20130 (Low power 6 VDC, 2000 RPM MAX) ☐

P/N 90335, Motor PN 20130 (Low power 9 VDC, 2000 RPM MAX) ☑

Vin 15V voltage across C2:	7.947	VDC	Current	11.8	mA
Vin 9V voltage across C2:	7.948	VDC	Current	11.0	mA
Vin 6V voltage across C2:	5.868	VDC	Current	10.2	mA

Pump submerged test, no load, Vin 12VDC Average current draw in water: 124 mA

PRESSURE TEST CERTIFICATES

Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **5/17/2004** Description **SBE-19 SeaCat Profiler**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **19**
Serial Number: **4617**

Pressure Sensor Information:

Sensor Type: **Druck**
Sensor Serial Number: **5513**
Sensor Rating: **1450**

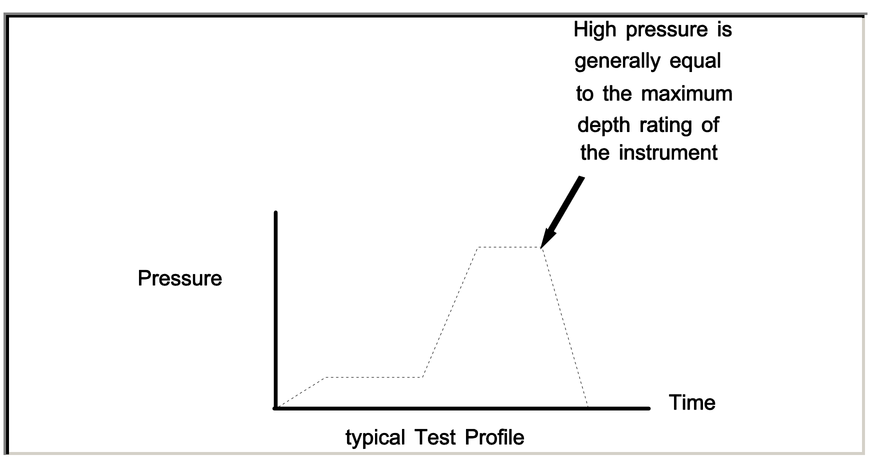
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **900** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: PC



Sea-Bird Electronics, Inc.
1808 136th Place NE, Bellevue, Washington 98005 USA
Website: http://www.seabird.com

Phone: (425) 643-9866
FAX: (425) 643-9954
Email: seabird@seabird.com

SBE Pressure Test Certificate

Test Date: **4/15/2004** Description **SBE-5M Mini-Submersible Pump**

Job Number: **36026** Customer Name **NOAA/PMC**

SBE Sensor Information:

Model Number: **5M**
Serial Number: **0649**

Pressure Sensor Information:

Sensor Type: **None**
Sensor Serial Number: **None**
Sensor Rating: **0**

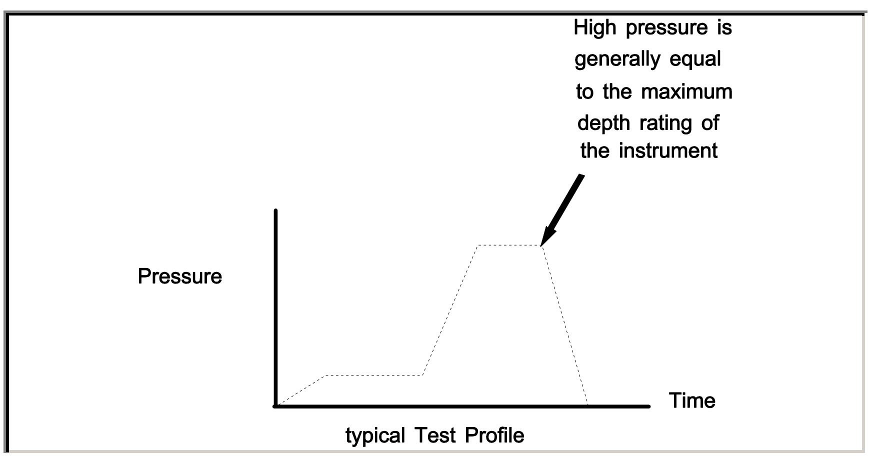
Pressure Test Protocol:

Low Pressure Test: **50** PSI Held For **15** Minutes

High Pressure Test: **10000** PSI Held For **15** Minutes

Passed Test: ☑

Tested By: DF



```
[SVP_VERSION_2]
04212141.svp
Section  2004-212  14:19   48:20:00  -123:30:00
       0.7           1505.9
       3.0           1502.1
       4.0           1501.2
       5.3           1500.6
       6.1           1500.2
       7.2           1499.3
       7.9           1498.6
       8.1           1498.2
      10.6           1498.2


[SVP_VERSION_2]
04212141.svp
Section  2004-212  14:18   48:20:00  -123:30:00
       0.6           1505.8
       3.0           1502.0
       4.0           1501.2
       5.3           1500.5
       6.1           1499.9
       7.2           1499.0
       7.9           1498.4
       8.1           1498.2
      10.5           1498.2


[SVP_VERSION_2]
04212143.svp
Section  2004-212  14:32   48:20:00  -123:30:00
       0.5           1505.8
       0.7           1505.6
       2.9           1501.6
       3.9           1501.1
       5.4           1500.5
       6.4           1500.0
       7.2           1499.2
       7.9           1498.5
       8.1           1498.1
      10.6           1498.1

[SVP_VERSION_2]
04212143.svp
Section  2004-212  14:32   48:20:00  -123:30:00
       0.6           1505.7
       2.9           1501.9
       3.9           1501.2
       5.4           1500.3
       6.4           1499.4
       7.2           1498.9
       7.9           1498.4
       8.2           1498.1
      10.8           1497.9
```

7/30/2004 COMPARE 2 FILES: 141_4616.FAQ, 141_4617.FAQ   SYSTEM: RESON 8111
RESULT: PERCENT DEPTH DIFF OK 0.06
Last line of travel time table:
0.02 10.32 0.01 0.06 23.14 0.00 -0.02

7/30/2004 COMPARE 2 FILES: 143_4585.FAQ, 143_4616.FAQ   SYSTEM: RESON 8111
RESULT: PERCENT DEPTH DIFF OK 0.15
Last line of travel time table:
0.02 10.32 0.02 0.15 23.14 -0.01 -0.03

7/30/2004 COMPARE 2 FILES: 141_4616.FAQ, 141_4617.FAQ   SYSTEM: RESON 8160
RESULT: PERCENT DEPTH DIFF OK 0.01
Last line of travel time table:
0.01 10.02 0.00 0.01 10.37 0.00 -0.02

7/30/2004 COMPARE 2 FILES: 143_4585.FAQ, 143_4616.FAQ   SYSTEM: RESON 8160
RESULT: PERCENT DEPTH DIFF OK 0.02
Last line of travel time table:
0.01 10.02 0.00 0.02 10.37 0.00 -0.03

7/30/2004 COMPARE 2 FILES: 141_4616.FAQ, 141_4617.FAQ   SYSTEM: RESON 8101
RESULT: PERCENT DEPTH DIFF OK 0.01
Last line of travel time table:
0.02 10.25 0.00 -0.01 34.67 0.00 -0.01

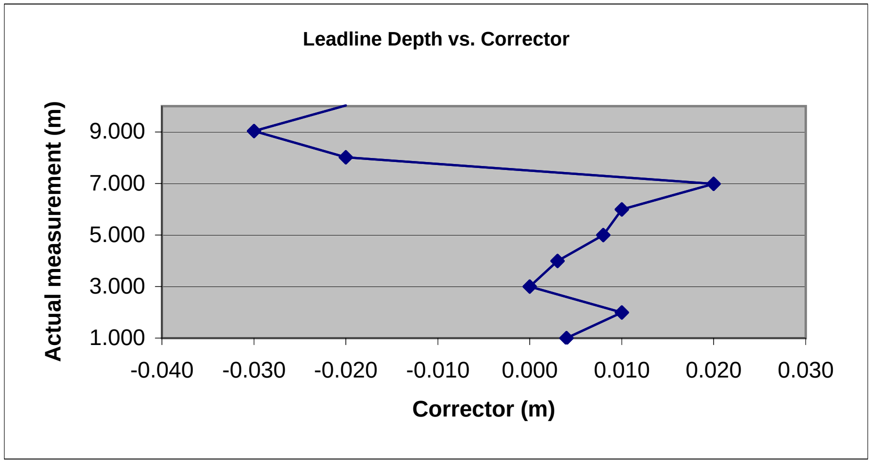
7/30/2004 COMPARE 2 FILES: 143_4585.FAQ, 143_4616.FAQ   SYSTEM: RESON 8101
RESULT: PERCENT DEPTH DIFF OK 0.02
Last line of travel time table:
0.02 10.25 0.00 -0.02 34.67 0.00 0.00

7/30/2004 COMPARE 2 FILES: 141_4617.FAQ, 143_4585.FAQ   SYSTEM: RESON 8111
RESULT: PERCENT DEPTH DIFF OK 0.09
Last line of travel time table:
0.02 10.31 -0.01 -0.09 23.14 0.00 0.01

FAIRWEATHER Leadline 10_01_04

calibrated 9/22/2004

Meter Mark	Actual Measurement	Corrector
1.0	0.996	0.004
2.0	1.990	0.010
3.0	3.000	0.000
4.0	3.997	0.003
5.0	4.992	0.008
6.0	5.990	0.010
7.0	6.980	0.020
8.0	8.020	-0.020
9.0	9.030	-0.030
10.0	10.020	-0.020
	Average correction	0.004
	Standard deviation	0.012

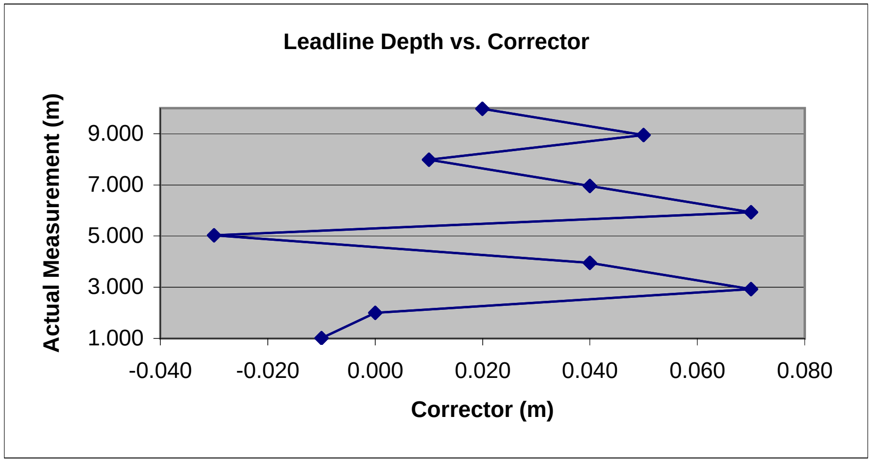


Measured by AST Mike Castle
Recorded by AST Verena Kellner

FAIRWEATHER Leadline 10_02_04

calibrated 9/22/2004

Meter Mark	Actual Measurement	Corrector
1.0	1.010	-0.010
2.0	2.000	0.000
3.0	2.930	0.070
4.0	3.960	0.040
5.0	5.030	-0.030
6.0	5.930	0.070
7.0	6.960	0.040
8.0	7.990	0.010
9.0	8.950	0.050
10.0	9.980	0.020
	Average correction	0.024
	Standard deviation	0.037

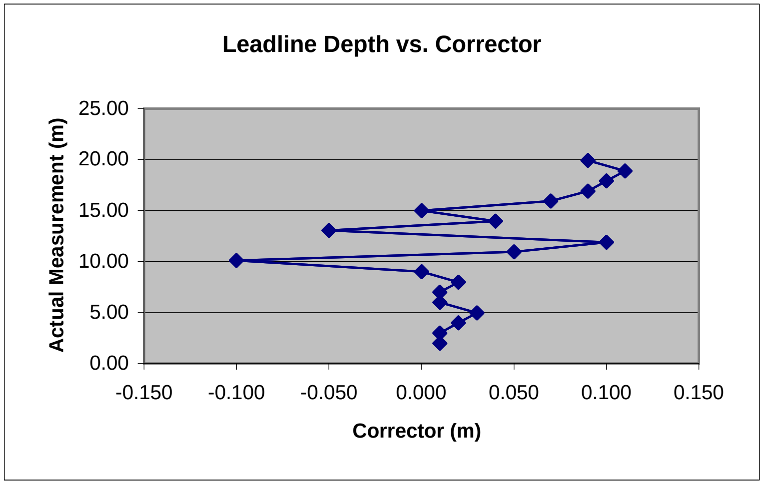


Measured by AST Mike Castle
Recorded by AST Verena Kellner

FAIRWEATHER Leadline 20_01_04

calibrated 9/26/2004

Meter Mark	Actual Measurement	Corrector
1.0	0.99	0.010
2.0	1.99	0.010
3.0	2.99	0.010
4.0	3.98	0.020
5.0	4.97	0.030
6.0	5.99	0.010
7.0	6.99	0.010
8.0	7.98	0.020
9.0	9.00	0.000
10.0	10.10	-0.100
11.0	10.95	0.050
12.0	11.90	0.100
13.0	13.05	-0.050
14.0	13.96	0.040
15.0	15.00	0.000
16.0	15.93	0.070
17.0	16.91	0.090
18.0	17.90	0.100
19.0	18.89	0.110
20.0	19.91	0.090
	Average Correction	0.040
	Standard deviation	0.053



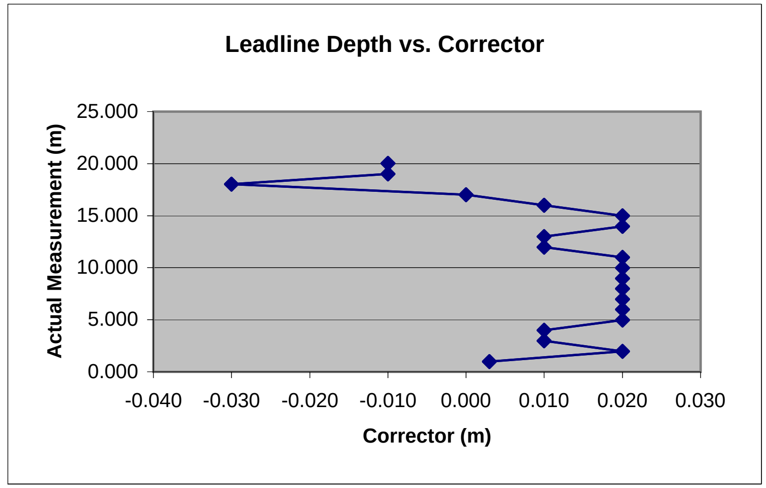
Measured by AST Mike Castle

Recorded by AST Verena Kellner

FAIRWEATHER Leadline 20_02_04

calibrated 9/26/2004

Meter Mark	Actual Measurement	Corrector
1.0	0.997	0.003
2.0	1.980	0.020
3.0	2.990	0.010
4.0	3.990	0.010
5.0	4.980	0.020
6.0	5.980	0.020
7.0	6.980	0.020
8.0	7.980	0.020
9.0	8.980	0.020
10.0	9.980	0.020
11.0	10.980	0.020
12.0	11.990	0.010
13.0	12.990	0.010
14.0	13.980	0.020
15.0	14.980	0.020
16.0	15.990	0.010
17.0	17.000	0.000
18.0	18.030	-0.030
19.0	19.010	-0.010
20.0	20.010	-0.010
	Average Correction	0.008
	Standard deviation	0.014



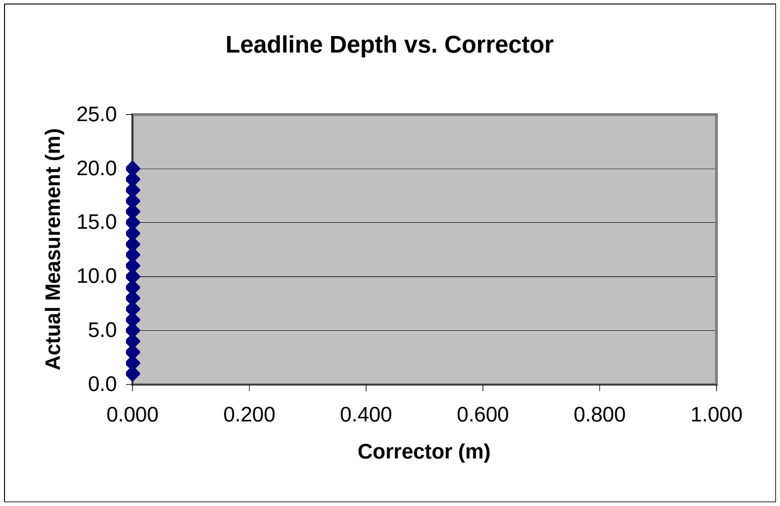
Measured by AST Mike Castle

Recorded by AST Verena Kellner

FAIRWEATHER Leadline 20_03

calibrated ?/?/2004

Meter Mark	Actual Measurement	Corrector
1.0	1.0	0.000
2.0	2.0	0.000
3.0	3.0	0.000
4.0	4.0	0.000
5.0	5.0	0.000
6.0	6.0	0.000
7.0	7.0	0.000
8.0	8.0	0.000
9.0	9.0	0.000
10.0	10.0	0.000
11.0	11.0	0.000
12.0	12.0	0.000
13.0	13.0	0.000
14.0	14.0	0.000
15.0	15.0	0.000
16.0	16.0	0.000
17.0	17.0	0.000
18.0	18.0	0.000
19.0	19.0	0.000
20.0	20.0	0.000
	Average Correction	0.000
	Standard deviation	0.000

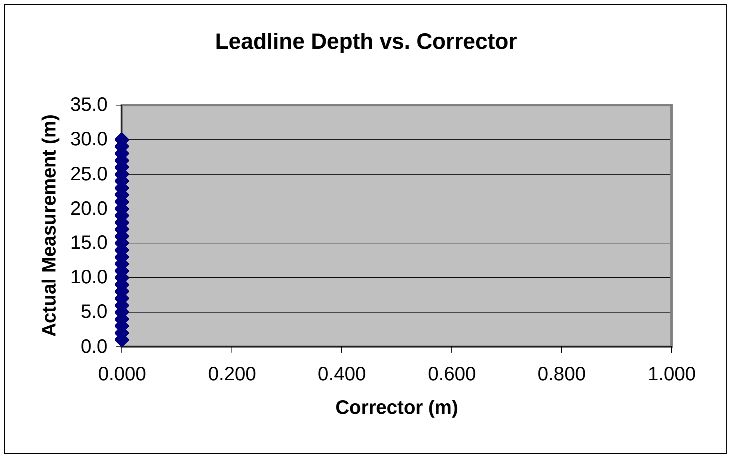


Leadline not to be finished until 2005

FAIRWEATHER Leadline 30_01

calibrated ?/?/2004

Meter Mark	Actual Measurement	Corrector
1.0	1.0	0.000
2.0	2.0	0.000
3.0	3.0	0.000
4.0	4.0	0.000
5.0	5.0	0.000
6.0	6.0	0.000
7.0	7.0	0.000
8.0	8.0	0.000
9.0	9.0	0.000
10.0	10.0	0.000
11.0	11.0	0.000
12.0	12.0	0.000
13.0	13.0	0.000
14.0	14.0	0.000
15.0	15.0	0.000
16.0	16.0	0.000
17.0	17.0	0.000
18.0	18.0	0.000
19.0	19.0	0.000
20.0	20.0	0.000
21.0	21.000	0.000
22.0	22.000	0.000
23.0	23.000	0.000
24.0	24.000	0.000
25.0	25.000	0.000
26.0	26.000	0.000
27.0	27.000	0.000
28.0	28.000	0.000
29.0	29.000	0.000
30.0	30.000	0.000
	Average Correction	0.000
	Standard deviation	0.000



Leadline not to be finished until 2005

Certificate of Calibration

Model: Nikon DTM310

Serial Number: 842575

This certifies that the above instrument has been inspected and calibrated by the GeoLine Positioning Systems Inc. Service Department. At the time of completion of this service, GeoLine Positioning Systems, Inc. certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, precision optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used have had current calibration.

Date of Calibration: 6/28/04

Next Recommended Calibration Date: 12/28/04

Signed: Sean Valker Date: 6/28/04

Title: Service Technician

GeoLine Positioning Systems, Inc.
1331 118th Avenue SE, Suite 400
Bellevue, WA 98005
425.452.2711 • 425.452.2703 fax

Certificate of Calibration

Model: Sokkia SET 5F

Serial Number: 16288

This certifies that the above instrument has been inspected and calibrated by the GeoLine Positioning Systems Inc. Service Department. At the time of completion of this service, GeoLine Positioning Systems, Inc. certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, precision optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used have had current calibration.

Date of Calibration: 7/19/04

Next Recommended Calibration Date: 7/19/05

Signed: Sean Vale Date: 7/19/04

Title: Service Technician

GeoLine Positioning Systems, Inc.
1331 118th Avenue SE, Suite 400
Bellevue, WA 98005
425.452.2711 • 425.452.2703 fax

Appendix VI

Procedures

Measuring Launch Offsets and Installation of Benchmarks

Table of Contents

0.0 Document Scope

The scope of this document covers the procedure on how to place launch benchmarks and to measure launch offsets using a theodolite and an auto level.

1.0 Background

In order to collect hydrographic quality multibeam data it is critical to have offset measurements between attitude sensors, heading sensors, antennas, and multibeam sonar heads. These offset measurements are used in configuring the Pos/MV (Attitude, Heading and Heave) for proper functioning and in CARIS to allow correctors to be applied.

Within the *Pos/MV V3 Installation and Operation Guide* dated 17 October 2003 there are specifications to how accurately a measurement must be accomplished in order to obtain the system accuracies defined in the manufacture's specifications. Offset measurements must be known to their standards. Furthermore, poor understanding of vertical offsets will create vertical errors in the data. If the separation between the phase center of the multibeam transducer and the waterline is only known to within 10 cm, that 10 cm becomes a limiting factor in your vertical error.

Traditionally within Office of Coast Survey these measurements were made with a steel tape, straight edge, plumb bob, carpenters square, carpenters level and a ruler. The accuracy of such measurements was not resolved.

With the implementation of Bathymetry Associated with Statistical Error (BASE) surface in CARIS 5.4, and Office of Coast Survey's adoption, the need for error modeling became necessary. The validity of bathymetric measurements is directly dependant on our knowledge and confidence of individual error sources that compose the error model. It is vital that the statistical error of the offset measurements be known for inclusion into the error model.

To enhance the precision and accuracy of launch offset measurements, and to aid in determining the statistical error of such measurements, permanent benchmarks must be welded to the launch and a ship's frame of reference (SFR) should be established.

2.0 Overview of Procedure

2.1 Initial Launch Leveling, Placing Benchmarks and Measurements (Building a SFR)

For the first time a launch is leveled and measured a significant amount of work is involved. The general steps are as follows:

- Level the Launch
- Position Bench Mark's (BM)
- Weld BMs in place
- Measure BM, antenna, IMU, and multibeam phase center positions vertically
- Measure BM, antenna, IMU, and multibeam phase center positions horizontally

2.2 Following Levels and Measurements

Any measurements required after a launch has been given a SRF are greatly simplified. With BM's near multibeam equipment the vessel is not required to be leveled again. Measurement errors for not being level are minimized by short horizontal and vertical distances and a ready reference frame of athwartships axis or longitudinal axis information is available. In general due to proximity, errors from measuring a known BM to a needed position should be less than 3 cm. This is well within the requirements for positioning equipment for the Pos/MV.

If there is need for precision measurements, less than a centimeter, the procedure would be to:

- Level the launch using known differences in elevation (DE's) between BMs.
- Measure BMs, antenna, IMU, and multibeam phase center positions vertically
- Measure BMs, antenna, IMU, and multibeam phase center positions horizontally

3.0 Required Equipment

3.1 Auto Level

A calibrated auto level is required prior to leveling and benchmarking a launch. The level must have an associated rod which reads in ½ cm or 1 cm increments.

3.2 Theodolite

The theodolite used to set in the benchmarks must be calibrated prior to setting and positioning bench marks and other offsets. The theodolite should utilize Electronic Distance Measuring Equipment (EDME) and have associated prisms for positioning.

3.3 Boat leveling gear

Screw type boat jacks simplify the leveling procedure. They allow the boats position to remain static over the process. A hydraulic jack can be used for some of the large vertical movements in the initial part of the leveling procedure. Blocking is handy for distributing the weight of the keel.

Leveling with a trailer, blocking and hydraulic jacks is also viable if there is sufficient blocking to get the rubber wheels off of the ground. The rubber wheels would prove to be a source of error as personnel moved around onboard the vessel.

3.4 Benchmarks

Small, low profile benchmarks made out of the same material as the vessel are needed to mark the vessel. These benchmarks are to be set in critical locations, near multibeam equipment, antennas and attitude sensors for ease of relocating the equipment at a later date.

3.5 Welder and Welding Gear

A welder and gear are required to place benchmarks.

3.6 Miscellaneous equipment

1. **Plumb bob**
2. **Steel Tape (metric)**
3. **Carpenter's squares**
4. **Tripods**
5. **High precision digital level**

4.0 Required Measurements for Hardware and Software

4.1 *Pos/MV*

Measurements required by the IMU are lever arm distances from the IMU, the multibeam transducer, the heave measurement location (roll point), and the primary GPS antenna to the chosen reference point. In the case of launch 1010 the reference point and the IMU are coincident. This simplifies installation. There is also a need for an antenna separation distance.

4.2 *CARIS*

Measurements required by CARIS are transducer to the reference point, IMU to the reference point and waterline to the reference point.

5.0 Leveling the XY Plane Orthogonal to Gravity (Z-Axis)

5.1 Justification for Leveling

The first step in measuring launch offsets and setting benchmarks is having the ability to make repeatable measurements. This is done by creating a reference plane for the launch. This is a critical step which has historically been omitted during offset measurements by OCS personnel. By not creating a reference plane there is no capability to utilize gravity to create a Z-axis that is orthogonal to a SRF. The magnitude of this oversight is depicted in Figure 1 and Figure 2.

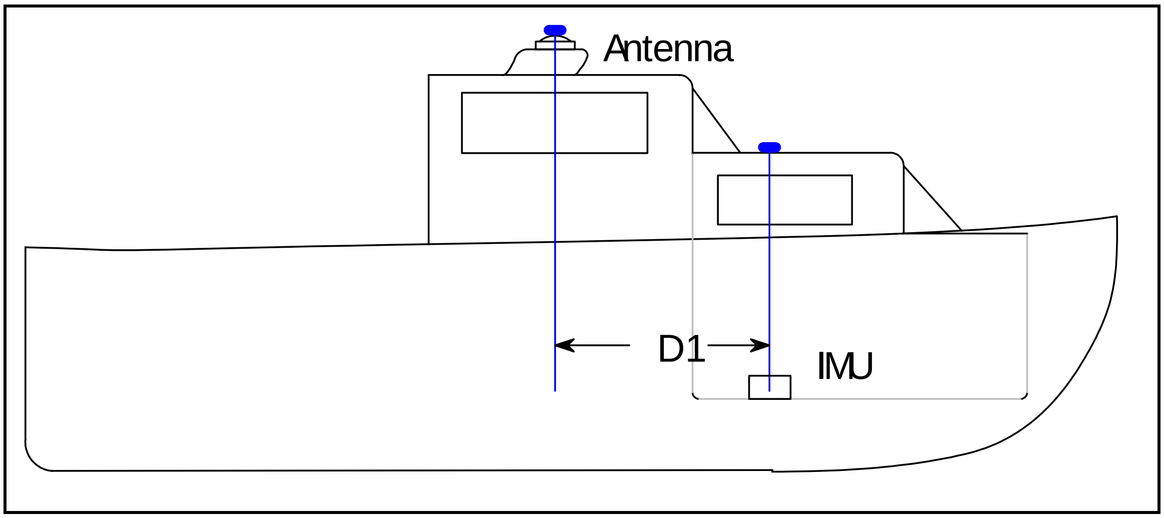


Figure 1 shows the separation between the IMU and the primary GPS antenna for the POS/MV. In the chosen level frame of reference this distance is D1. The blue marks are static from Figure 1 to Figure 2.

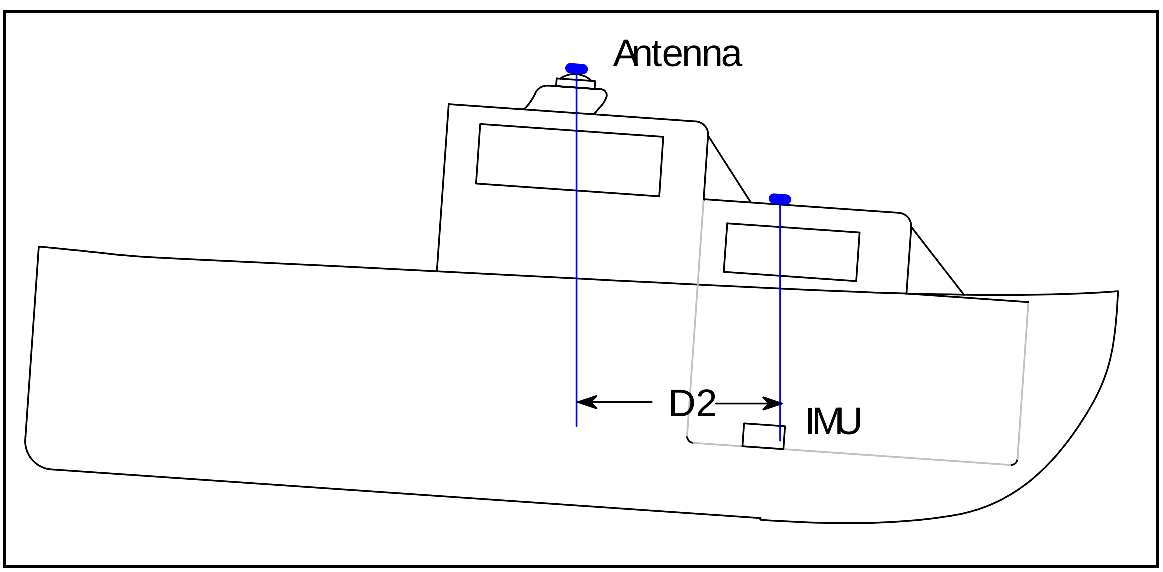


Figure 2 shows the separation between the primary GPS antenna and the mark which was above the

IMU in the chosen level frame of reference. Note that D2 is smaller than D1. The launch is down 4˚ by the bow.

Figure 1 and Figure 2 visually depict the importance of defining a frame. What is shown is that the horizontal separation between the IMU and the antenna is decrease with a pitch angle of bow down. Taken to absurdity if the launch was to continue to pitch down the antenna would be directly over the IMU creating a zero separation.

Another critical fact is that horizontal differences are created. Figure 3 shows a 14.5 cm horizontal change based upon a 4˚ pitch down by the bow and a 2.1 m vertical drop from the mark at the top of the cabin to the IMU.

In order to avoid such “variations” to the offsets it is critical to define a SRF for each vessel. The definition of the SRF would allow the vessel to have a XY plane defined such that it could always be perpendicular to gravity and that “leveling” the vessel would be repeatable from year to year. Benchmarks, A, B, C and D in Figure 3 are used for repeatable “leveling”.

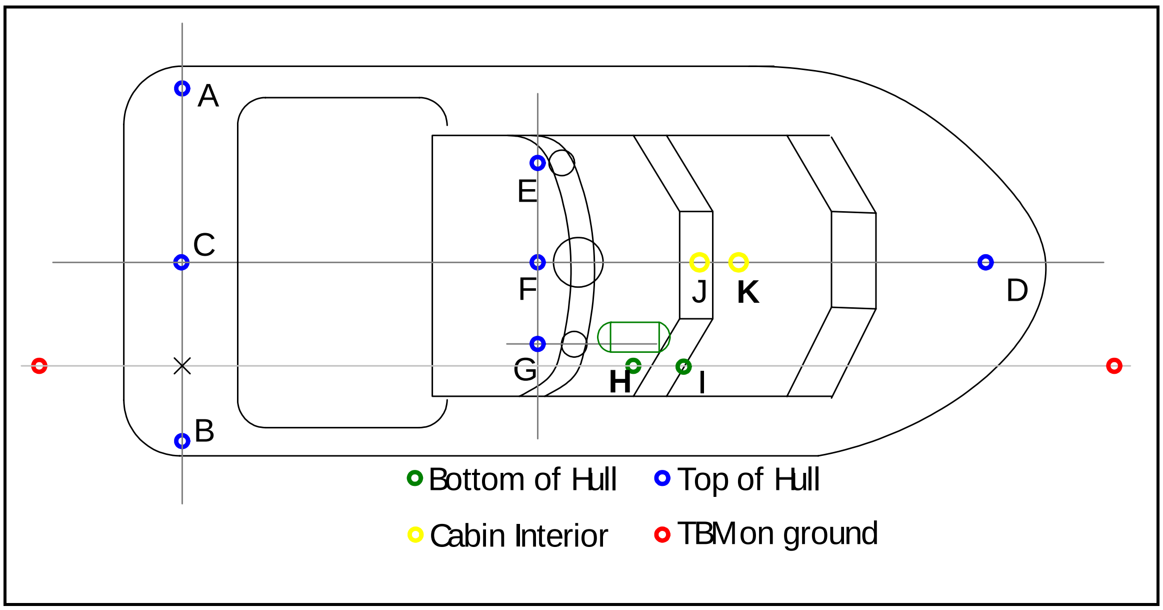


Figure 3 depicts a launch benchmarking scheme.

5.2 Leveling Procedure Method A: Leveling to an Installed IMU

On the FAIRWEATHER Jensen’s leveling was accomplished to the surface of the POS/MV’s IMU. This can only be done if and only if the vessel level and the IMU level are close to equivalent. This is the case on the FA launches since the IMU's are located on, and parallel to, the keels of the vessels.

The leveling procedure is an iterative process. A high precision digital level is zeroed with respect to local gravity and then placed upon the IMU in the athwartships direction. Level the launch athwartships using the jack screws and/or hydraulic jacks and blocking. Rotate the level to the IMU's longitudinal axis. Level the launch longitudinally. Repeat this process until no changes are made in either direction.

Ensure that the results are reasonable (i.e. that the launch and the IMU's level are nearly equivalent). For the leveling of a vessel by leveling the IMU the athwartships error must be less than ½ degree and the longitudinal error must be less than 2 degrees. There is difficulty in making such measurements due to the camber and sheer on the vessel.

If the above specification is met then the launch considered to be leveled. There is no such state as absolute leveling of the launch. Theoretically the launch is symmetric so the port side aft stern location should be identical to the starboard side aft stern, but boats are built by people and they warp. Level fore and aft is even a much more difficult concept because of sheer on a launch and the fact that pitch changes with loading.

Repeatability of measurements from year to year is accomplished by using differences in elevations (DE's) of known benchmarks after they are placed and positioned. These DE's are used to create the SRF.

Required DE's are between BM A and BM B for athwartships level and between BM C and BM D for longitudinal level. See Figure 3 for BM positions.

5.3 Leveling Procedure Method B: Leveling the Vessel to Symmetric Points

This leveling procedure is also an iterative process. This procedure is accomplished before a launch is benchmarked. The first step is to approximate the positions of BM A, B, C and D. These do not have to be completely accurate, but will be refined later before actual BM installation.

Step 2 is to level athwartships use BM's A and B with an auto level atop of the cabin. Jack the trailer on the low side until the difference in elevation between the benchmarks read zero.

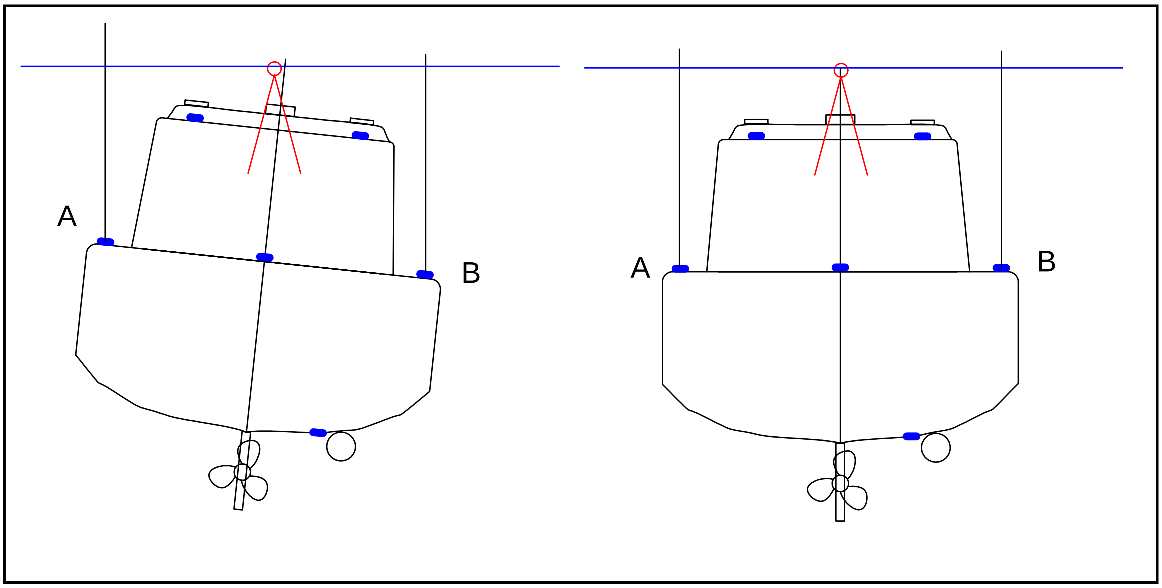


Figure 4 shows athwartships leveling.

Leveling fore and aft is a bit more complicated as there is no true "level". One could choose to define level by using the design waterline of the vessel, or base level off of flat surfaces. Another method would be to use an actual waterline, but that may change with loading. What is needed is an approximation of a longitudinal level. Once it is defined, that is going to be the longitudinal level for the vessel; the reference frame is defined which is orthogonal to gravity.

In Figure 5 the setup for leveling the launch longitudinally is depicted. Since the longitudinal level is "arbitrary" it is critical that the difference in elevation between benchmark C and D be recorded in the Offset Measurement spreadsheet located in a Data Acquisition and Processing Report appendix. It is only by using that difference in elevation that the launch can be leveled again.

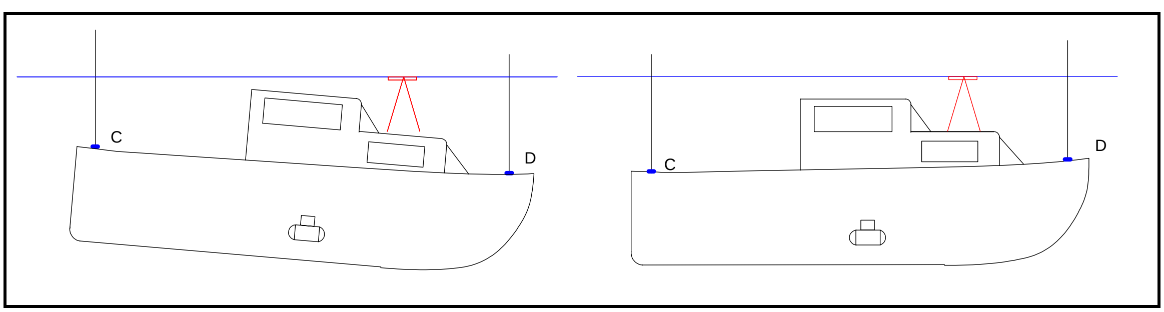


Figure 5 shows leveling the launch longitudinally. The critical measurement to record for future leveling operations is the difference in elevation between benchmark C and D.

Once the launch is leveled fore and aft check the athwartships level as it may have changed with the jacking of the bow. Repeat the athwartships leveling and then fore and aft leveling as necessary.

6.0 Installation of Benchmarks

6.1 Benchmark Requirements

It is recommended that the BMs be installed permanently on the launch to increase accuracy and repeatability of offset measurements and to establish reference points in which future equipment can be surveyed into. The benchmarks should be located in close proximity to survey equipment (Inertial Motion Unit, Antenna, Transducer) so that future measurements from a benchmark to such equipment would be small. This would decrease measurement error if the launch were not level. For example if a mark was .5 m away from a relocated instrument and there was an error of 3˚ on all axes the total error vector would be less than 2 cm. This is within NOS accuracy tolerances for differential GPS positioning as defined in the Specification and Deliverables and within the positioning error for installing equipment for the POS/MV.

6.2 Setting Benchmarks

Prior to setting the benchmarks the vessel MUST be level. This is necessary for determining the axes using a sight plumb bob.

Establish the vessels longitudinal axis of the vessel by setting a benchmark on the bow and the stern, referred to as BM C and BM D, respectively in Figure 3. The location for BM C can be determined by measuring the distance athwartships on the stern and dividing by 2. Set the mark in a location which the tripod can be set up over. On the bow set BM D on a reasonable approximation of the centerline in a manner that the tripod can be set up over the location. BM C and BM D are also used to define the athwartships axis of the vessel.

Once the marks are in place set the theodolite on BM C and sight the plumb bob line over BM D. Zero the angle on the theodolite. Turn 90˚ to Port and align BM A. Flip the telescope and align BM B. BM A and BM B should be inboard enough to allow a tripod with a prism over the marks.

Next align all other center line BM's visible from the setup on BM C. That would be BM F, BM J and BM K. Again the marks should be set in such a manner that a tripod can be placed over them.

To place the remaining marks on the cabin top set the theodolite over the BM F and align the instrument to the center by sighting the fore or aft centerline benchmark. Set the card to zero. Turn the instrument 90˚ to port from the centerline and use it to align BM E. Flip the telescope and align BM G. Again they should be inboard enough to set up the tripod and, if possible, in line with the POS/MV antennas.

Setting in BM H and BM I is accomplished by measuring horizontally from the keel to the desired off-axis location of the marks. Then measure from BM C to a temporary location the same distance off-axis. Punch the location and record the distance (it will be the same as the X-Axis offset distance for both BM H and BM I. Set up the theodolite over the location and sight BM A. Zero the card and turn aft 90˚. Place a TBM near the stern on the ground. Flip the telescope and sight a plumb bob line at the forward end of the vessel. Place another TBM. Set up the theodolite on the aft TBM and sight the forward TBM. This line should be parallel to the longitudinal axis of the launch. Place BM H and BM I in line with a one meter separation. Their alignment can be used to determine parallel and perpendicular axis for the purpose of measuring short distances during the field season when re-leveling and realigning the launch is impractical. This allows for more precision in measuring distances.

7.0 Positioning BMs and Equipment on the Z Axis

In order to position BMs with respect to Z the methodology used is shooting three wire levels according to the procedures defined in the *Users Guide for the Installation of Bench marks and Leveling Requirements for Water Level Stations* dated October 1987.

Each point is to be measured twice in accordance with the leveling procedure, and the runs between benchmarks are to be checked for closure. According to Users Guide, the maximum closure tolerance for a single third-order section, one setup, less than 0.1 km in length, is 2 mm. For launches the implication is that DE's between benchmarks must be less than 2 mm.

In order to measure elevations to BMs or equipment on the bottom of the launch a rod must be inverted. This is accomplished by shooting a metric tape which is held vertical with the 0 end on the BM. The values read are then made negative. This has the effect of adding the reading to the height of the instrument.

Reading tape can also be done on the interior of the launch where a level rod would not fit.

8.0 Positioning BMs and Equipment on the XY Plane

This is the most complicated portion of positioning the benchmarks in instruments on the launch. The key is to work is having a defined centerline of the vessel. The concepts for measuring and calculating the offsets are relatively simple:

1. Always reference angle measurements with respect to the centerline.
   - This is accomplished by setting up over known marks, or making TBMs as needed for alignment, and backsighting known marks.
2. Measuring horizontally, using an accurate instrument with proper technique, from point to point or BM to BM. Ideally this is done with a total station with EDME.
3. Use simple trigonometry and geometry for positioning BM's and equipment with both horizontal distances and angles.

An example of the aforementioned concepts is shown in Figure 6. The distances and angles required to calculate the horizontal position of BM H is shown. The procedure would be to setup the theodolite on BM C, sight a plumb bob line on BM D and zero out the card. Turn 90˚ to starboard and tack in a temporary benchmark. Measure the distance from BM C to the TBM and record (d1 in the diagram). Setup on the TBM and backsight BM C. Turn the angle from BM C to BM H (a1 in the diagram). Measure the horizontal distance from the TBM to BM H (d2 in the diagram). Now d3 and d4 can be calculated and referenced back to BM C, thereby tying in BM H with the rest of the BM's.

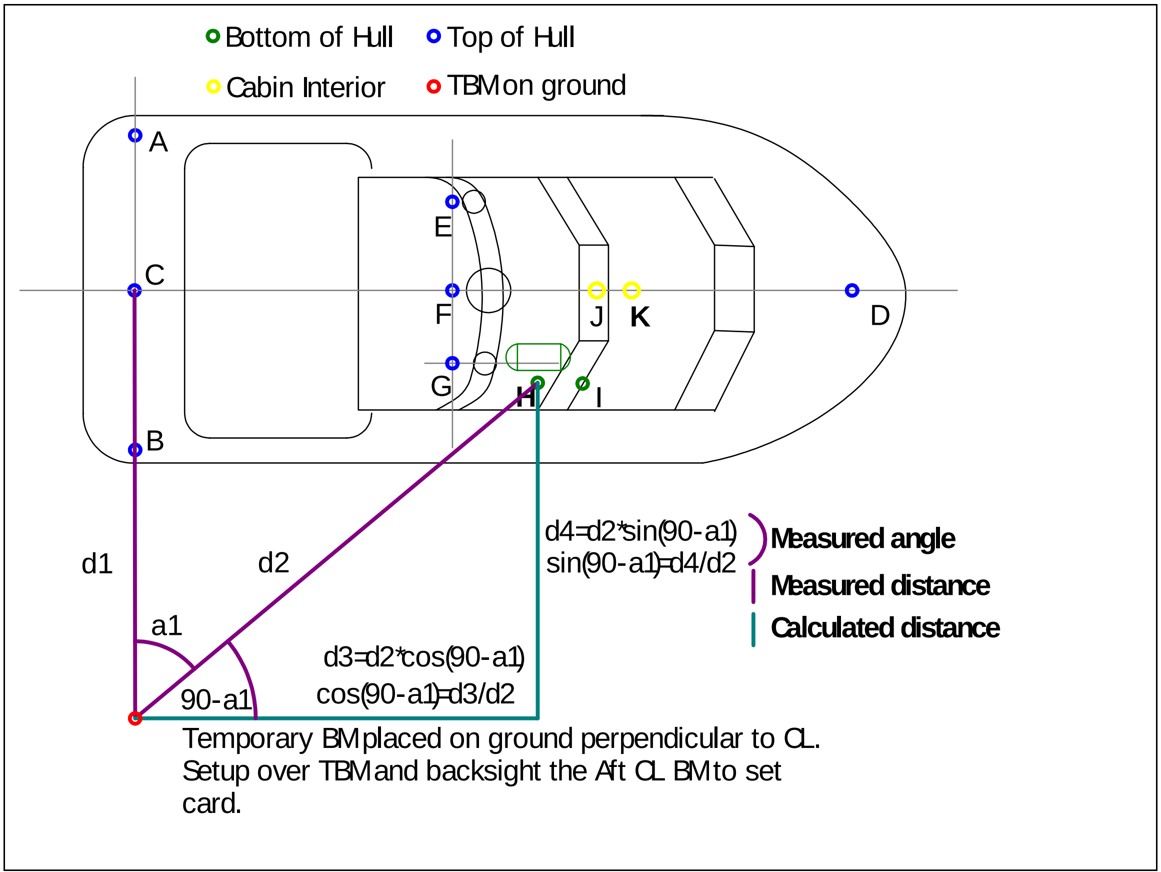
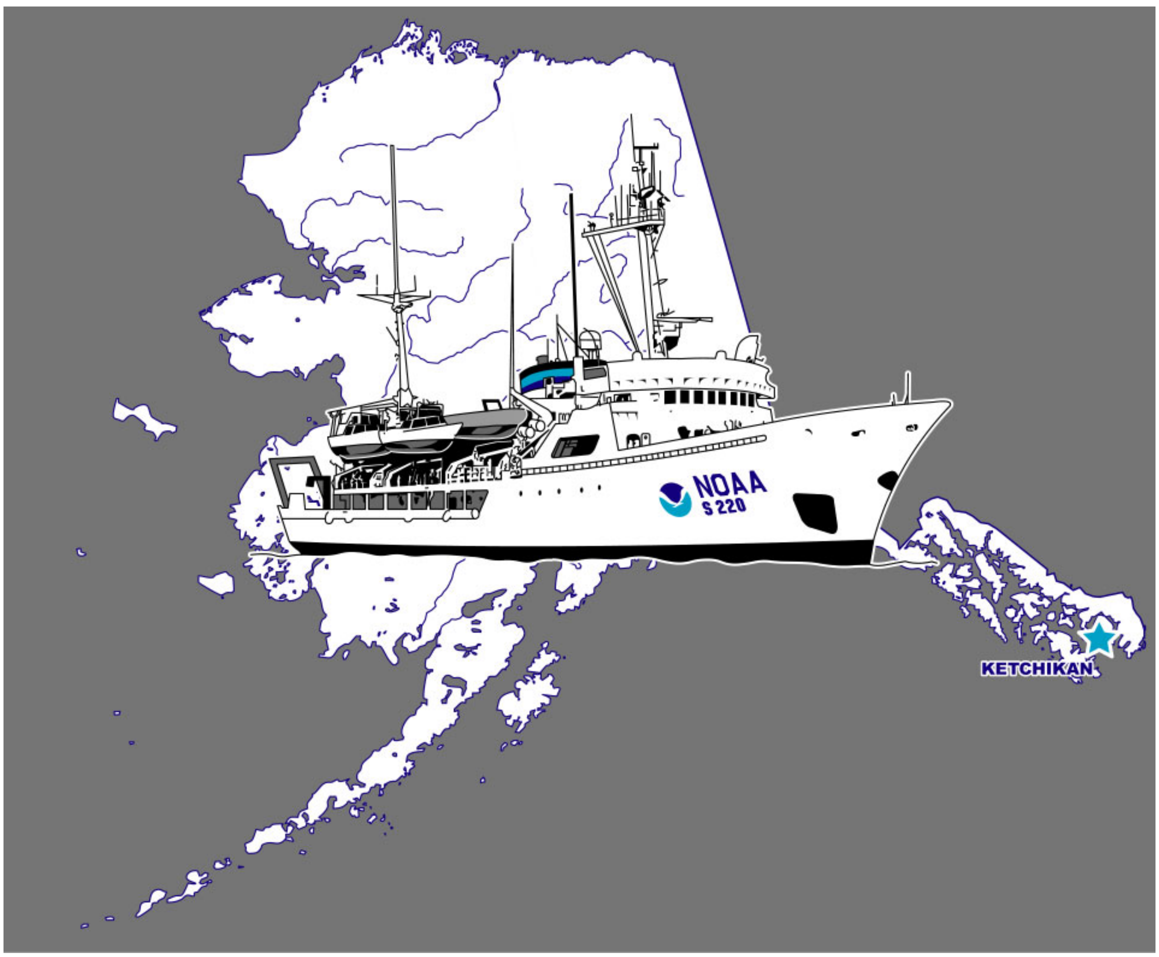


Figure 6 shows positioning BMs on the launch horizontally. It is important to always zero the theodolite to a known axis of the vessel.

Configuring Real Time Bathy



Configuring Real Time Bathy

Table of Contents

0.0 Document Scope

The scope of this document covers installing software and configuring COM ports necessary for the utilization of Reson 81XX series sonars and TEI Real Time Bathy. It does not cover hardware installation such as Digi Boards or wiring. This should be performed by the ET.

1.0 WARNING!

Seek the FOO's permission before performing any of these tasks! If you haven't performed any of these tasks before, ask for help from an SST/CST/FOO. If improperly performed these tasks can seriously hinder survey operations!

2.0 Removal of old software

Completely remove all previous versions of TEI Isis Sonar and TEI Suite if they are installed on the computer. This includes manually deleting the TEIdll folder from the WINDOWS directory.

3.0 Install new versions of TEI software

3.1 Install Isis Sonar v6.6 (or newer)

Follow the prompts and install the complete setup using the defaults supplied by the installer program on both Hull#_Acq and Hull#_Nav

3.2 Install TEI Suite v2.10 (or newer)

Follow the prompts and install the complete setup using the defaults supplied by the installer program on Hull#_Nav

4.0 Install Applanix POS/MV Controller Software v2.1

For the FA setup the POS/MV PCS must have TrueHeave installed. This feature makes it possible to fully utilize the "Paint the Bottom" paradigm that the FA has adopted. TrueHeave removes any induced heave caused by turns during acquisition. See the ET for help on installing this feature if it is not already.

4.1 Install Wizard

Follow the prompts and install the complete setup using the defaults supplied by the installer program on Hull#_Nav

5.0 Install Sentinel System Drivers

These are the dongle drivers that license the TEI programs. If not installed, the TEI software will not work.

5.1 Install Wizard

Follow the prompts and install the complete setup using the defaults supplied by the installer program on Hull#_Nav & Hull#_Acq

6.0 Install Digi Board Drivers

This is the software that controls the Digi Board, which allows for the expansion of COM ports beyond the standard two COM ports.

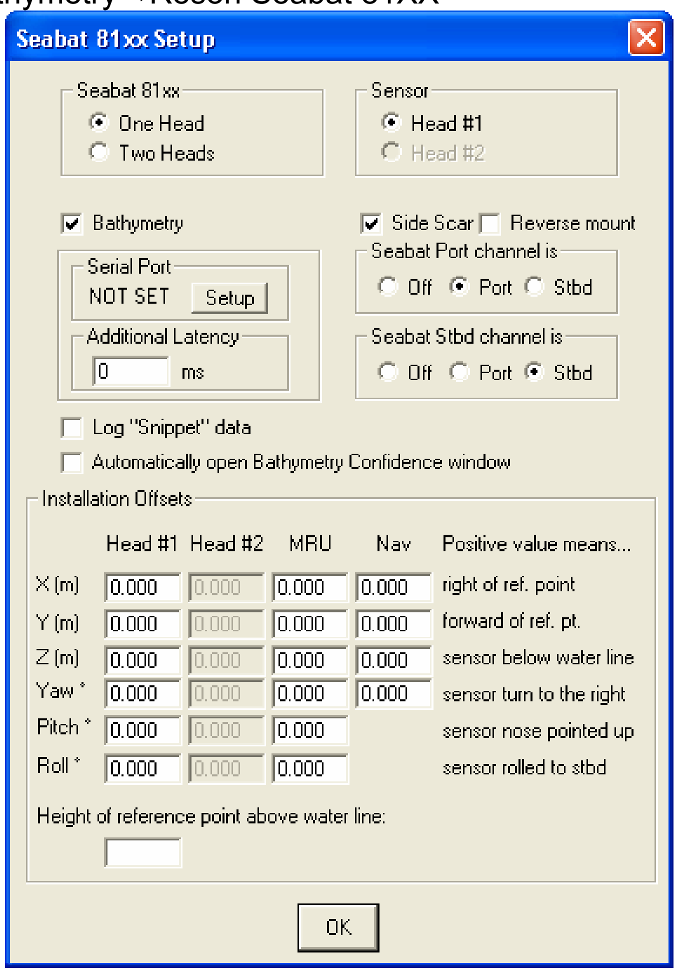
6.1 Install Wizard

Follow the prompts and install the complete setup using the defaults supplied by the installer program on Hull#-Acq

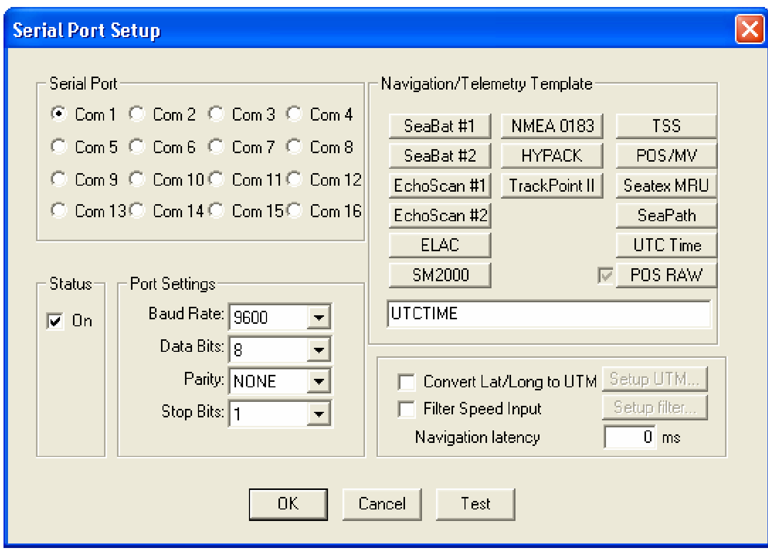
7.0 Configure Hull#_Acq Isis Sonar

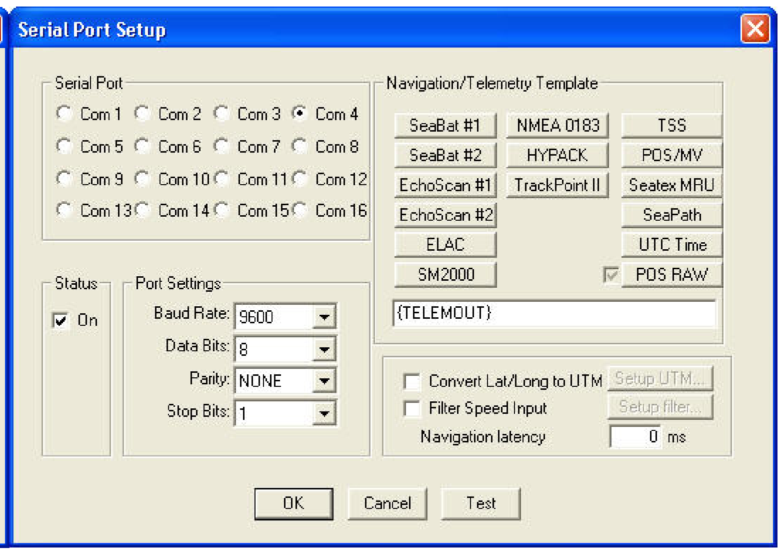
7.1 Setup Sonar

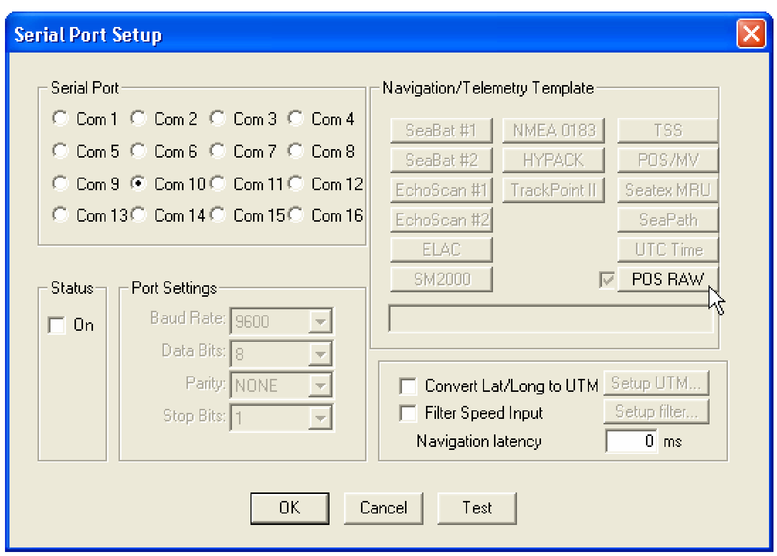
1. File→Record Setup→Sonar Setup→Multibeam Bathymetry→Reson Seabat 81XX



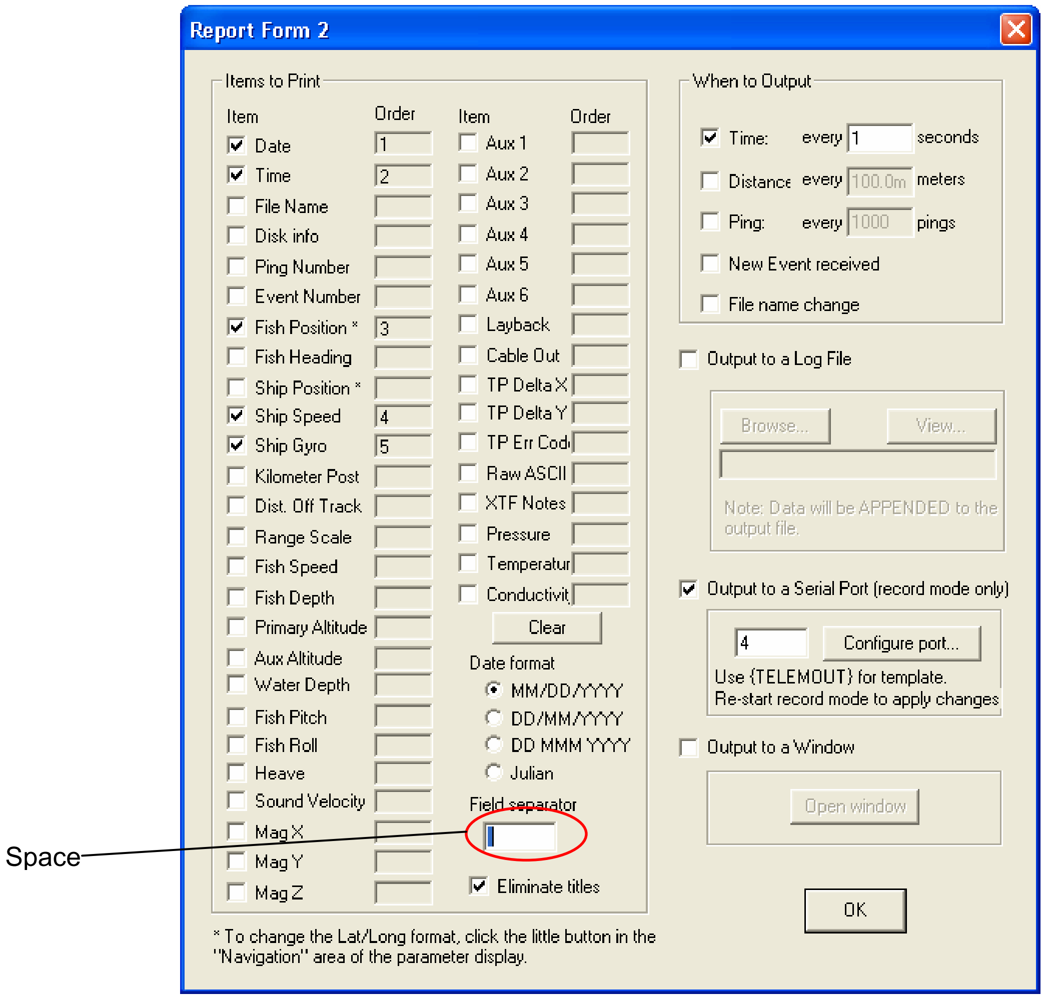
2. File→Record Setup→Serial Ports (n.b. This may differ depending on wiring diagram)





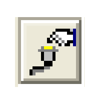


3. Tools→ASCII Report→Form 2

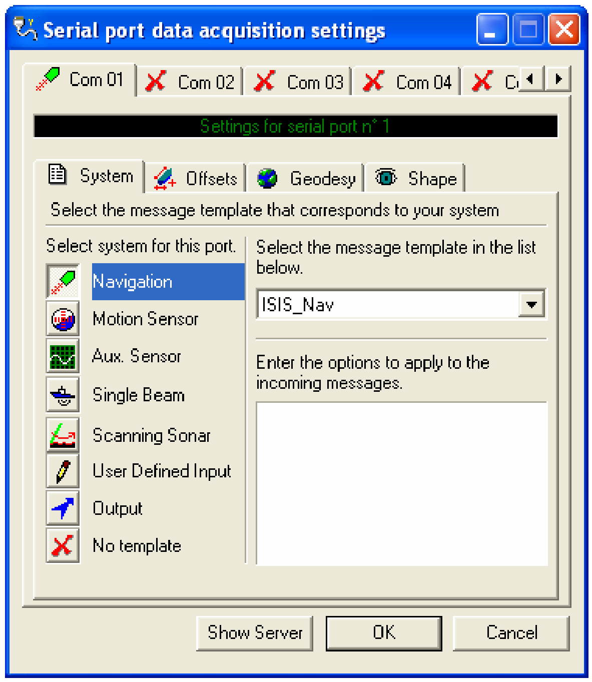


8.0 Configure Hull#_Nav DelphMap

8.1 Setup DelphMap Navigation Template

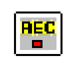


1. Serial port data acquisition settings→COM →Navigation→Isis_Nav

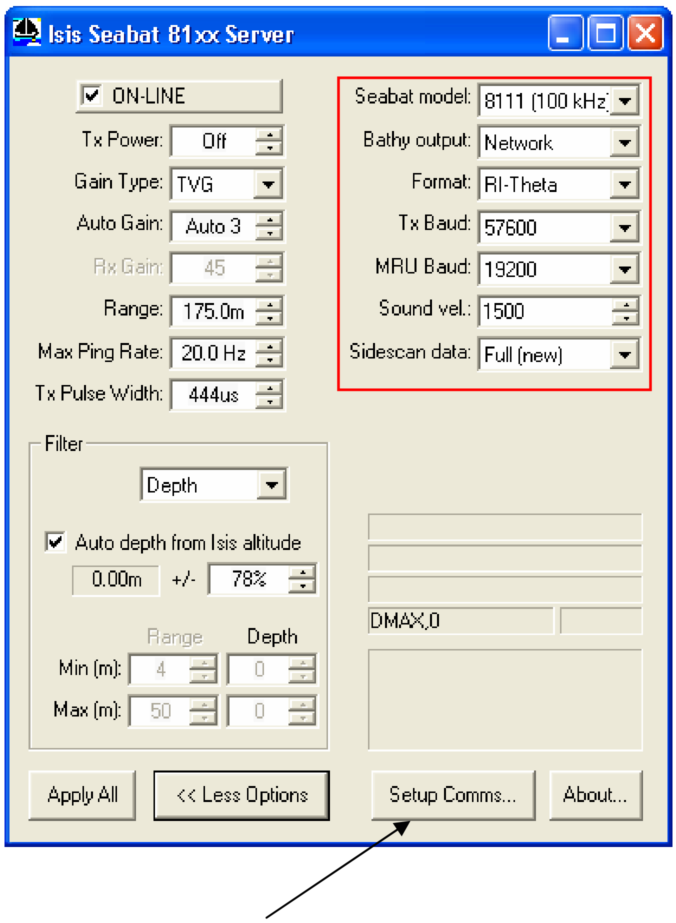


9.0 Configure TEI 81XX Server

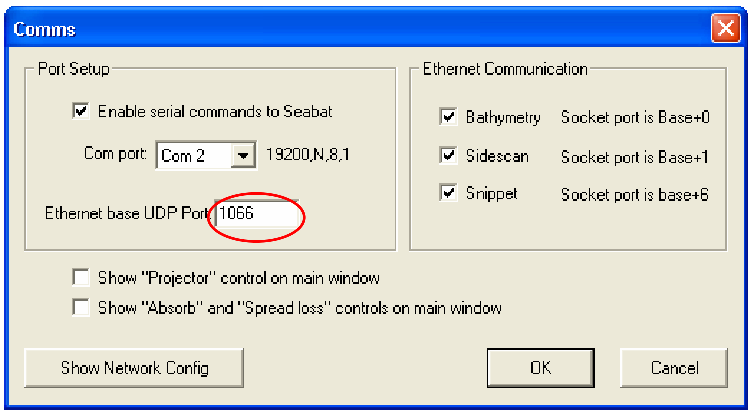
9.1 Configure 8111 Server



1. Open the 81XX server by either clicking Record on the Isis screen or by opening the 81XX server through the executable (Sbat8100.exe).
2. Configure the 8111 as follows from the highlighted column in the following screen grab.



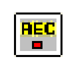
3. Click on Setup Comms... to setup the communication protocols for the 8111.

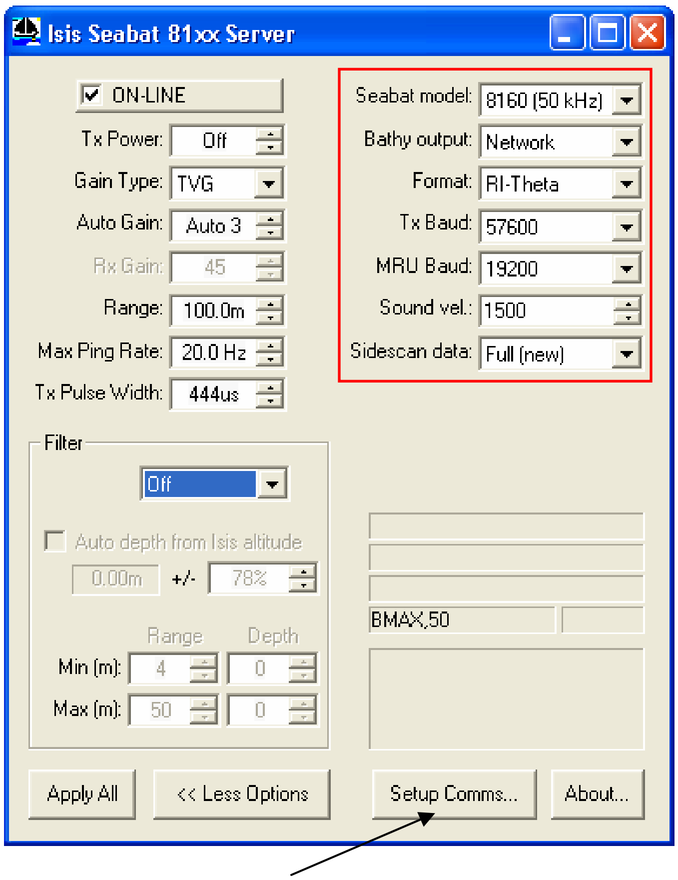


9.2 Configure 8160 Server

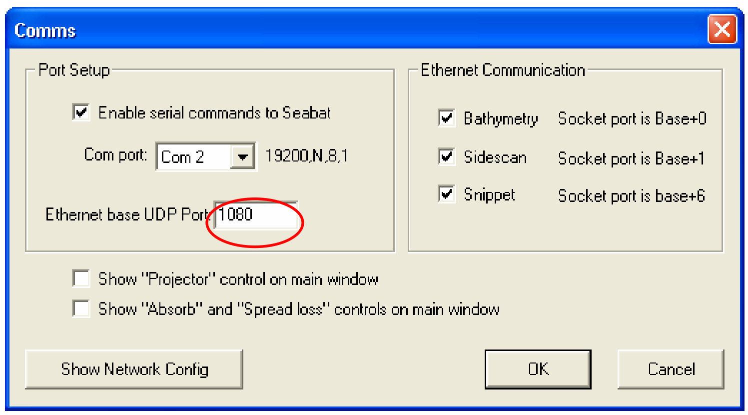
At this time you can only have one Reson system controlled through Isis at a time. If you are switching to the 8160 use the following setup.

1. Open the 81XX server by either clicking Record on the Isis screen or by opening the 81XX server through the executable (Sbat8100.exe).
2. Configure the 8160 as follows from the highlighted column in the following screen grab





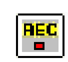
3. Click on Setup Comms... to setup the communication protocols for the 8160.

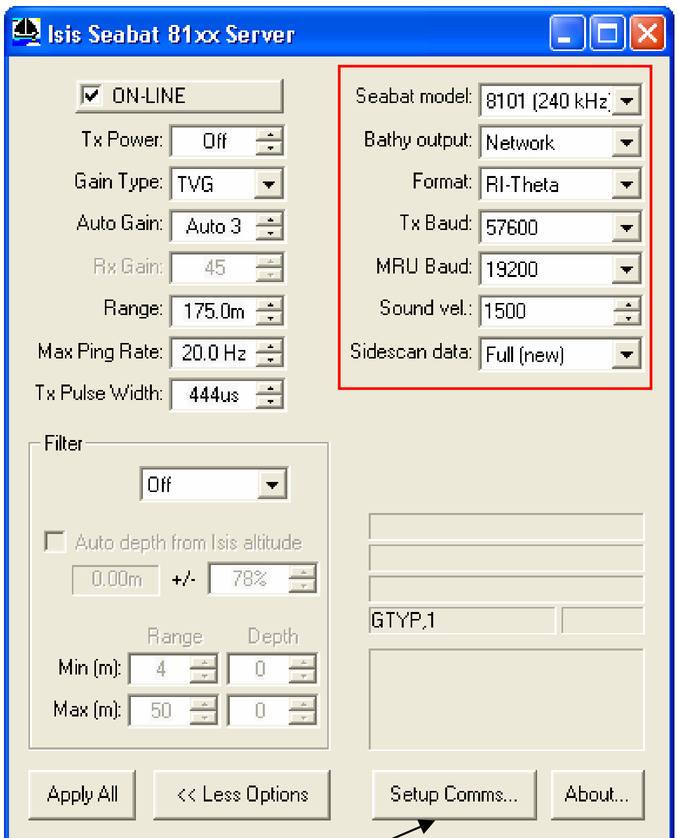


9.3 Configure 8101 Server

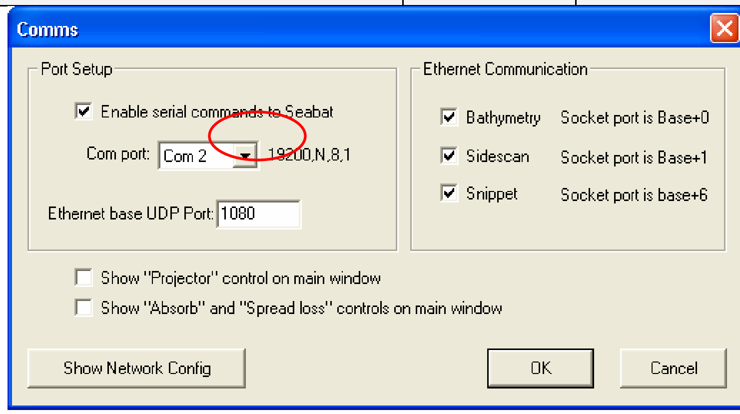
The 8101 is only utilized on 1010 and 1018. Do not use the 8111 or 8160 settings for either of those platforms.

1. Open the 81XX server by either clicking Record on the Isis screen or by opening the 81XX server through the executable (Sbat8100.exe).
2. Configure the 8101 as follows from the highlighted column in the following screen grab.





3. Click on Setup Comms... to setup the communication protocols for the 8101.



Comms
Port Setup
Enable serial commands to Seabat
Com port: Com 2
19200,N,8,1
Ethernet base UDP Port: 1080
Ethernet Communication
Bathymetry Socket port is Base+0
Sidescan Socket port is Base+1
Snippet Socket port is base+6
Show "Projector" control on main window
Show "Absorb" and "Spread loss" controls on main window
Show Network Config
OK
Cancel

Upgrading NOAA Multibeam Acquisition Systems to "Precise Timing"

Document Custodian: LTJG Ben Evans, HSTP-West
Last Update: 10 May 2004

I. Background

"Precise Timing" is a multibeam sonar data acquisition configuration which improves the timing of sonar, attitude, and positioning data by applying a time stamp at the point of acquisition and retaining that time in the xtf data logged in ISIS, rather than applying a time tag as the data arrives in ISIS. This reduces the effect of latency in the serial and Ethernet interfaces NOAA has traditionally employed to transfer bathymetry, imagery, position, and attitude data to ISIS for logging.

This configuration was developed and tested by Doug Lockhart of Fugro TGPI (formerly Thales Geosolutions), in cooperation with Applanix and Triton Elics International. It was further tested by HSTP and NOAA Ship RAINIER on Launch 1021 (RA-3) with excellent results. **At this point, precise timing has only been implemented on data acquisition systems consisting of Reson 81xx series multibeam sonars with the 81-P processors, POS MV position and attitude sensors, and Triton Elics ISIS data acquisition software.**

The intent of this document is to explain Precise Timing to NOAA's hydrographic platforms, and provide a "how to" for performing the upgrade for the aforementioned Reson + POS MV + ISIS system configuration.

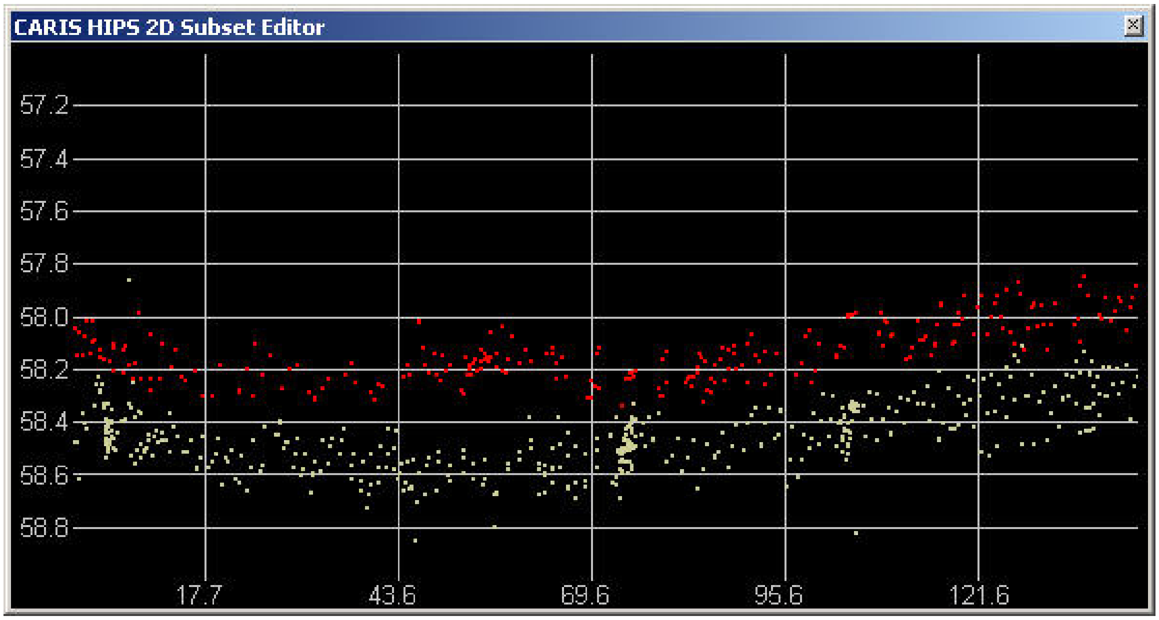
II. Theory

Accurate bathymetry from multibeam sonar systems requires merging data from several different sources create a final product fully corrected for vessel characteristics, position, and dynamics, water levels, and water column properties. The quality of this product is dependent not only on the accuracy of these independent measurements, but their synchronization in time. Obviously, applying corrections measured at one time to soundings acquired at another could result in erroneous results.

Because of their highly dynamic nature, position, attitude, and bathymetry are the three datasets which must be most accurately synchronized. Traditionally, NOAA hydrographers have accomplished this by logging all data in a single data acquisition system (ISIS) whose clock (Windows NT+ PC timer) is set to GPS time. Each data packet which arrives in ISIS is stamped with this time, and logged. Any time stamp available from the originating instrument is ignored. While this requires that only the data logging system's time must be correct, it assumes that data logged remotely will still be valid at the time they actually arrive and are logged in ISIS. Any latency between measurement and logging must be assumed to be constant, and is estimated from the navigation timing section of the patch test. However, NOAA hydrographers have consistently found that this latency can be variable, particularly when transferring data between instruments and ISIS via RS-232 serial interfaces. This commonly manifests itself as “jitter” in the delta time between successive navigation fixes and attitude measurements as data is examined in CARIS HIPS. Severe cases can produce noticeable “attitude artifacts” in digital terrain models.

Precise Timing is an alternate approach to the problem of synchronizing data from multiple sources. Rather than marking bathymetry, navigation, and attitude datagrams with “real-world” time as data arrive in ISIS, a timing message generated by the POS MV is used to synchronize the ISIS computer and Reson multibeam with the POS MV’s UTC time. Data are time stamped at the point of measurement, and transferred to ISIS via Ethernet rather than serial interface simply for file storage. CARIS HIPS honors the precise time stamps contained in the datagrams, rather than using the noisy PC-based timing present in the XTF data packet headers. The latency in the serial reference-UTC time message is determined by patch testing, and corrected during processing in CARIS. Replacing several individual serial interfaces with this single serial message results in significantly lower correction values, and more precise synchronization of bathymetry, position, and attitude. Simulations and field tests conducted by Fugro and additional field testing aboard NOAA Ship RAINIER have confirmed this improvement.

The figure below compares data from two lines run during RAINIER’s spring 2004 patch tests in Lake Washington, Seattle. The data in red were acquired by Launch 1021 (Reson 8101 with Precise Timing) and the beige from Launch 1006 (Reson 8101 with standard timing). The view is looking across the track of a roll calibration line for both vessels, with the best angle and time biases applied. (Note that these data have not been corrected for water levels, hence the vertical offset.) Conditions were very calm in both cases, so dynamic input to the vessels was limited. However, a qualitative difference in the spread of the data due to imprecision in roll timing is apparent. Quantitatively, the standard deviation of the delta time between successive navigation fixes is 0.0898 seconds for the line acquired with standard timing, compared with 0.0005 seconds for the precise timing line.



III. What you will need

The following materials are needed to replicate the Precise Timing configuration of RAINIER's Jensen launches, assuming the system to be upgraded is already configured for traditional serial position and attitude data and ISIS timing. The exact requirements will vary from system to system.

A. Basic System Prerequisites
- Version 3 POS MV
- Reson multibeam sonar with 81-P processor
- ISIS data acquisition system
- CARIS HIPS 5.3 with SP3 and all SP3 hotfixes applied (v5.3.3+). Support for Precise Timing is included in the base HIPS v5.4 install. Tests have only been exercised using v5.3.3, but there are no known problems with v5.4 in regards to Prcise Timing.

B. New Hardware
- <u>Three output serial data Y</u> to split the POS MV Com 1 output to the Hypack computer, ISIS computer, and Reson 81-P processor. It should also be possible to use an **unbuffered** Black Box data broadcaster, though this has not been tested.
- <u>Sufficient serial cables</u> to make the above connections.
- <u>Additional Ethernet switch</u> with at least three ports for the POS MV subnet to distribute the Group 102 message to ISIS and retain the controller software on the Hypack machine. Note preference for "switch" vice "hub", to minimize any latency. While it may be possible to eliminate this additional switch by combining either the Reson or POS subnets with the ship network, this is not preferable.
- <u>One additional 10baseT network card</u> to connect the ISIS computer on the POS MV subnet.

- Sufficient network cable to make the required connections.

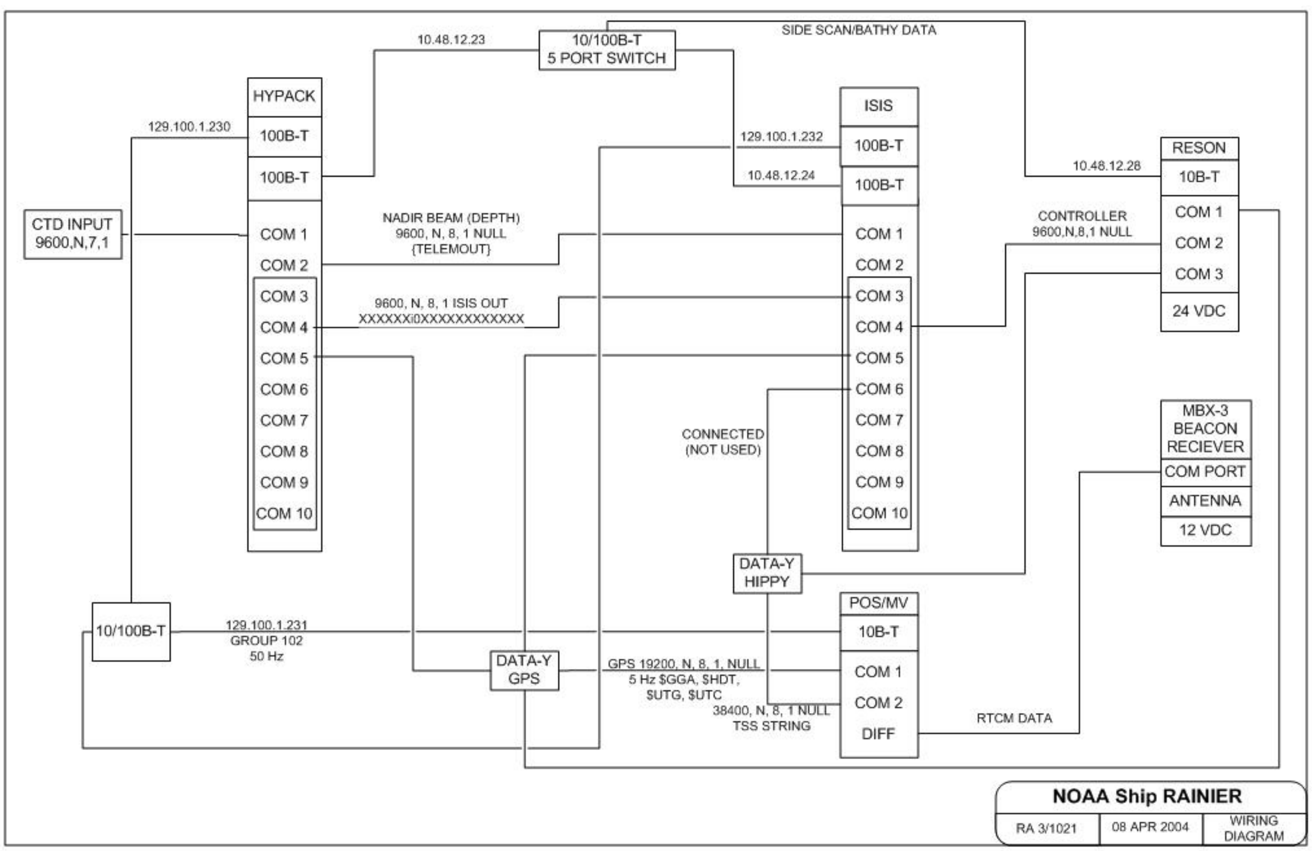
C. New Software

- ISIS Version 6.5 (March 2004 release), available as a service pack to v6.41 (November 2003 release). Posted on Hydro3 FTP server and to be included on May 2004 Hydrosoft DVD.
- POS MV firmware version 2.1, available from Applanix. Contact Peter Stewart (pstewart@applanix.com) with the serial number of the POS MVs you wish to upgrade.
- POS MV controller software version 2.1, available on Hydro3 FTP server and to be included on May 2004 Hydrosoft DVD.

IV. Acquisition System Configuration

A. Wiring Configuration

The hardware changes required to implement Precise Timing are relatively simple. The wiring diagram below shows an example of Precise Timing implementation from NOAA Launch 1021 (RA-3). The exact configuration will obviously differ slightly from vessel to vessel, but the essential elements are described here.



Timing String:

The key to precise timing is the $UTC serial timing string which synchronizes the ISIS and 81-P clocks to the POS MV. This message can only be generated from Com 1 of the POS MV. Ideally, $UTC would be the only sentence on this serial line in order to further limit any latency in transfer of this data. However, while ISIS can now receive position and attitude via Ethernet (see below), Hypack still requires the NMEA $GGA, $HDT, etc. via serial. These messages also can only be generated on Com 1 of the POS MV, so currently the position and timing sentences are enabled together. In the near future, Hypack may be capable of reading the POS Ethernet message (this is an active HSTP project with Hypack and Applanix), or NOAA may transition to line navigation in ISIS. Either of these scenarios would eliminate the need for the NMEA messages on this string.

Note that although all data arrive in ISIS with time tags applied, it is still necessary to synchronize ISIS time to the $UTC string. This is because the POS MV Group 102 data transmitted to ISIS via ethernet (see below) is accurately timed, but does not include a date. The date is applied in ISIS, so the ISIS clock must be synchronized to the POS MV time to ensure that the date and time match.

On Launch 1021, the output of the POS MV Com1 is sent to a three way data Y, with one output going to Hypack Com 5 for line navigation, and the other two to ISIS Com 5 and Reson 81-P RS-232 Port 1 for time synchronization. **To take full advantage of the benefits of the limited timing latency afforded by this configuration, it is important <u>not</u> to use a buffered data broadcaster in place of the data Y**. Also, note that while any open com port can be used for this string on the ISIS machine, the Reson 81-P requires that the UTC time input be on Com 1. Systems still using Com 1 of the 81-P to transmit bathymetry data to ISIS will need to be reconfigured for Ethernet bathymetry to take advantage of Precise Timing.

During testing, RUDE found that it was necessary to move the $UTC input to a high numbered com port on the ISIS machine for ISIS to read the data properly.

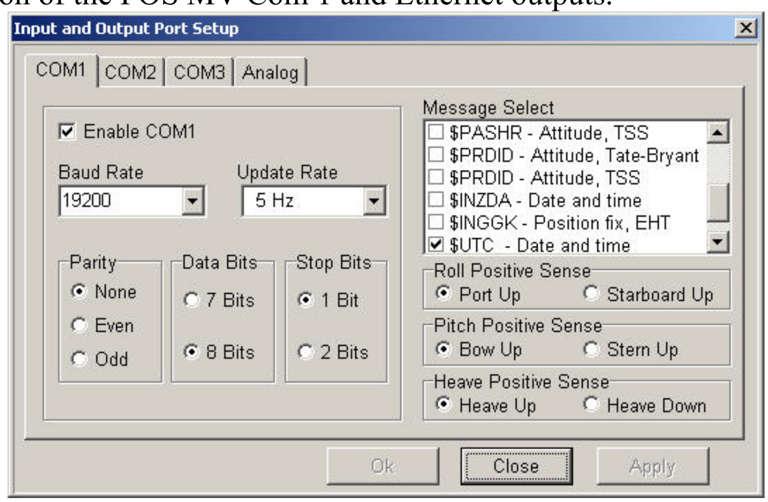
<u>Ethernet Group 102 Message:</u>
Precise Timing uses the Ethernet logging function of the POS MV to broadcast time stamped position and attitude data to ISIS. Assuming the POS MV controller software is running on the Hypack computer, this requires installation of an additional 10baseT card in the ISIS machine and connection to the POS MV LAN. This additional network connection must be configured with an IP address compatible with the POS MV subnet. Again, to avoid delay in data transfer, ensure that an Ethernet switch rather than a hub is used on this subnet. (While the data is time tagged and will be logged correctly, Ethernet delay may cause noticeable latency in the update of data displayed in ISIS during acquisition.) If the POS MV controller software is installed on the ISIS computer, this network switch can be replaced with a crossover cable directly from the POS to ISIS.

<u>POS MV TSS String:</u>

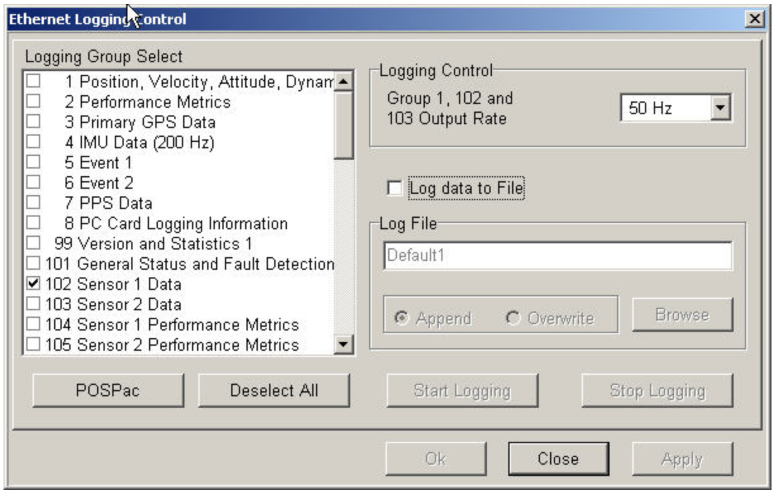
Since ISIS reads attitude data from the POS MV Ethernet message, there is no need for serial attitude input to the ISIS. The connection from Com 2 of the POS MV to Com 6 of ISIS shown above is a legacy of the previous configuration on Launch 1021, but is disabled in the ISIS software. The TSS string input to RS-232 Port 3 on the Reson 81-P is not absolutely essential either, but is important for roll compensation of the depth filters.

<u>Side Scan / Bathymetry Data:</u>
Note that Launch 1021 is configured with the Reson 81-P on the ship subnet. This is not ideal, as it could result in delay in the bathymetry and side scan data reaching ISIS in the unlikely event of high ship network traffic during acquisition, and more importantly necessitates assigning the Reson 81-P an IP address which is unique on the ship's network. However, this configuration does eliminate the need to install a third NIC in the ISIS computer.

B. Software Configuration
<u>POS MV</u>:
See the screen grabs below from the POS MV Controller for the correct configuration of the POS MV Com 1 and Ethernet outputs.



The "$UTC" message must be enabled on the Com 1 output, along with any other NMEA messages necessary for Hypack. An update rate of 1 Hz is sufficient for the timing sentence alone, but a higher update rate may be necessary for the position and heading data in Hypack. As always, the baud rate should be selected appropriately for the length of the serial string and the update rate.



Ethernet Logging control must be enabled to transmit position and attitude data to ISIS. Select “Ethernet Logging” from the “Logging” drop down menu in the POS MV Controller to access the dialog box above. Enable only the Group 102 Sensor 1 Data message. Although RAINIER’s testing was all conducted at a 50 Hz update rate, 25 Hz is probably sufficient. When these settings are applied, the software may prompt the user to enable other data groups in addition to 102. These are unnecessary, and the error should be ignored.

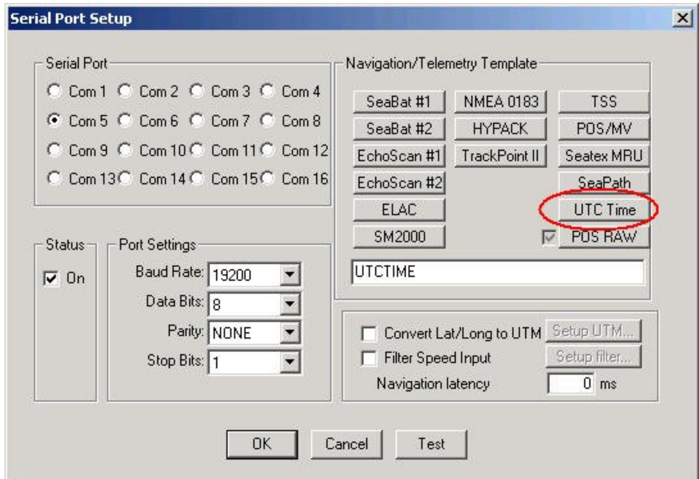
Also, in the “Tags, Multipath, and Autostart” dialog box under Settings → Installation, ensure that Time Tag 1 is set to UTC time.

In addition to these two data outputs, if the TSS string is required for the Reson processor, the POS MV Com 2 output must be set up appropriately.

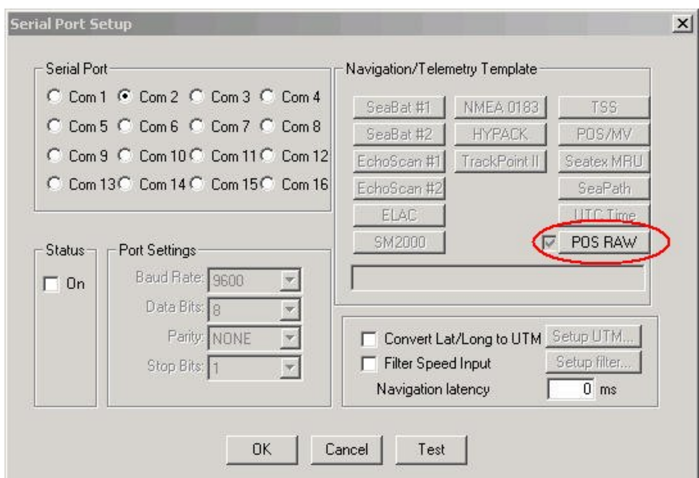
Note that any permanent changes made to the POS MV output configuration must be saved to non-volatile memory by choosing the “Save Settings” option under the “Installation” drop down menu, or simply saving settings upon exiting the POS MV controller.

<u>Isis:</u>
First, the serial position and attitude inputs to Isis from the POS MV must be disabled in Isis in the “Serial Port Setup” dialog box. Multiple inputs with the same data to Isis will cause problems in the .xtf data. Ensure that these obsolete inputs are disabled by unchecking the “Status On” box for the appropriate entries in the “Serial Port Setup” dialog box.

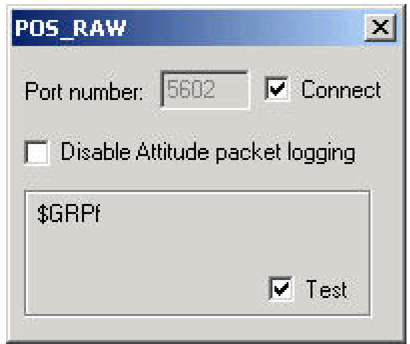
The ISIS configuration must be updated to enable reading the $UTC timing string and the Group 102 message from the POS MV.



The $UTC timing input is enabled by setting the input port's status to "On" in ISIS Serial Port Setup, and checking the "UTC Time", as shown above. The Port Settings must match the output settings on Com 1 of the POS MV. Hexidecimal data will be visible in the ISIS Serial Port Test window and should update at the rate selected in the POS MV Com 1 setup.



The Ethernet position and attitude input from the POS MV is enabled by selecting an unused serial port, and clicking the "POS RAW" template (see above). This brings up the following dialog box:



Ensure that "Connect" is checked. Port Number 5602 is correct, and cannot be changed. Although the attitude packet will no longer used for bathymetry, the CARIS converter still uses this packet for Side Scan conversion (for both "Heading from Attitude" or "Heading from Ship" choices), so it should be left enabled. The "Test" function does not produce a recognizable data stream, though it will print data in the test area if the connection has been made.

Reson 81-P:

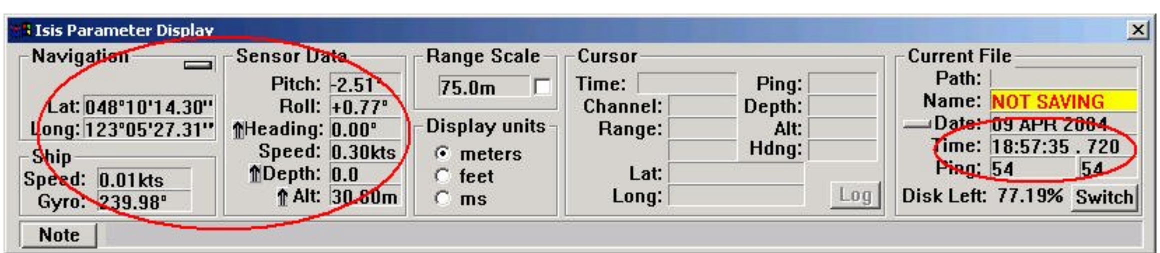
To enable the $UTC input to the Reson processor, set the "TimeBd" variable in the Config menu (accessible only from the BITE screen) to the output baud rate of Com 1 of the POS MV.

C. Testing

To confirm that the $UTC serial string and Group 102 Ethernet inputs are working correctly, check the following:

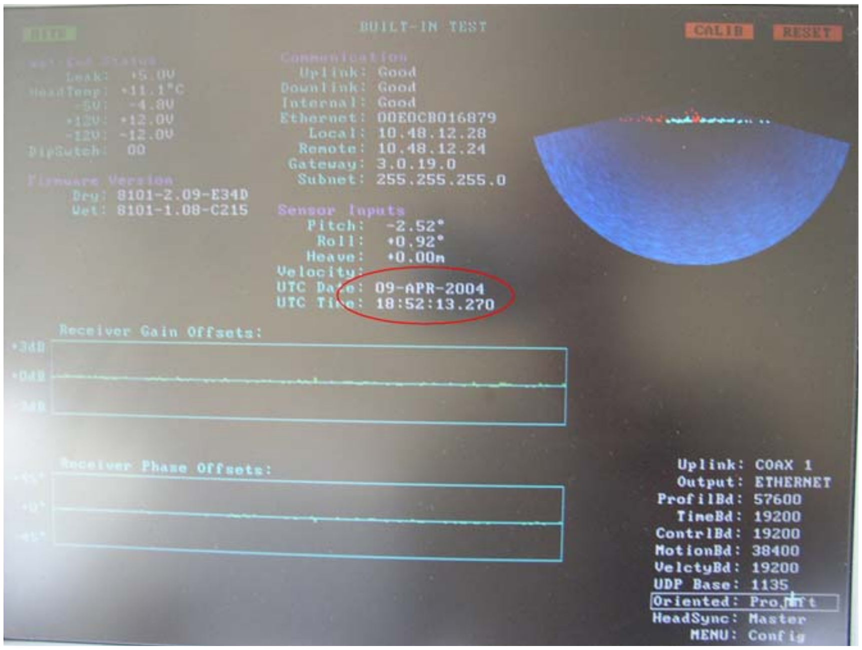
Isis:

With the POS MV and Reson up and running, start "Record" mode in Isis. Check the Parameter Display window to confirm that Navigation and Sensor Data are updating and match the values displayed on the POS Controller software. Time should also match the POS MV UTC time, and should update at the rate set in the POS MV Com 1 output setup. (Some units have noted that this time updates with the Reson 81-P input rather than the POS MV. TEI has not been able to explain this behavior, but since ISIS uses only the date from the $UTC string, it should not be a problem.)



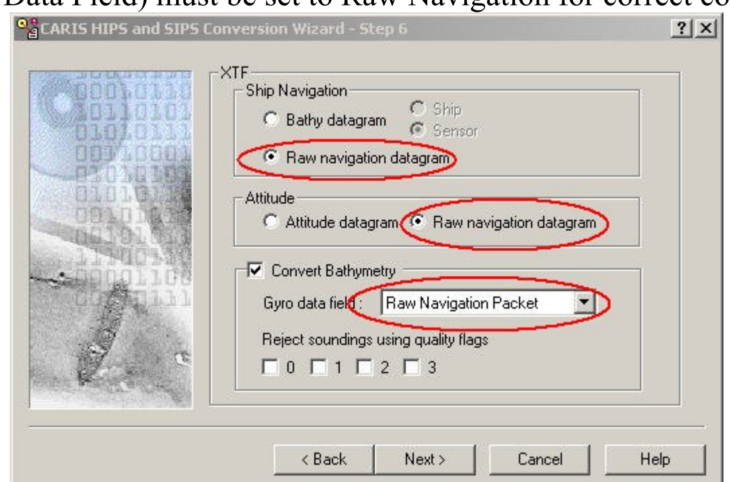
Reson:

In the BITE Menu, check to see that the UTC Time and Date are displayed, updating, and match the values displayed on the POS MV controller.

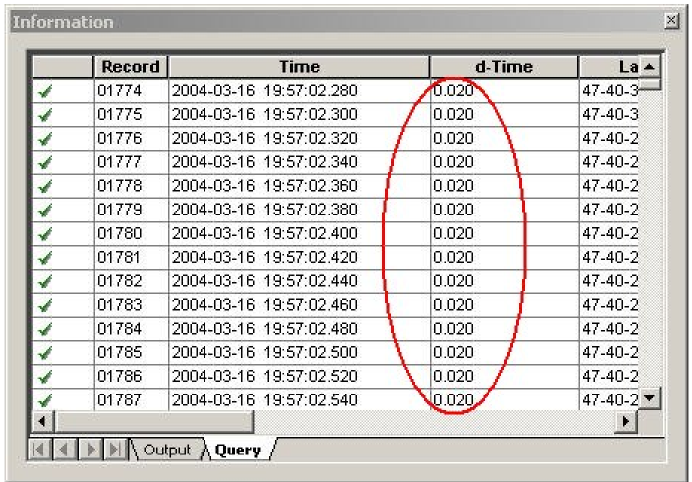


V. Data Processing in CARIS HIPS

Precise timing requires a slight change to data conversion procedure in CARIS HIPS. When using the Precise Timing configuration, ISIS stores navigation and attitude data in the "Raw Navigation Datagram" packet of the .xtf file, rather than the traditional "Sensor", "Ship", and "Attitude" fields. See the screen grab of Step 6 of the .XTF converter below for details. Note that all three parameters (Ship Navigation, Attitude, and Bathy Gyro Data Field) must be set to Raw Navigation for correct conversion.



Check that the data were acquired and converted correctly by checking the navigation and attitude data update rate in the appropriate editors. The delta time ("d-Time" in the HIPS Query) for these data should be constant and correspond to the update rate set in Ethernet Logging Setup on the POS MV, as in the screen grab below.



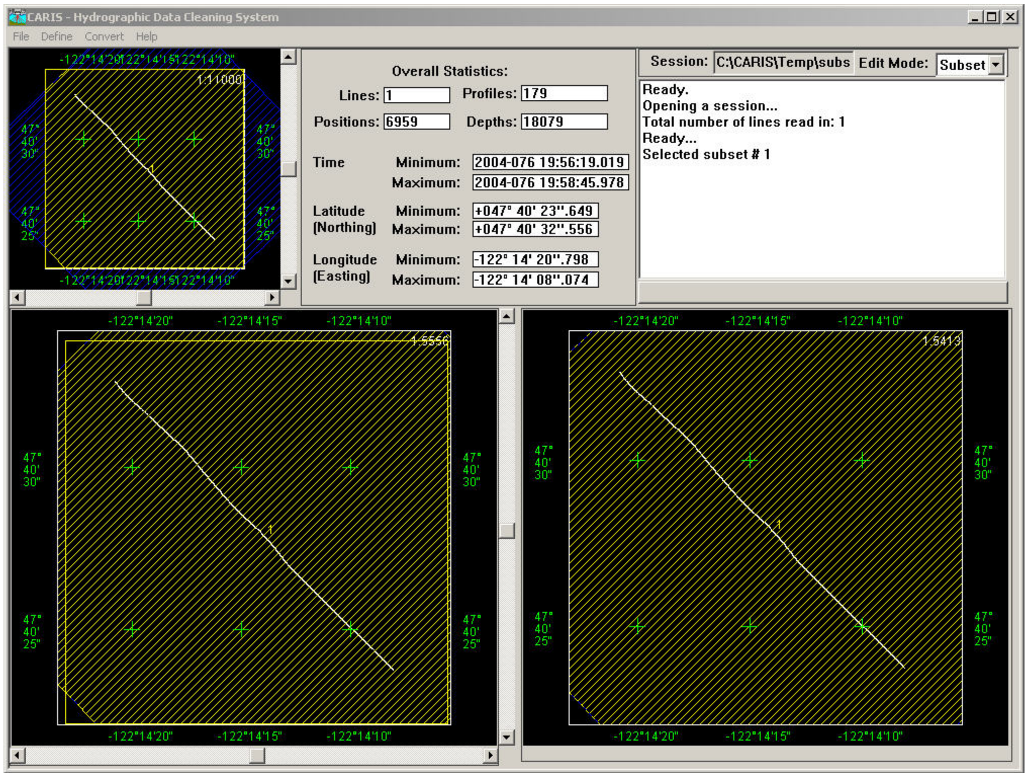
	Record	Time	d-Time	La
✓	01774	2004-03-16 19:57:02.280	0.020	47-40-3
✓	01775	2004-03-16 19:57:02.300	0.020	47-40-3
✓	01776	2004-03-16 19:57:02.320	0.020	47-40-2
✓	01777	2004-03-16 19:57:02.340	0.020	47-40-2
✓	01778	2004-03-16 19:57:02.360	0.020	47-40-2
✓	01779	2004-03-16 19:57:02.380	0.020	47-40-2
✓	01780	2004-03-16 19:57:02.400	0.020	47-40-2
✓	01781	2004-03-16 19:57:02.420	0.020	47-40-2
✓	01782	2004-03-16 19:57:02.440	0.020	47-40-2
✓	01783	2004-03-16 19:57:02.460	0.020	47-40-2
✓	01784	2004-03-16 19:57:02.480	0.020	47-40-2
✓	01785	2004-03-16 19:57:02.500	0.020	47-40-2
✓	01786	2004-03-16 19:57:02.520	0.020	47-40-2
✓	01787	2004-03-16 19:57:02.540	0.020	47-40-2

V. Patch Testing

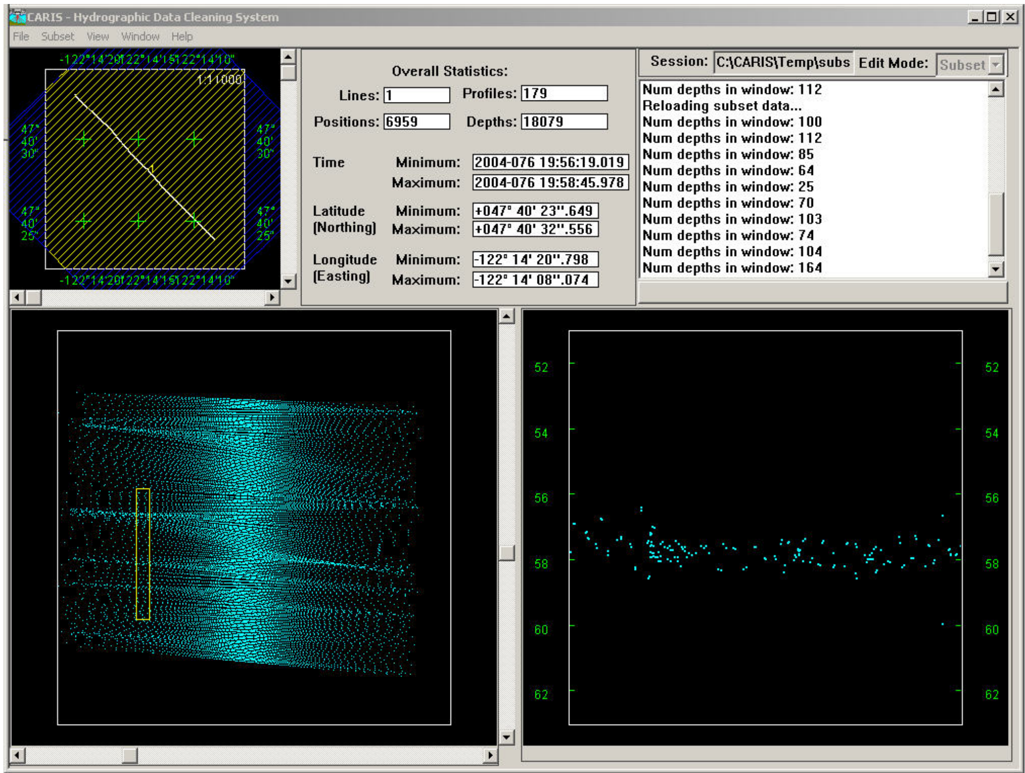
Calibration lines for pitch, roll, and yaw are all acquired as usual. However, rather than running lines in the same direction but different speeds over a feature or steep slope to determine time latency from navigation, this value can be determined more precisely from any single line by examining the residual uncorrected roll at the edge of the swath. This is most easily accomplished by examining one or two of the roll bias calibration lines, but requires some non-trivial amount of dynamic roll (i.e., need a line of data wherein roll is not “dead flat”). As usual, latency should be the first value determined in the patch test, and rechecked as the other parameters are determined. The procedure is described in detail below:

1. With all bias values set to zero, open a line or pair of lines in the HIPS Calibration Utility (the old HDCS Editor). To accentuate the affect of timing latency, these lines should be acquired in fairly deep water over a smooth bottom. In general, the lines acquired for roll bias determination will work well for timing too.

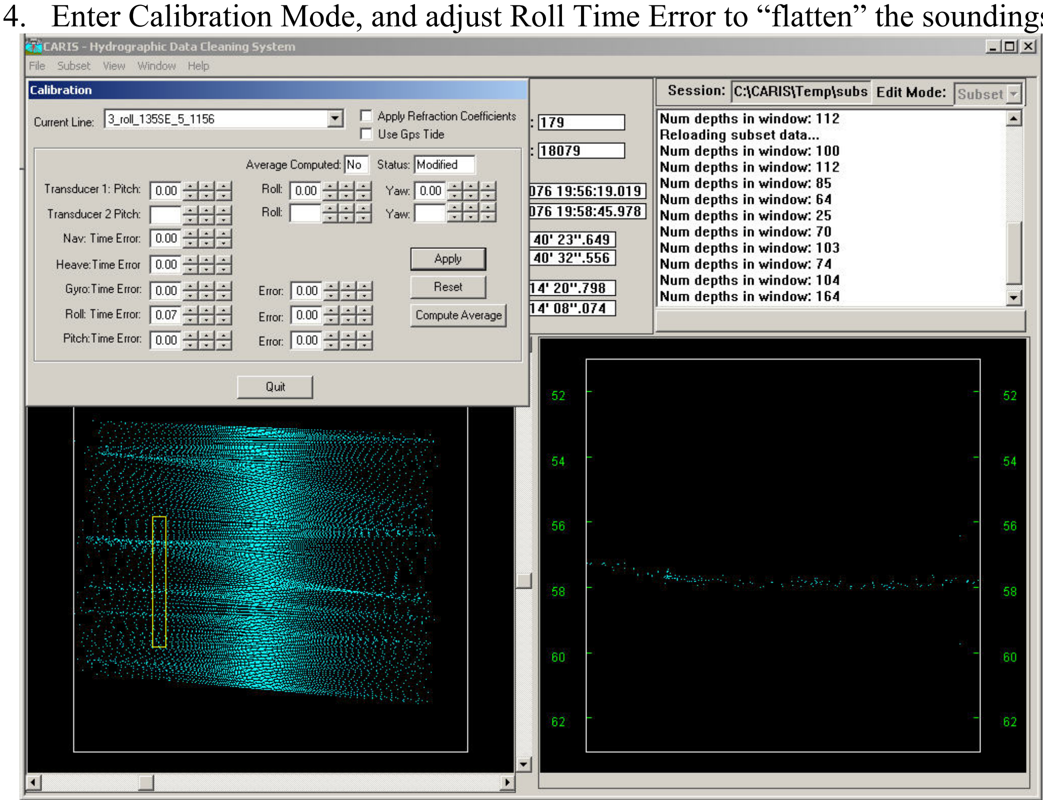
2. Create a subset which runs along the line, and is wide enough to include the outer beams.



3. Open the subset, and orient the viewing rectangle so that it is long in the along track direction, and several beams wide across track. Set the View Orientation to look across track, and note any vertical spreading of the soundings or along track periodic ripple (see below). These artifacts are caused by slight mismatch between the times used to tag the roll and bathymetry data. This is caused by the latency in the $UTC serial timing string from the POS MV to ISIS and the Reson processor.

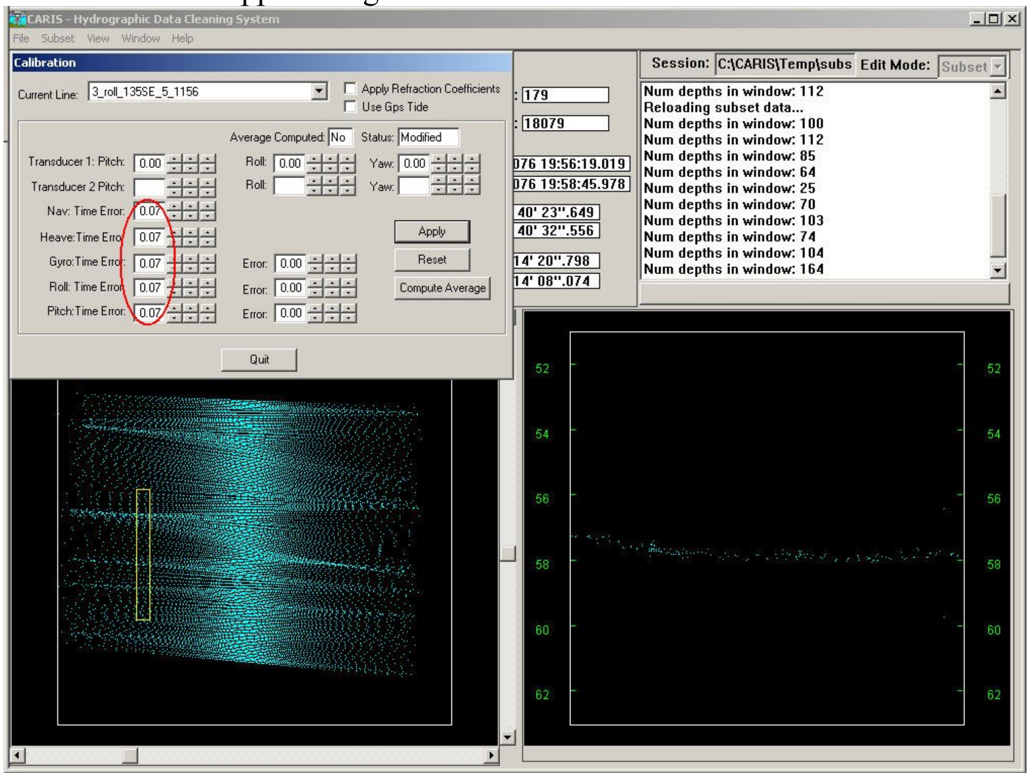


4. Enter Calibration Mode, and adjust Roll Time Error to "flatten" the soundings.



5. Since this latency results from delay in the timing synchronization string, all data are affected by it. Thus, once a value has been determined by examining the roll,

enter this as the Time Error value for Navigation, Heave, Gyro, and Pitch as well. (Alternately, these values can be left set to zero, and the time latency value entered with the opposite sign as the "Swath Time Error"



6. Process the rest of the patch test normally, rechecking the time latency value at each step.

Upgrading an existing system to Precise Timing requires a new time latency value for the VCF. However, Precise Timing does not affect the physical parameters of the system, so the mounting angle biases (roll, pitch, and yaw) in VCF remain the same. Thus, running a partial patch test consisting of one or two lines over a deep, flat area and following the procedure above to determine the new latency value is sufficient.

AF. SOUNDING EQUIPMENT

AF.1. Manual Depth-Measuring Devices

AF.1.1. LEAD LINE. All field units engaged in hydrographic surveys where general depths are less than 20 fm shall have one or more lead lines marked and calibrated. Lead lines are required for the following purposes:

1. To search for or to confirm least depths over shoals and sunken rocks.

2. To confirm echo soundings in kelp or grass areas.

3. To obtain bottom samples (when sampling device is attached).

4. To obtain vertical cast comparisons with echo soundings.

5. Occasionally to suspend instruments for temperature and salinity observations from a small vessel.

Standard lead-line material is mahogany-colored tiller rope with a phosphor-bronze wire center. The center consists of six strands of seven 33-B (S-gage) wires each. The wire core is flexible and should not break after continual use and coiling. The rope is size 8 (about 0.24 in. in diameter), and is made of waterproofed, solid braided, long-staple cotton. The braid should be tight enough so that broken wire strands will not protrude through the covering and injure a leadsman's hands. Material for lead lines may either be requisitioned from the Marine Centers or be purchased from a well-equipped marine supply dealer.

AF.1.1.1. *Marking lead lines.* Depending on the depths in which they will be used and on the size of the vessel, lead lines should be 15 to 30 fm long. Each lead line is identified by a consecutive number stamped on a metal disk attached at the inboard end of the line. Identification is made when a line is initially graduated. This number is to be retained throughout the life of the lead line or until re-marking is necessary.

The braided covering of an unseasoned lead line tends to shrink when wet causing the wire core to buckle and the strands to break. Broken strands are likely to protrude through the covering and cause hand injuries. To prevent rupturing the core with repeated use, preseason each lead line as follows:

1. Prepare the lead line by soaking it in salt water for 24 hr. Then, while the line is still wet, work the cotton covering along the wire by hand until the wire protrudes from the covering. The wire should protrude about 1 ft for each 10 fm of line. This is a tedious procedure requiring the cooperative efforts of several people. The covering can be pushed back and slackened only a few inches at a time; this length of slack must be pushed nearly the full length of the line before the next few inches can be started. The excess protruding wire is cut off. The covering must not be worked back too far, or it will form bulges along the wire. Lead lines so prepared will maintain an almost constant length for future use.

2. Next, the line is dried under tension (about 50 lb) and then soaked again for 24 hr. Never boil a lead line as this destroys the waterproofing of the cover.

3. After attaching a lead to the line, the line should be wetted down again and placed under a tension equal to the weight of the lead; this tension is maintained while the line is being graduated. Temporary marks made at this time can be used for later permanent marking. Graduation marks on a new lead line may be laid off with a steel tape. The best method, however, is to mark the distances permanently on a suitable surface such as on the deck of a ship or on a wharf if the survey party is shore based. Permanent markings are convenient when verifying the graduations in the future.

Two units of measurement, the fathom and the foot, have traditionally been used to mark lead lines for hydrographic surveys in the United States. Only one unit is to be marked on a lead line. Hydrographic parties surveying in both depth units should be equipped with at least one lead line graduated in each unit.

Traditional markings for lead lines graduated in fathoms are shown in Table AF-1.

Intermediate marks are placed between the fathom marks to permit readings to the nearest tenth of a fathom. Each half of a fathom is marked by a seizing of black thread; each even tenth of a fathom (0.2, 0.4, 0.6, and 0.8) is marked by a seizing of white thread. Odd tenth readings are estimated.

Each fathom mark should extend 2 in from the lead line. Leather marks are made in one piece with strips (about ¼ in in width) that are slit in the free end of the mark. Bunting marks are made by folding a small piece of bunting to about 5/8 in wide by 5 in long; this length of folded bunting is then folded once again in the middle then secured to the lead line so the folded end is free.

TABLE AF–1. — *Markings for lead lines graduated in fathoms*

Fathoms	Marks
1, 11, 21	One strip of leather
2, 12, 22	Two strips of leather
3, 13, 23	Blue bunting
4, 14, 24	Two strips of leather secured in the middle so that two ends point upward and two downward
5, 15, 25	White bunting
6, 16	White cord with one knot
7, 17	Red bunting
8, 18	Three strips of leather
9,19	Yellow bunting
10	Leather with one hole
20	Leather with two holes

Waxed linen thread should be used to secure marks to the lead line in such a manner that there can be no possibility of slippage. Do not insert the thread through the braided covering of the line. All marks except 4-, 14-, and 24-fm marks should be secured so that their free ends are up when sounding. Marks so secured will tend to stand out more from the line when vertical.

Traditional markings for lead lines graduated in feet are shown in table AF-2.

Intermediate odd feet (1, 3, 5, 7,...) are marked by white seizings. Leather markings at the 10-ft multiples should be the same size as the fathom marks on lines graduated in fathoms. Bunting marks that identify intermediate even feet should be slightly smaller in size.

On occasional surveys for which the depth unit is the meter, soundings may be taken with lead lines graduated in feet, provided that the measurements are converted to meters prior to plotting. In such cases, the hydrographic records must clearly and unmistakably identify which soundings are in feet. When extensive soundings in meters are anticipated, a metric lead line should be prepared. Each meter and half meter is marked using an identification system convenient to the observers. A marking similar to that of a lead line graduated in feet is recommended (such as red, white, blue, yellow, and leather).

TABLE AF–2.— *Markings for lead lines graduated in feet*

Feet	Marks
2, 12, 22, ...	Red bunting
4, 14, 24, ...	White bunting
6, 16, 26, ...	Blue bunting
8, 18, 28, ...	Yellow bunting
10, 60,110	One strip of leather
20, 70, 120	Two strips of leather
30, 80, 130	Leather with two holes
40,90, 140	Leather with one hole
50	Star-shaped leather
100	Star-shaped leather with one hole

AF.1.1.2. *Verification of lead lines.* Lead lines used for sounding are compared with a standard at the beginning of a season and at frequent intervals thereafter, depending on usage. When the checks are made, lead lines must be wet and under a tension equal to the weight of the attached lead in water. The testing standard should be a good recently calibrated steel tape or premeasured graduation marks on deck or ashore.

Stamp 5 (figure 4-29, section 4.8.3.6), Lead-Line Comparison, is used to record comparison results in sounding records. A comparison should be made either at the beginning or at the end of each day a lead line is used. (See 4.8.3.6.) If a lead line is found to be correct, a statement to that effect is sufficient. When incorrect, comparison results are entered for each fathom or for each 5 ft to the extent of the depths measured. True lengths of the graduation marks as determined by comparison against the standard are entered on stamp 5 in the column headed "D"; corresponding graduation mark values are entered under the column headed "M." Corrections to lead-line soundings are obtained by subtracting column M from column D. Replace or re-mark lead lines if the errors exceed 0.5 ft or 0.2 fm.

AF.1.1.3. *Sounding leads.* These in standard weights of 5, 7, 9, 14, and 25 lb are requisitioned from the Marine Centers. Each survey unit should have one or more leads with a snapper-type bottom-sampling device attached. (See AK.2.7.) Various methods may be used to attach the lead to the lead line. The preferred method is to have a galvanized thimble at the lower end of the lead line to which the lead can be attached by a shackle. The sounding lead and the snapper sampling lead can then be interchanged on the same line.

POS MV V3 Installation and Operation Guide

PUBS-MAN-000032

Revision 1

Antenna Installation Calibration

Note: For a successful antenna installation calibration, the GPS Azimuth Measurement Subsystem (GAMS) must be able to use data from five or more satellites with a Positional Dilution of Precision (PDOP) equal to or less than three. Perform the antenna installation calibration at a time when there is ‘good satellite geometry’.

Note: It is recommended that the user make use of the GPS mission planning software to identify an optimal time of day during which the PDOP is at a minimum in order to achieve a good GAMS calibration.

You should perform the following procedure with the vessel under way in an area where unrestricted manoeuvring is possible. You have the option of allowing POS MV to start the calibration automatically (this is called a Calibration auto-start), or to start the calibration manually.

1. Select **Tools, Configuration**, then select **Use GAMS Solution** check box in the GAMS pane. This permits POS MV to use GAMS heading aiding in its antenna calibration solution, refer to Figure 16 on page 4-26.
2. Select **View, GAMS Solution** to open POS MV GAMS Solution window shown in Figure 25 on page 5-16.
3. Select the following from the Controller’s menu bar in the order indicated to re-initialise the POS MV:
   a) Settings, Mode, Standby
   b) Settings, Mode, Navigate
4. Select **Settings, Installation, GAMS Installation** to open the GAMS Parameter Setup window shown in Figure 17 on page 4-26.

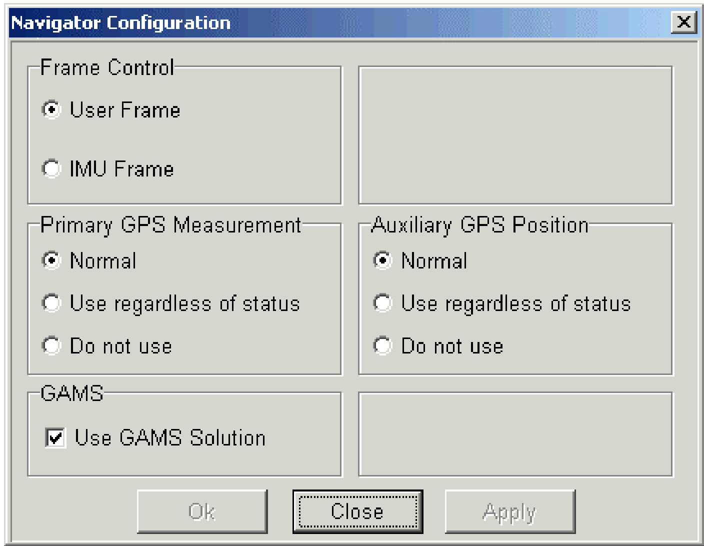


Figure 16: Navigator Configuration Window

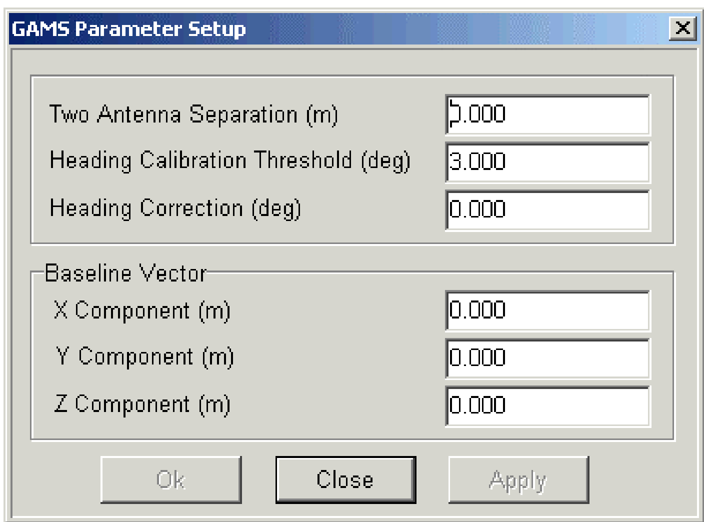


Figure 17: GAMS Parameters Setup Window

5. In the GAMS Parameter Setup window, enter a value between 0.5 and 5.0 degrees in the Heading Calibration Threshold field. Choose **OK**.

   When the indicated RMS heading error falls below the setting for Heading Calibration Threshold, POS MV will start the antenna installation calibration routine. Choose an easy value for POS MV to achieve as you perform a series of calibration manoeuvres with the vessel:

   - Set a lower value (approximately 0.5°) if you can manoeuvre the vessel aggressively.
   - Conversely, set a higher value (approximately 1°) if the most aggressive manoeuvres you can perform are 180° turns followed by a straight run.

6. In the GAMS Parameter Setup window, (Figure 17), perform the following:

   a) In the Two Antenna Separation field enter a value in metres. Choose **Apply**. You should ensure the accuracy of this value to within ±5 mm (±$^{3}/_{16}$ in).

      Refer to Installation Checklist on page 2-51 for instructions to measure the antenna separation distance

   b) In each of the component fields in the Baseline Vector pane, enter '0'. Chose **Apply** and then **OK**.

7. Manually transition POS MV to Navigate mode. This also commands GAMS to begin execution of its on-the-fly ambiguity resolution algorithm. You can monitor the progress of this algorithm through the GAMS Solution screen.

Note: Perform steps 8 and 9 *only* if you use 'calibration auto-start'. Otherwise, go straight to step 10 if you wish to start the calibration manually.

8. Select **Settings, GAMS Calibration Control, Start** from the main window of the POS MV Controller program. The displayed GAMS Status becomes **CAL Requested**. See Figure 18 on page 4-28 for a view of the controller settings menu and status pane.

   This command prepares the system for an automatic start to the calibration process, but does not actually start it. Instead, the calibration process will start automatically when the POS MV RMS heading error falls to below the value that you set for the Heading Calibration Threshold field in paragraph five above.

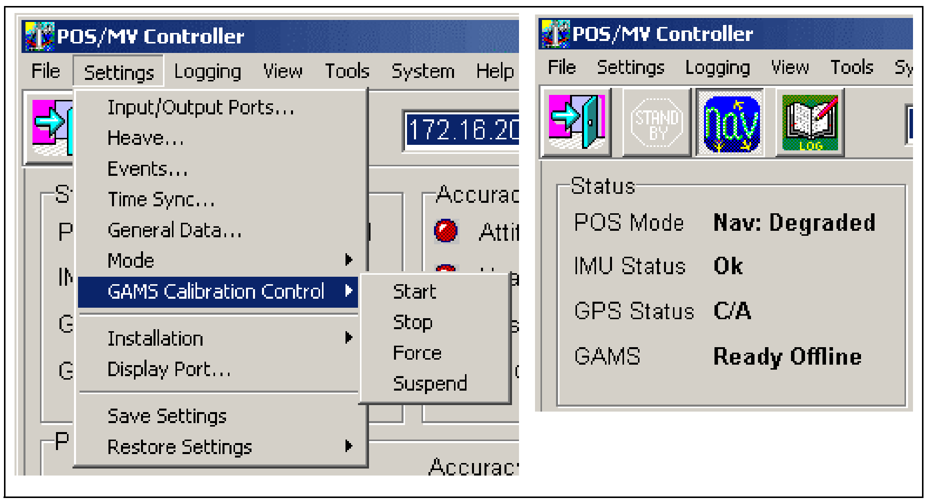


Figure 18: Controller Settings Menu and Status Pane

9. If possible, when GAMS has resolved the carrier phase ambiguities (GAMS Status on the main screen of the controller will read **Ready**

Offline), perform a series of full turns, ‘S-turns’ or ‘Figure-8’ manoeuvres, each lasting approximately one minute.

On the main window of the POS MV Controller program, monitor the POS MV heading accuracy. When the value displayed falls below the setting for Heading Calibration Threshold, finish the turns and manoeuvres and hold the vessel steady on a course and at a fixed speed.

The displayed GAMS Status becomes **CAL in Progress** and this condition lasts for approximately 60 seconds. When POS MV has completed the calibration, the displayed GAMS Status becomes **CAL Completed**. This condition lasts for approximately five seconds and then changes to **Online**.

Note: Perform steps 10, 11 and 12 *only* if you use the manual start to the calibration. Otherwise, go straight to step 13 if you used the ‘calibration auto-start’ feature described in paragraphs 8 and 9.

Note: Before you proceed to step 10, make certain the GAMS Parameters Setup window displays the values that you entered in steps 5 and 6.

10. When GAMS has resolved the carrier phase ambiguities, the displayed GAMS Status becomes **Ready Offline**. You can start the calibration manually at any time.

    If possible, perform a series of full turns, ‘S-turns’ or ‘Figure-8’ manoeuvres, each lasting approximately one minute. During these manoeuvres, monitor the POS MV heading accuracy on the main window of the POS MV Controller program. Ideally, the heading accuracy displayed should be as small as possible.

Wait until the heading error becomes as small as possible before you start the calibration. If you can perform only limited manoeuvres in the vessel, even a simple change of course will cause the heading accuracy to improve.

11. To start the calibration, select **Settings, GAMS Calibration Control, Force** from the main window of the POS MV Controller program. This will command an immediate start to the calibration process.

    The GAMS Status becomes **CAL in Progress** and this condition lasts for approximately 60 seconds. When POS MV has completed the calibration, the displayed GAMS Status becomes **CAL Completed**. This condition lasts for approximately five seconds and then changes to **Online**.

12. If you wish to suspend the calibration while it is in progress for any reason, select **Settings, GAMS Calibration Control, Suspend**. The displayed GAMS Status then becomes **CAL Suspended**.

    The system suspends the partially completed calibration process until you resume it. To resume the calibration process select **Settings, GAMS Calibration Control, Start**.

13. If you wish to stop the calibration while it is in progress for any reason, select **Settings, GAMS Calibration Control, Stop**. The displayed GAMS Status then becomes **Ready Offline**. The system cancels the partially completed calibration process.

    To start a new calibration process, select **Settings** and then select **GAMS Calibration Control, Start** or **GAMS Calibration Control, Force**.

14. Select **Tools, Configuration** and make certain you have selected the **Use GAMS Solution** button in the GAMS pane. Choose **OK** and then select **Settings, Save Settings**. Wait until the POS MV Controller program displays the 'Settings Saved' message panel. Choose OK to close the message panel.
15. Monitor the system operation and look for the following indications of a successful calibration to appear on the main window of the POS MV Controller program:

    - The displayed GAMS Status remains **Online**.
    - The displayed heading accuracy drops slowly to less than 0.15° and eventually settles to a value of 0.02° in a low multipath environment. The actual value that it settles upon will depend on the current setting for multipath environment.

    If the calibration was successful and no GPS dropouts occur, POS MV should settle into steady-state operation using GAMS heading aiding as indicated by the 'Online' status.

    If the calibration was not successful, GAMS will reject the carrier phase ambiguities repeatedly and will eventually reject the installation parameters. If this occurs, repeat the calibration process.
16. If the installation parameters appear to be correct, select **Installation, GAMS Installation** and write down the displayed parameters. Keep the written record in a safe place for future reference.

Refer to Operation with GAMS on page 5-15 for a description of how GAMS uses the GAMS installation parameters to aid the On-the-Fly (OTF) ambiguity search.

Installation Parameter Correction

The surveyed antenna baseline vector may include the following errors:

- The length of the vector may not be correct if there were large multipath errors during the calibration process. This may affect the reliability of GAMS ambiguity resolution during future POS MV initialisation sequences.
- There may be an azimuth error similar in size to the displayed heading accuracy that existed during the calibration process. This results in a constant offset in the displayed heading during normal operation of POS MV with GAMS heading aiding.

To correct these errors:

1. If the displayed antenna separation differs by more than 5 mm ($^{3}/_{16}$ in) from the value that you measured after you installed the antennas, clear the installation parameters and then re-enter the measured separation distance in the GAMS Parameter Setup window, see Figure 17 on page 4-26. Choose **OK** to install the new antenna separation distance.

   Begin a new calibration procedure as described in Antenna Installation Calibration on page 4-25.

   The 5 mm ($^{3}/_{16}$ in) allowance accounts for differences that may exist between the antenna phase centres and their geometric centres.
2. If you can identify the heading offset then enter a Heading Correction in the GAMS Parameter Setup window. Choose **OK** to install the new correction value.

POS MV will then compute new components of the surveyed antenna baseline vector having a corrected azimuth.

3. Select **Settings, Save Settings** to save the new values to the PCS.

Note: The Heading Correction entry in the GAMS Parameter Setup window allows you to correct an inaccurately surveyed baseline vector. You can use this method to obtain a more accurate vector.

Note: You should *not* use this facility to implement the installation angles of the IMU body frame with respect to the echo-sonar frame. Refer to Installation Parameters on page 2-37 and Initial Configuration on page 4-14 for instructions to measure and enter these installation parameters.

System Power-Off

Once the initial configuration of POS MV is completed select **Settings, Save Settings** from the POS MV Controller program to save all the settings to non-volatile memory.

The POS MV Controller program will display a message panel to confirm that it has saved the settings successfully to non-volatile memory. Wait for this message to appear and then choose OK to close the message panel before you power-off the PCS.

If you power-off the PCS before the program has displayed the confirmation message panel you may corrupt the settings in non-volatile memory.

Check that the PCS has stored the parameters correctly:

1. Select **File, Exit** or press **Alt, F4** to close the POS MV Controller program. Press the green POWER switch on the PCS front panel to power-off POS MV.

2. Wait for thirty seconds and then press the green POWER switch to power-on the PCS. Re-start the POS MV Controller program.
3. Select **Settings, GAMS Calibration Control** and check that the PCS has saved all the GAMS installation parameters correctly. Select **Cancel**.

Leave POS MV powered-on to reduce the electrical and thermal stresses that occurs when the system is powered-off and powered-on.

Note: Applanix recommends you use an uninterruptible power supply to power POS MV. If you follow this recommendation, you will not need to power-off the system while switching on board generators.

To power-off POS MV for transportation, storage or repair:

1. Close the POS MV Controller program (if it is running).
2. Press the green POWER switch on the PCS front panel.

Save Settings

⚠ Cycling power while saving may result in lost settings.

Save the POS MV parameters after any modification, otherwise changes will be lost when the POS MV power is cycled (powered down and up). Each time POS MV is powered up, the settings default to the stored values. To save the settings, select **Settings, Save Settings** from the POS MV Controller menu bar. The POS MV Controller indicates when the settings are successfully saved (may take up to 30 seconds to save the settings).

NOAA Ship FAIRWEATHER

FAIRWEATHER (S220), 1010 and 1018 PATCH TEST Procedures

Created by SST Abrams

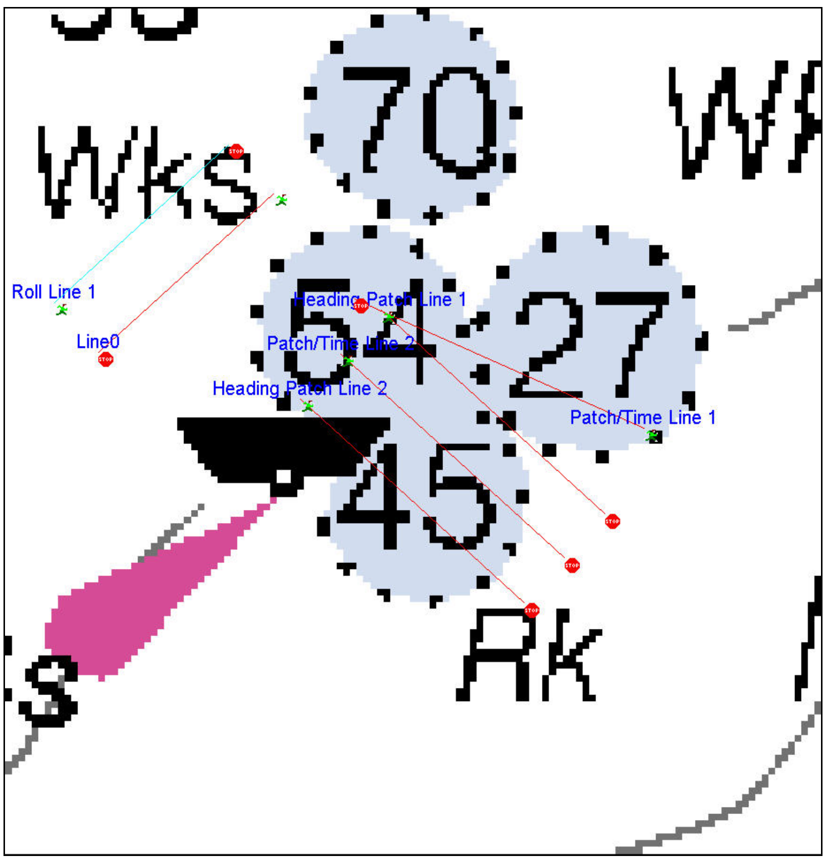
Background:

Survey launches 1010 and 1018 are equipped with Reson SeaBat 8101 multibeam echosounders. Positioning data for each launch is provided by a POS/MV 320. Residual biases due to misalignment of the sonar will be assessed in CARIS HIPS and entered in the hydrographic vessel files (HVFs) for 1010 and 1018.

FAIRWEATHER (S220) is equipped with a Reson SeaBat 8111ER and a Reson SeaBat 8160 multibeam echosounder. Positioning is provided by a POS/MV 320. Residual biases due to misalignment of the sonar will be assessed in CARIS HIPS & SIPS v5.4 and entered in the hydrographic vessel files (HVF) for each system.

Patch Test Location, Date, and Personnel:

The launch patch tests will be performed in Ketchikan, AK at a time to be determined. The launch patch tests will include pitch, precise timing, roll, and heading lines. See Graphic 1 for an example of patch test line plans.



Graphic 1: Example of Launch Patch Test Lines

The ship patch tests will be performed in Port Angeles, WA at the end of July, 2004. If ship schedule changes or equipment problems arise, the ship patch tests may be conducted in Ketchikan, AK at a time to be determined. Deep water is necessary for patching the Reson 8111ER and Reson 8160 systems. The ship patch tests will include precise timing, pitch, roll, and heading lines.

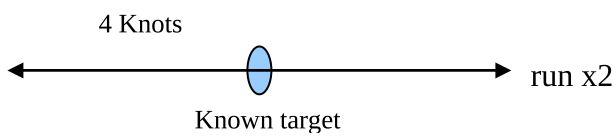
Equipment:

- Reson 8101 multibeam echo-sounder
- TSS POS/MV 320 with True Heave
- DGPS receivers (type and model TBD)
- Seacat SBE19*plus* sound velocity profiler

Procedure:

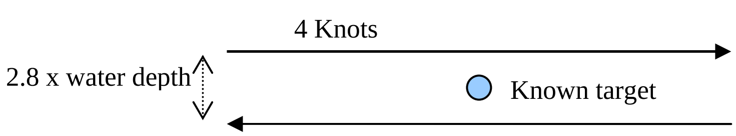
1. Precise Timing: Run one line in a moderate sea state (Beaufort 1-2), where there will be some dynamic roll (i.e. not flat calm). One of the roll lines can be used for this test.

2. Pitch: Run two pair of coincident lines at same speed (4 Knots) and opposite directions over a known target. The nadir beams must be run directly over the target. Only one pair of lines is completely necessary, the other set is for comparison and redundancy.



3. Roll: Run two pair of coincident lines at same speed and opposite directions over a flat or gently sloping bottom. Speed is arbitrarily set at 4 Knots, though any speed will do as long as the lines are run at the same speed. Only one pair of lines is completely necessary, the other set is for comparison and redundancy.

4. Heading: Run one pair of lines offset by 2.8 x water depth to either side of a known target at the same speed in opposite directions. Water depth is defined as the top of the known wreck. The actual line spacing will be determined in the field to acquire the target in the ideal outer beams.



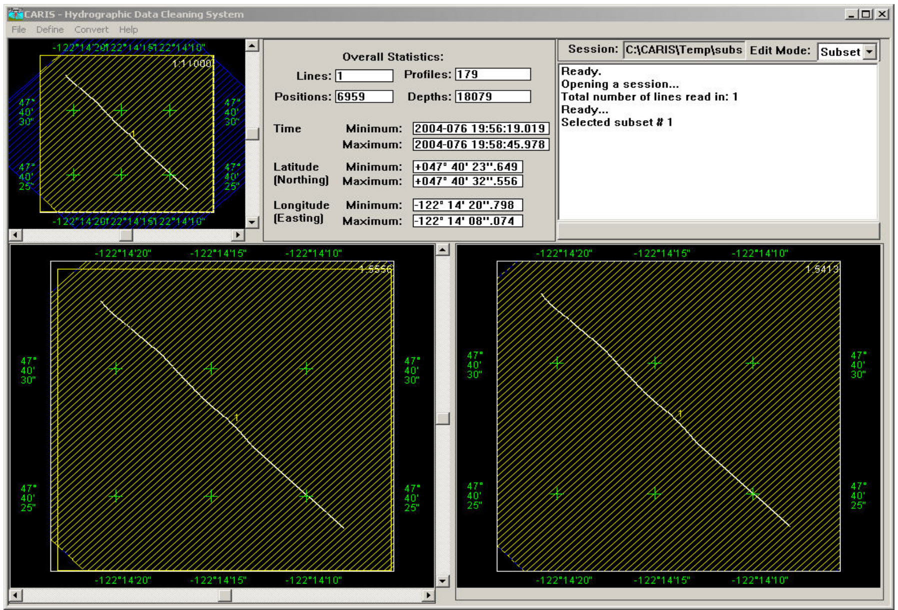
Processing[i]:

A. Make New Hydrographic Vessel File
   - Put in lever arm numbers—Reference Point (RP), IMU, transducer(s), and settlement & squat measurements.
   - Time, pitch, roll, and heading numbers stay at zero.

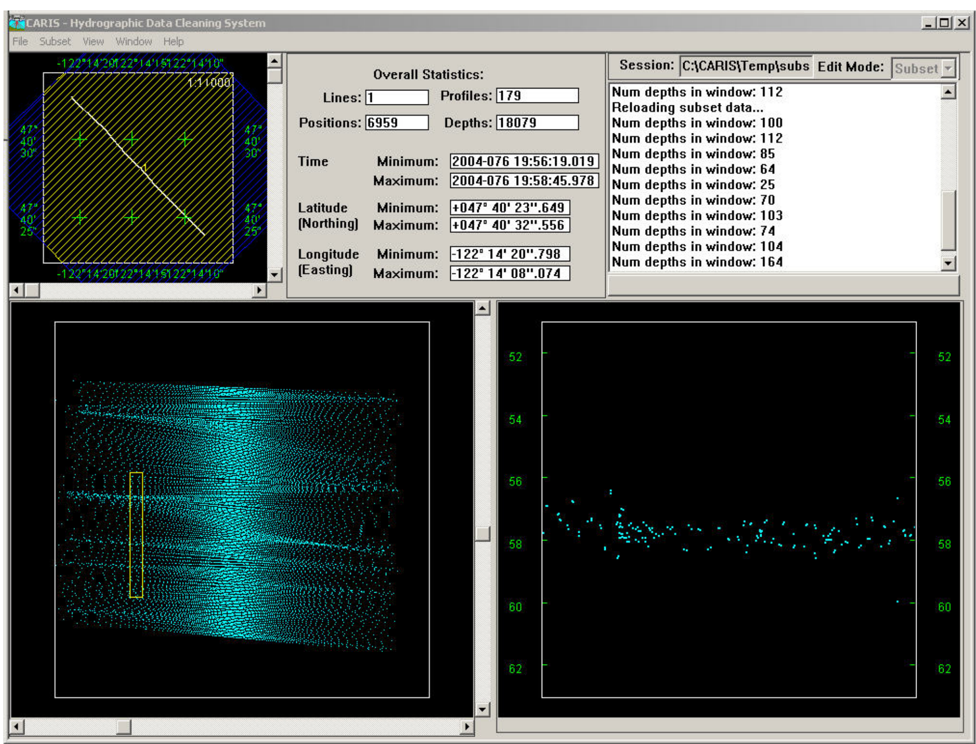
B. Convert Data
   - Tide, SVP correct, and merge. DO NOT FILTER.
   - Roughly clean the data, getting out the major flyers only.

C. Computing Correctors—Order of Operations
   1. Precise Timing
   2. Pitch Bias
   3. Roll Bias
   4. Heading Bias

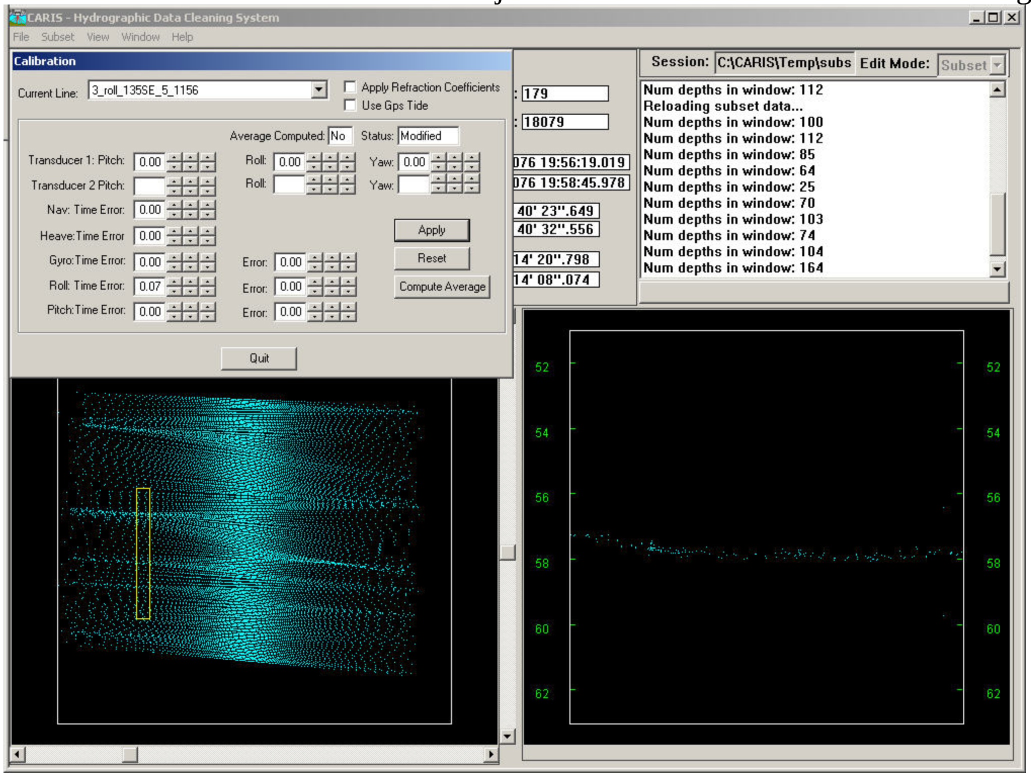
1. Precise Timing Bias[ii]
   - With all bias values set to zero, open a line or pair of lines in the CARIS HIPS Calibration Utility. It is fine to use the roll lines for the precise timing determination.
   - Create a subset which runs along the line and includes the outer beams.



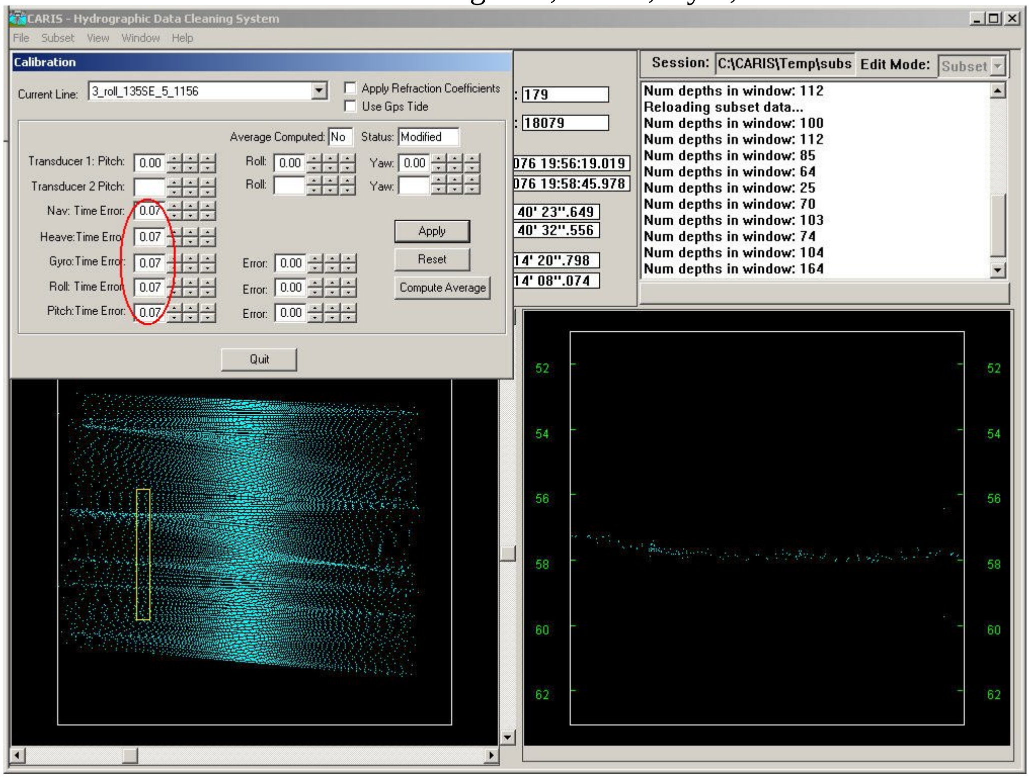
   - Open the subset, and orient the viewing rectangle so that it is long in the along-track direction and several beams wide across-track. Set the view orientation to look across track and note any vertical spreading of the soundings or along-track periodic ripple (see image below). These artifacts are caused by slight mismatch between the times used to tag the roll and bathymetric data. This is caused by the latency in the $UTC serial timing string from the POS/MV to ISIS and the Reson processor.



- Enter the Calibration Mode and adjust Roll Time Error to "flatten" soundings



- Since the latency results from delay in the timing synchronization string, all data are affected by it. Thus, once a value has been determined by examining the roll, enter it as the Time Error value for Navigation, Heave, Gyro, and Pitch as well.



- Place the results of the precise timing determination in the HVF.
- Process the rest of the patch test, rechecking the time latency value at each step.

2. Pitch Bias

- Two pitch lines on top of each other.
- View subsets for pitch bias parallel to track.
- Adjust the pitch.
- Compute average, apply, and close out.
- Merge all lines.

3. Roll Bias
   - Two roll lines on top of each other.
   - View subsets perpendicular to track.
   - Adjust the roll.
   - Compute average, apply, and close out.
   - Merge all lines.

4. Heading Bias
   - Two lines offset from one another.
   - View subsets parallel to track.
   - Adjust yaw.
   - Compute average, apply, and close out.
   - Merge all lines.

D. Review--Look Over the Data
   - Create a grid—make a tight one and look for artifacts that could be related to heave, pitch, roll, or time errors.
   - Open the data in subset mode in multiple places—see if the data is lining up well everywhere.
   - Have as many eyes over as much of the process as possible. Have more than one person compute all the errors and compare and average out the different answers.

---

[i] Adapted from the NOAA Ship RAINIER patch test write-up, done 03/21/03 by SSTs Stuart and Morgan.
[ii] Taken from “Upgrading NOAA Multibeam Acquisiton Systems to ‘Precise Timing’, done 05/10/04 by LTjg Evans.

Dynamic Draft Settlement and Squat Method (DDSSM) Procedure

Compiled by SST Abrams
Last updated: 07/22/04

PURPOSE
The intent of this document is to define a test procedure for the Dynamic Draft Settlement and Squat Method (DDSSM). The DDSSM replaces the optical level measurement method of determining settlement and squat. The DDSSM will be used on NOAA Ship FAIRWEATHER (S220) and survey launches 1018 and 1010.

EQUIPMENT

FAIRWEATHER Configuration 1	FAIRWEATHER Configuration 2	1010	1018
POS/MV 320 with True Heave	POS/MV 320 with True Heave	POS/MV 320 with True Heave	POS/MV 320 with True Heave
Reson 8111ER	Reson 8160	Reson 8101	Reson 8101
SeaCat 19*plus*	SeaCat 19*plus*	SeaCat 19*plus*	SeaCat 19*plus*
	SBE 45 Micro TSG		

REQUIREMENTS
The DDSSM test has to be performed in an area with a well-known tidal signal. Alternately, an area where the water level does not vary much, such as a lake, is acceptable.

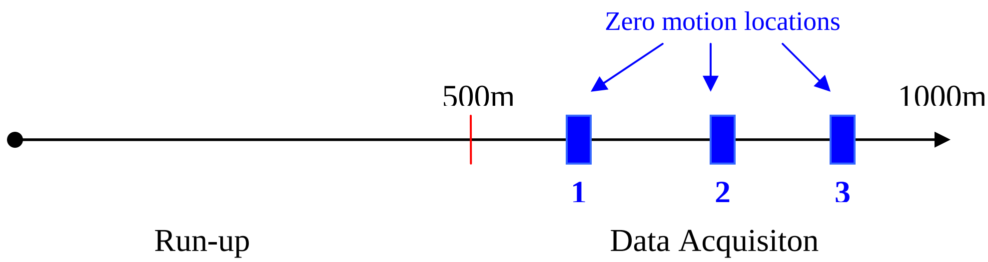
The bottom of the test area should be flat or gently sloping. A shallow water depth, approximately 7-10 meters, is ideal for minimizing attitude errors.

In previous implementations of the DDSSM test, the heave sensor was a limiting factor. With the introduction of True Heave in POS/MV, induced heave error *should* no longer be an issue.

LOCATION
The DDSSM tests for 1010 and 1018 will be performed in Ketchikan, AK in a area with minimum tidal variation, a flat bottom, and a relatively shallow depth (~10 meters). The exact location and time of the tests is to be determined.

The DDSSM test for S220 will be performed in Ketchikan, AK at a time to be determined. Tidal correctors will have to be acquired in cooperation with CO-OPS.

METHOD
The DDSSM test consists of running the same planned line repeatedly in one direction at idle and a series of pre-defined RPM’s. The survey launch will also sit motionless in neutral at three locations on the planned line for comparison. The lines must be run within 3 meters of the planned line so that nadir beam overlap is achieved. To eliminate the possibility of induced heave error not neutralized by True Heave, the line should be run for 1 minute and 30 seconds before beginning data acquisition. The planned line will be approximately 1000 meters long. See Graphic 2 of the planned line below.



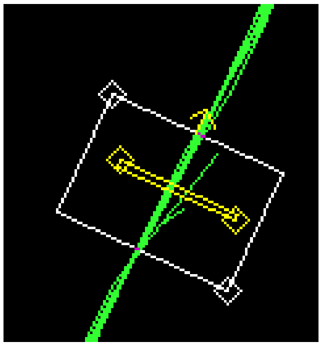
Graphic 2: DDSSM test planned line

The DDSSM test should be performed at least once for each vessel. If time permits, run the DDSSM two to three times for each vessel in order to provide comparison data.

PROCESSING

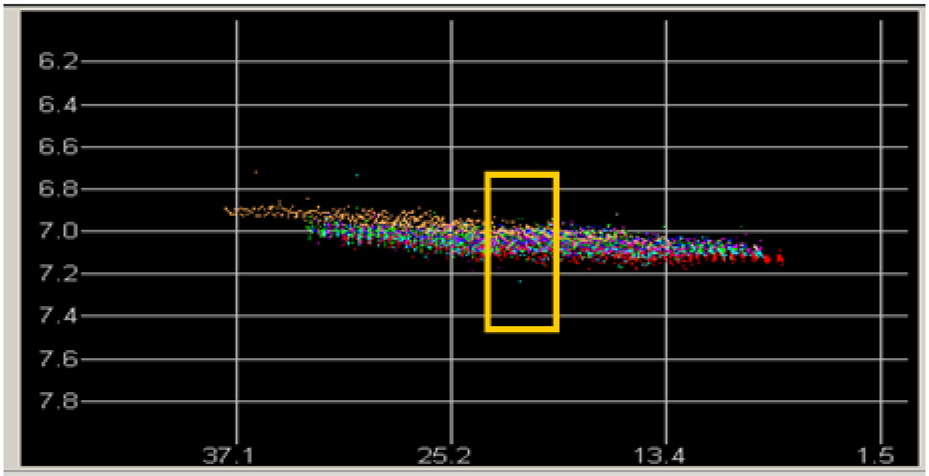
After the DDSSM data has been acquired, determine all other vessel biases (roll, pitch, heave, heading) and apply them before processing the dynamic draft lines. Convert the dynamic draft lines in CARIS v5.4 with batch converter. The batch conversion should filter swaths to 45°/45°, filter depths, apply tides, sound velocity, and merge the data.

After conversion, open the lines in CARIS v5.4. Open subset editor and create a thin rectangle over one of the zero motion locations.



Graphic 3: Subset Example

In the 2-D subset window, draw a rectangle over the nadir lines.



Graphic 4: Selecting Nadir Beam Soundings

Query the selected soundings. Right click in the Query window and save the information to a text file.

Open Cygwin, or an equivalent Unix command program.

- At the prompt, type **grep 2 filename > tempfile** and enter. The filename is the saved query text file and the tempfile is a temporary file where the information is sent.
- At the prompt, type **awk '{print $2, $5}' tempfile > basefile** and enter. This will cull out the unnecessary fields. Field $2 contains the line name and field $5 contains the depth values.
- At the prompt, type **grep line_name basefile > line_name.txt** and enter. This will copy each line into its own file.

Repeat this entire process for each line*.

**If this process doesn't work, import the query text file directly into Excel and edit fields there.*

Import each text file into Excel and average the depth column. Record the average depth for each location (3 locations) for all of the separate lines (RPM).

Enter the average depth values for each location in the results table. The results table has functions entered to difference the locations and average the differences. The results are the dynamic draft values for use in the Hydrographic Vessel File (HVF). Create an Excel Graph of the dynamic draft results with speed in knots on the X-axis and dynamic draft in meters on the Y-axis.

REPORTING AND RESULTS

The blank ship and launch acquisition and results forms are in the file DDSSM Data Collection and Results Forms.xls. An acquisition and results form should be filled out for each DDSSM test performed. The final results forms should be placed in the DAPR.

The final dynamic draft values for each vessel should be entered into their respective Hydrographic Vessel File (HVF).

DGPS System Check Procedures

10/8/2004

The purpose of a DGPS system check is to ensure your positioning system is functional and to check for any blunders in positioning of a beacon, USCG or our flyaway beacon, or in your geodetic survey parameters. As a general rule this should be completed on the first day of acquisition, on a weekly basis for every system, and on the last day of every project.

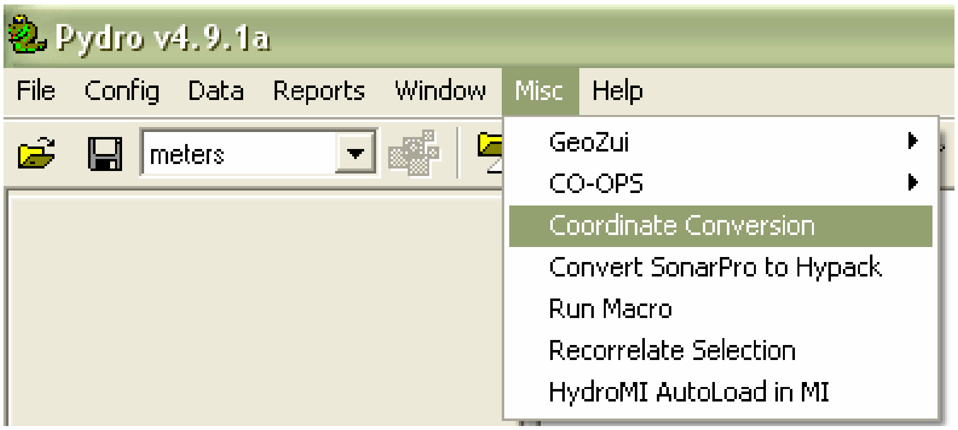
The check must be between two completely independent systems, which means receiving correctors from two different beacons. During the system check process, each platform must manually force the use of a different beacon.

System Check Procedure:

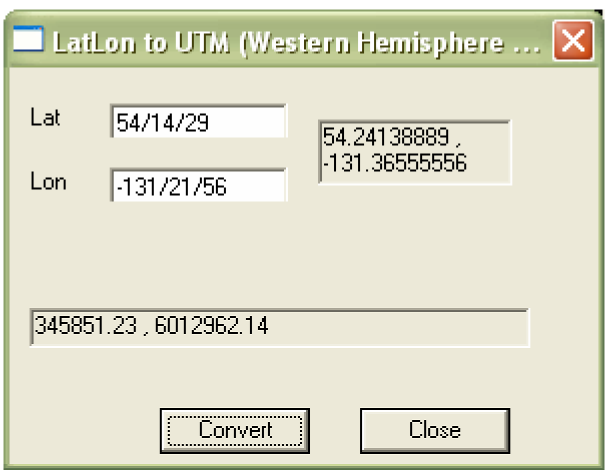
1) Set up the Trimble Backpack so that its antenna is directly above the IMU on the launch.
2) Ensure one platform (launch or backpack) is set to use the primary beacon as listed on the POD and the other platform has the secondary beacon selected.
3) Coordinate between one person at the Acquisition computer on the launch and someone with the Trimble Backpack in order to simultaneously capture a screen grab of the POS and log a position with the Trimble unit.
    a. Save the screen grab files as dddSC_#, where ddd is the Julian day number, SC for Systems Check and # is the number of the screen capture (1, 2, 3).
    b. For Trimble logging, name the data file TRB#_ddd, where # is the Trimble unit (1 or 2) and ddd is the Julian day number. Use the Generic dictionary and simply create generic points.
4) Record the number of satellites and HDOP on the Launch Systems Check Form, which can be printed from the digital copy located in *R:\Utilities\Survey_Forms*.
5) Repeat this process two more times.
6) Visually check to make sure the positions are relatively close and begin running the day's hydro. The allowable HDOP is 2.5 meters, so one would hope the position difference is on the order of 5 meters or less. However, given an estimated system error of 4 meters for a USCG beacon, the Pmax (max position error) must be less than 15 meters + actual separation to meet specs.

Data Transfer Procedure:

1) When transferring data to the ship, create a new folder for that day in: *I:\200X_Projects\OPR_XXXX_FA_0X\Project_Reports\HVCR\System_Checks\Boat#*
2) Copy and paste screen grab files directly into this new DN folder.
3) Open the first screen grab.
4) Open Pydro.
5) Select *Coordinate Conversion* under the *Misc* menu.

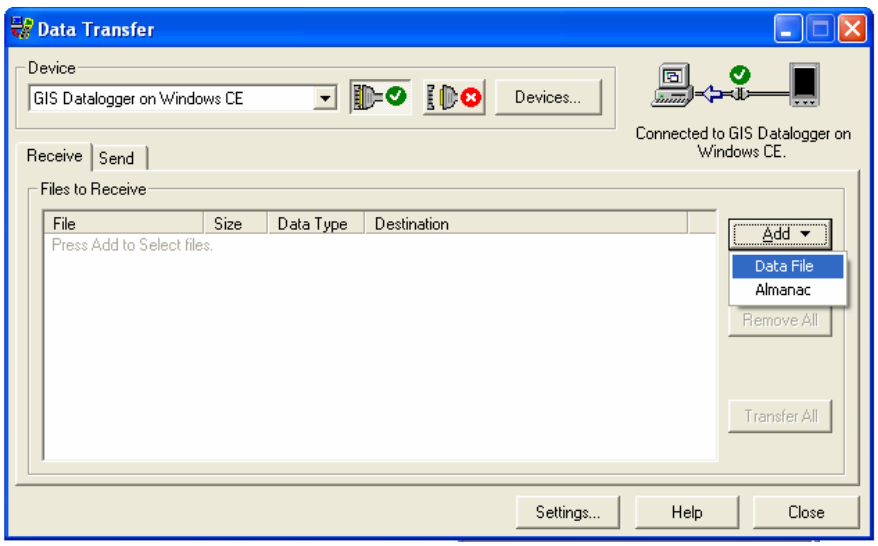


6) Enter the latitude and longitude from the screen grab into the appropriate fields in the conversion window and click *Convert*. The Easting and Northing will be displayed in the bottom bar of the *LatLon to UTM* window.

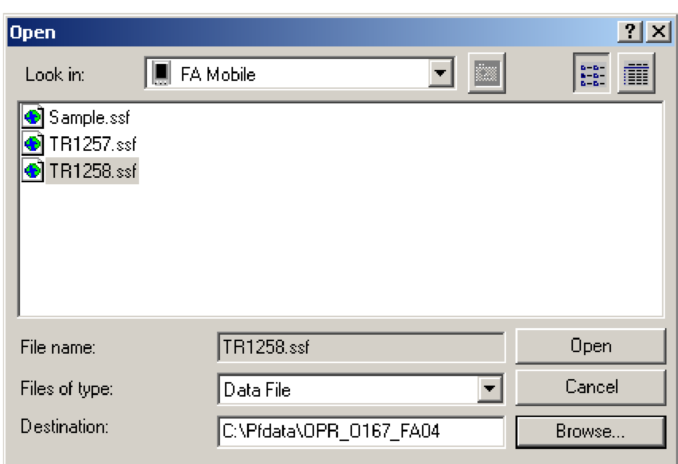


7) Navigate to *R:\Utilities\Systems_Check*, and open the *Launch_System_Check* worksheet.
8) Enter the converted positions into the appropriate Easting and Northing fields for the launch.
9) To get position data off the Trimble unit, use the following procedure:
   a. Connect the hand held Trimble unit to one of the computers that has Pathfinder Office on it. (O-lab, Processor_3 or Tough Book)
   b. In the main Pathfinder window, select *Data Transfer* from the *Utilities* menu.

c. Select *GIS Datalogger on Windows CE* from the *Device* pull-down menu.
d. Under the *Receive* tab, press *Add* and select *Data File* from the menu.

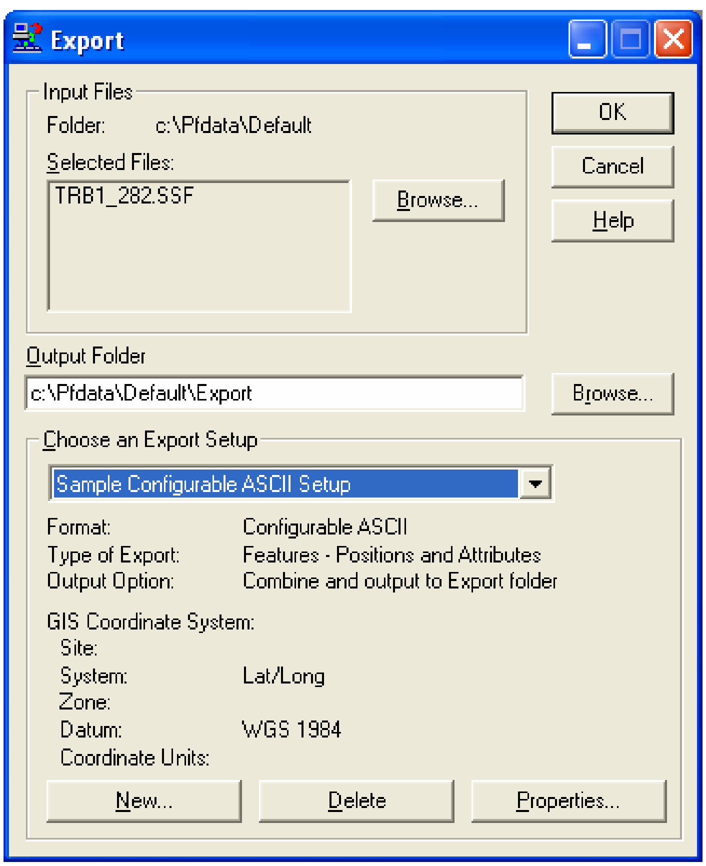


e. Navigate to the data file to be exported (labeled TRB#_ddd).
f. Click *Browse* and navigate to the export file location, which will be the DN folder created on the *I*: drive, as indicated above (if you're connected to the network).

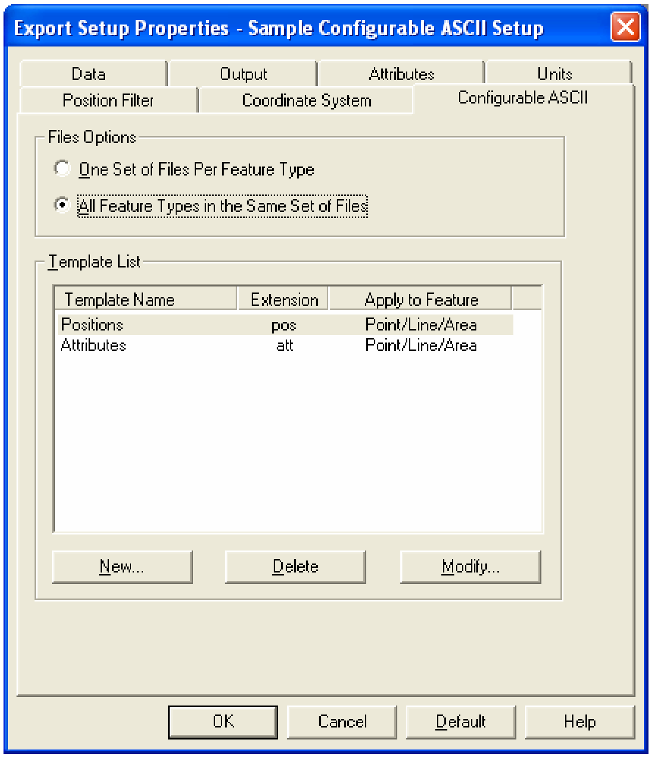


g. Click *Open*.
h. In the *Data Transfer* window, select *Transfer All*.
i. Once the transfer is complete, click *Close*.
j. In Pathfinder Office, select *Export* from the *Utilities* menu.

k. Under the pull-down menu called *Choose an Export Setup*, select the *Sample Configure ASCII Setup* option. The *Input File* should automatically select the file you transferred in the previous steps. If not, click *Browse* to navigate to it. The *Output Folder* should be the DN folder created on the *I*: drive, as indicated above (if you're connected to the network).



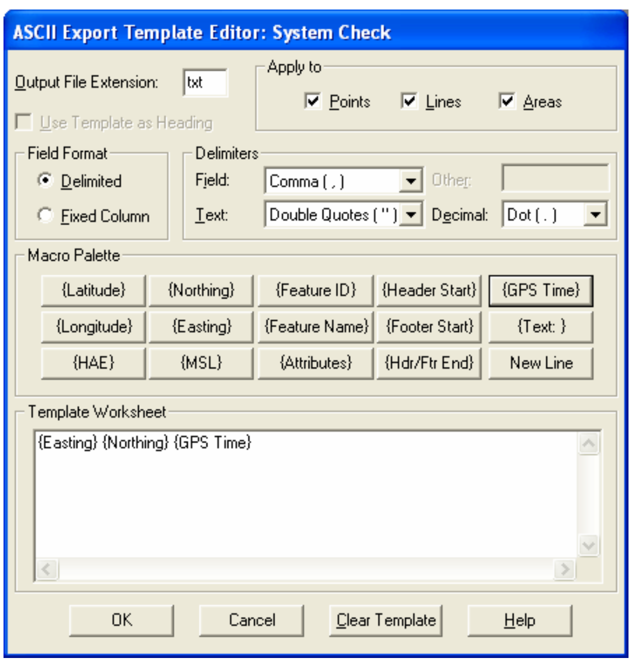
l. Click the *Properties* button and select the *Configurable ASCII* tab.



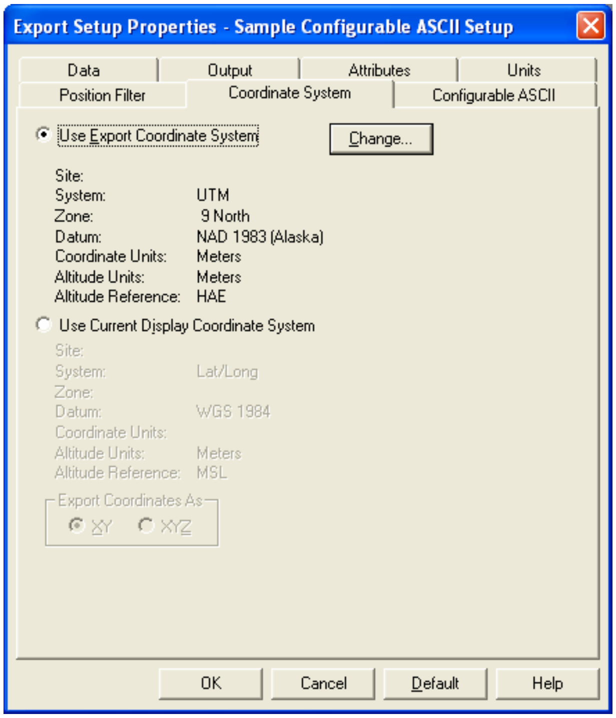
m. Click the *New* button and name the template *System Check*, then click *OK*.

n. In the *ASCII Export Template Editor* window, make the *Output File Extension* *“txt”*.

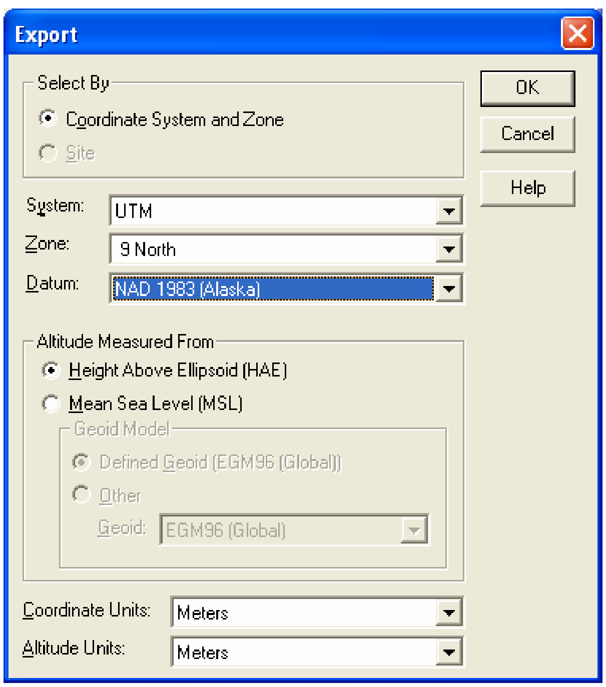
o. Select *Easting*, *Northing* and *GPS Time* from *Macro Palette* and click *OK*.



p. Select the *Coordinate System* tab in the *Export Setup Properties* window.
q. Choose *Use Export Coordinate System* and click the *Change* button.

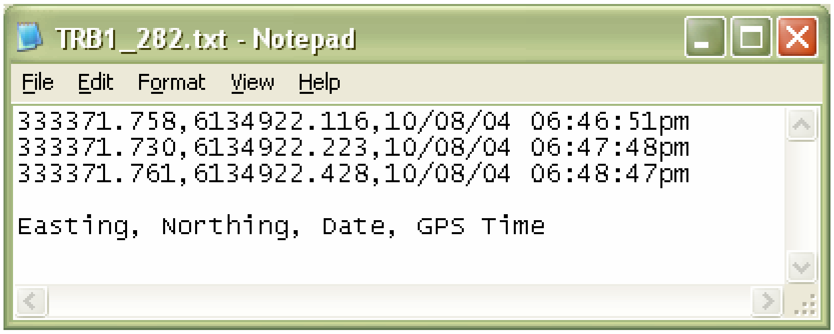


r. In the *Export* window that appears, change the coordinate system to the appropriate UTM Zone in NAD 1983.



s. Click *OK* in the *Export* window and in the *Export Setup Properties* window. A text file will be created in the output location you selected.

10) Use Notepad or WordPad to open the files transferred from the Trimble Backpack.



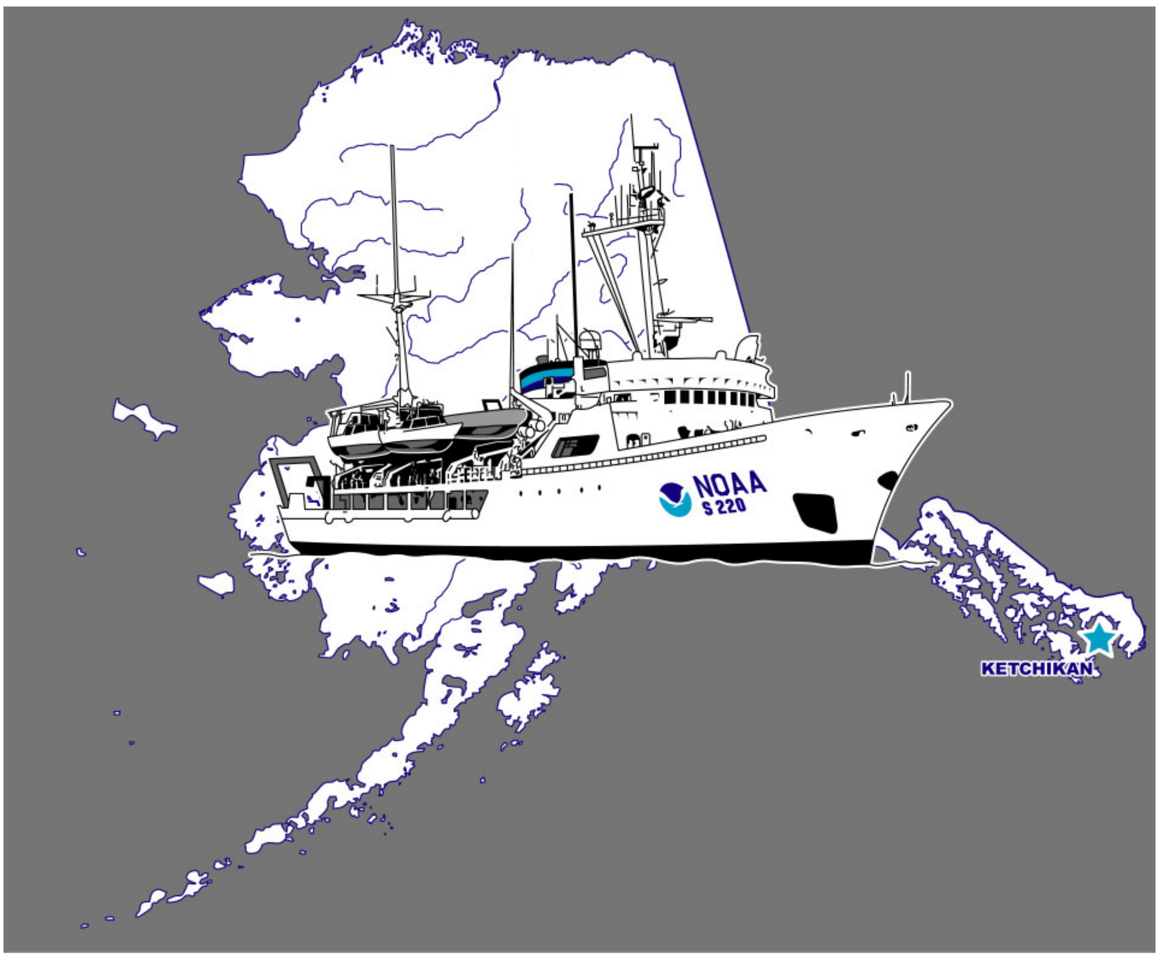
11) Enter the position information into the appropriate Easting and Northing fields in the *Launch_System_Check* worksheet.

12) Transfer Satellite and HDOP information from the acquisition form to fill the remaining fields in the worksheet.

13) Save a copy of the worksheet to the DN folder on the *I*: drive. Name it Boat#_SC_ddd

14) If the System Check fails, notify the FOO or CST.

TEI Real Time Bathy SOP



TEI Real Time Bathy SOP

Table of Contents

0.0 Document Scope

The scope of this document covers setting up and acquiring multibeam data using TEI Isis and TEI DelphMap/DelphNav/RT Bathy Programs.

1.0 RT Bathy Set Up

Currently you need two machines to run Real Time Bathy properly. Both must have Isis v6.6 (or newer) installed and one must have TEI Suite v2.10 (or newer) installed. For this document I will call the acquisition Isis (connected to Reson) "Hull#_Acq" and the processing Isis (performing RT Bathy) "Hull#_Nav".

2.0 Setup in Hull#_Nav

2.1 Isis Sonar

1. Open Isis
2. Configure→Playback speed→Set Pings to read per update to 50
3. Tools→Realtime BathyPro Map→Multibeam Bathymetry

2.2 BathyPro Real Time

1. Open Project (HXXXXX.dmp) in DelphMap from C:\Project\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\. If you do not have DelphMap open, BathyPro will open it for you.
2. Set the **DTM File settings**. Under Encoding Type choose "Average". Save the DTM to the correct folder (see Section 5.0).
3. Set the **Map Projection and Settings**. *You must uncheck the Set Default Limit Box.*
4. Under Boundaries in the **Map Projection and Settings** menu, enter a bounding box for the area you wish to create the DTM for. Use a reasonable resolution for the DTM size (i.e. don't use 1m resolution for a 10,000m x 10,000m box).
5. Enter the North-West corner of the bounding box for the area you wish to create the DTM for.
6. The input projection is Not Projected (Lat/Long) (using NAD83 as datum)
7. The output projection is UTM with the correct zone (using NAD83 as datum)
8. Click on START
9. The box next to START should switch to "Waiting…"

2.3 DelphMap

1. Right click on Background
2. Import an Background Image
3. Browse to the folder where the coverage map is located and select it (see Section 5.0).
4. Click on "Change..." to change the projection of the chart. It should be in UTM with the correct zone number (using NAD83 as the datum).

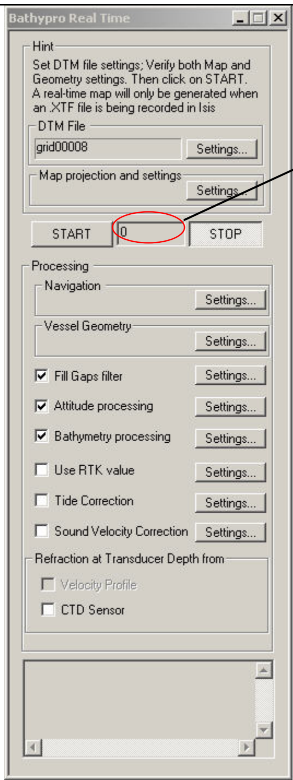


Figure 1. RT Bathy Window

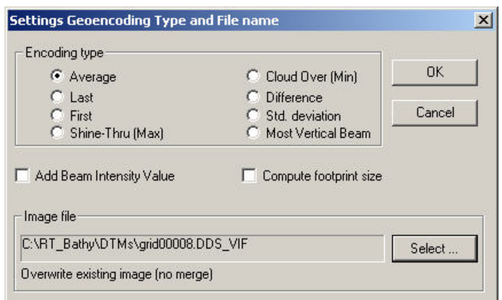


Figure 2. Setting grid type and location

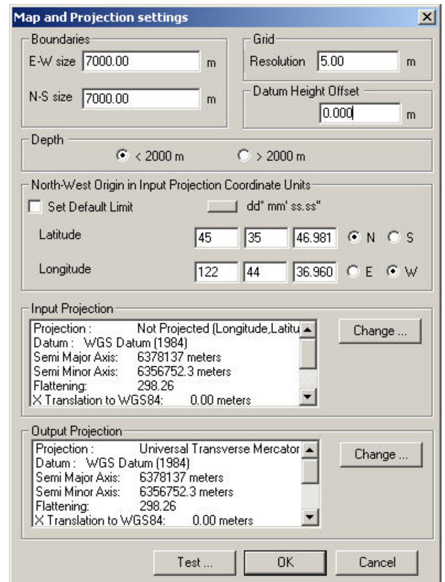


Figure 3. Setting Bounding box and grid projection

3.0 Recording data on Hull#_Acq

1. Click on Switch button
2. Click on Record data to File Name radio button and browse to correct storage location (see section 5.0)
3. When ready to start recording, click on the Switch Now! button. This will start logging data.
4. When getting close to end of line click on the Display Only radio button
5. When ready to stop logging, click on the Switch Now! button. This will end data logging.

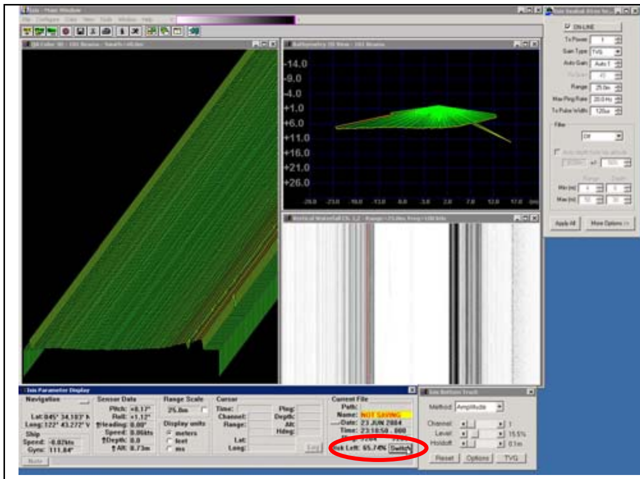


Figure 4. Click on Switch to open recording dialog

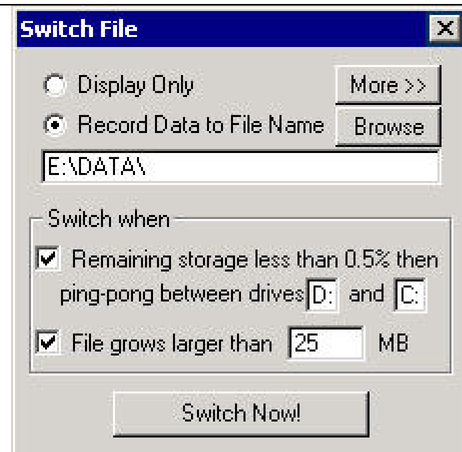


Figure 5. Switch File Dialog

4.0 Playback on Hull#_Nav

4.1 Isis Sonar

1. Hit the Play button on Hull#_Nav.
2. Navigate to the folder that contains the .XTF files.
3. Open the .XTF that you just created in Hull#_Acq

4.2 BathyPro Real Time

1. The box next to START should be counting up. The number should correlate to the ping number on the Isis computers. If the box says "Outside", then Isis thinks your bounding box coordinates are off. Double check to make sure that they are correct.
2. If the box next to START still says "Waiting…" after a few moments, then click STOP in the BathyPro window and Stop in Hull#_Nav. Close the BathyPro window and repeat Section 2.2.

4.3 DelphMap

1. Click on Plug to display boat navigation
2. Click on arrows to bring up Left/Right indicator

5.0 File Structure/Data Management

The following are the file structures that shall be used from now on. It is no longer acceptable to place files wherever you choose. These structures are specific to each platform and must be followed as such.

5.1 Ship S220 File Structure

5.1.1 220_Acq

XTF Data:
D(Data):\Projects\OPR-XXXX-FA-XX\HXXXXX\DNXXX\

5.1.2 220_Nav

TrueHeave:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\TrueHeave\DNXXX\
RT Bathy Projects (HXXXXX.dmp):
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\
RT Bathy Grids, Tracks, Coverage, etc:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\DNXXX\
RT Bathy Shoreline:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\Shoreline\
RT Bathy Polygons:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT-Bathy\Polygons\

5.1.3 Velocity

Velocity files will be directly transferred to the preprocess folder on the I: drive from the O-Lab

5.2 Launch 1010 File Structure

5.2.1 1010_Acq

XTF Data:
\\1010_Nav\Projects\OPR-XXXX-FA-XX\HXXXXX\XTF_Data\DNXXX\

5.2.2 1010_Nav

TrueHeave:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\TrueHeave\DNXXX\
RT Bathy Projects (HXXXXX.dmp):
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\
RT Bathy Grids, Tracks, Coverage, etc:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\DNXXX\
RT Bathy Shoreline:

C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\Shoreline\
RT Bathy Polygons:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT-Bathy\Polygons\
Velocity files:
C:\Sound_Velocity\

5.3 Launch 1018 File Structure

5.3.1 1018 _Acq

XTF Data:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\

5.3.2 1018 _Nav

TrueHeave:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\TrueHeave\DNXXX\
RT Bathy Projects (HXXXXX.dmp):
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\
RT Bathy Grids, Tracks, Coverage, etc:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\DNXXX\
RT Bathy Shoreline:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\Shoreline\
RT Bathy Polygons:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT-Bathy\Polygons\
Velocity files:
C:\Sound_Velocity\

6.0 Issues/Things to watch for

1. If you minimize Hull#_Nav then RT Bathy won't work. Isis must be visible.
2. Making the Hull#_Nav Isis window very small (not minimized) will help the speed of playback.
3. Hull#_Acq must display Lat/Long in Decimal Degrees (i.e. 34.9827271 -120.12891717) for navigation in Hull#_Nav to display correctly.
4. The POS/MV must be booted up first before any other equipment. If it is not, then it will not work correctly.
5. Telemetry output must be on Form 2. Nicole Stagner (TEI Rep) thinks that Form 1 may not know how to correctly output at 1 Hz. Problems seem to arise.
6. Logging TrueHeave at >2Hz causes Real Time Bathy lag.
7. Real Time Bathy lag increases with depth.
8. Use the "Slider Bar" to increase the playback speed to catch up the real time bathy display.

S57 Shoreline Presurvey

Table of Contents

0. Document Scope

This document outlines the new standard operating procedures for creating a data dictionary, preparing georeferenced background files, and creating and configuring a project with the necessary settings for efficient and S-57 compliant shoreline data acquisition.

1. Data dictionary

The data dictionary is a customized list of features that allows the user to assign S-57 attribution directly in the field rather than during processing back on the ship or in the office. The data dictionary itself does not contain positions or feature-specific information, but rather structures data collection in the field and prompts the user to enter relevant information. NOTE: Check your data logger under C:\MyDocuments\TerraSync for an existing data dictionary and verify it is the approved version (Fairweather_DD.ddf). If the data dictionary is created you can skip ahead to section 2: TerraSync Configuration.

1.1. Pathfinder Office

You will use GPS Pathfinder Office throughout the suitcase shoreline process, for everything from creating a data dictionary to processing GPS data and exporting shapefiles to Pydro. Upon opening GPS Pathfinder Office, a dialog box will prompt you to select a project. Later in the process you will create a new project; for now select Default.

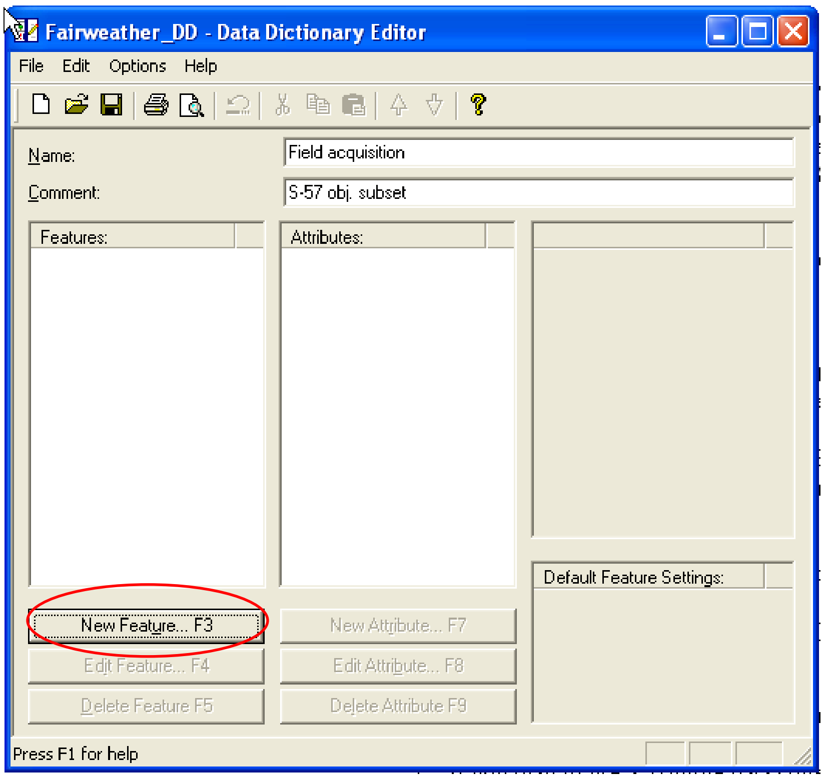
1.2. Data dictionary creation to S57 standards

To create a new data dictionary, choose Data Dictionary Editor from the Utilities menu in Pathfinder Office. When the Data Dictionary Editor opens, select File → New. Fill out the Name and Comment fields. Give data dictionary a descriptive name and save (File →Save) to the ship's designated network folder (2004 Fairweather data dictionary: R:\Utilities\Shoreline_S57\Trimble\Data Dictionary\Fairweather_DD.ddf). Eventually, the final data dictionary will be transferred to the TerraSync folder of the acquisition laptop or data collector.

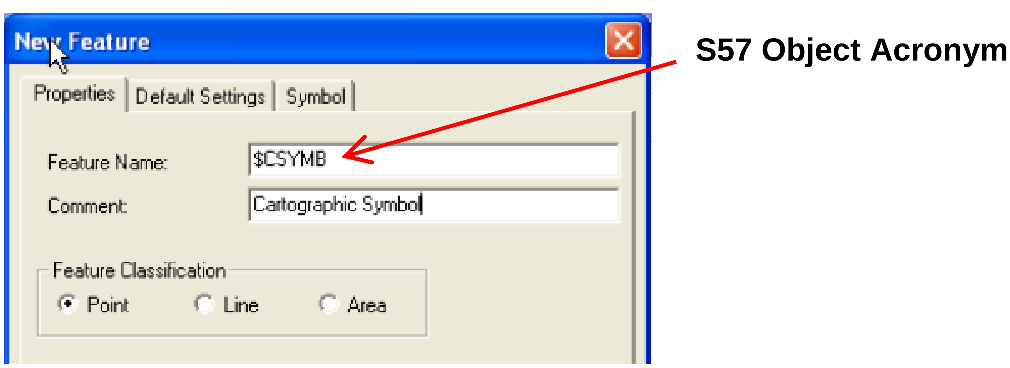
1.2.1. Add new features

Now that the dictionary has been created, it must be populated with the potential feature objects and attributes you will want to record in the field. Consult the CARIS S57 catalog (C:\Program Files\Python23\Pydro\S57\S57cat\frames\S57catalog.htm) for a list of S-57 feature objects, attributes, and coding information. The NOAA point features file (C:\Program Files\Python23\Pydro\forms\NOAAHydroS57PointObjects.xls) is a good resource to help determine which features and attributes are necessary to include.

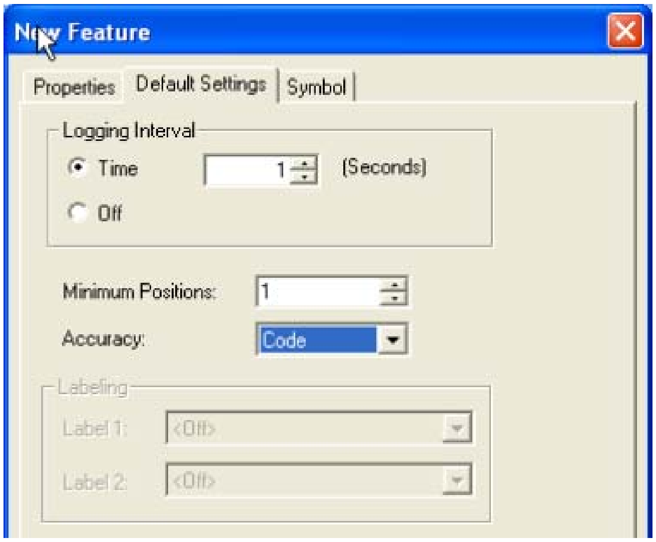
To add a new feature, click the New Feature button at the bottom of the left-hand (Feature) column.



Click on the Properties tab and fill in the Name and Comments fields for your new feature: name the feature after the S57 feature object acronym, and use the comment field to describe what the code represents. Under Feature Classification, select Point.



Change symbol style preferences for this feature by clicking on the Symbol tab; these can be edited later as well. In the Default settings tab, set GPS logging preferences:



NOTE: Carrier phase logging can be collected, but requires a minimum lock of 10 minutes which is generally impractical and unnecessary for shoreline acquisition.

1.2.2. Add new attributes

Each feature must have certain pieces of descriptive information, or attributes, attached to it in order to be useful. Highlight the feature you wish to add an attribute to, then click New Attribute in the right-hand (Attribute) column. Select attribute type. Most of your attributes will be Menu, Numeric, and Text types, but for each detached position (DP) you will also need Date and Time attributes. Refer to the Pathfinder Office help menu for more information on the different specific attribute types.

1.2.2.1. Add "menu" type attributes

Fill in Attribute Name and Comment fields. You must decide whether you want this feature to be required for entry in the field. If you do not want this attribute to be required, leave the On Creation: Normal option selected in the Field Entry section at the bottom, otherwise choose Required. Note the distinction between a *mandatory* S-57 attribute and a *required* data dictionary attribute; for instance the OBJNAM (Object name) and INFORM (Information) attributes are not mandatory for S-57, but you will want these fields to be required in order to record unique identifiers and feature object names for each position, so that they can later be correlated with DP forms and other notes.

Click New. Fill in Attribute Value and check the Default box if you want to set this value as the default for the attribute, otherwise leave it unchecked.

In order for Pydro to recognize the S-57 assignment, each menu-type attribute value must also have a code attached. Consult the attribute's entry in the S-57 catalog and fill this into the Code Value 1 field:

Attribute: Colour

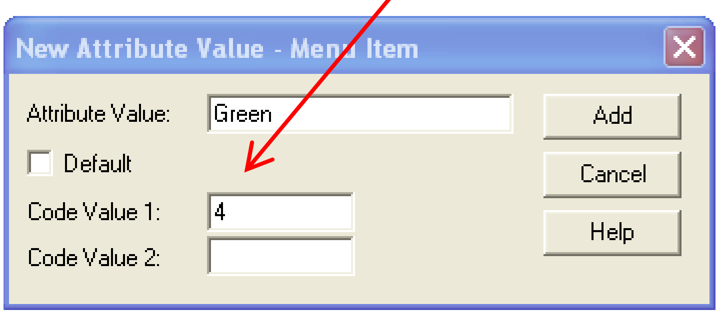
Acronym: COLOUR

Code: 75

Attribute Type: L

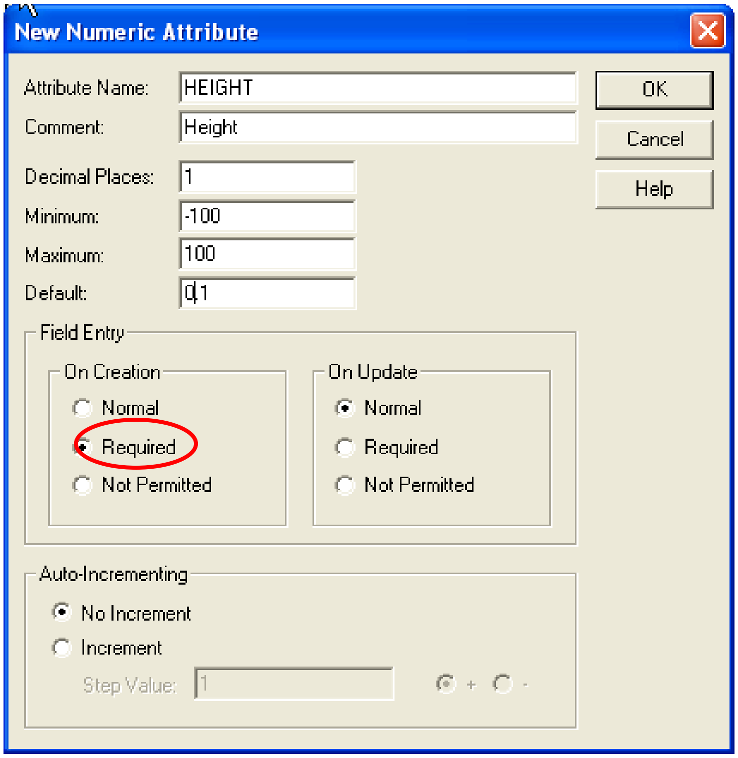
Expected input:

ID	Meaning	INT 1	M-4
1	white	IP 11.1	450.2-3
2	black		
3	red	IP 11.2	450.2-3
4	green	IP 11.3	450.2-3
5	blue	IP 11.4	450.2-3

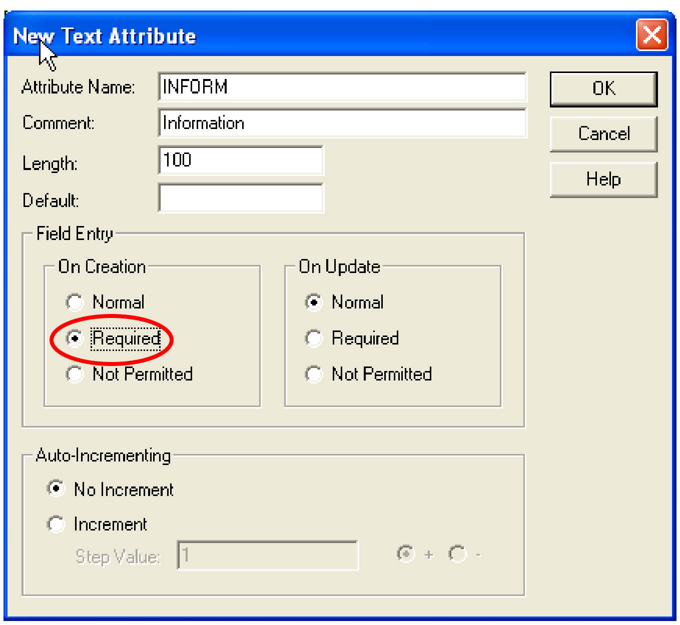


After you click Add, the New Attribute Value window will stay open for you to insert remaining attribute values. Close the window after all values have been added.

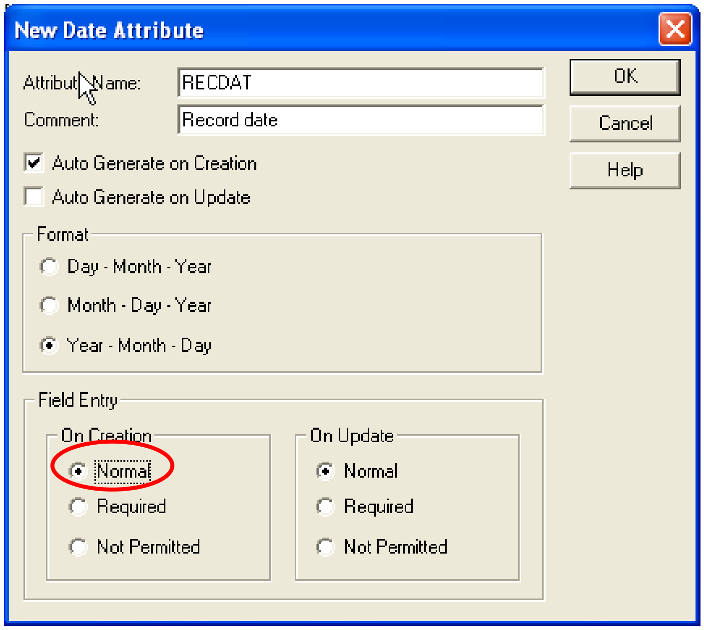
1.2.2.2. Add numeric, text, time, and date attributes

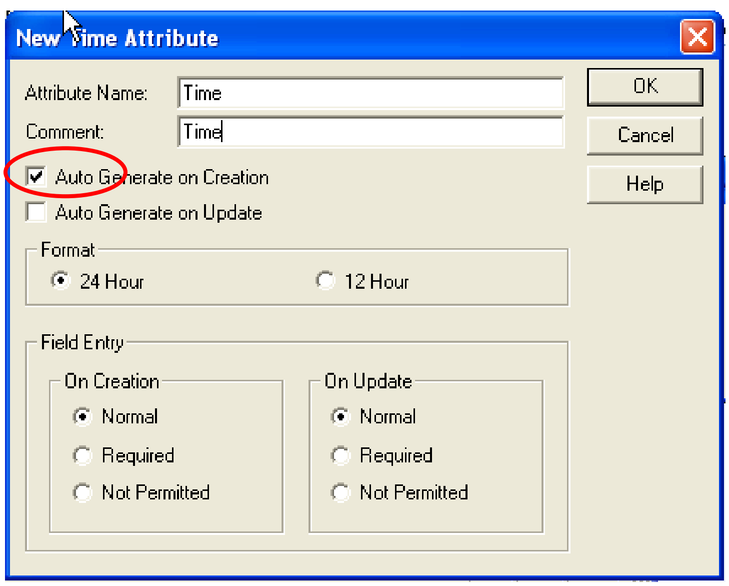


New Numeric Attribute
Attribute Name:
HEIGHT
OK
Comment:
Height
Cancel
Decimal Places:
1
Help
Minimum:
-100
Maximum:
100
Default:
0.1
Field Entry
On Creation
Normal
Required
Not Permitted
On Update
Normal
Required
Not Permitted
Auto-Incrementing
No Increment
Increment
Step Value:
1



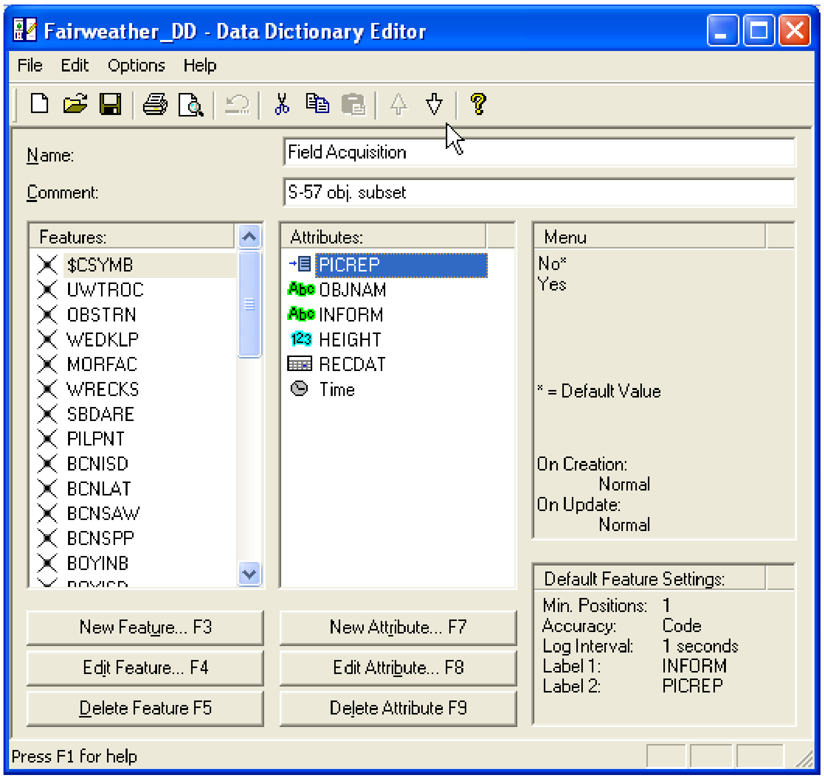
New Text Attribute
Attribute Name:
INFORM
OK
Comment:
Information
Cancel
Length:
100
Help
Default:
Field Entry
On Creation
Normal
Required
Not Permitted
On Update
Normal
Required
Not Permitted
Auto-Incrementing
No Increment
Increment
Step Value:
1





1.2.3. Organize features and attributes

Arrange features and attributes in a convenient order for field acquisition. The more efficient you are when collecting positions, the more data you will be able to gather. Using the up and down arrows on the toolbar at the top of the Data Dictionary Editor, arrange features so that the most commonly used ones are at the top of the list. In the attributes column, move required attributes to the top of the list for each feature. You may want to consider consistently putting a common attribute (i.e. INFORM) as the last required field so that, at a glance, you can tell which attributes are required and which are discretional.



2. TerraSync Configuration

TerraSync, the GPS logging interface you will be using during feature collection, has five modes: Map, Data, Navigation, Status, and Setup. The mode you're in is determined by which of these options is selected in the uppermost left-hand menu. When you switch modes, the display windows and menu options will automatically change.

There are two ways to change TerraSync GPS Settings. The first method will work in a pinch; the second is recommended.

2.1. Change GPS settings in TerraSync

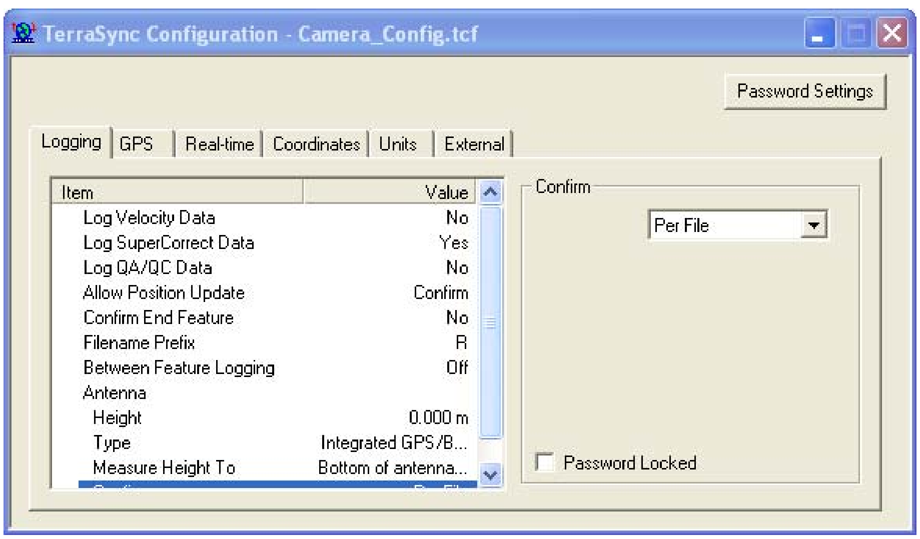
In Setup mode, click on each of the different buttons (Logging, GPS, Real-time, Coordinates, Units, and External) and set your preferences.

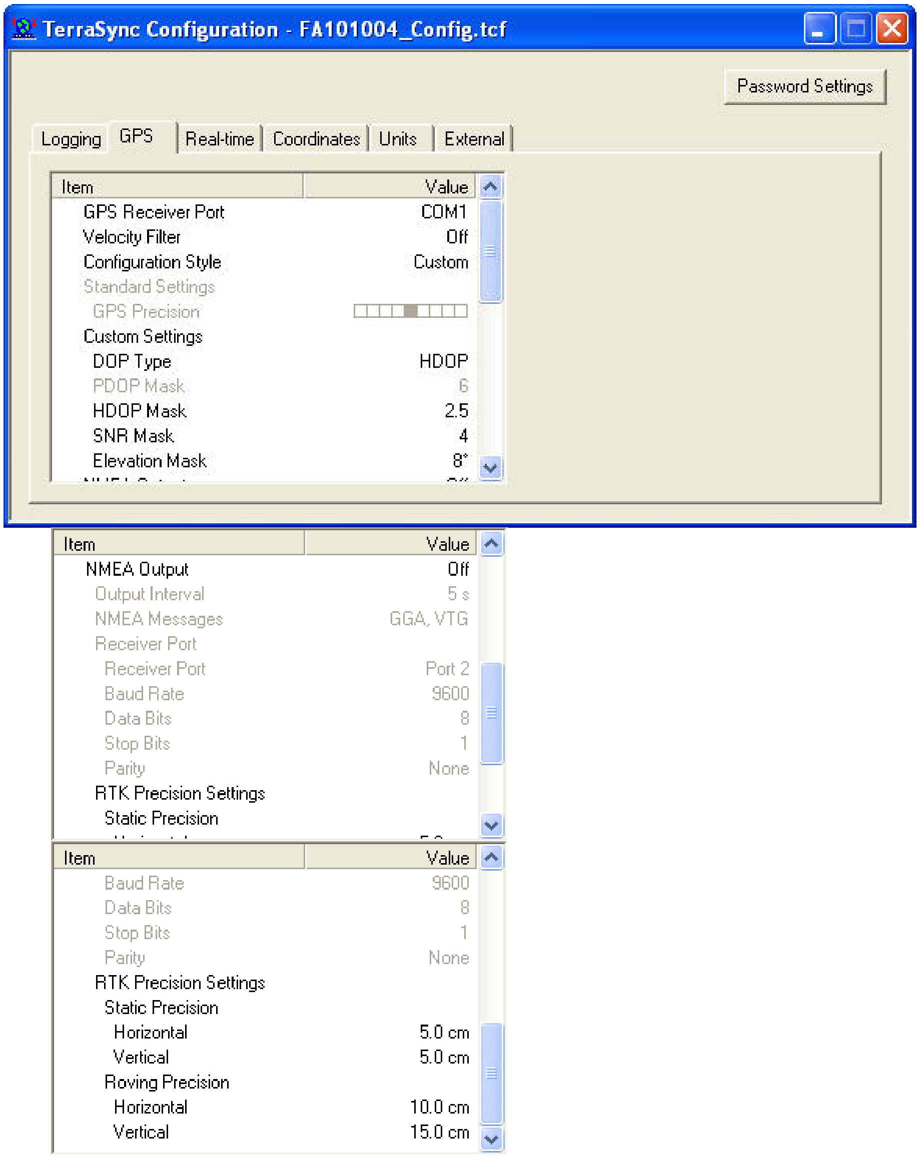
2.2. Change GPS settings by creating a Configuration File

You can save your desired settings by creating a configuration file in Pathfinder Office Configuration Manager (located in Pathfinder Office folder from Windows Start menu, or Utilities→ Other→ Configuration Manager, if Pathfinder Office is already open). Through File→ New, choose TerraSync Configuration in the next window, and say OK. If multiple data collectors may be used, it is a good idea to save the configuration file in an accessible location (*R:\Utilities\Shoreline_S57\Trimble\Configuration Files*) rather than just the C:\\ drive of one computer or datalogger. This file can be referenced or updated easily for future projects.

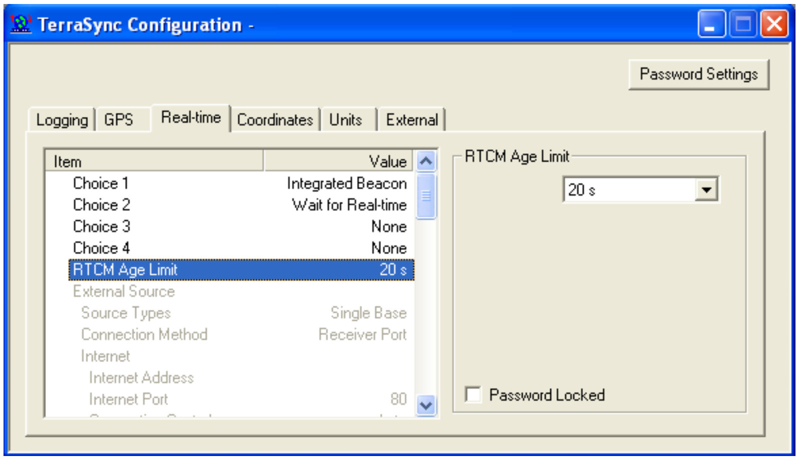
NOTE: Creating a new configuration file for each project is recommended since the DGPS beacon frequency will change for each area. Each file should be well labeled with the project name and/or date. The project configuration file may have already been created so it is a good idea to check for an existing configuration file on the data logger under C:\MyDocuments\TerraSync\Configuration and verify if it is correct.

To create a new configuration file, click on each tab and set according to your preferences, or follow the examples:

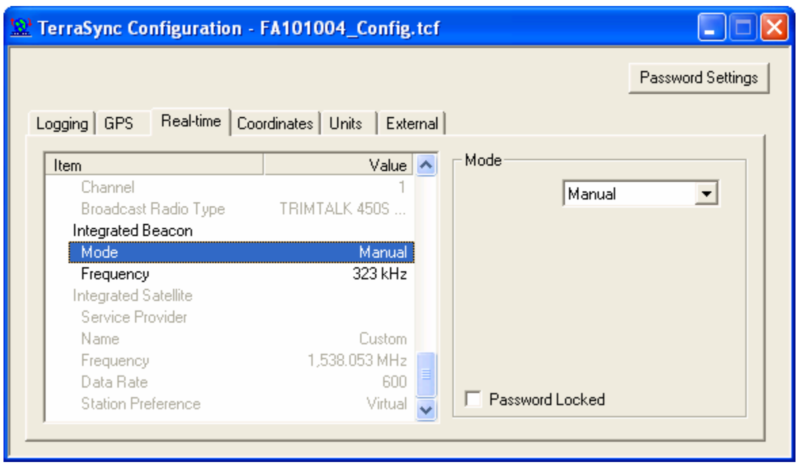




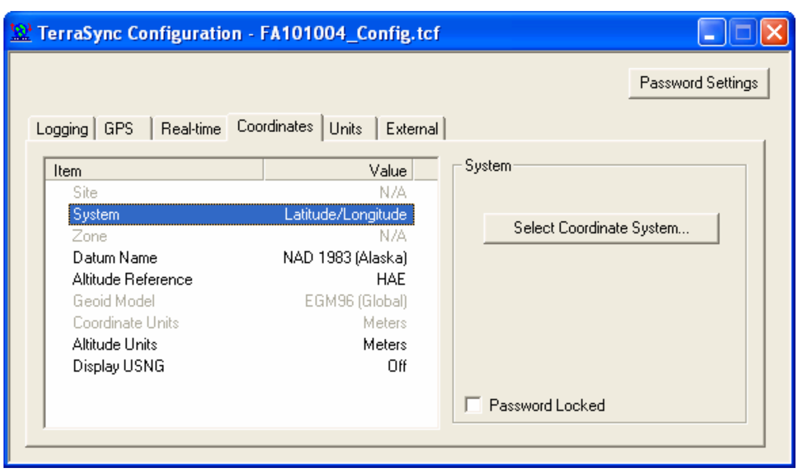
NOTE: In the Real-time tab, Frequency must be determined prior to configuration and entered manually. The frequency you will enter depends on which U.S. Coast Guard DGPS base station in the area is being utilized, which will vary by project and location.



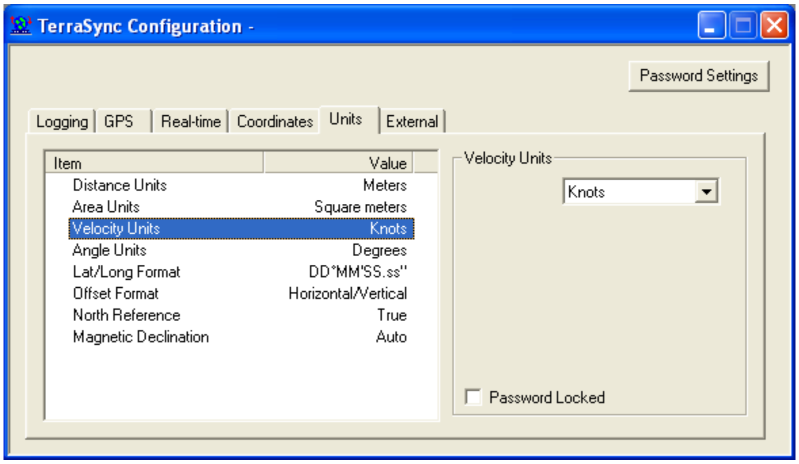
TerraSync Configuration -
Password Settings
Logging
GPS
Real-time
Coordinates
Units
External
Item
Value
Choice 1
Integrated Beacon
Choice 2
Wait for Real-time
Choice 3
None
Choice 4
None
RTCM Age Limit
20 s
External Source
Source Types
Single Base
Connection Method
Receiver Port
Internet
Internet Address
Internet Port
80
RTCM Age Limit
20 s
Password Locked



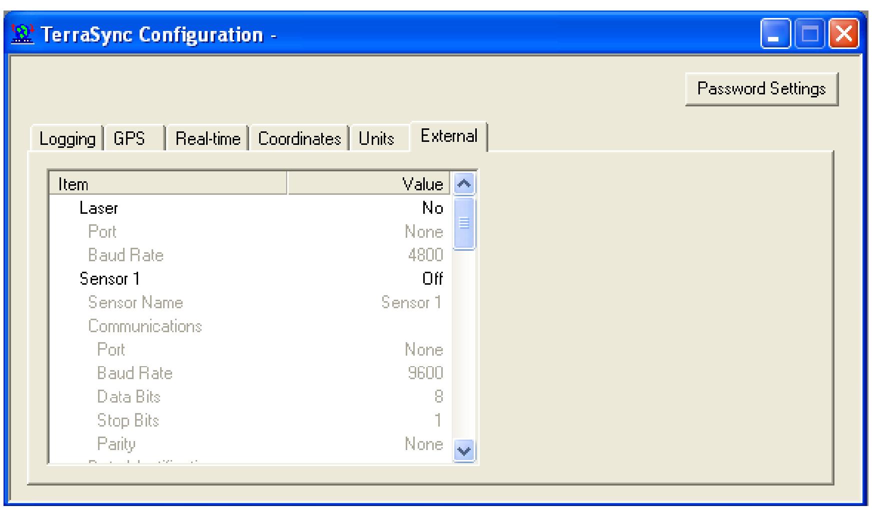
TerraSync Configuration - FA101004_Config.tcf
Password Settings
Logging
GPS
Real-time
Coordinates
Units
External
Item
Value
Channel
1
Broadcast Radio Type
TRIMTALK 450S ...
Integrated Beacon
Mode
Manual
Frequency
323 kHz
Integrated Satellite
Service Provider
Name
Custom
Frequency
1,538.053 MHz
Data Rate
600
Station Preference
Virtual
Mode
Manual
Password Locked

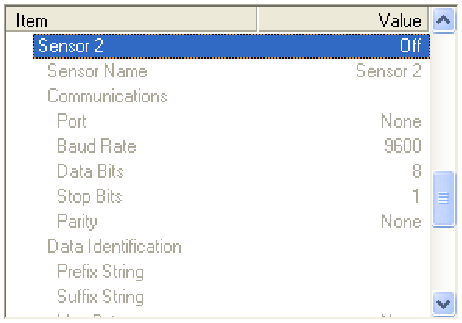


TerraSync Configuration - FA101004_Config.tcf
Password Settings
Logging
GPS
Real-time
Coordinates
Units
External
Item
Value
Site
N/A
System
Latitude/Longitude
Zone
N/A
Datum Name
NAD 1983 (Alaska)
Altitude Reference
HAE
Geoid Model
EGM96 (Global)
Coordinate Units
Meters
Altitude Units
Meters
Display USNG
Off
System
Select Coordinate System...
Password Locked



NOTE: While it is possible to configure a laser range-finder or other external sensor to feed directly into the GPS log, this capability is not part of the Fairweather's procedure as of 2004. Thus far, the laser has not been accurate or consistent enough to warrant automatic association with GPS positions without first passing through a human filter. A digital camera with the proper functionality can also be connected to a laptop or data collector and set up as a sensor.





When all properties are set as desired, choose a descriptive name and File→ Save the configuration file to the data logger in the folder *C:\My documents\TerraSync\Configuration*.

3. Project and data file setup

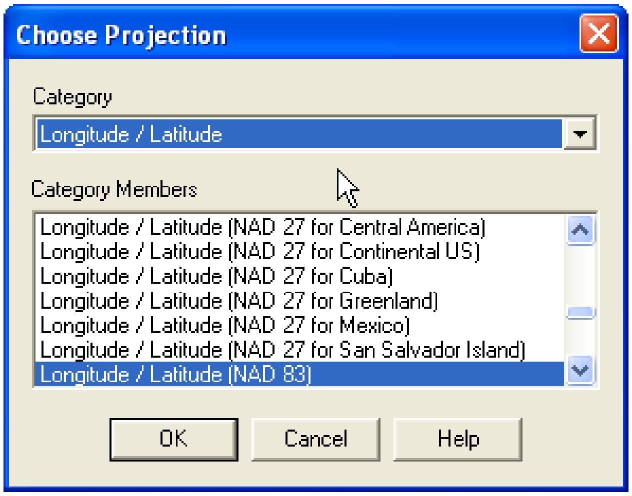
3.1. Create background files

In order to navigate through and collect good data from the areas you are interested in, you will need to make one or more geo-referenced background file from existing images, both raster (charts) and vector (shoreline, features, etc.).

In MapInfo, go to File→ Open and navigate through the project's folder to a BSB chart or shoreline file that you want to work with. If multiple charts of the same area are available, choose the one with the largest scale. You can now work with this image in the form of a MapInfo table. Start by setting the projection; all background files must be georeferenced in a coordinate system that matches the coordinate system of your TerraSync configuration.

3.1.1. Set Map Window projection for vector images

For vector files, set map window projection using the Map→ Options command, click on the Projection button, and choose Longitude / Latitude (NAD 83). This does not change the projection of the table but only the way it is displayed in the map window.



3.1.2. Set projection for raster images

To set the projection for a raster image, navigate to Table→ Raster→ Modify Image Registration, select Raster Table, and say OK. Choose Projection and again specify Longitude / Latitude (NAD 83). The projection of all background files must match the settings your TerraSync file in order for them to be compatible.

When using a raster image, the window projection will change automatically to match that of the raster file, and does not need to be set manually.

3.1.3. Additional tables

Open any other images you want to include in your background file by using the File→ Open command. To rearrange or edit the layers' properties, right click on the window and select Layer Control. To change the projection of a vector table, all raster layers must first be removed from the workspace.

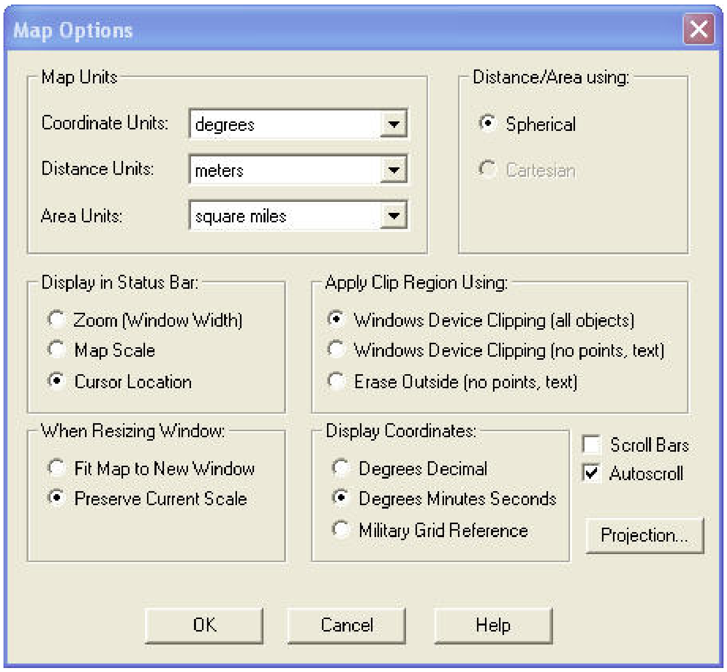
To remove a layer from your workspace, do so through File→ Close, then highlight the layer you wish to close. Simply clicking the X in the upper right-hand corner will close the table from view but won't actually remove it.

If you wish to continue working with the group of tables that are currently open, save your session as a workspace (.WOR file) to the survey shoreline folder.

3.1.4. Save background image as a georeferenced TIF file

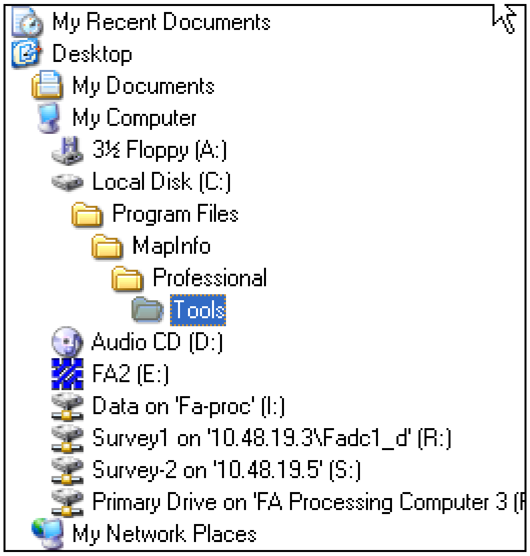
To set the scale (1cm=10,000 cm seems to work well), zoom, or re-center the image, right-click and select Change view and then Map Scale. If you are happy with the scale of the image but want to resize the window, change the When

Resizing Window field from Fit Map to New Window to Preserve Current Scale, under Map→ Options:

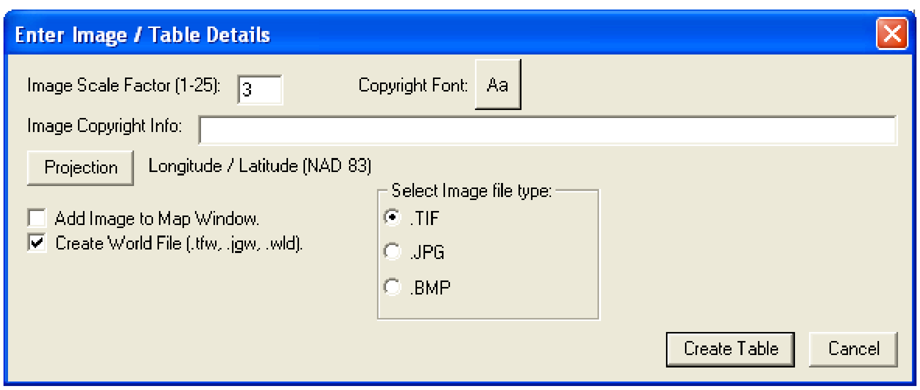


When you are satisfied with the display, you are ready to capture it as a georeferenced TIF file.

If your copy of MapInfo has no menu called WorldReg, you can add the WorldReg program so that it automatically loads every time you open MapInfo. Choose Tools→ Tool Manager→ Add Tool, and on the local drive, navigate to the WorldReg tool:

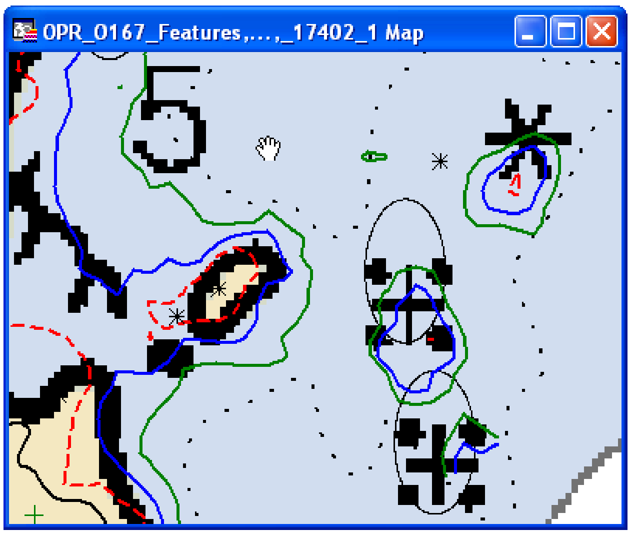


Under the WorldReg menu choose Save window as TAB. Make sure to check the Create World File box, Select Image file type as TIF, and say Create Table.



The naming convention for background files is to use the number of any charts that are included in the image, and the H number of any shoreline data or features. Two different chart images may be called 17402_1 and 17402_2, a TIF file with shoreline/features might be H11362_1, and an image including both types of raster and vector tables would be 17402_ H11362_1. Make sure that whoever will be acquiring shoreline data knows what each different image represents. It might be useful to include some cardinal direction in the naming convention to benefit different users. Save the TIF images to a temporary location like R:\\Transfer\Hxxxxx\Trimble\Trimble_background_files (when you're done working with them you will transfer them to the datalogger).

After you've saved the image, check to make sure the size is appropriate by opening the TIF file you just created and zooming in to the scale you'll be working at in the field. Raster images should be clear and not too pixellated to be useful; otherwise return to your table and experiment with different scales (Change View→ Map Scale) until you are satisfied with the resultant image. It may be necessary to break the image into more than one background file if you have a large area to cover.



The coordinates in the TFW file should make sense based on the selected coordinate system:

```
.0000140329
0.00000000
0.00000000
-.0000079338
-130.764134
55.58588
```

As long as the Create World File box was checked when saving the image, each TIF should have an associated TFW (World File) that lists the image's coordinates and can be opened in any text editor. Open the TFW in WordPad or TextPad to ensure that Longitude and Latitude coordinates appear reasonable.

3.2 Transfer data dictionary to datalogger

In order to use the data dictionary to collect and attribute positions in the field, you will need to transfer the data dictionary into TerraSync on a GPS data collector or field PC. If you choose to use a laptop as your field device, this machine could double as your office computer. Whether you log positions on a laptop or a handheld data collector is a choice that will have to be made based on available equipment, quantity of data to be collected, familiarity and efficiency of the field team with each type of device, durability of the equipment, and weather considerations.

NOTE: If your datalogger is a separate device from your processing computer, you will need to utilize some type of data transfer software. If no such program is included with your datalogger, download Microsoft ActiveSync to your processing computer: www.microsoft.com/windowsmobile/resources/downloads/default.mspx.

Connect handheld unit and processing computer via serial port, USB, or infrared port (refer to device's User's Guide for details).

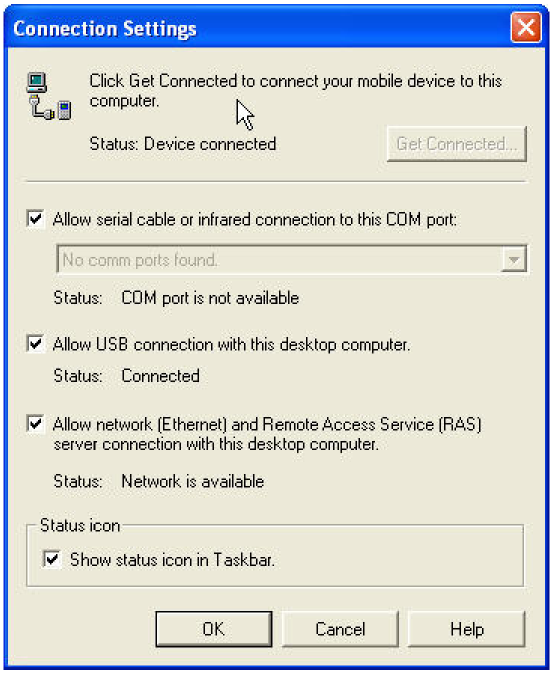
Under the Utilities menu in Pathfinder Office on your processing computer, select Data Transfer. If using a separate datalogger, connect the device to your computer using appropriate serial and/or USB cables. Choose a device from the pull-down menu, or add a new one by clicking the Devices button; then press New.

If you plan to use a Trimble data collector as your field device, choose GIS Datalogger on Windows CE. If using a Windows laptop as the field device, choose GIS Datalogger on Windows PC.

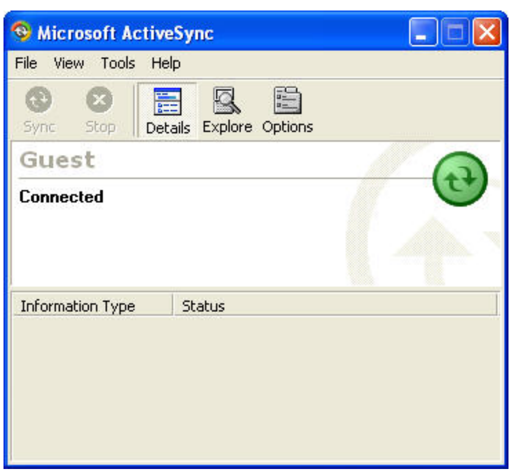
The follow-up screens will vary depending on the type of device you select. Fill in the location of your datalogger, enter the correct port when prompted if using an outside device, type in a name and click Finish. Minimize Pathfinder Office.

Turn datalogger on, and open Microsoft ActiveSync. In the Partnership window that pops up, just say No and set up a guest partnership.

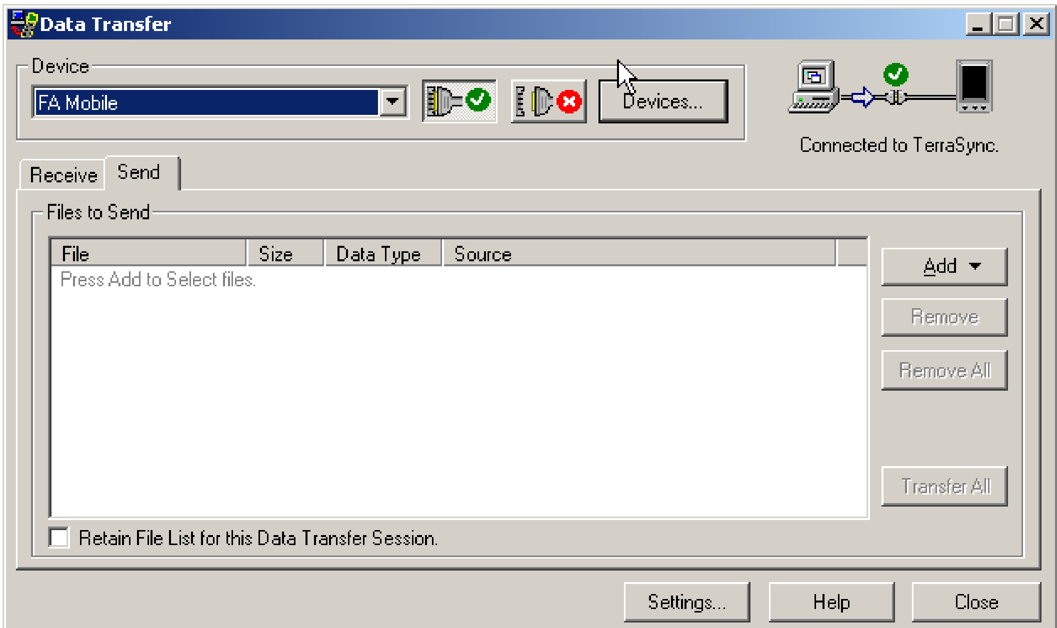
In ActiveSync, check to make sure the correct port for your device is allowed, through File→ Connection Settings, and say OK.



If ActiveSync does not automatically detect your device after this window closes, navigate to File→ Get Connected. After your device is found, ActiveSync should indicate that the status is connected:



Minimize ActiveSync and reopen Pathfinder Office. The icon in the upper right corner of the Data Transfer window (Utilities menu) indicates the status of your computer's connection with the field device. If "Not connected" is displayed, click the button with the green checkmark to connect to the device (the button with the red arrow disconnects).



Click the Send tab and then press Add; select Data dictionary from the pull-down menu. Navigate to your data dictionary and Open.

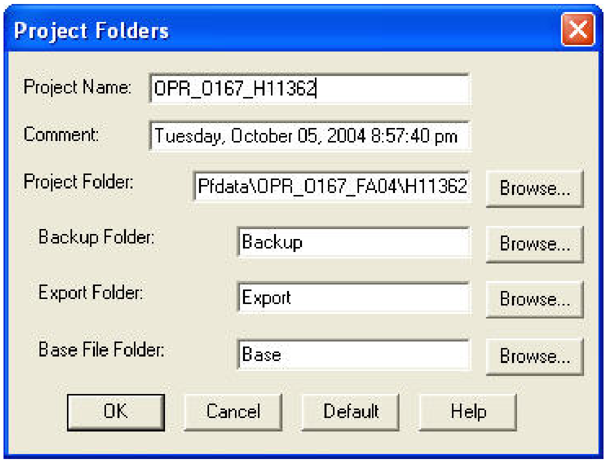
In the Data transfer window select Transfer All. Once the transfer is complete, press Close.

3.3. Create a new project

If creating a new project, it is best to first use an explorer window to manually create new folders with the desired Pathfinder project name (OPR_OXXX_FA_04\HXXXXX) in the Pathfinder local drive (C:\Pfdata\).

In Pathfinder Office, select File→ Projects. Choose a project from the drop-down menu or click New.

Type in desired project name and click Browse to find the folder you just created. Accept default settings for Backup, Base and Export folders.



Click OK in the Project Folders window, and again in the Select Project window. Exit Pathfinder Office.

NOTE: You are now ready to acquire shoreline data! Before actually venturing out in the field, you may want to set up a TerraSync data file and load it with the correct configuration settings so that you don't have to waste any time during your shoreline window. To create TerraSync data and configuration files, proceed on to Shoreline Acquisition SOP.

Back to top

S57 Shoreline Acquisition

Table of Contents

0. Document Scope

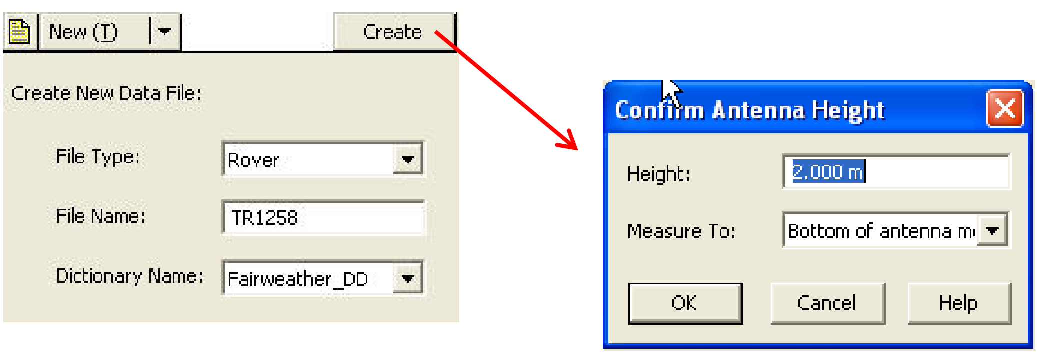
This document outlines the new standard operating procedures for acquiring shoreline data and logging detached positions to meet S57 standards. Effectively, this SOP outlines everything that needs to be done in the field or immediately before collecting data. To set up for this process, see Shoreline Presurvey SOP.

1. Set up TerraSync for GPS logging

Everything in this section should be done in preparation for a specific survey, but should be set up before actually going out in the field.

1.1. Create a new TerraSync data file

In TerraSync, enter Data mode (select "Data" in the upper left-hand menu). In the menu directly below it, choose New File (If you are resuming work from an old file, choose Existing File). All the data you acquire in a given session will be stored in the file you are now creating, so make sure to give it a descriptive name, i.e. TR1258 (Trimble Unit 1 data from day 258). Leave antenna Height and Measure To fields as default; these are not necessary as they apply only to vertical GPS positions. Select your data dictionary from the pull-down menu (in order to be accessible it must be located directly in C:\My Documents\TerraSync).

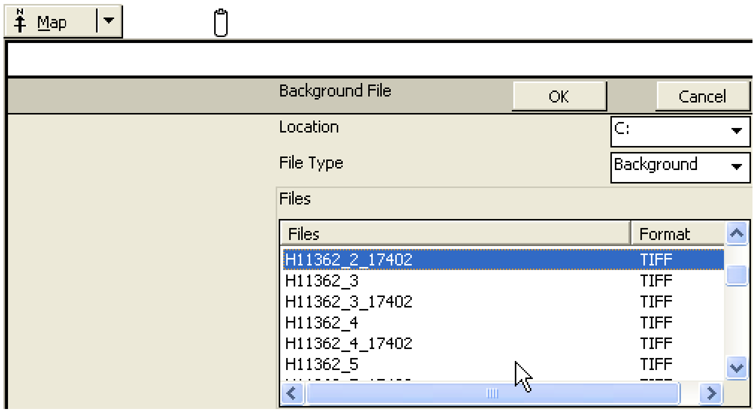


1.2. Load background files into TerraSync

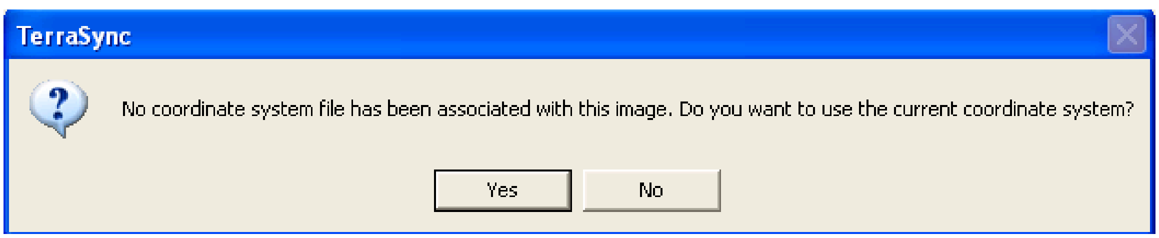
All final background files must be saved into the datalogger's TerraSync folder to be accessible. If the datalogger is the same machine that background files are currently saved on, simply copy all TIF's and associated files to C:\My documents\TerraSync.

If background files are located on a separate machine, these will need to be transferred in ActiveSync. Open ActiveSync and connect to datalogger and transfer the files with the procedure outlined above in Section 3.2 of the Shoreline Presurvey SOP, substituting file type "Background" for "Data Dictionary."

Open TerraSync on your datalogger and select Map mode. From Layers→ Background File, navigate to your file. Select File Type→ Background, find the desired image, and click OK.



The first time you load a background image you will get this message (select yes):



If the image does not immediately appear in the map window, try pressing the Zoom Extents button (equal sign with a circle around it in the lower left-hand corner of the map window).

NOTE: Upon transfer of the georeferenced TIF file to TerraSync, a CS (coordinate system) file will be created, among others. If the coordinate system of the image is changed and then reloaded into TerraSync, the original CS file must be deleted before TerraSync will acknowledge the new coordinate system.

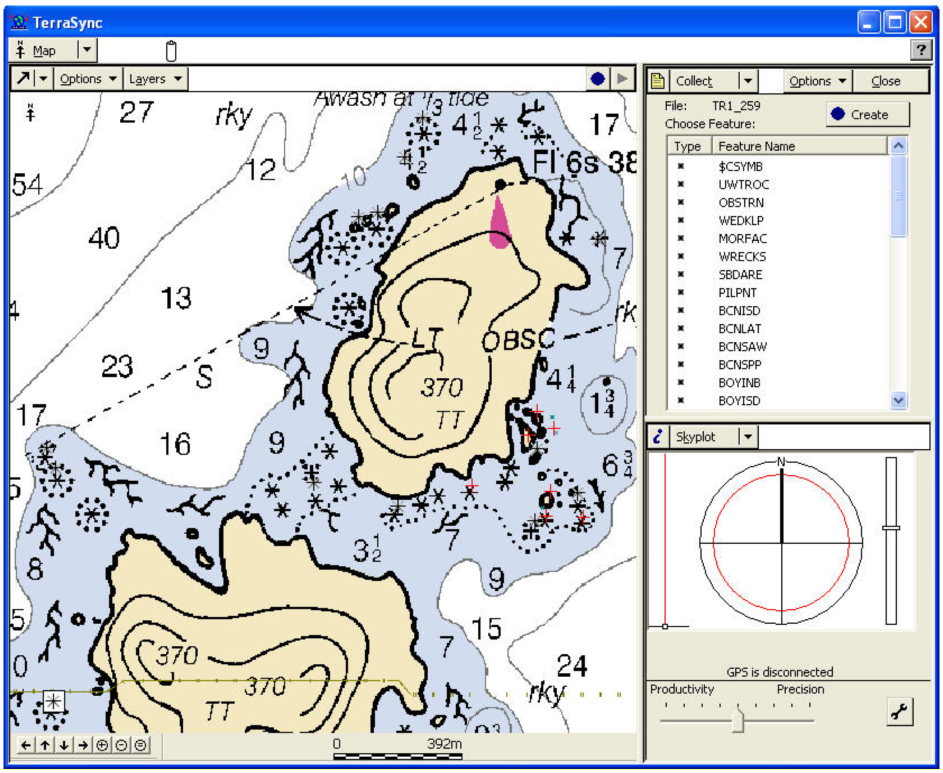
1.3. Load configuration file into TerraSync

Even if the correct configuration file is already listed, you may need to reload it if the GPS is not connecting: from Setup mode, press the Change button, and then Load. As long as it was saved directly into your datalogger's local TerraSync folder (C:\My documents\TerraSync\Configuration), the configuration file you created for the current project should be listed as an option. Select the file and then press Load.

1.4. Customize TerraSync Display

Immediately before going out to survey, open TerraSync and the project you created if it is not already open, choose Existing File from the second menu in the Data window and select the file you created. If prompted for antenna height, leave as default; antenna height does not matter unless you are using GPS for vertical heights.

There are three different windows that can simultaneously display different sections, or modes (i.e. Map, Data, and Status); set them up the way you want them to be when you start collecting points.

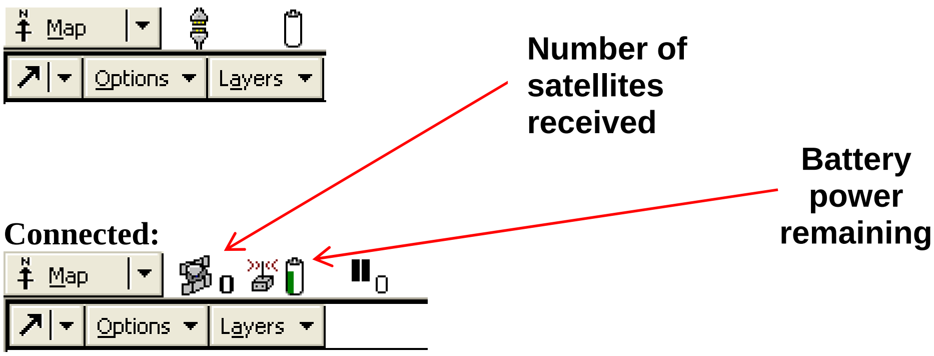


2. Collect GPS positions

2.1. Connect to GPS in TerraSync

Make sure your GPS receiver is connected to the data logger through the appropriate COM port (specified under GPS Settings in Setup mode). From Setup mode, Click on the Options button and choose Connect to GPS, or simply click the “GPS” button in the upper right-hand corner of the window. Icons on left-hand side of the upper toolbar display current status; clicking on each icon provides additional details.

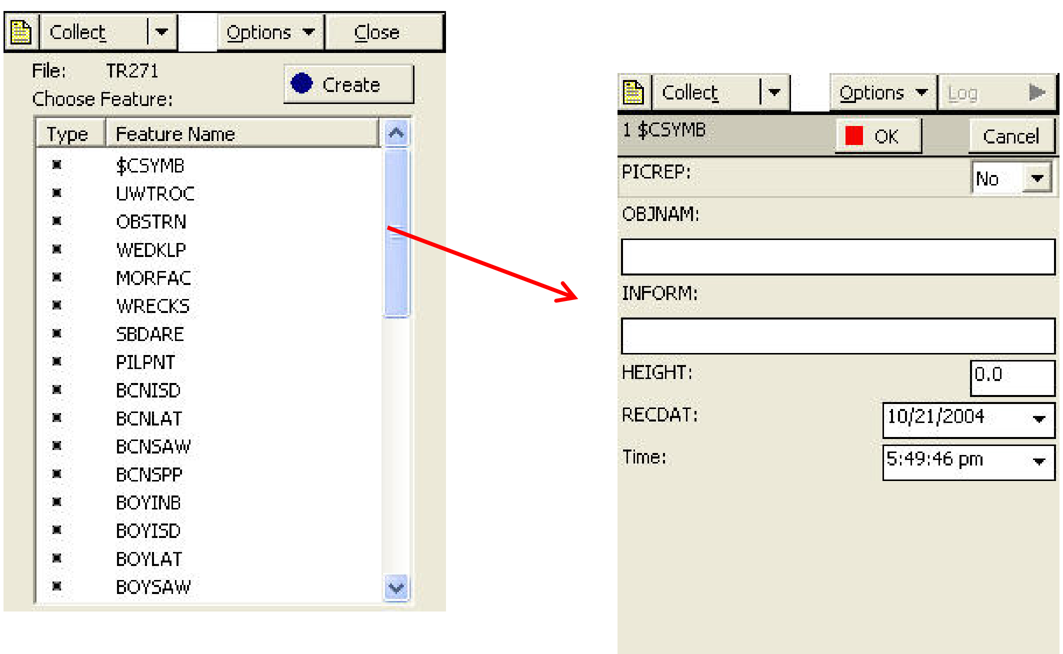
Connecting to GPS:



In Data mode, choose Collect Features from the second pull-down menu, then Log Later from the Options menu. This setting is recommended for logging precise positions from a launch because the time required for S57 attribution is most likely longer than the boat can stay still. Choosing Log Later allows you to enter feature attributions at a leisurely pace, and to acquire a GPS signal only when you are ready. Select Collect Features from the Data menu to prepare for acquisition.

2.2. Collect GPS data with S57 attribution

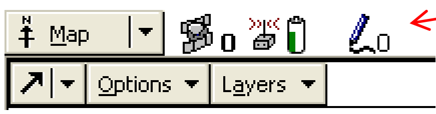
When you are ready to begin taking a position, highlight the desired feature type from the list in TerraSync's Collect Features mode, and click Create (this will not begin logging).



Fill in all required fields (all those above and including the INFORM field) as well as any desired optional fields; click OK. To abandon the feature or switch feature types, click Cancel and start again.

NOTE: It is important to enter the correct *feature* type before beginning to log; as attribute fields are specific to feature type you won't easily be able to change feature type in Pydro. *Attributes* can easily be altered in Pathfinder or Pydro, so it is fine to take more detailed notes by hand and electronically update attribute fields later.

To begin logging, click the Log button in the upper right hand corner of the Data window in Collect mode. The pencil icon on the left-hand side of the upper toolbar indicates that positions are being logged and displays the number of positions recorded for this feature.

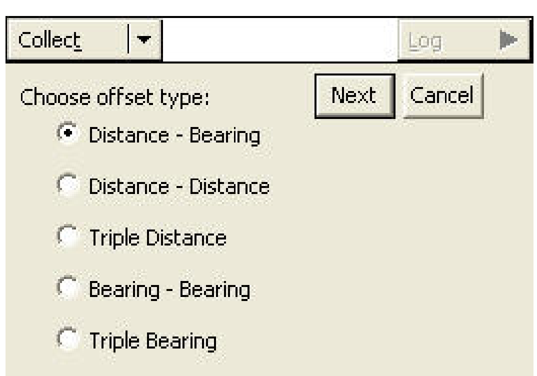


Positions recorded for current feature

After several positions have been logged (if the boat is drifting it is better to get just a few localized points than many spread-out ones), press Pause to end logging for this feature. It is possible to add more positions to the feature by hitting Resume and then Pause, but this option should be used with discretion and not while drifting.

2.2.1. Account for offsets

Often, a feature will be at some distance and bearing from the actual GPS antenna when a position is logged. Offsets can be accounted for during creation of a new feature: from Data mode, choose Collect, then click the Create button. From the Options menu select Offset. The simplest way to measure offset from a shoreline vessel is through the Distance - Bearing technique; select this option, then Next.



While logging the position, another person should determine range (visually or with a laser rangefinder) and bearing (with a compass adjusted for true North) from the Trimble antenna to the point of interest of the feature. After logging but before closing the position, follow instructions on the Offset screen to enter Bearing (T) and Horizontal distance in the blank fields. Vertical distance does not need to be entered.

Press OK to return to the feature attributes; press OK when values have been filled in and you are ready to record the position.

2.2.2. Input external sensor data to GPS

It is possible to connect external sensors (i.e. a laser rangefinder or camera) to the GPS unit so that data transmitted by the sensor will automatically be recorded and associated with a DP. However, the laser rangefinder was not consistently accurate enough in moving seas to make this option desirable in 2004.

3. Complete Detached Positions (DP's) form

To log a detached position (DP), fill out all information on the DP form: DP form_FA_04.

A system should be set in place in order to keep track of all the positions that are logged and to ensure that no positions with duplicate names are recorded. For example, use a Unit #, Day #, DP# format, where 12581 represents Trimble Unit 1, Day 258, DP 1, and 225913 represents Trimble Unit 2, Day 259, DP 13. This is the same unique number that is entered as OBJNAM attribute when entering information in the data logger.

For each DP, make sure to record the position number (i.e. 12581) and feature type ($CSYMB, UWTROC, BCNLAT) as well as the position of the actual feature in relation to the GPS antenna. It is also important to record how the depth or height was determined. Range may be determined visually or with a laser rangefinder; use the INFORM field to note any other relevant pieces of information.

3.1. Associate photographs with DP's

If possible and desirable to take photos, keep track of how many photos were taken of each feature or make some sort of notes to indicate which pictures correspond to each

DP so they can be correlated back on the ship. It is helpful to mention any other relevant information as well, such as the direction the picture was taken toward or the water level at the time.

Continue on to Shoreline Processing SOP!
Back to top

caris®

TECHNICAL NOTE

SHP file to Notebook Edit Layer: conversion procedure

Prepared By:

Serge Lévesque

January 19, 2005

115 Waggoners Lane
Fredericton, NB Canada
E3B 2L4
Phone +1.506.458.8533
Fax +1.506.459.3849

www.caris.com

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

caris®
A Universal Systems Ltd. Company
info@caris.com www.caris.com

DOCUMENT HISTORY

Date	Name	Changes
01.19.2005	SL	First draft

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

TABLE OF CONTENTS

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

1 INTRODUCTION

The purpose of this Technical Note is to describe the procedure involved in converting SHP files to a Notebook Edit Layer. The advantage of this method is the transfer to an Edit layer of the spatial components of the SHP file and mapping of relevant attributes to their S-57 counterpart. Once in the Edit layer, the data can be edited. Relevant S-57 attributes can also be specified.

In order to provide SHP file conversion support, Notebook now includes options for the following tools:

- The CARIS conversion utility was added to Notebook. It allows conversion of SHP files into a CARIS file and Access .mdb database file.
- A new Visual Basic tool was developed for Notebook to allow merging the CARIS file's spatial components with the original SHP file attributes contained in the Access .mdb file. This uses the output from the conversion utility to produce a merged Access .mdb file. This file can be parsed into Notebook using the Object Import Utility.

These utilities support the following workflow for SHP file conversion to Notebook's Edit layer (stand-alone HOB). This support provides Notebook with a self-contained import solution for SHP files.

- SHP file -> Conversion utility -> CARIS File + MDB file
- CARIS File + MDB file -> CARIS To MDB -> Merged MDB file
- Merged MDB file -> OIU -> OIU layer
- OIU layer -> Import Selection -> Edit Layer

The details of this procedure are provided below.

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

caris®
A Universal Systems Ltd. Company
info@caris.com www.caris.com

2 REQUIREMENTS

Note that the visual Basic tool CARIS2MDB requires the Windows .NET framework 1.1 OS extension in order to operate normally. The option to install this free OS extension is provided in the CARIS Notebook 2.2 beta install. This upgrade can also be made by a system administrator by accessing the Microsoft Windows site, downloading the Microsoft Windows .NET framework 1.1 install and installing it on the computer.

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

3 THE CONVERSION UTILITY

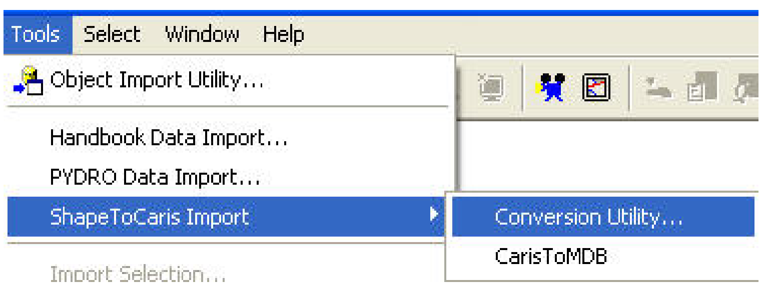
The conversion utility allows mapping of the SHP file to a CARIS file and an Access database (.mdb) file.

After conversion, the CARIS file will contain the spatial elements of the shape file. One attribute field must also be mapped as a unique identifier allowing the link between the CARIS map and its corresponding attributes in the Access .mdb file. In the following example, the OBJECTID attribute field in the SHP file will be mapped to two CARIS identifiers: CARIS Key and Source ID. These will be used later to merge the spatial contents of the CARIS map together with the attribute content of the Access .mdb file.

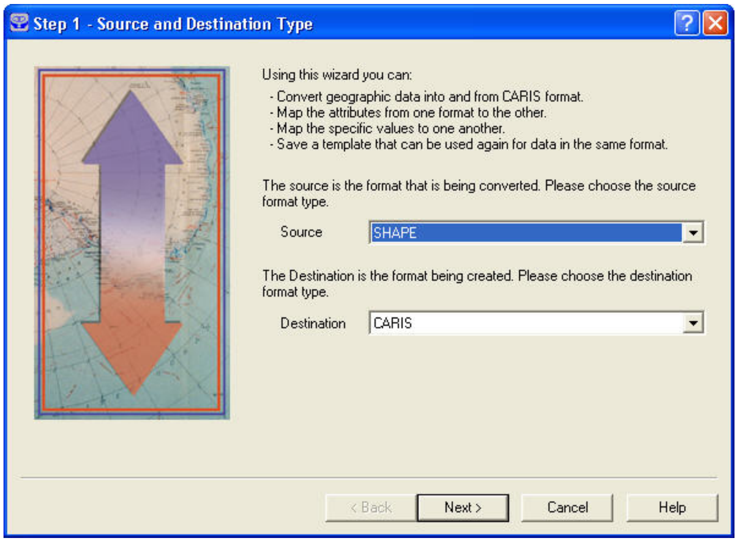
The Access .mdb file will contain the attributes that must be preserved for the S-57 objects but that do not map to CARIS identifiers.

The user must first open a data set in CARIS Notebook 2.2 beta. This data set can be one of the SHP files to convert or a S-57 ENC for the same area. The following command is used to launch the conversion utility.

Tools > SHP to CARIS import > Conversion Utility

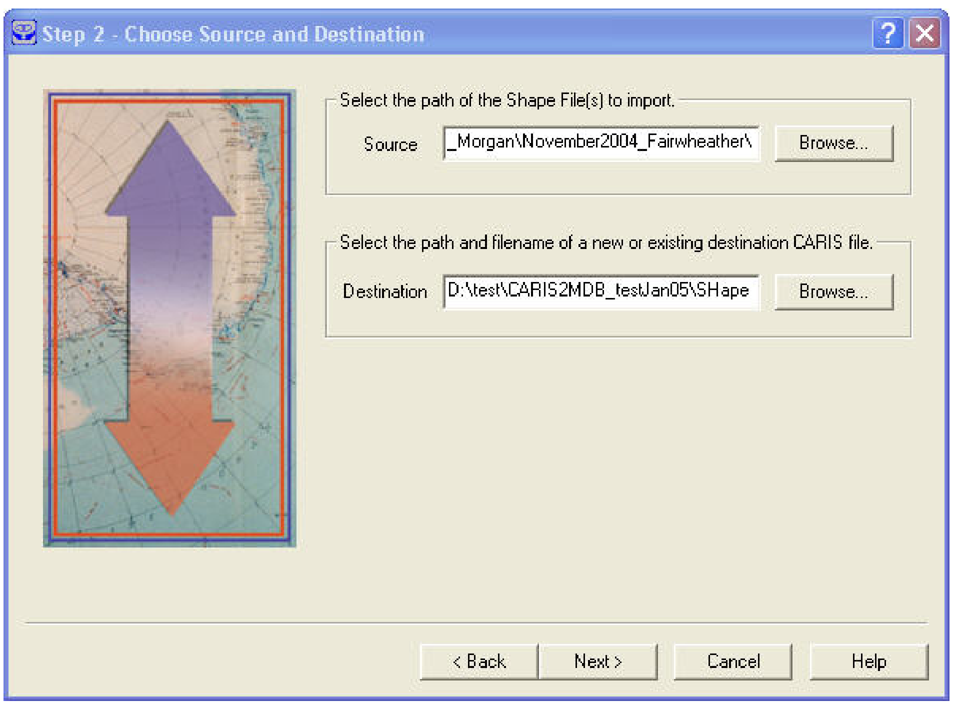


This will open the Conversion Utility's interface at step 1 (see on next page).



For this conversion we are going from SHAPE (Source) to CARIS (Destination). Specify these two entries and click on Next.

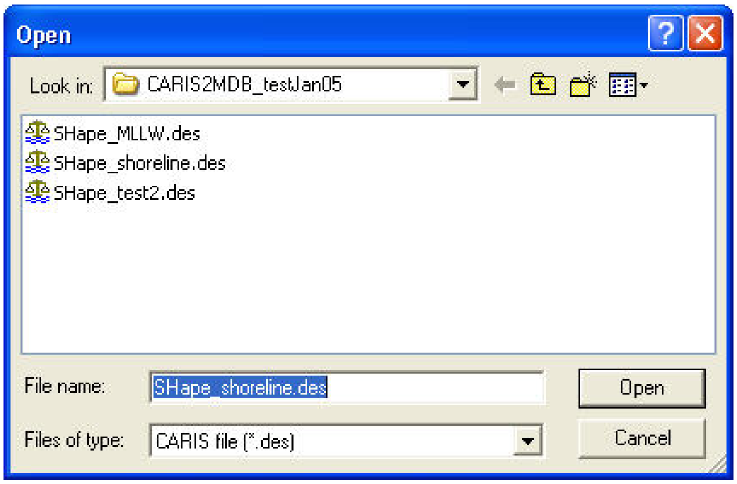
At step 2 of the conversion, the user must specify the source directory where his SHP files are stored and the CARIS file that will be created as part of the conversion.



The user must select the path to the directory acting as the Shape file's repository. This source directory can be selected with the Browse button in the top section of the window.

Note that a special care must be given to avoid very long path names for either the source or the destination directory.

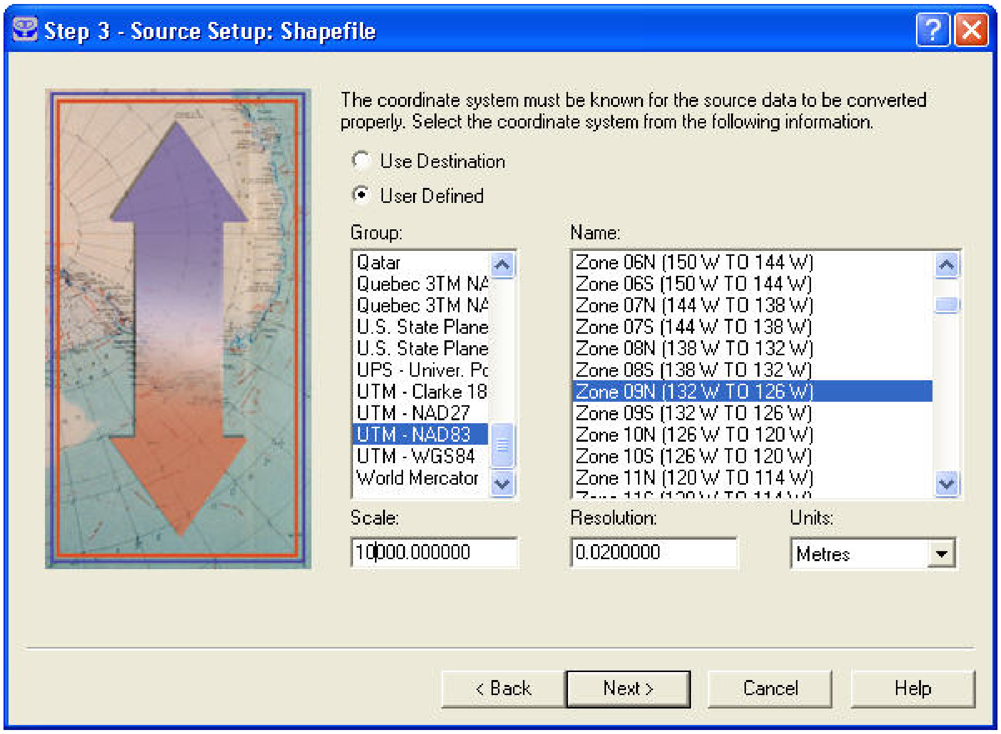
The path and name of a new or existing CARIS file that will be used as destination must be specified. This is done through the use of the Browse button in the lower entry section of the window. The path must first be specified with the browser. In the case of the creation of a new CARIS file as part of the conversion, the new file name must be typed and Opened. Since the default file format is a CARIS map, there is no need to add the extension.des in the file name. See below in the screen capture.



Specify the file name and click on Open.

Click on Next at the bottom of step 2's window.

The step 3 window appears. This is where the source setup is done:



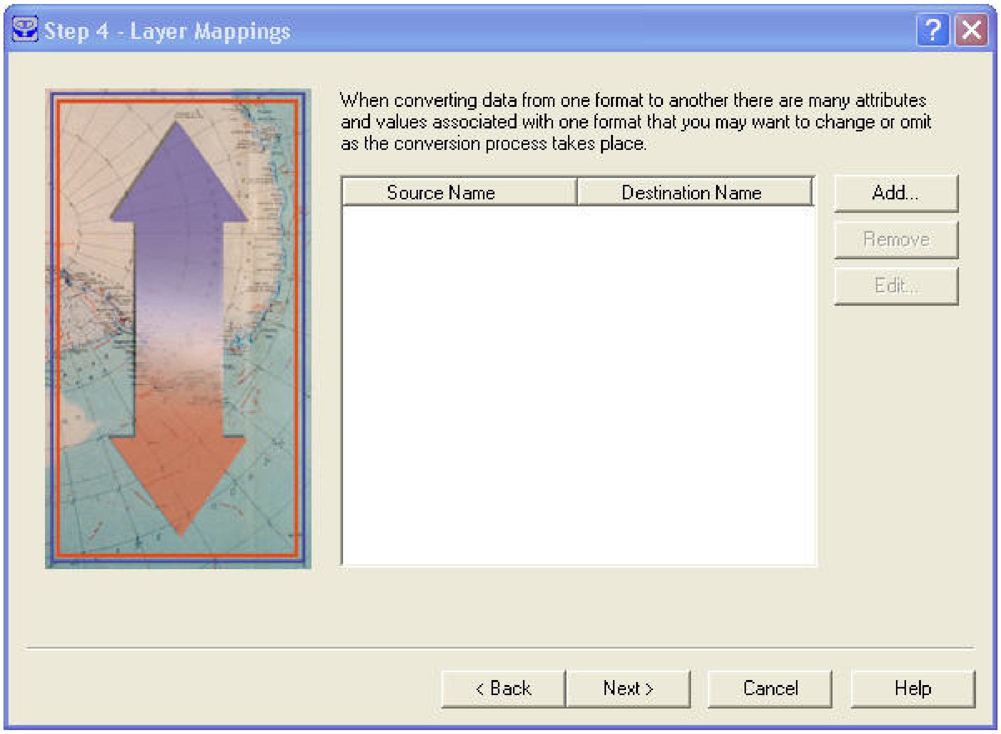
At step 3, the user must know what the projection of the SHP file is. Because a new CARIS file is being created, the appropriate coordinate system of the SHP file must be known and used.
Select the option: User defined

In this case the SHP file's coordinate system is a UTM grid, Zone 9 N, on the datum NAD83. The preferred scale is 1:10000 and the resolution and units can stay as they are: 0.02 m on the ground.

Select Group: UTM-NAD83
Select Zone: Zone 09N (132W to 126W)
Set Scale: 1:10000
Set Resolution: 0.02
Set Units: Metres

Click on Next.

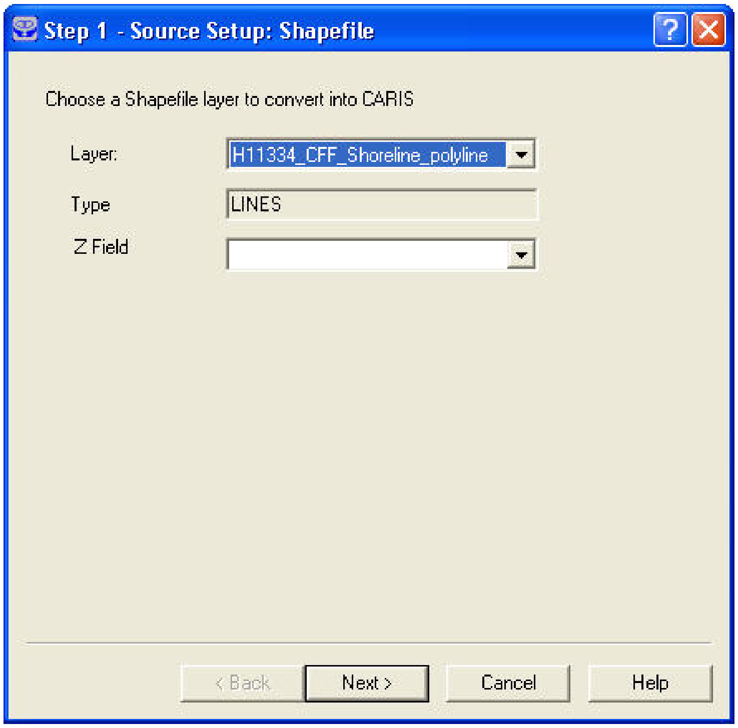
At step 4, the layer mapping is done.



Click on Add.

The layer mapping is divided into # steps:

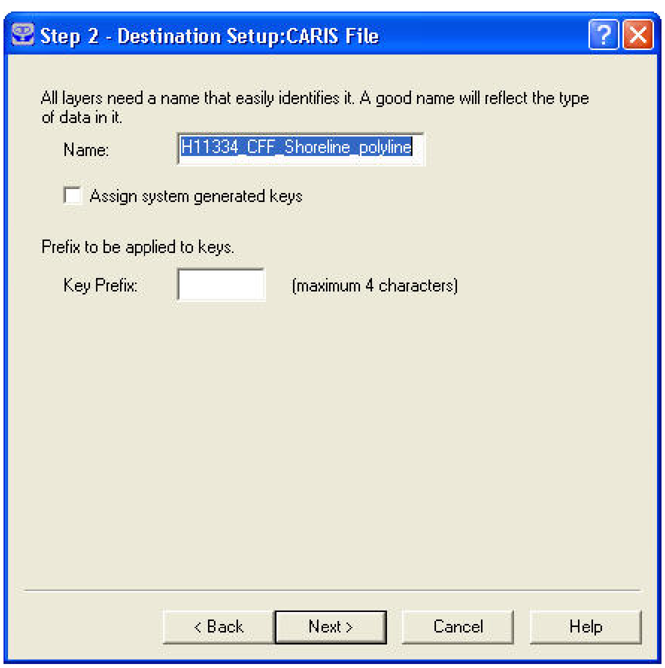
Step 1 of layer mapping allows to setup the Source SHP file data to convert. See below:



Select the layer or SHP file to convert. Automatically, the data type is selected. In this converter, the SHP file must always be of only one data type: points or lines.

Click on Next

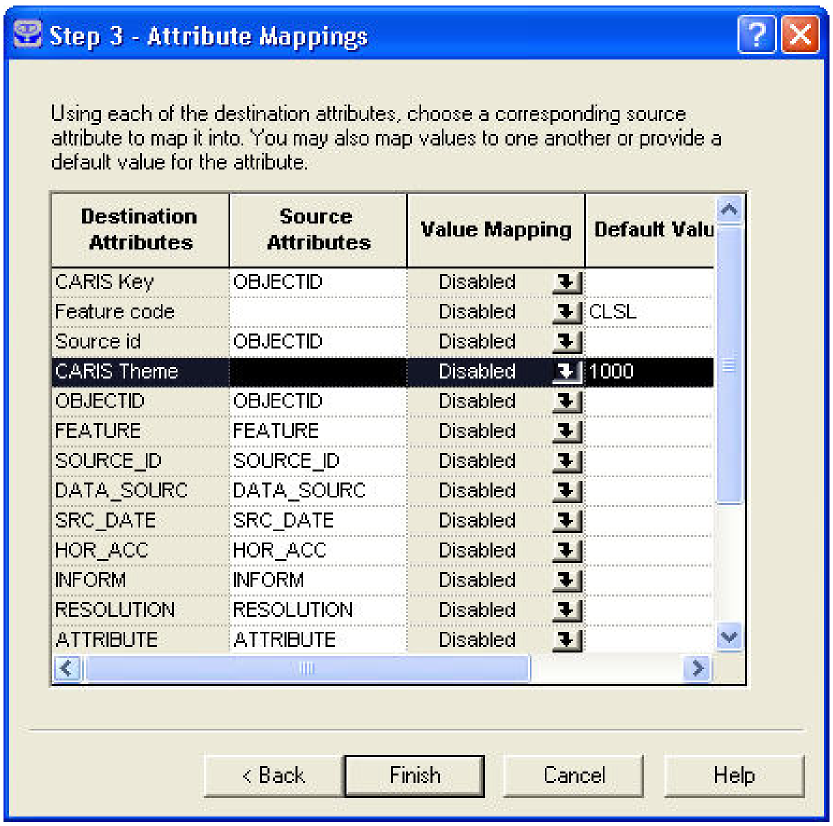
At step 2 of layer mapping, the destination CARIS file is setup. An layer name is chosen.



There is no need here to assign system generated keys.

Click on Next.

At step 3 of the layer mapping, the attributes of the SHP file are mapped to the CARIS identifiers:

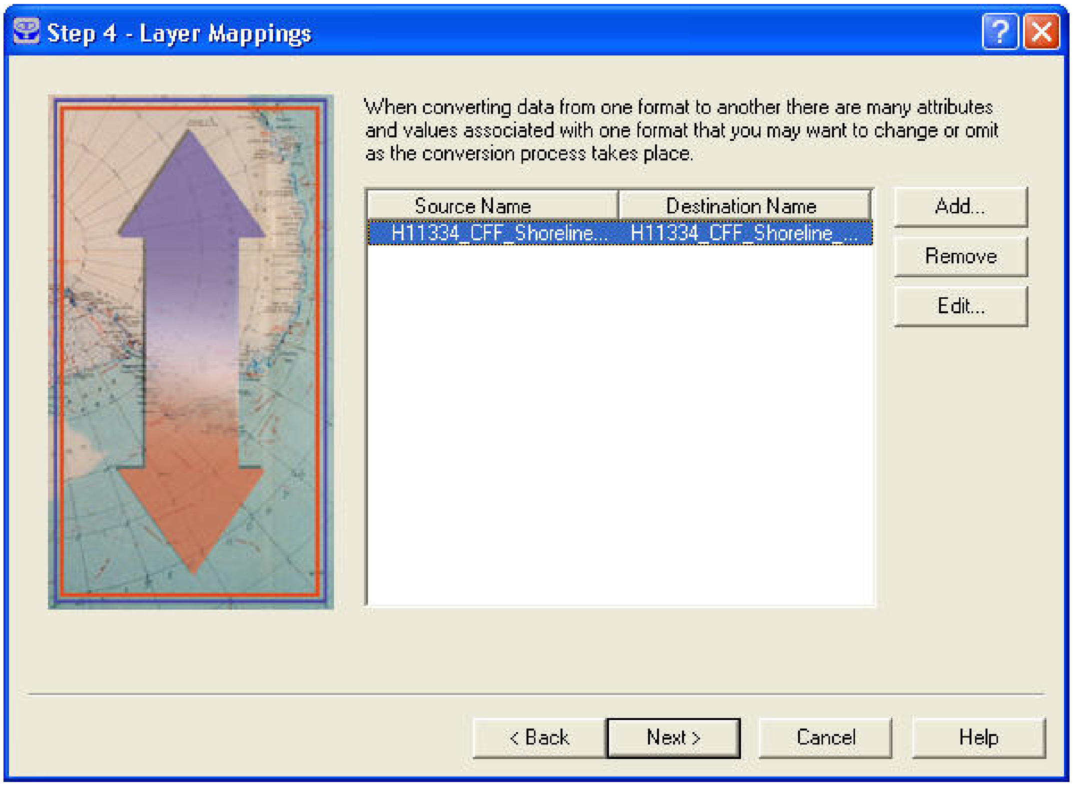


The attribute field OBJECTID from the SHP file is being mapped to both the CARIS Key and to the Source ID destination attributes. Both the Feature Code and the CARIS Theme are set as default values. The Feature code is set as CLSL (CoastLine Surveyed Line). The CARIS Theme or layer number is assigned as 1000 (any number can also be selected between 0 and 2000000).

Note that it is very important at this step to assign the same SHP attribute field to both the CARIS Key and the Source ID. This will be required when the CARIS and MDB files are merged together.

Click on Finish.

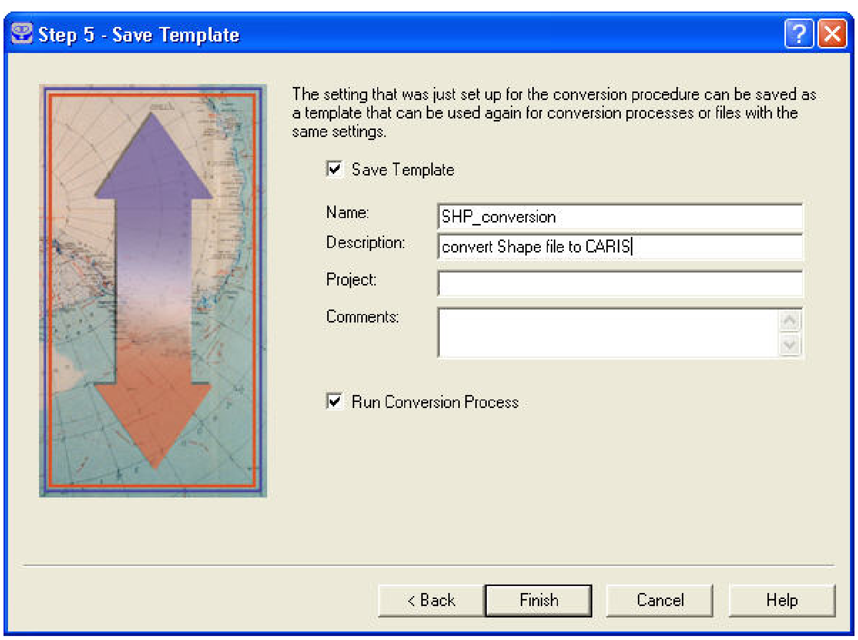
The program returns to step 4 of the Conversion Utility (see on the next page).



Highlight the conversion to be done.

Click on Next

The final step of the conversion (step 5) appears on the screen.



CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

The conversion can be saved as a template.

Put a check mark in the Run Conversion Process

Click on Finish.

The conversion runs and provides a status window. At the end of this conversion a CARIS map and an Access .mdb file are created.

CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

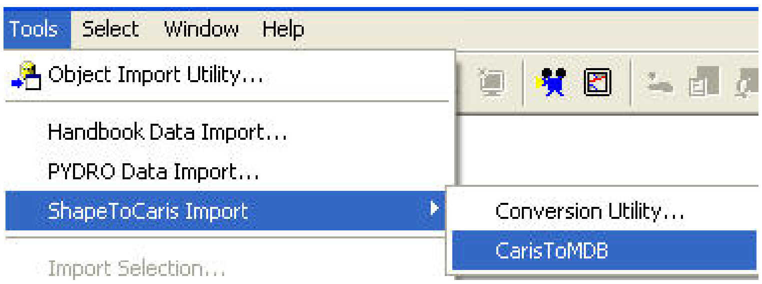
A Universal Systems Ltd. Company
info@caris.com www.caris.com

4 CARISTOMDB: MERGE CARIS AND .MDB FILES

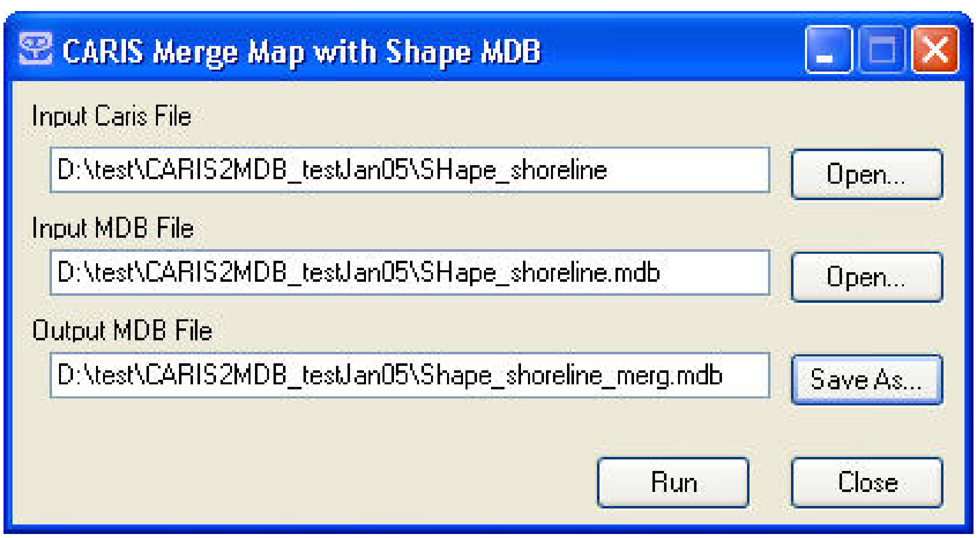
At the end of the Conversion Utilities, the two files produced contain the spatial information (CARIS file) and the attributes of the SHP file (Access .mdb file). CARISToMDB is a new utility added to Notebook to merge the information from the two files, the CARIS map and the Access .mdb file into a single Access .mdb file.

To use this utility, make sure that data is opened in Notebook and use:

Tools > Shape to CARIS Import > CarisToMDB



This will call the following interface:



Using the Open and Save As browse buttons, select the 2 input files and the merged output file.

Example:
Input Caris File: D:\test\CARIS2MDB_testJan05\Shape_shoreline
Input MDB File: D:\test\CARIS2MDB_testJan05\Shape_shoreline.mdb
Output MDB file: D:\test\CARIS2MDB_testJan05\Shape_shoreline_merg.mdb

Click on Run to launch the merge procedure.

This resulting single Access .MDB output file is needed to allow the mapping of the S-57 attributes through the Object Import Utility.

5 OIU: MAPPING THE MDB FILE TO S-57 OBJECTS

Now that the SHP file's information has been regrouped into a single Access Database file that includes both the spatial components and the original SHP attributes, it can be parsed into S-57 objects using the Object Import Utility (OIU).

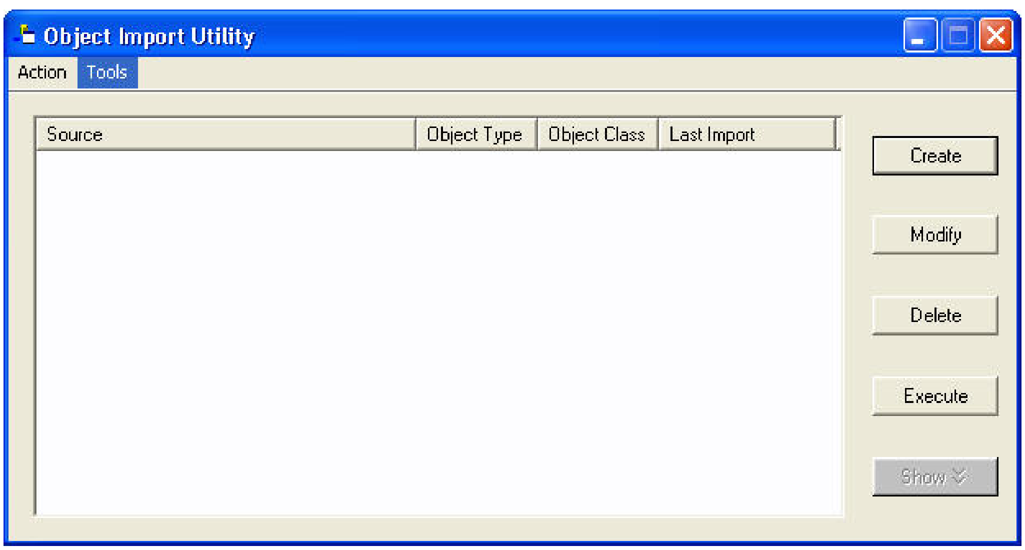
This utility can convert points or lines data into S-57 objects. For each input file, a single type of S-57 object will be created.

Several scripts will be created to allow the parsing of different types of S-57 objects. Make sure that a scripts directory has been setup to receive these.

The OIU is launched from the menu bar or by using its icon:

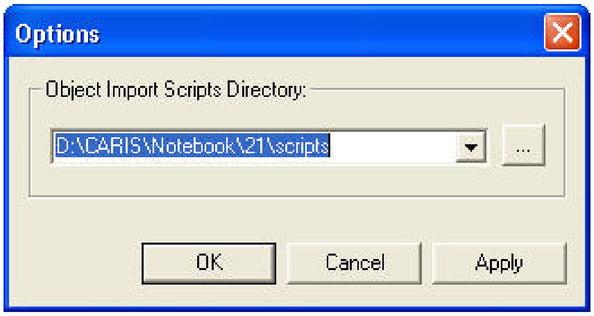
Select: Tools > Object Import Utility

The OIU interface is launched.



Click on Tools > Options

This allows setting the directory where the OIU scripts will be stored (see next page).



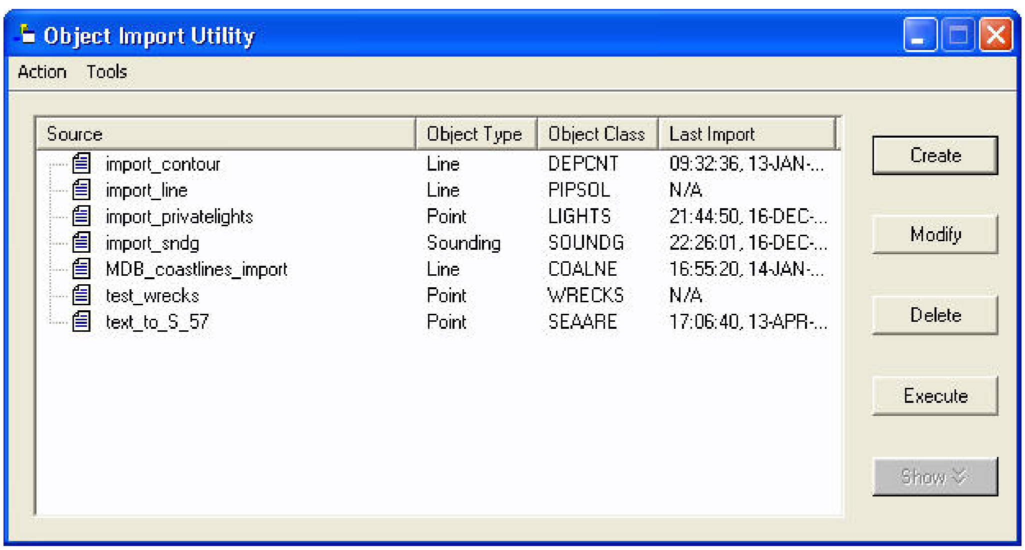
Use the browse button to set and select the Object Import Utility Scripts Directory.

Example: D:\CARIS\Notebook\21\scripts

Click on Apply.

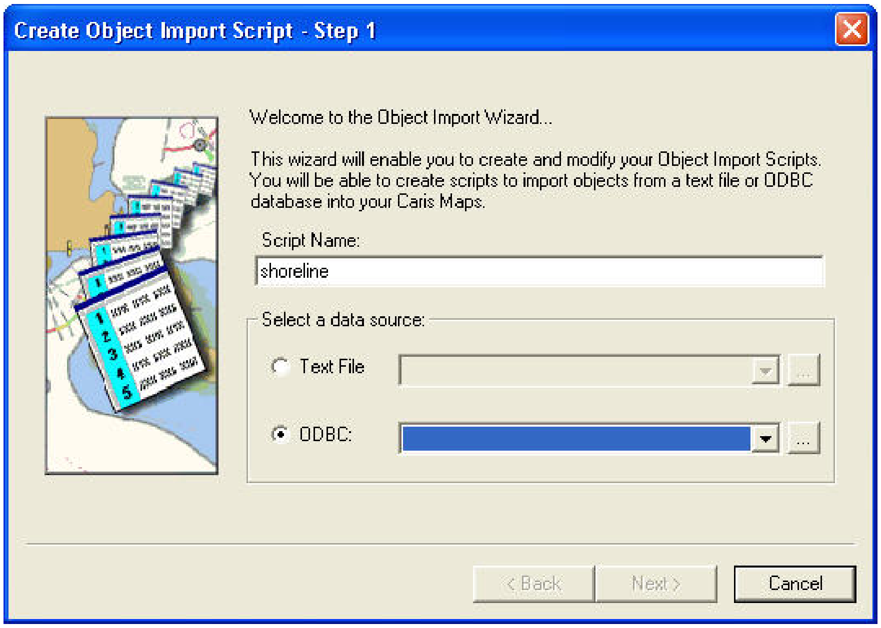
Click on OK.

If there are already scripts generated in the scripts directory, they will be listed when the Object Import Utility Window is refreshed.



To add a new OIU script, click on Create.

The Step 1 window for Creating an Object Import Utility Script appears (as seen on the next page):



Choose a good name for the script.

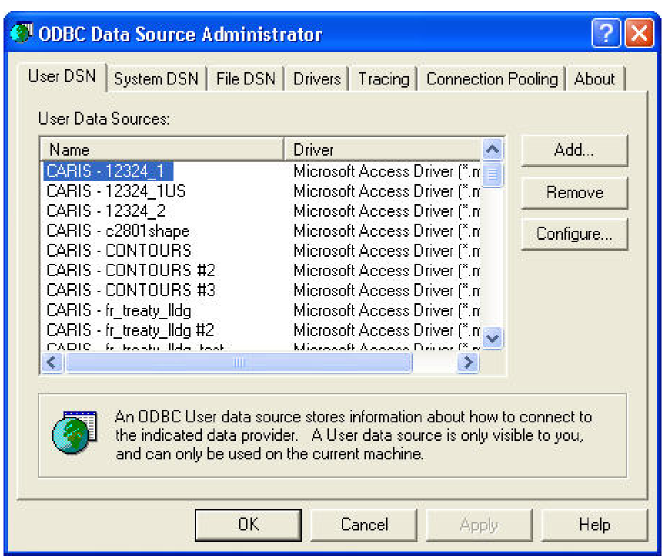
Script name: Shoreline

Select the Access .MDB data source. This Access database is an ODBC compliant source.

Choose ODBC as the data source.

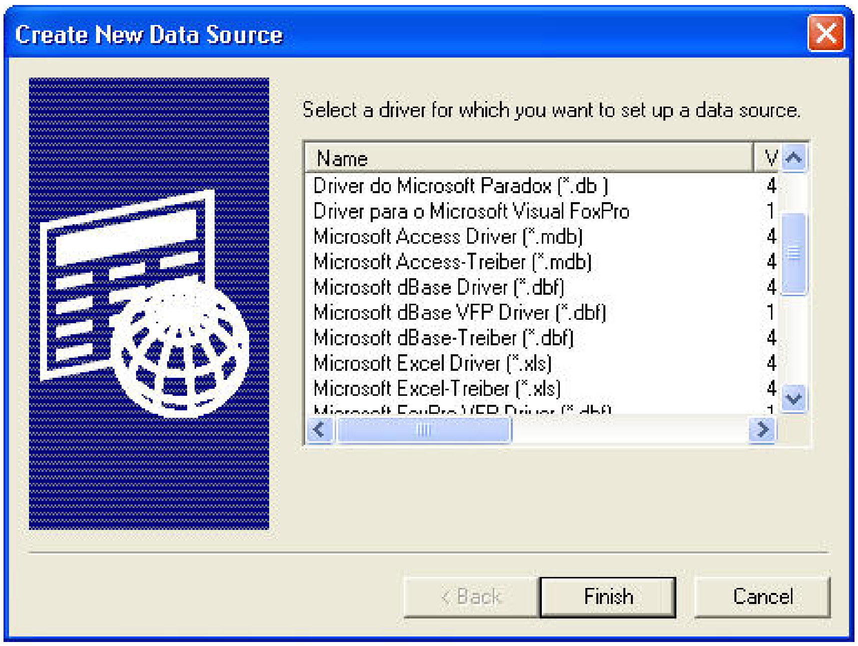
Click on the Browse button to select setup the ODBC source.

The ODBC Data Source Administrator Window appears.



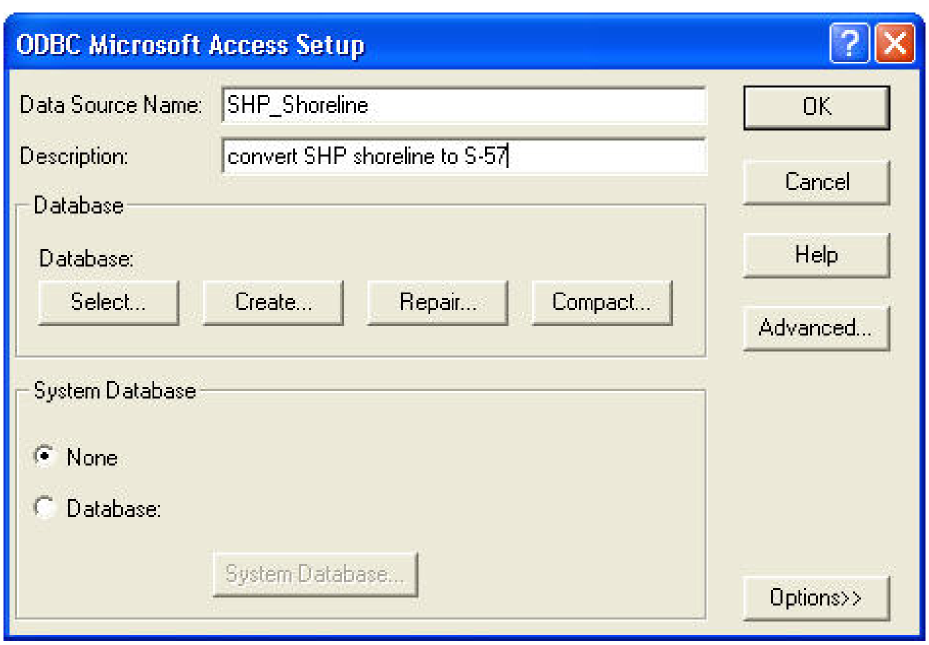
Click on Add.

The Create New Data Source Window appears. This is where the type of ODBC source is selected. Look for Microsoft Access .mdb and select it.



Click on Finish.

The conversion script's ODBC type of connection must be named and the output file must be specified.

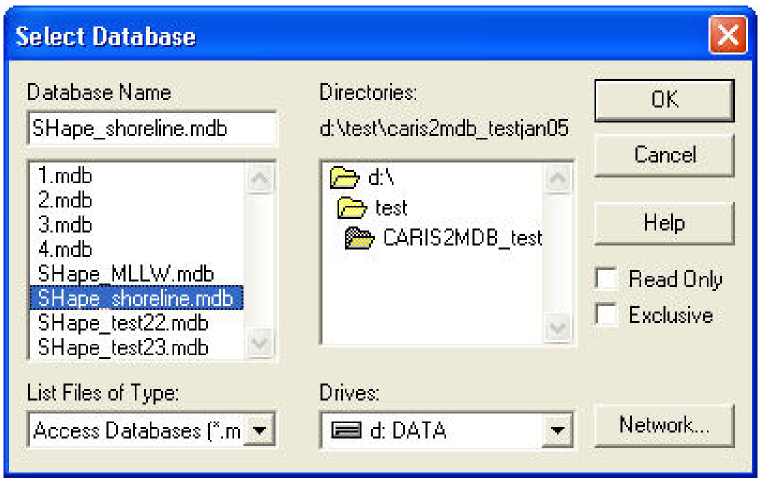


In the example, the Data Source name is: SHP_shoreline
The Description is given as: Convert SHP shoreline to S-57

The input database must be specified in the Database section:

Click on Select.

Select the merged Access .mdb generated at the previous step with CarisToMDB.

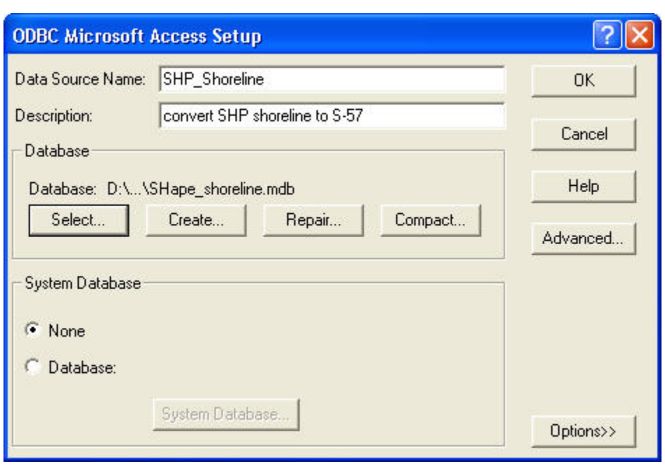


Select the directory where the merged Access .mdb was created and select the proper merged .mdb file.

In the example,
Directory: D;\test\CARIS2MDB_testjan05
Database name: Shape_shoreline_merg.mdb

Click on OK

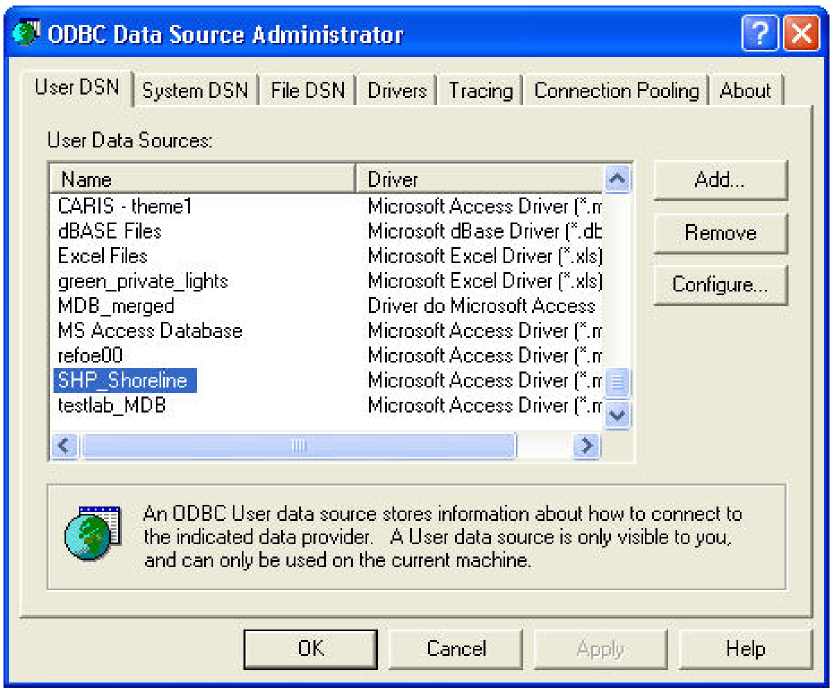
The ODBC Microsoft Access Setup window reappears.



Click on OK.

The ODBC Data Source Administrator window comes back. This is where the source setup must be selected.

Select the Source setup just configured:

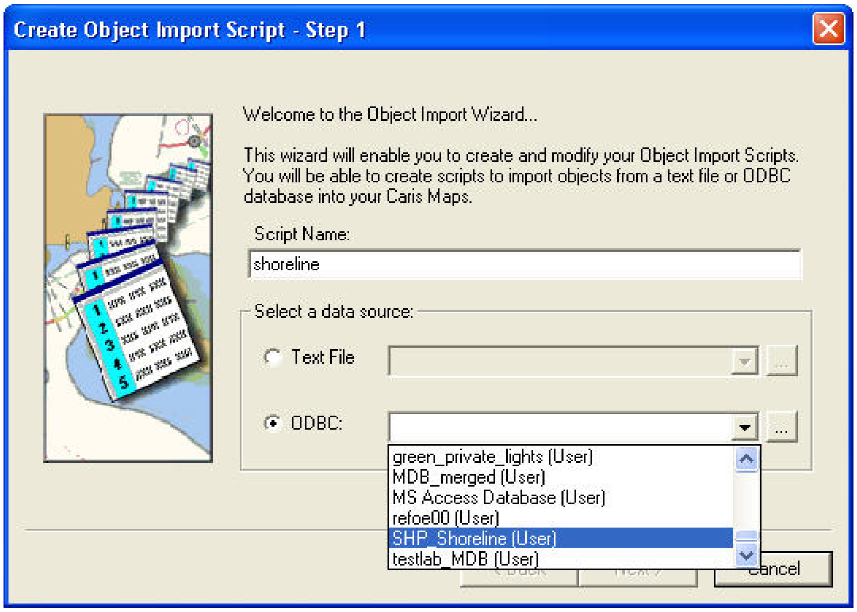


The User Data Source SHP_Shoreline is selected.

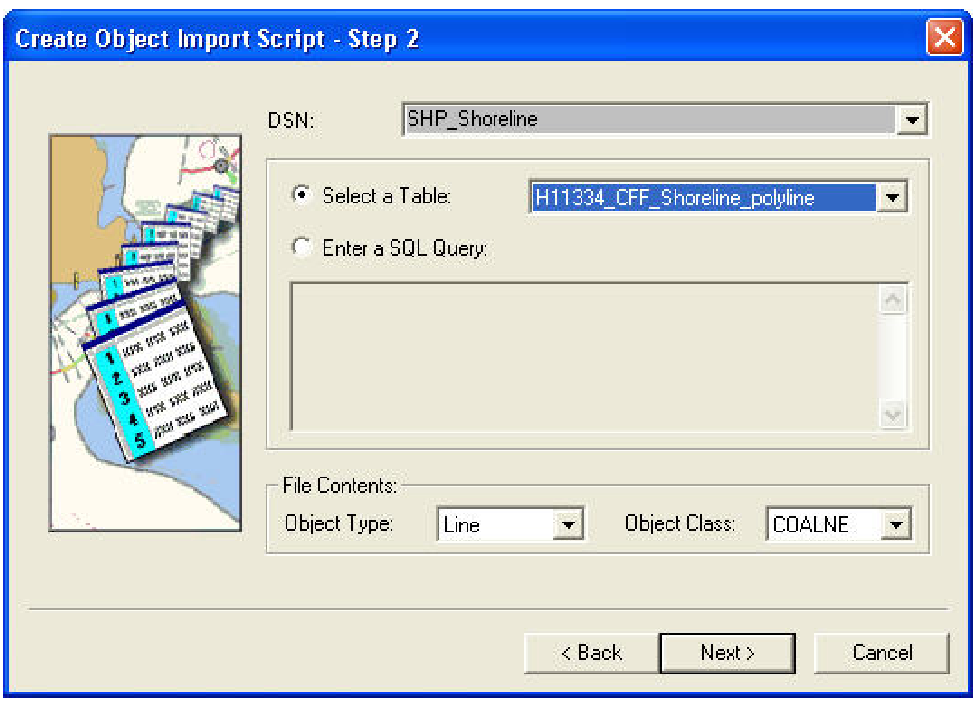
Note that selecting the User Data Source and clicking on Configure allows changing the input database (.mdb) used by the script.

Click on OK.

This brings you back to Step 1 of the Create Object Import Script procedure (see next page).



Click on the tab on theright of the ODBC entry box to get the drop down menu shown on the figure above. Select the ODBC setup called SHP_Shoreline (User)



Select a Table. There should be a single table in the .mdb file.

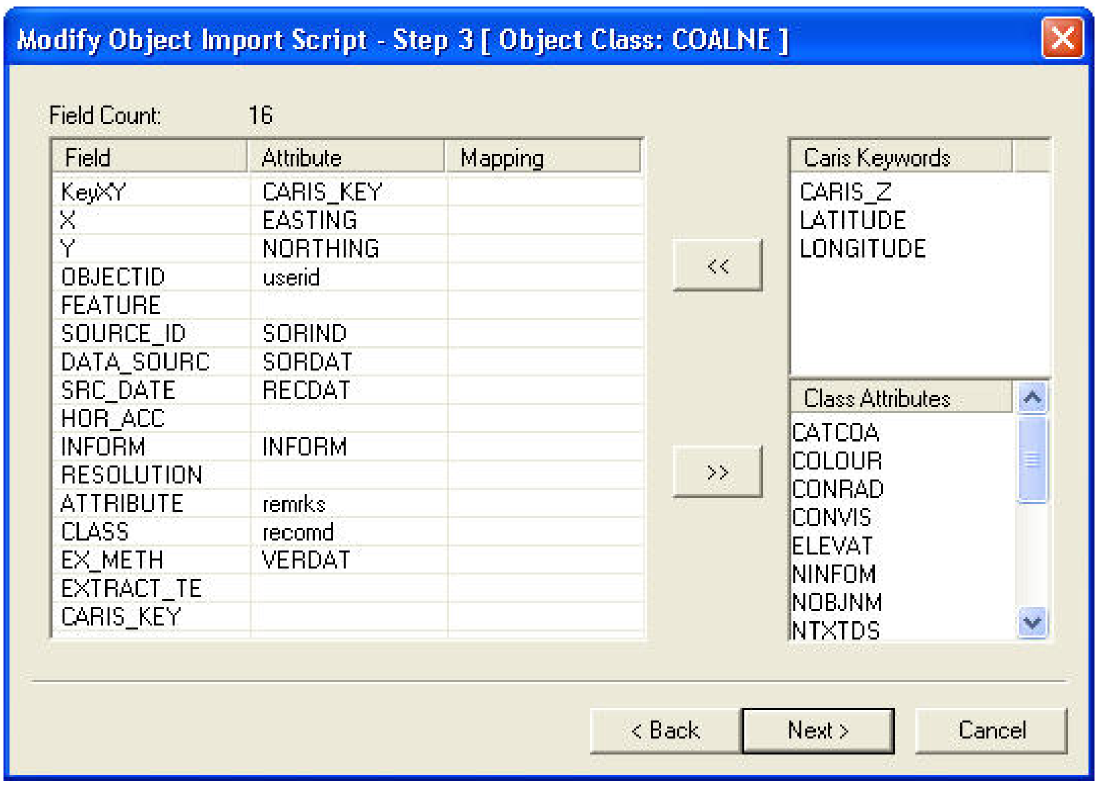
The file contents must then be specified. Here, the data is of Line Type. It is being mapped to the S-57 Object Acronym: COALNE (which stands for coastline). Select the proper Object Type from the drop down list and the proper Object Class.

In this case:
Table: H11334_CFF_Shoreline_polyline
Object Type: Line
Object Class: COALNE

Note here that the SQL query is a powerful tool that could be used to isolate objects with certain attributes (example: Attribute field content: Natural: Mean High Water). This could be used to restrict the conversion to these entries only.

Click on Next

The final step of the OIU script setup is the mapping of the S-57 Object's attribute to the attributes given in the input .mdb file. See below. The following is only an example.



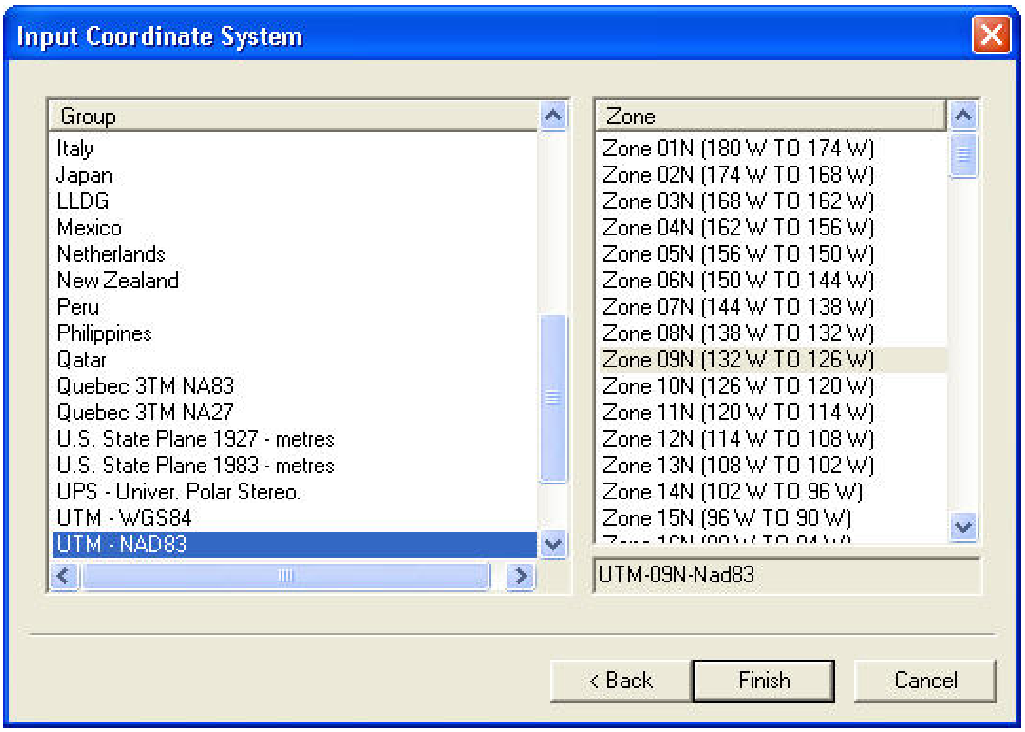
Note that the Merge operation added the 3 top fields to the .mdb file. The mapping is as shown above. The ground coordinates in eastings and northings are mapped to the appropriate CARIS Keywords. The KeyXY field must be mapped to the CARIS Key.

Note that additional attribute definitions were added to the S-57 dictionary to allow storing 3 new user specified fields: userid, remrks and recomd.

As shown their mapping is as follows:
userid: OBECTID

remrks: ATTRIBUTE
recomd: CLASS

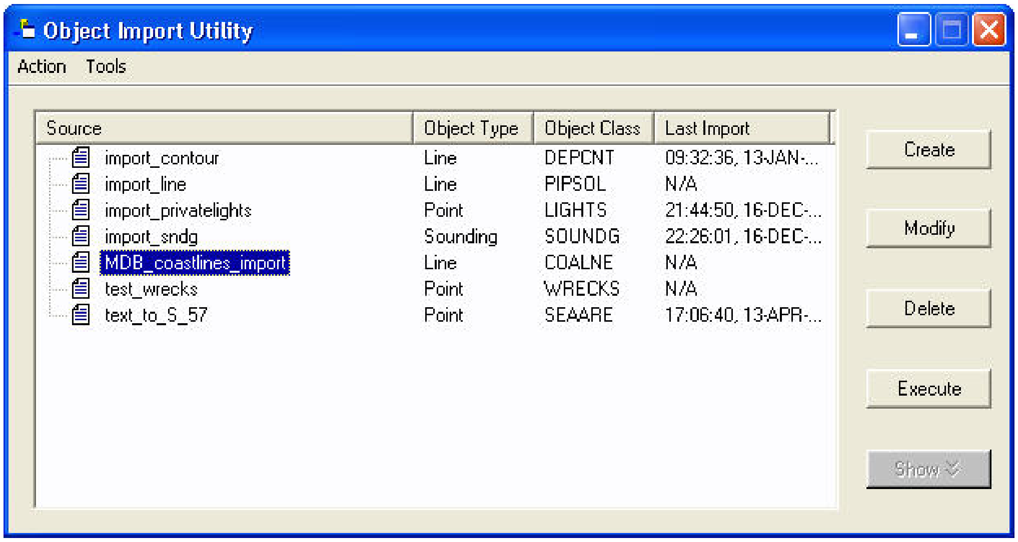
Click on Next.
Specify the Input Coordinate system. This coordinate system is still the same: UTM Zone 9N on Datum NAD83.



Select the appropriate selection for the Group and the Zone.

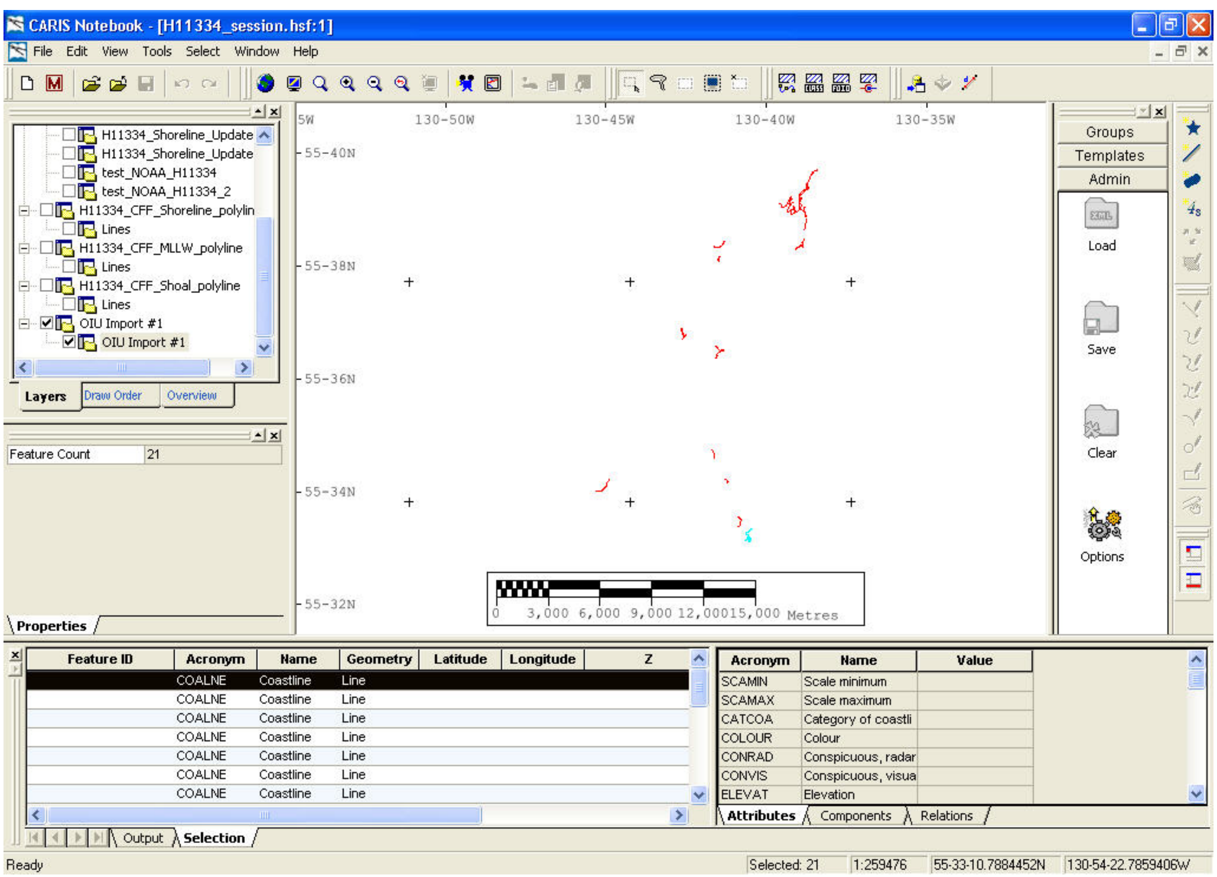
Click on Finish.

In the OIU’s main screen, select the appropriate script for converting the merged Access .mdb file into S-57 objects.



Click on Execute.

The data contained in the merged Access .mdb file is now residing on a temporary OIU layer (see below). It needs to be imported and saved into a permanent Edit Layer (Stand-alone HOB file).



CARIS
115 Waggoners Lane
Fredericton, New Brunswick
Canada E3B 2L4
Tel +1.506.458.8533 Fax +1.506.459.3849

caris
A Universal Systems Ltd. Company
info@caris.com www.caris.com

6 COPY THE OIU LAYER TO AN EDIT LAYER

To finalize the transfer, the new S-57 data must be transferred from the OIU virtual layer to an Edit Layer (permanent stand-alone HOB file). This will be achieved with the Import Selection utility.

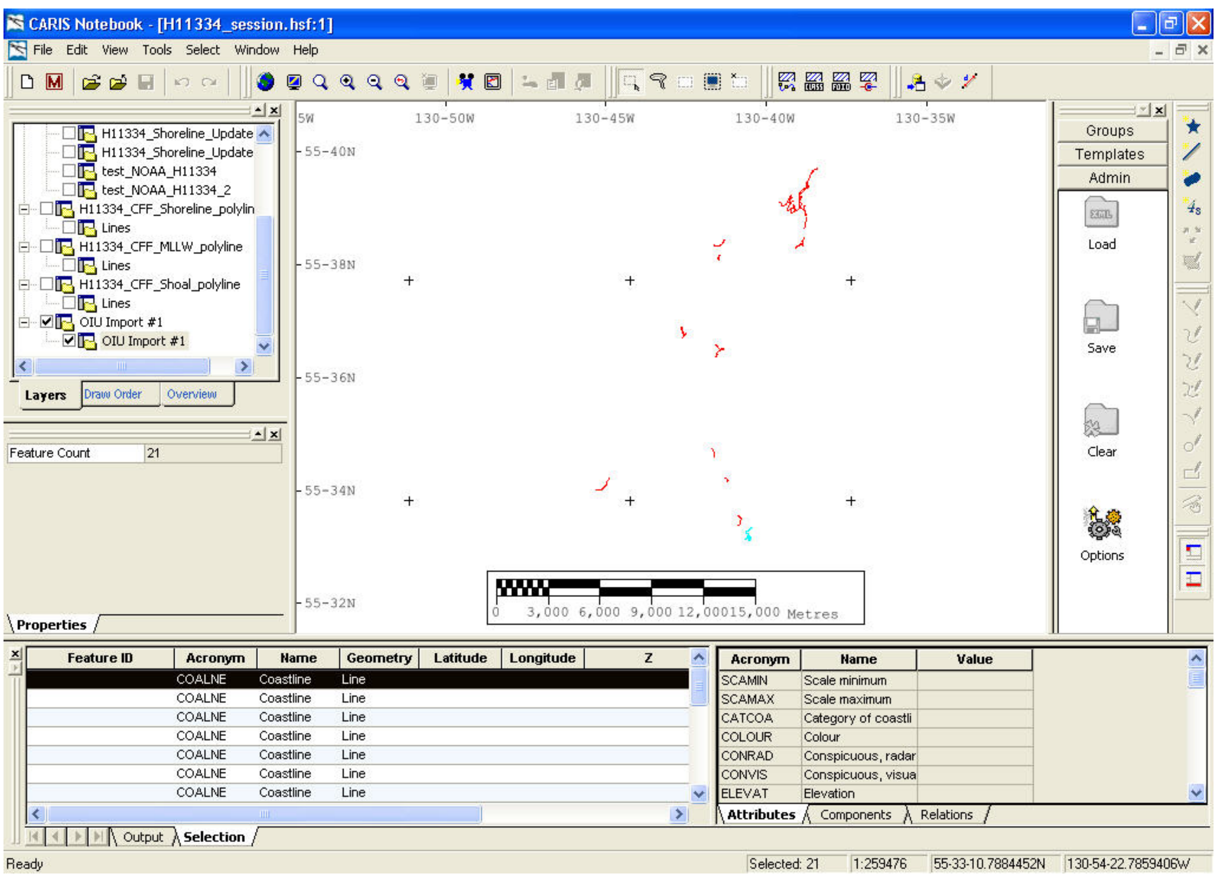
The following steps must be done:

Create the Edit Layer intended for receiving the new information. Make sure that the name will reflect both the source and content of the new S-57 data.

Example : create an empty Edit Layer called: test_NOAA_H11334

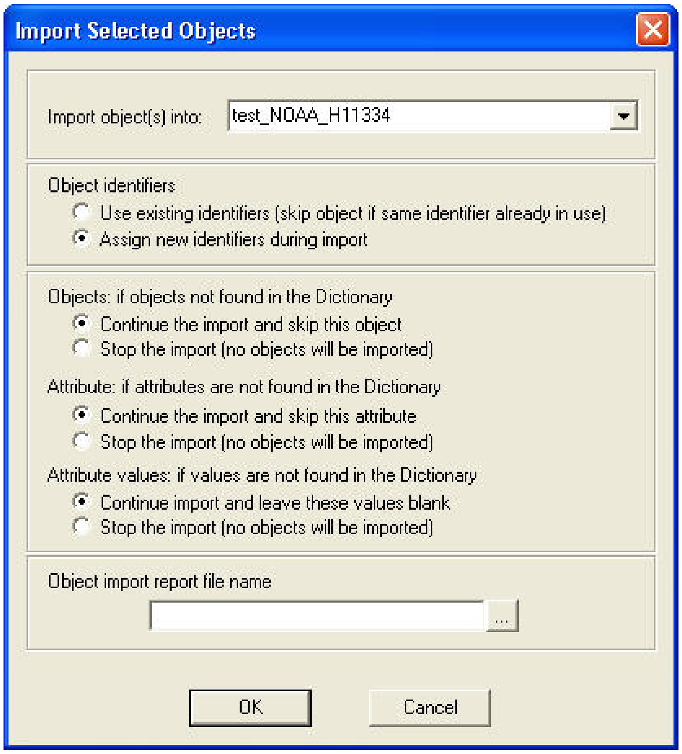
Select the new OIU layer in the layer tree.

Select all on the OIU layer.



To perform the transfer, use the Import Selection from the Tools menu.

Tools > Import Selection

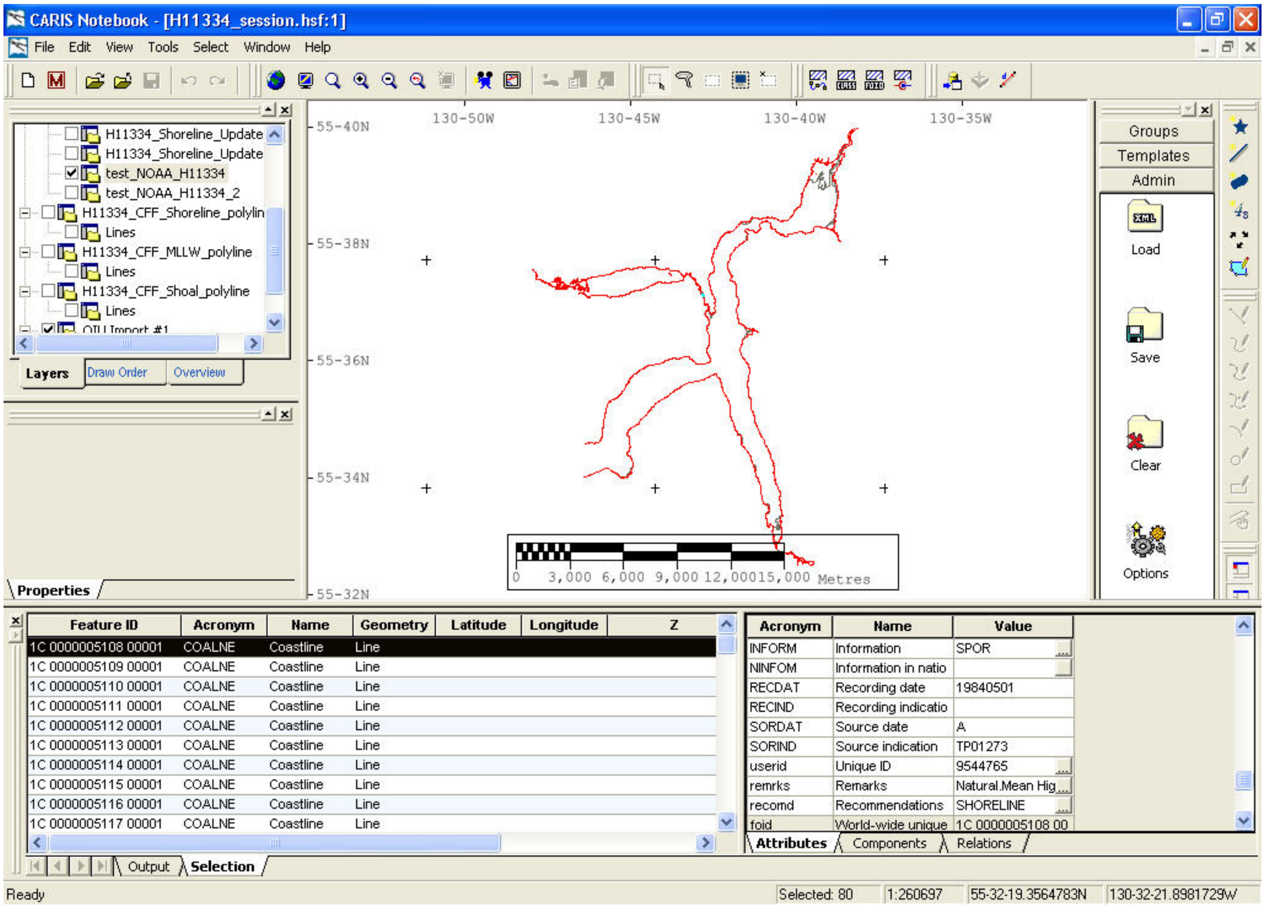


Use the tab in the “Import Object(s) into” section to select the new Edit layer from the list.

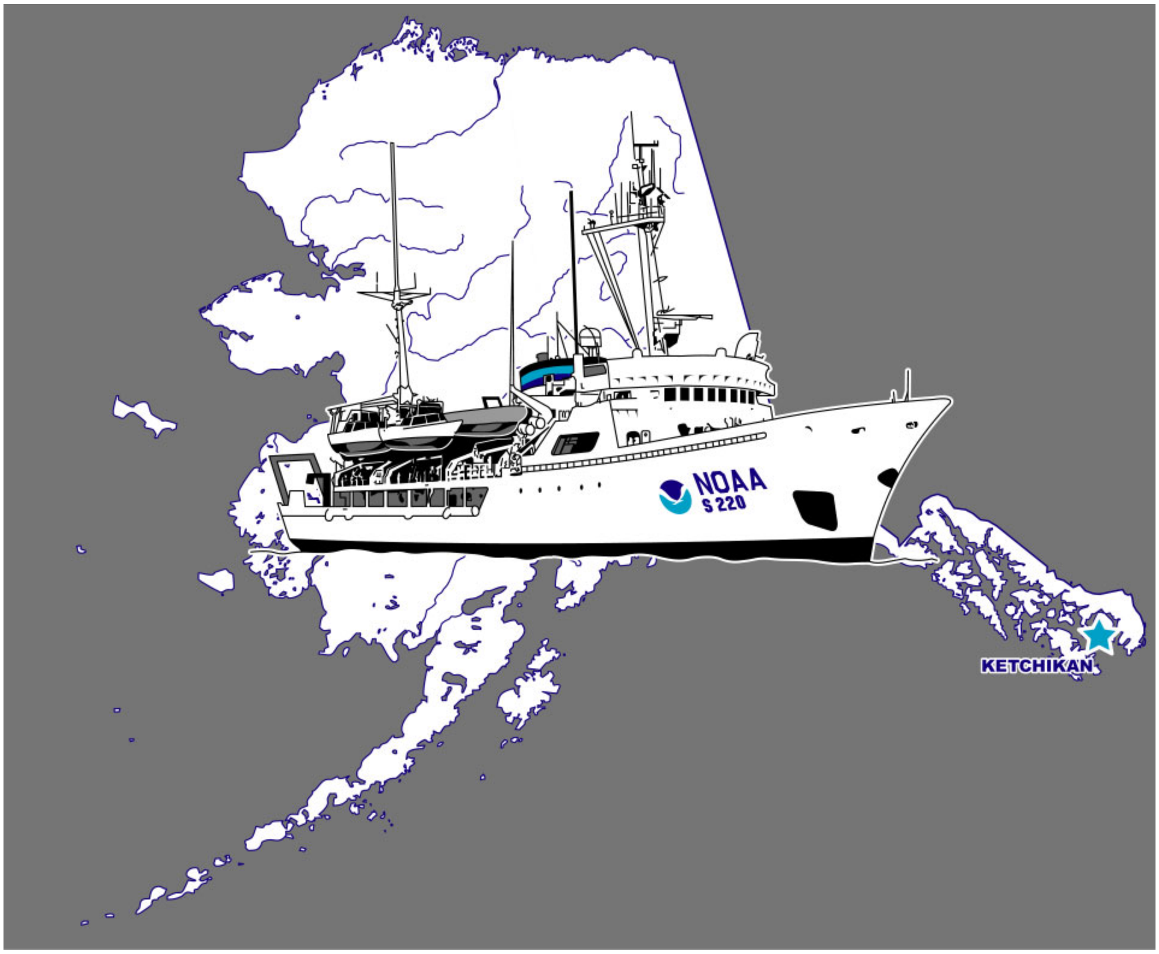
In the case where there are no previous foid (S-57 unique Feature Object ID) attributes recorded for the new objects, keep all the defaults and click on OK.

For the case where original S-57 foids need to be preserved, choose the “Use existing identifiers (…” in the “Object identifiers” section and click on OK.

The result will be as given on the next page:



At this point, the original SHP data has been mapped and converted into S-57 objects on an Edit layer. Standard S-57 attributes can now be populated and specified as required.



RESON 8101/8111/8160
Data Acquisition

RESON 8101/8111/8160 Data Acquisition

Table of Contents

0.0 Document Scope

This is a step by step guide to acquiring RESON data.

1.0 Start-up Procedure

1.1 Turn on ISIS computer.

1.2 Make Day Number Folder on the Isis machine under appropriate project and sheet in Windows Explorer. It is also helpful to have this folder open and visible in Windows Explorer somewhere on screen to make sure that the lines are being recorded and saved correctly.

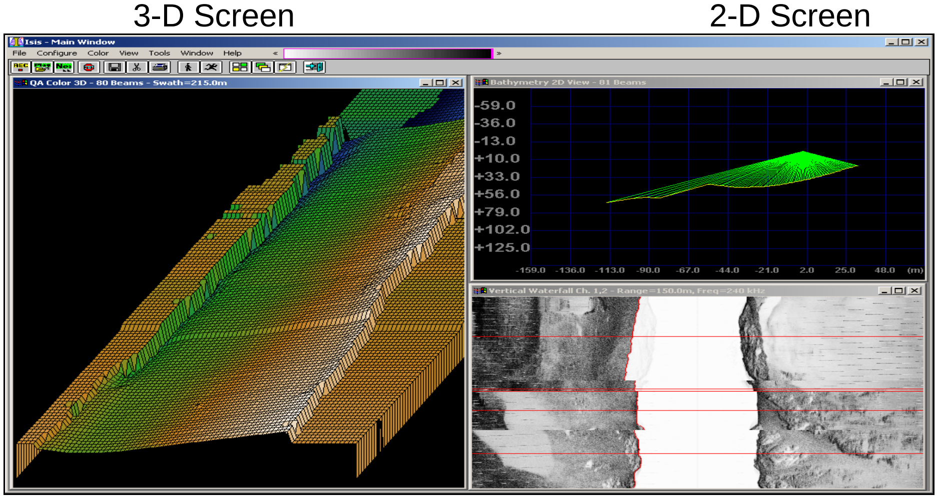
1.3 Launch Isis Sonar from the desktop. An empty shell will come up.

1.4 Turn on RESON machine.

1.5 On the upper left hand corner of the ISIS screen, hit “REC” (RECORD).

1.6 Three important image screens will come up in the Isis Main Window:

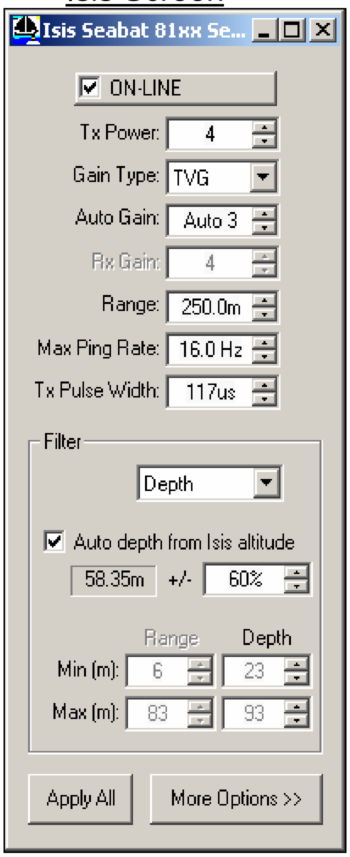
3-D Screen 2-D Screen



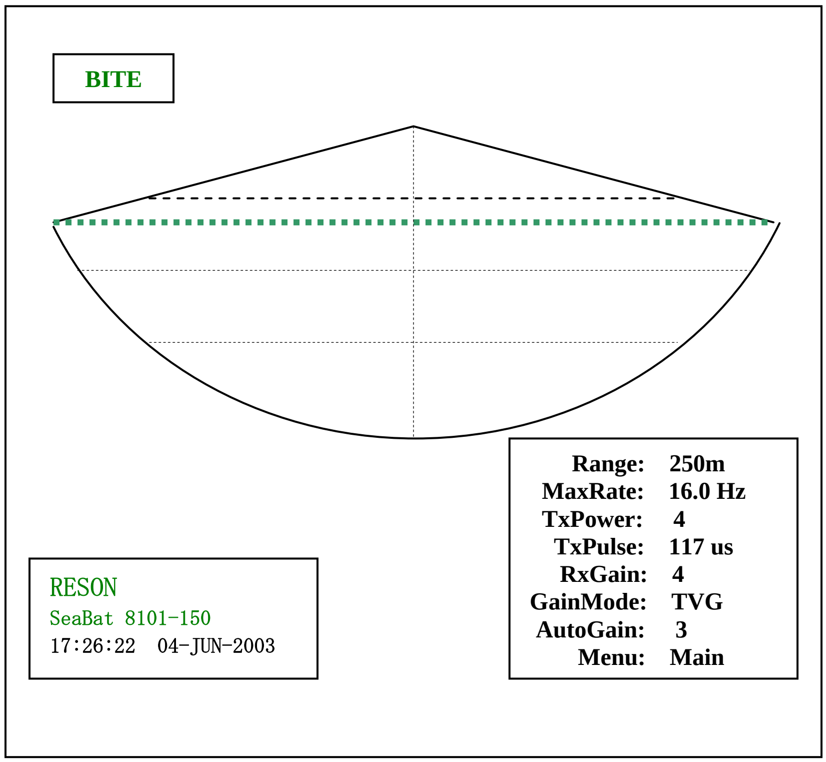
Vertical Waterfall/Sidescan

The Isis Seabat 81xx Server menu will come up that will allow you to change the settings that affect these three ISIS image screens as well as the RESON screen—i.e. general data quality of the sonar itself.

Isis Screen



Reson Screen



2.0 Isis Seabat 81xx Server

2.1 ON-LINE

This box should be checked all the time except to playback lines (See the Acquisition Tools section on page 12 for this procedure).

2.2 Tx Power

This controls how much power is going to the sonar. The power settings for the 8101 ranges from OFF to FULL with 1 to 7 in between. The power setting should be set as low as possible without getting too many flyers. When the power is set too high, often there will be a glow or a halo around each ping (this can be a result of other settings being too high also), as well as flyers. Do what you can to prevent this from happening.

2.3 Gain Type

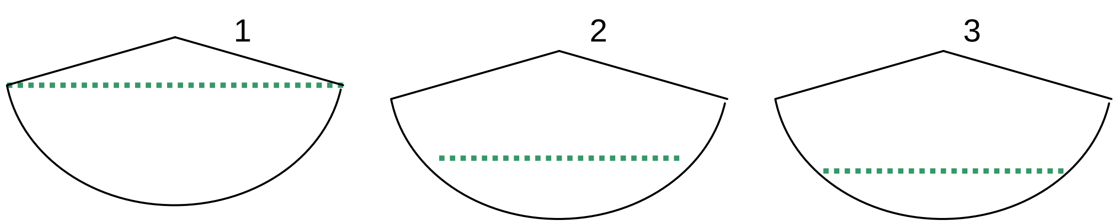
Gain type should always be TVG (Time Varied Gain).

Auto Gain – Auto Gain is an automatic gain function that can be used instead of Rx Gain, which is where the gain can be set manually. The setting for this ranges from Auto 1 to Auto 10. This will analyze the bottom return to increase or decrease the receiver gain. Auto 2 through 4 are the typical settings for acquisition. Again, try and set this as low as possible to prevent possible flyers and the “power glow” that will be seen if any setting is too high. To run the gain manually, hit “Off” on the drop down menu.

Rx Gain – Gain is the “ears” of the sonar. The Gain function controls the amount of receiver gain to be applied to the returned sonar signal. If you are using manual Gain mode, keep the number as low as possible, ranging from about 4 to 12 for best results.

2.4 Range

The Range setting determines ping rate and how far down the sonar will “see”. The 8101 minimum range is 0 (though the setting will never be seen so low) and maximum is 400. This will be the setting that will most likely be changed the most because it is so closely linked with water depth. The 8111 minimum range is 5 and maximum is 1400. The 8160 minimum range is 5 and the maximum is 5000. The Range should be kept above or even with the widest part of the wedge on the RESON computer screen, as in the first illustration below.



Good Too Low Bad
Outer Beams are Lost

2.5 Max Ping Rate

This will be already be set 20.0 Hz for the 8101. For the 8111 it is set at 20.0 Hz. For the 8160 it is set to 15.0 Hz. The only reason to change these values is if the vessel is in shallow water and moving very slowly and you wish to reduce superfluous data. These values should never be changed without approval of the FOO.

2.6 Tx Pulse Width

Pulse Widths on the 8101 ranges from 21µs to 225 µs, but keep these numbers within 70µs to 120µs for best results during acquisition. On the 8111 this value ranges from 50 µs to 670 µs, the recommended/minimum value for the 8111 is 225 µs. Donot go below 225 µs, nothing is gained by going lower. On the 8160 this value ranges from 0.2 ms to 10 ms. For the 8160 the pulse width is range dependent. At 750m, the minimum is 150 micro sec, at 1000m the minimum 300 micro sec, and at 1750 the minimum is 1 milli sec (the minimum is listed here, pulse width can be set higher but resolution decreases). The smaller the number, the narrower the pulse width. A narrow pulse width means higher resolution while cutting back on range capabilities; likewise a larger pulse width lowers the resolution while increasing the range (better outer beam response. Therefore, in sloping areas, increasing the pulse width will increase how much slope the Reson can acquire.

2.7 Filter

There are two types of filters that can be used during acquisition: The “Auto Depth Filter from Isis Attitude” and the Filter based on “Depth”, “Range”, or “Both” for depth and range together.

2.7.1 Auto Depth Filter

Percentage ranging from 1% to 100%. This filter is most helpful in sloping areas, i.e. the steeper the slope, the better the sonar will pick it up when the percentage is set high. However, a high percentage on a flat area will create flyers, so keep the percentage low in these cases.

2.7.2 Filter based on Depth or Range

Auto Depth Filter must be unchecked. To select between Depth, Range, or Both, simply click on the drop down menu to highlight your choice. For multibeam, utilize only the Depth option. Under Min (m); and Max (m); set depth values appropriate to the depth of water that you are working in, keeping in mind that any depths outside of this minimum and maximum will not be acquired.

2.7.3 No Filter

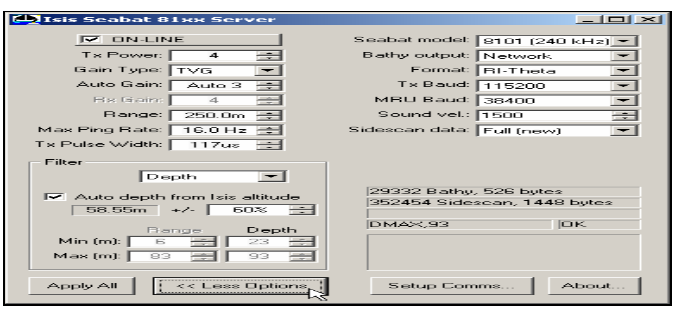
It is also possible to run with no filter by selecting "None" in the drop down menu.

2.8 Apply All

This button is inessential because every change made in the Seabat Server is immediately applied. Another reason it is not recommended to use this is it can cause the system to crash.

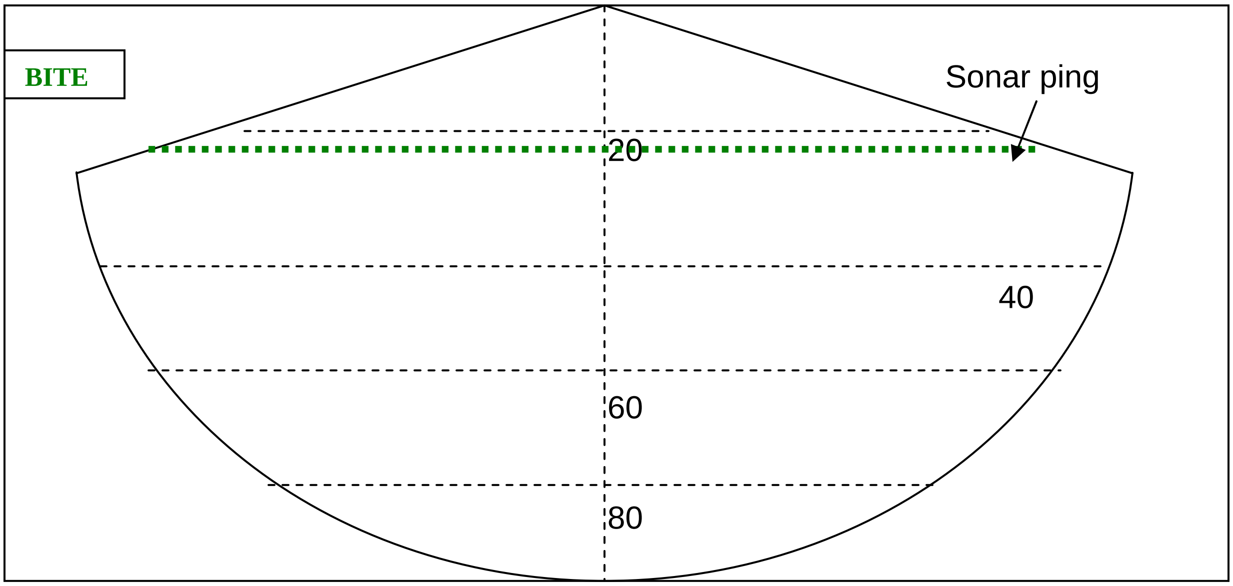
2.9 More Options

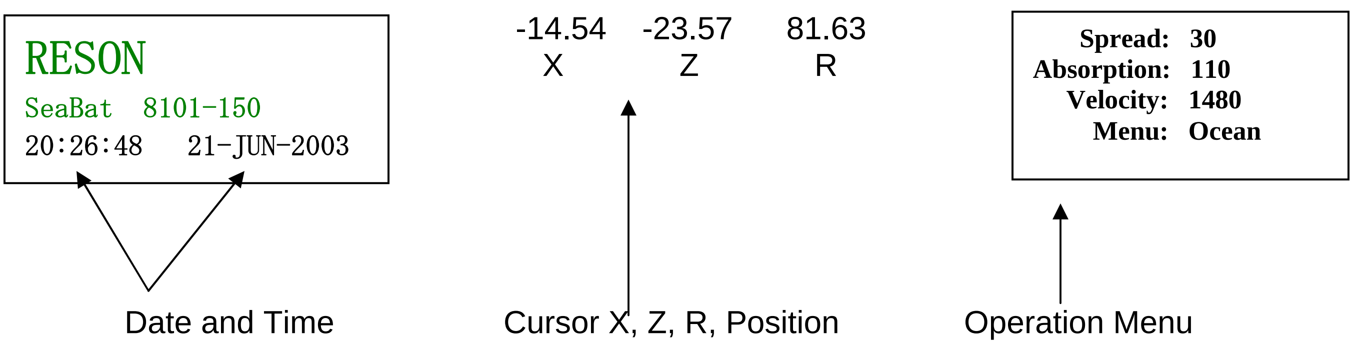
These are mainly configuration options. It is important to know where they are found, however these options should not be changed without FOO or CST approval.



3.0 Reson Display Screens

The Main Sonar Display Screen, which is used for acquisition, is shown below.





3.1 Cursor Position

When the cursor is within the wedge, its position is displayed. X = Across Track, Z = Depth, R = Range.

3.2 Operation Menu

There are four different menus, Main, Ocean, Filters, and Display. There is also the Menu Off option. To change between menus, simply click on Menu to scroll to the menu you need.

3.2.1 Main Menu

The Main Menu shares the same information that is found in the top half of the Isis Seabat Server: Range, Max (Ping) Rate, Tx Power, Tx Pulse (Width), Rx Gain, Gain Mode, and Auto Gain. These numbers should mirror the numbers in the Isis Seabat Server. If for some reason this is not the case, and changing settings in Isis has no effect on the sonar, the settings in the Main Menu can be changed by using the three-button trackball. The three buttons function as so: Left button—down, Right button—up, Middle button—speeds up the direction when held with the right or left button.

3.2.2 Ocean Menu

There are three options: Spread, Absorb, and Velocity. Spread and Absorption are linked together, where the numbers represent the amount of spreading and absorption loss that can be expected. These values will factor into the TVG, which in turn affect the return signal. For the 8101, keep these numbers at 30 and 70 in salt water and 30 and 20 for fresh water for the spread and absorption respectively. For the 8111, keep these numbers at 30 and 30 for salt water and 30 and 5 for fresh water.for the 8160 keep these numbers at 30 and 13 for salt water and 30 and 2 for fresh water. Velocity is the speed of sound for the area. This only applies for the 8160 which receives surface sound velocity via the SBE 45 TSG. This value should roughly correspond to the sound velocity seen during the last CTD cast. If it differs greatly then you should consider taking a new cast.

System	Spread	Absorb (sea)	Absorb (fresh)
8101	30	70	20
8111	30	30	5
8160	30	13	2

3.2.3 Filters Menu

Found in the bottom half of the Seabat Server, namely Filter, Min Range, Max Range, Min Depth, Max Depth, and Head

Tilt. Head Tilt has to do with if the transducer had been mounted with a roll offset, which does not apply to our Reson transducers.

3.2.4 Display Menu

Color, Contrast, Dots, Grid, and Freeze. This menu has to do with how objects on the Reson screen are being displayed. These options do not need to be changed.

3.3 BITE Menu

By clicking on “BITE” in the upper left-hand corner, the Built-In Test Environment (BITE) Screen opens up. This menu is available for viewing diagnostic and configuration information—like some of the information found in More Options of the Isis Seabat Server. The color of the BITE button shows if the Reson system is operational or not:

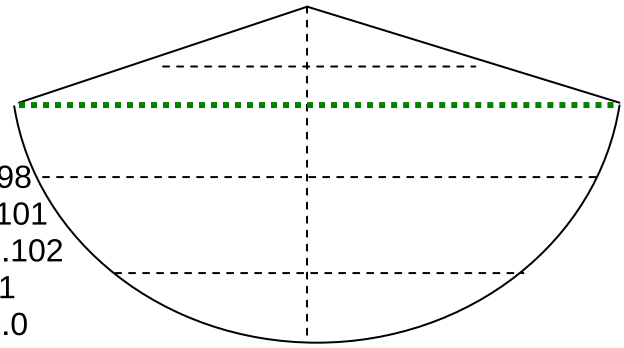
GREEN = System is operational;
YELLOW = System is operational but some areas are not working properly or are out of sync;
RED = System is not operational—there is a malfunction somewhere. Inside the BITE menu, the text will also be in one of three different colors depending on the status of each particular setting. The color code is same as above except that text will also be WHITE to show that the system is operating OK

The BITE Menu Screen looks something like this below:

BITE

BUILT- IN TEST

CALIB **RESET**



Wet-End Status
Leak: +5.0V
HeadTemp: +18.4°C
-5V: -4.8V
+12V: +12.0V
-12V: -12.0V
DipSwitch: 50

Commication
Uplink: Good
Downlink: Good
Internal: Good
Ethernet: 00E0CB030498
Local: 192.168.195.101
Remote: 192.168.195.102
Gateway: 192.168.1.1
Subnet: 255.255.255.0

Firmware Version
Dry: 8101-2.09-E34D
Wet: 8101-1.08-C215

Sensor Inputs
Pitch:
Roll:
Heave:
Velocity:
UTC Date:
UTC Time:

Uplink:
Format:
Sidescan:
TestPtrn:
Output:
ProfilBd:
TimeBd:

Receiver Gain Offsets:

- 3db

ContrlBd:
MotionBd:
VeloctyBd:
UDP Base:
Oriented:

Receiver Phase Offsets:

- 45°

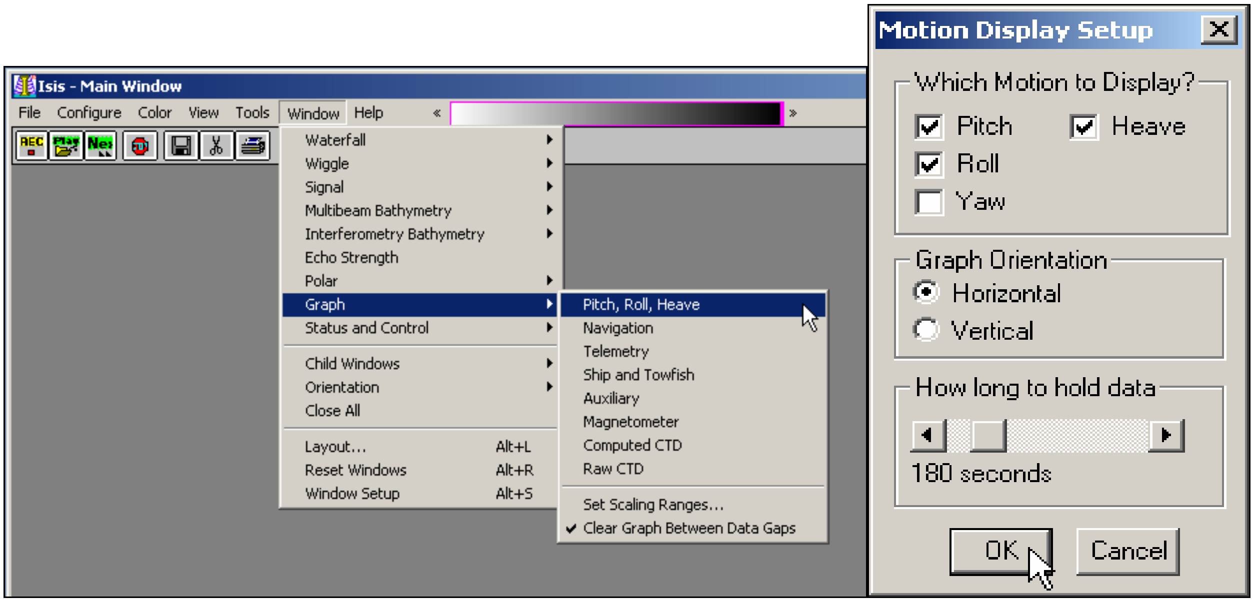
HeadSync:
Projectr:
MENU:

Config

In the upper right hand corner, the BITE menu displays the sonar data wedge, so that it can still be viewed while in this menu.

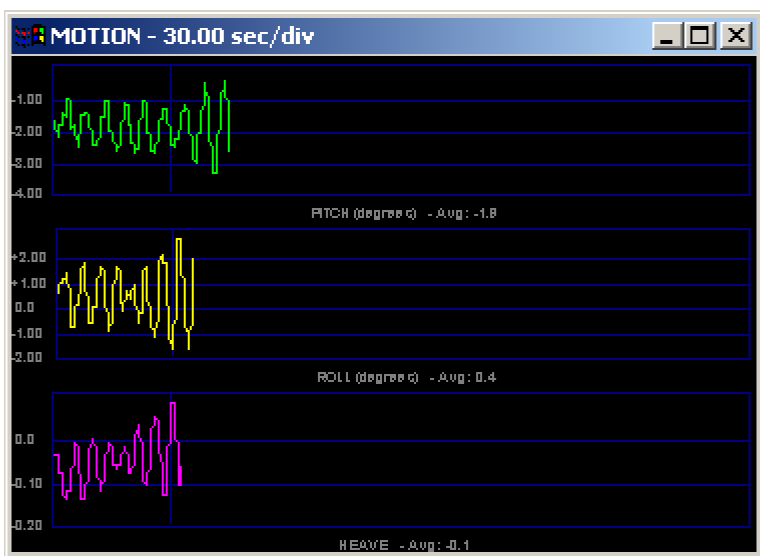
3.4 Sensor Inputs

Here are where the numbers are found for Heave, Pitch, and Roll for the Reson system. Next go to Window\Graph\Pitch, Roll, Heave



The window that pops up will only show Pitch values. In order to view Roll and Heave as well, right click inside the graph box and under "Which Motion to Display?" check each of the boxes for the other sensors.

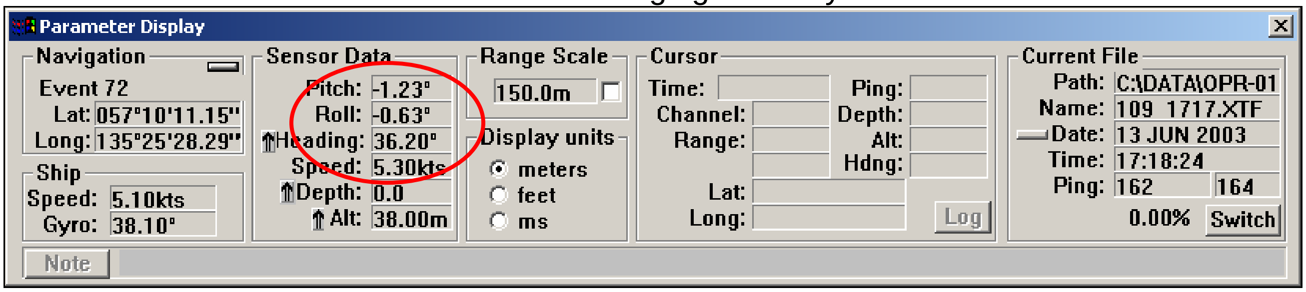
3.4.1 Good motion sensor data will look like this



3.4.2 Parameter Display

Sensor data is also visible through the Parameter Display.

Look to see that these values are changing and they are not zero.



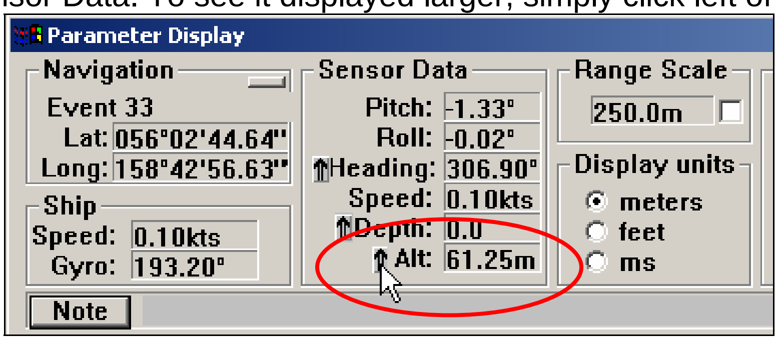
3.4.3 ISIS Shutdown

If any or all of these sensors values are not changing or flat-lining in the Pitch, Roll, and Heave Motion Window, the ISIS computer must be shut down—DO NOT RESTART, SHUT DOWN. After, beginning again with the start-up procedure; make sure that the RESON has been turned off before the Isis is brought up again.

A possible reason for this communication error is if the Isis computer was never shut down. Check to see if the Isis computer is on upon first getting in the launch. If it is, log in and shut down.

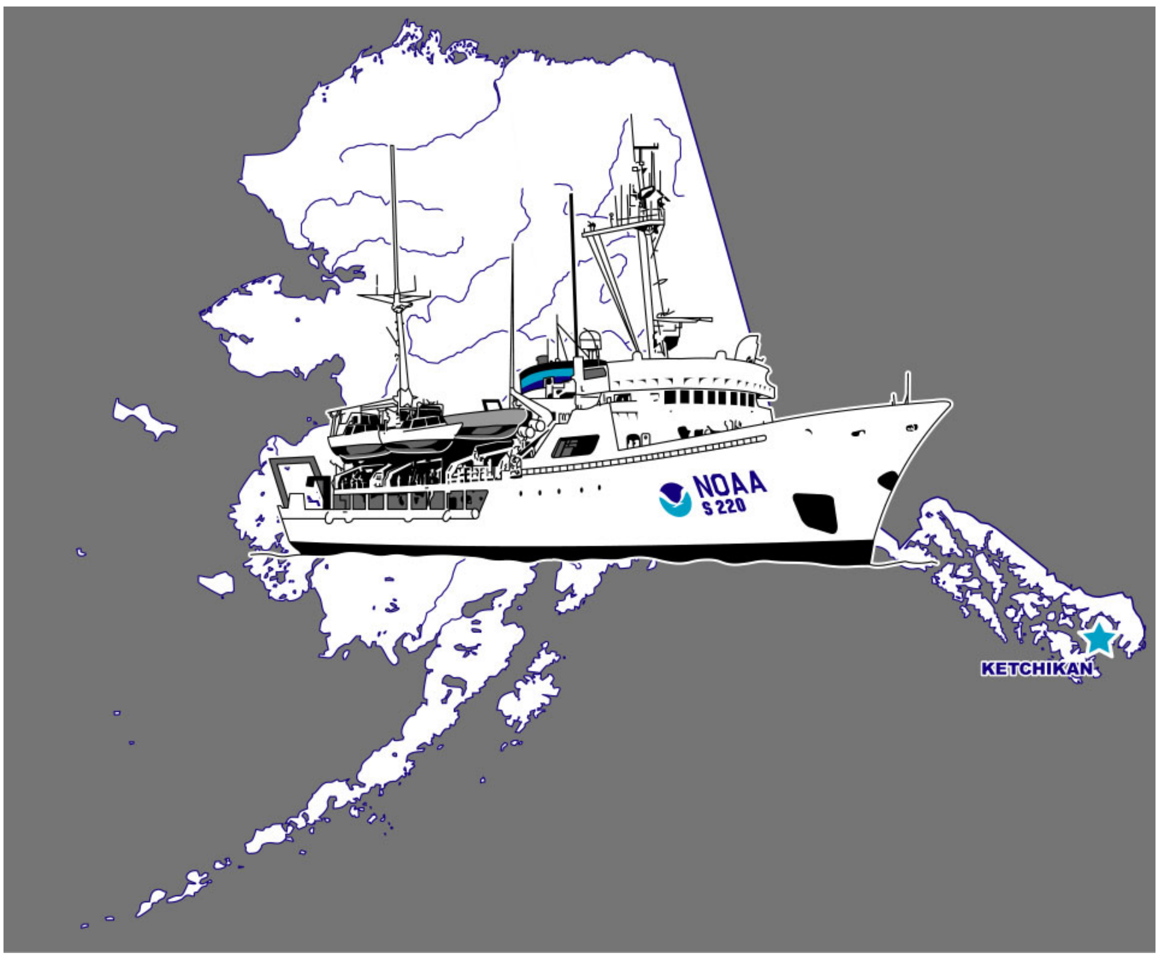
3.4.4 Altitude

Another value to monitor is the Altitude. It is found in the Parameter Display under Sensor Data. To see it displayed larger, simply click left of the Alt button:



This is what will pop up:

Creating/Updating Projects in DelphMap



Creating/Updating Projects in DelphMap

Table of Contents

0.0 Document Scope

The scope of this document is to familiarize the reader with the process of creating a new project and updating the current project in TEI DelphMap.

1.0 Importing Chart Files

Currently there is a rounding issue with DelphMap importing .BSB/.KAP files. With small scale charts it is very obvious. The work around is to reproject the charts into GeoTiffs using NOAA Chart Reprojector.

1.1 Reprojecting Charts

1. Open NOAA Chart Reprojector
2. Select .KAP to be reprojected
3. Give to new .TIFF the same name as chart
4. Give the new .TIFF the format TIFF
5. Give the new .TIFF the projection UTM and the correct zone (using NAD83 as datum)
6. Rename the .TIFW extension to .TFW

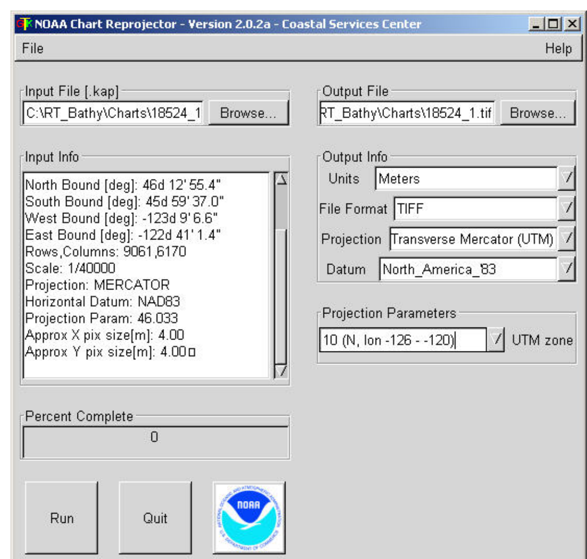


Figure 1. NOAA Chart Reprojector Window

1.2 Inserting Charts (Reprojected .Tiffs) into DelphMap

1. Right click on Background
2. Import an Background Image
3. Browse to the folder where the charts are located and select the chart for the project
4. Click on “Change...” to change the projection of the chart. It should be in UTM with the correct zone number (using NAD83 as the datum)
5. DelphMap will then ask for a projection for the project. This should be in UTM and have the correct zone number (using NAD83 as datum). (This step only occurs when first importing objects into a new project)

1.3 Inserting Charts (.BSB/.KAP’s) into DelphMap

1. Open the “project” menu, scroll down to “import,” and click on “Import an Image Background”
2. When the “Insert a Background Layer” window opens, click on the top button with three dots on it. An “Open” window will appear. Change the “Files of type” to “BSB Chart (*.kap),” and browse to the correct folder. Double click on the correct file so it will appear in the “File name” box. Click on open.
3. On the “Insert a Background Layer” window, click the “Change” button. A “Projection settings” window will appear. Select “Not Projected (Longitude, Latitude)” and click next.
4. A “Projections settings” window will open. Select “North American Datum (1983)” as the datum (unless you know the datum of the chart to be otherwise). Click “Finish”.
5. Check the North and West most coordinates in the “Insert a Background Layer” window. If the latitude or longitude are obviously incorrect, there has been an error importing the file (it may be a corrupt file).
6. Click on the “OK” button in the “Insert a Background Layer” window.
7. The chart should appear in the DelphMap project. As of right now, there is a registration issue, so the chart will appear skewed. The best thing to do is reproject the chart as a GeoTIFF, and import that into DelphMap.

2.0 Importing Polygon Files

Polygon files are setup by the Sheet Manager before and during the project. These files outline the area to be covered by the acquisition unit. They should be imported before a project and re-imported as they are updated to reflect current coverage needs.

1. Right-Click on Vector layers in DelphMap
2. Insert layers→change the file type to Shape *.SHP
3. Select the Polygon file from the Project folder
4. Click on Change… to change projection of the shape file.

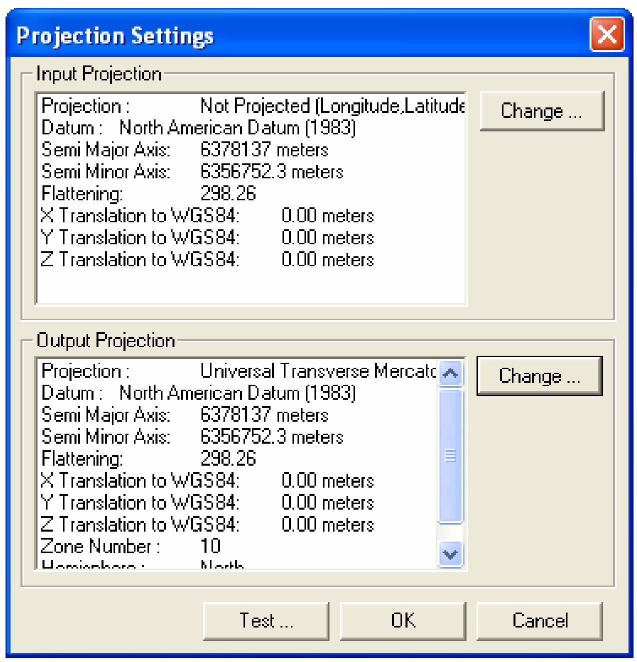


Figure 2. Setting .shp projection

5. The Input Projection is usually UTM/NAD 83 with correct zone number
6. The Output Projection is UTM/NAD 83 with correct zone number
7. Place in project folder (see TEI_RT_Bathy_SOP.doc Section 5.0).
8. Specify layer name (i.e. HXXXXX_Poly_region_A)

3.0 Importing RSD Shoreline Files

1. Right-Click on Vector layers in DelphMap
2. Insert layers→change the file type to Shape *.SHP
3. Select the Shoreline file from the Shoreline folder (see TEI_RT_Bathy_SOP.doc Section 5.0).
4. Click on Change… to change projection of the shape file.

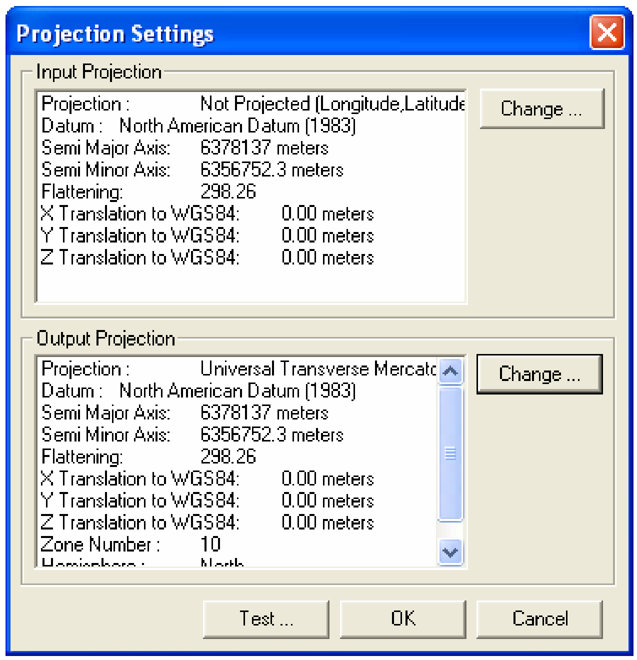
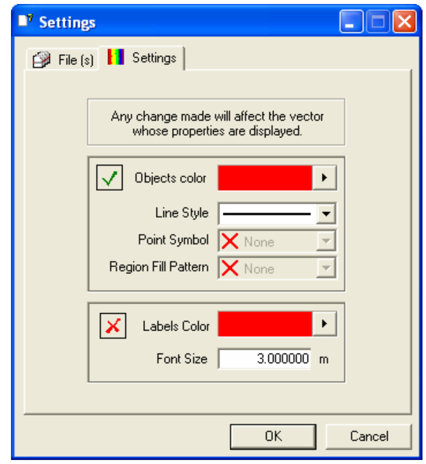


Figure 2. Setting .shp projection

5. The Input Projection is usually Not Projected (Lat/Long) but can be UTM/NAD 83 with correct zone number
6. The Output Projection is UTM/NAD 83 with correct zone number
7. Place in shoreline folder (see TEI_RT_Bathy_SOP.doc Section 5.0)
8. Use ATTRIBUTE as label
9. Specify layer name (i.e. HXXXXX_CFF_Shoreline)



4.0 Coloring RSD Shoreline Labels and Lines

1. Right click on the layer you wish to change the colors
2. Click on Properties
3. Click on Settings
4. Color RSD Shoreline and Points as Green

5.0 Saving the Project

1. Save the project as the H number (i.e. HXXXXX.dmp)
2. Save the project to:
C:\Projects\OPR-XXXX-FA-XX\HXXXXX\RT_Bathy\

Acquisition Information

Date: ________ *Dn#* ________ *Vessel:* ________ *Pg* ____ *of* ____

Personnel: ________________ *# of XTF Files Transferred:* ____

Weather & Sea State: ________ *Local Area:* ________ *Survey:* ________

LOADING from B.M. B (Starboard side): *AM:* ________ *PM:* ____ *Why not taken?* ________

Sound Velocity Information

Cast #:					
Cast Name:					
UTC Time:					
Latitude:					
Longitude:					
Ext. Depth:					
Back timed to:					
For Lines:					

Sound Velocity Comments: ________________

True Heave Filename(s): ________________ *Depth Range (m):* ________

Acquisition Comments: ________________

____

____

____

Delete lines: ________________ *# of Lines Deleted:* ________

XTF Line Remarks *(Need only list lines with issues)*

Filename:	*Remark:*

Please contact AST Kellner for changes to this form.

Conversion and Processing Information

Software Version & Update: CARIS 5.4 SP1 HF 12

Number of HDCS Files: ____________

Processor(s): ____________

Batch File: *Insert batch as an object here only if used.*

End of day processing

(Note Processing Steps only if Manually Applied)

Converted: ______
Open (HXXXXX_Daily) Session & add lines: ______
SV profile selection method: ______
Tide file: ______
True Heave Applied: ______
Merge ______
Compute TPE: ______
Filtered (0-100) IHO 1 and 0 Qlty-Rejected: ______
Filtered (100-500) IHO User def - 1/0.023/5/5: ______
Query Lines: ______
Create daily Field Sheet: ______
Create daily BASE Surface & save session: ______
Open (HXXXXX_QC) Session & add lines: ______
Update/Recompute Coverage BASE(s): ______
Export to I & Copy to R: ______

Nightly Review & QC

Open (HXXXXX_Daily) Session: ______
Create Subset Tiles for daily FS: ______
Review Daily BASE Child Layers: ______
Additional Filters Applied: ______
Clean Data: ______
Contour: ______
Generate Soundings: ______
Review for DTONS: ______
Chart Comparison: ______
Mark Examined Soundings: ______

Recompute Coverage BASE Surfaces: ______
Export to I & Copy to R: ______

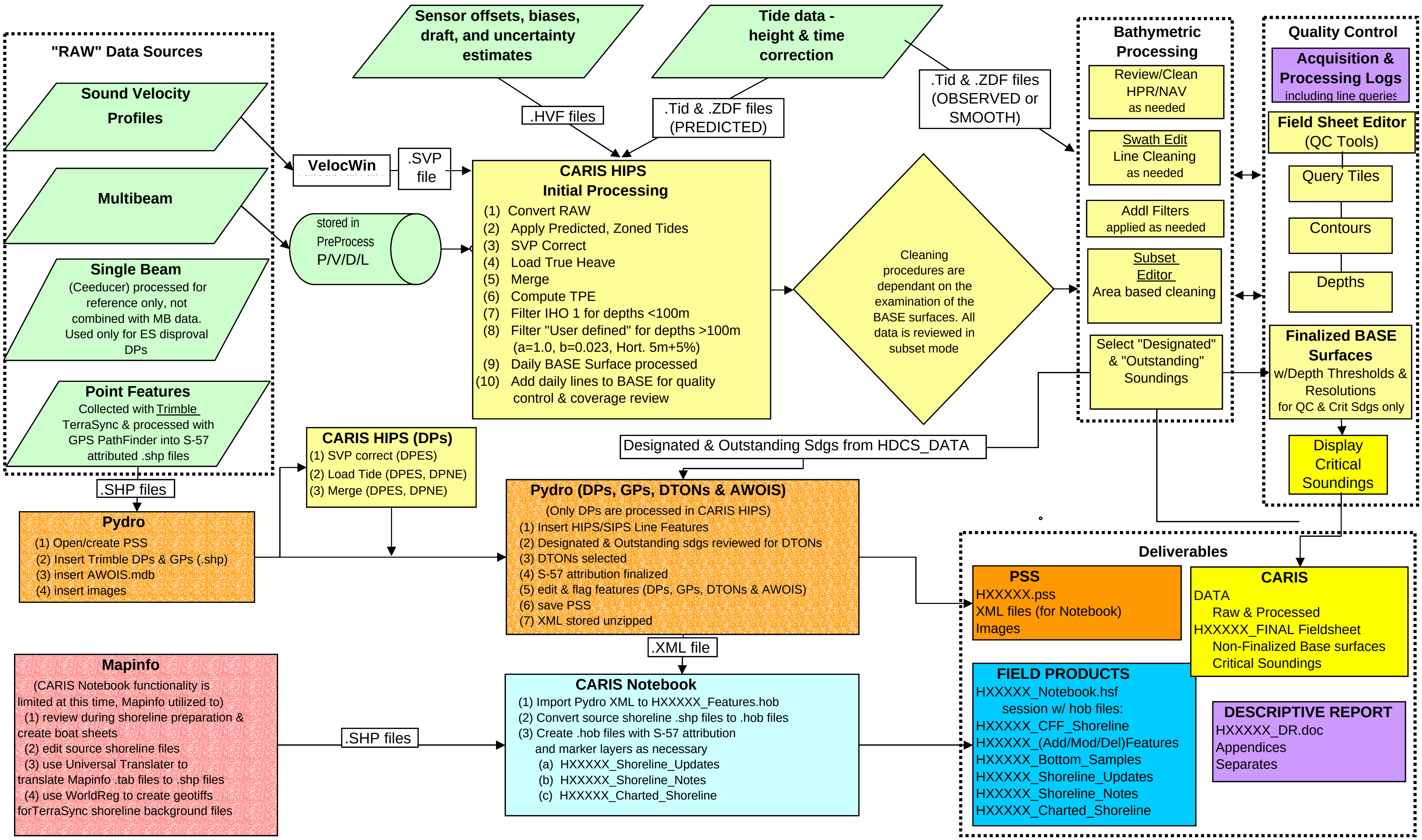
Processing Comments: ____________

Processing Query

Total Mileage
0

Length	Line	Project	Vessel	Day	TideLoaded	TideFile	SVPCorre	SVPFile	Merged	Outdated	TPE Com	Speed	Heading	TotalTime

FAIRWEATHER Data Processing 2004



DRAFT DRAFT DRAFT DRAFT DRAFT DRAFT

MEMORANDUM FOR: Distribution

FROM: W. Michael Gibson
Chief, HSD, OCS

SUBJECT: Hydrographic Surveys Technical Directive 2004-3
(HSTD 2004-3)

TITLE: CARIS HIPS 5.4 BASE Surface Processing

EFFECTIVE DATE: September 10, 2004

SECTION 1. PURPOSE

This Hydrographic Surveys Technical Directive (HSTD) grants permission for NOAA field units to process hydrographic survey data using CARIS HIPS 5.4 BASE surfaces. BASE surface processing may replace the line by line swath editing and shoal bias binning process that is currently authorized. Each command may choose the time to switch depending on project requirements, capabilities of personnel and familiarization with the new techniques. It is anticipated that all NOAA field units will be formally trained and ready to process all data using BASE surfaces beginning in early 2005.

SECTION 2. POLICY

Effective immediately, NOAA field units may deviate from current documented procedures (project instructions, NOS Hydrographic Surveys Specifications and Deliverables, Field Procedures Manuel, etc.) in order to process hydrographic survey data using BASE surfaces. Deliverables to the Processing Branches will be affected as described in Section 5 of this memorandum. Draft versions of Chapter 4 of the Field Procedures Manual, THOMAS JEFFERSON Base Surface Standard Operating Procedures, and RAINIER BASE Surface Creation and Data Processing documents are available to provide guidance.

All NOAA field units should continue to work closely with their Processing Branch to ensure that new deliverables meet requirements for charting and that all new processes are properly documented in the Descriptive Report and Data Acquisition and Processing Report.

Management must stress that the new processing techniques do not remove the requirement for hydrographers in the field (or personnel at the Processing Branch) to review full resolution data. All critical soundings and dangers to navigation must be thoroughly reviewed to ensure that the appropriate depth will be forwarded for chart compilation. This may require selecting a 'designated' sounding, essentially overriding the BASE surface, or simply a check by an experienced hydrographer to ensure that the BASE surface node accurately reflects the desired depth to be charted.

SECTION 3. RESPONSIBILITIES

The approval, promulgation, revision and amendment of this policy shall be the responsibility of the Chief, Hydrographic Surveys Division or his designee. All employees associated with the NOAA hydrographic survey program are encouraged to suggest policy changes, via their supervisor, that will promote increased efficiency and quality of the services provided by the division.

NOAA field units shall continue to work closely with the Processing Branches to ensure data submitted can be readily verified and efficiently compiled for nautical charting.

The Atlantic Hydrographic Branch (AHB) will continue to develop procedures to verify and compile the THOMAS JEFFERSON (TJ) BASE surface surveys already submitted. Special steps will be taken to verify and document that proper and accurate depths are being compiled for charting.

The TJ has the most experience using the new techniques, they will continue to update their Standard Operating Procedures (SOP) documentation and provide guidance on best practices.

SECTION 4. GENERAL

Background

Suggested background reading includes, "NOAA's Office of Coast Survey Adopts a Surface-Based Approach to High Density Hydrographic Data Analysis and Archiving, A Brief Overview", by LT Rick Brennan, NOAA, and "Implications of the Navigation Surface Approach for Archiving and Charting Shallow Survey Data", by Andrew Armstrong, Rick Brennan and Shepard Smith. Copies of the papers can be made available upon request.

Due to the volume of data collected by modern multibeam sonars, NOAA no longer has the luxury of manually reviewing and verifying every individual sounding. In addition, we need to change our processing and archiving of survey data to end the practice of forcing the data into a pipeline created for lead lines.

New techniques for handling multibeam data have been developed at the NOAA funded Center for Coastal and Ocean Mapping and Joint Hydrographic Center (CCOM/JHC). The techniques use the power of the multitude of measurements obtained from modern multibeam echosounders to compute a statistically valid depth for a given spot on the sea floor.

To do this effectively, an error model is needed for all systems supplying measurements to compute a sounding (sound velocity probe, motion sensor, GPS, tide gages, etc.). Once this comprehensive error model is assembled, then all the inherent errors in each measurement can be propagated to each individual sounding. Once each sounding has an associated error, or Total Propagated Error (TPE), we can then compare each sounding in an objective manner with its neighbors.

In the past, when only a couple of soundings were obtained on each spot of the sea floor, it made sense to choose the shoalest. However, if we have dozens of soundings, we should use our knowledge of the inherent accuracy of each sounding (TPE) to determine the highest probability of the depth at a location. To fully benefit from the statistical power provided by having millions of soundings, we can form a surface model of the sea floor, in this case a regular grid. The node spacing is driven by the highest resolution the data will support, primarily the type of sonar and water depth. For example, in depths less than 15 meters, we should achieve a grid resolution of 0.5 meter. Each node of the grid will have a computed depth composed of many soundings, each sounding weighted by its TPE and distance from the node. Each node will also include other attributes, such as, an associated uncertainty, standard deviation, density (number of soundings used in the computation), minimum depth, maximum, etc.

It is important to note, that the Hydrographer must always have the capability of over riding the depth computed by the algorithm and have tools available to check the relevance of depths. For instance, an echosounder return from the top of a submerged piling may be combined with soundings from the surrounding sea floor to compute a depth at the grid node that is deeper than the piling top. In this case, the Hydrographer will notice a problem due to the high standard deviation of the grid at that point. After review of the full resolution data, she can select the sounding at the top of the piling as a special ‘designated’ sounding. This forces the grid node (and surface) to that sounding.

BASE Surfaces

The process of using high resolution grids to process multibeam data is part of the newest CARIS HIPS release (version 5.4). CARIS implementation of the grid concept is called Bathymetry with Associated Statistical Error (BASE) surface.

The first step in processing with BASE surfaces, is to create a HIPS Vessel File (HVF). This is an essential component in calculating the Total Propagated Error (TPE) for each sounding. This file includes error estimates for each sensor, as well as offset measurements (and the potential error of those offset measurements). Examples of HVF files used by the THOMAS JEFFERSON and RAINIER, with references are available upon request. The examples may be used as a guide, but each vessel’s HVF will be unique. The entries of the HVF are dependent on specific models of equipment installed on the vessel.

The THOMAS JEFFERSON (TJ) has been processing data using the new CARIS tools for over a year. They have worked closely with CARIS, troubleshooting the software, suggesting improvements and ensuring that the software can function in a 'real world' environment.

Primary Objective

The primary objective of developing a new pipeline for Hydrographic survey data, is to streamline the ping-to-chart process to shorten the time required in getting sounding data to MCD for charting.

The new tools when fully implemented should reduce the processing time required by field units, allowing surveys to get off the ships faster with a higher confidence that an area was properly and completely surveyed.

Once in the Processing Branches, the data should be verified quickly and chart compilation from a final surface should be faster and more accurate than current methods.

Secondary/Parallel Objectives

The final BASE surface for a survey can be archived to provide products for users outside OCS. Currently, the final product of a hydrographic survey is a smooth sheet, a sounding plot at the scale of the survey. At survey scale, we can plot soundings at a spacing not much tighter than 5 mm, therefore, for a typical 1:10,000-scale survey, we have a single sounding every 50 meters. NMFS, USGS, marine geologists, state agencies, etc., will have interest in the higher resolution BASE surface data.

Current products delivered to MCD include a smooth sheet and H-drawing (compilation of the survey data at chart scale) as MicroStation drawing files. We could update our processing pipeline as described above and still provide these products. However, PHB has been working on an ENC S-57 initiative to update these products.

The primary deliverables from HSD to MCD will become a S-57 exchange set (H-cell) representing the chart revisions from a new hydrographic survey. An interim deliverable will be an S-cell, which is an S-57 version of a smooth sheet created in CARIS. Once fully implemented, these products will replace the current production system which requires the drafting of a smooth sheet in MicroStation, and subsequent manual chart compilation in SCARS.

The H-cell initiative will eventually eliminate the MicroStation drafted smooth sheet as the final archive of a hydrographic survey (and thus reliance on MicroStation). It will also reduce the use of in-house customized software for the compilation of smooth sheets and chart revisions.

Official guidance on changing the deliverables to MCD will be provided under separate cover when appropriate. HSTD 2004-3 is intended to just change the processing procedures and data submission of NOAA hydrographic field units. If required, the new field unit deliverables could be used to create a traditional MicroStation smooth sheet and H-drawing.

Testing of New Technologies

The Joint Hydrographic Center (JHC) developed the algorithms and ideas behind processing hydrographic data via TPE and gridded surfaces. JHC has conducted several tests of the concept using actual survey data in Snow Passage, Valdez, Woods Hole and Portsmouth. Several academic papers have been written. They have conducted many tests showing that the techniques are a valid, efficient and accurate tool for processing hydrographic data in support of nautical charting.

The TJ has spent the last year or more processing data using early beta versions of HIPS' BASE surface processing routines and more recently with the final version of CARIS HIPS 5.4. They have found no major problems that would require them to 'reprocess' the data. In all instances, the BASE surface process provided meaningful results.

HSD has reprocessed a WHITING survey using the latest version of HIPS. The analysis continues, but overall the final soundings agree very well. No major issues were found to discredit the BASE surface process.

The RAINIER has started to implement full HIPS 5.4 capabilities by dual processing several surveys. The new techniques allowed them to troubleshoot and fix problems in the data that were not noticeable with earlier processing procedures.

As the organization moves forward with the new technology, all hydrographers, cartographers and physical scientists both in the field and in the Processing Branches must take steps to ensure that accurate depths are compiled for charting. The accurate depths will not in all cases be the shoalest sounding available, but must be the most accurate depiction of the seafloor. All critical soundings and dangers to navigation must be analyzed, comparing the BASE surface nodes to the full resolution data to ensure that appropriate least depths are available for chart compilation.

SECTION 5. EFFECT ON OTHER ISSUANCES

This Directive supersedes the processing procedures and deliverables detailed in current versions of Project Instructions, Standing Instructions, Field Procedure Manual (FPM) and the NOS Hydrographic Surveys Specifications and Deliverables.

NOAA field units that implement BASE surface processing will submit to the Processing Branches the following deliverables:

1. CARIS Field Sheet (FS) to include:

- original source BASE surface
- finalized BASE surfaces with a naming convention indicative of the resolution

2. Descriptive Report (DR)
   - The DR should explicitly describe the finalized BASE threshold resolutions used (i.e. a table of depth ranges vs. BASE resolution)
   - explain variances from the pre-existing threshold guidelines listed in the draft FPM
   - describe the number of BASE surfaces used (i.e. the 5M BASE may be split into several 5M surfaces),
3. Data Acquisition and Processing Report (DAPR)
   - the DAPR and DR must reflect and describe the new processing procedures, including the source and value of HVF entries,
4. Full resolution CARIS HDCS files, PYDRO S-57 features and associated supporting files are still required.

Additional HSTDs will be issued as the process continues to evolve. If during the processing and verification of data there are immediate concerns that must be addressed, please contact HSD as soon as possible. Jeffrey Ferguson (jeffrey.ferguson@noaa.gov) will be the primary point of contact for all comments and questions on this Directive.

Distribution:
(1) All HSD Employees
(2) NOAA Ship RAINIER
(3) NOAA Ship THOMAS JEFFERSON
(4) NOAA Ship RUDE
(5) NOAA Ship FAIRWEATHER

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

JAN 8 2005

MEMORANDUM FOR: Distribution

FROM: W. Michael Gibson *William M. Gibson*
Chief, HSD, OCS

SUBJECT: Hydrographic Surveys Technical Directive 2004-3 (HSTD 2004-3)

TITLE: CARIS HIPS 5.4 BASE Surface Processing

EFFECTIVE DATE: January 3, 2005

SECTION 1. PURPOSE

This Hydrographic Surveys Technical Directive (HSTD) grants permission for NOAA field units to process hydrographic survey data using CARIS HIPS 5.4 BASE surfaces. BASE surface processing may replace the line by line swath editing and shoal bias binning process that is currently authorized. Each command may choose the time to switch depending on project requirements, capabilities of personnel and familiarization with the new techniques, as well as coordination from the appropriate Quality Assurance Branch (AHB/PHB). All NOAA field units will be formally trained and ready to process all data using BASE surfaces beginning in early 2005.

SECTION 2. POLICY

Effective immediately, NOAA field units may deviate from current documented procedures (project instructions, NOS Hydrographic Surveys Specifications and Deliverables, Field Procedures Manual, etc.) in order to process hydrographic survey data using BASE surfaces with all additional attributes (shoal, depth, density, standard deviation, etc.). Current documented procedures are in the process of being updated to reflect the new procedures. In addition, data collected in 2004, prior to the effective date of this HSTD, may be processed and delivered using the new BASE surface processing techniques. Deliverables to the Quality Assurance Branches will be affected as described in Section 5 of this memorandum. Draft versions of Chapter 4 of the "Field Procedures Manual", the THOMAS JEFFERSON's "Base Surface Standard Operating Procedures", the FAIRWEATHER's "Survey Bathymetric Processing", and the RAINIER's "BASE Surface Creation and Data Processing" documents are available to provide guidance.

All NOAA field units should continue to work closely with their Quality Assurance Branch to ensure that new deliverables meet requirements for charting and that all new processes are properly documented in the Descriptive Report, Data Acquisition and Processing Report, and System Certification documentation.

The new processing techniques do not remove the requirement for hydrographers in the field (or personnel at the QA Branch) to review full resolution data. All critical soundings and dangers to navigation must be thoroughly reviewed to ensure that the appropriate depth will be forwarded for chart compilation. This may require selecting a 'designated' sounding, essentially overriding the BASE surface, or simply a check by an experienced hydrographer to ensure that the BASE surface node accurately reflects the desired depth to be charted. The Descriptive Report (DR) shall explain the steps taken to ensure that all significant soundings have been properly represented and that the BASE surface soundings are accurate.

SECTION 3. RESPONSIBILITIES

The approval, promulgation, revision and amendment of this policy shall be the responsibility of the Chief, Hydrographic Surveys Division or his/her designee. All employees associated with the NOAA hydrographic survey program are encouraged to suggest policy changes, via their supervisor, that will promote increased efficiency and quality of the services provided by the division.

NOAA field units shall continue to work closely with the Quality Assurance Branches to ensure data submitted can be readily verified and efficiently compiled for nautical charting.

The Atlantic Hydrographic Branch (AHB) will continue to develop procedures to verify and compile the THOMAS JEFFERSON (TJ) BASE surface surveys already submitted and the Pacific Hydrographic Branch (PHB) will work to develop procedures to evaluate and compile BASE surfaces to be submitted by RAINIER, FAIRWEATHER and NOAA's current time charter vessel R/V DAVIDSON. Special steps will be taken to verify and document that proper and accurate depths are being compiled for charting. It is essential that AHB and PHB work closely to coordinate the development of new office procedures to evaluate BASE surfaces.

All hydrographic vessels and HSD personnel shall work towards ensuring that the Field Procedures Manual (FPM) and other supporting documentation are properly updated to reflect current and appropriate best practices. Suggested changes to documentation related to BASE surface processing should be made to Jeffrey Ferguson (jeffrey.ferguson@noaa.gov) through the appropriate chain of command. Mr. Ferguson will, as needed, promulgate the changes as an updated HSTD, or change to the FPM or other appropriate documentation. In addition, a copy of any internal Standard Operating Procedures (SOPs) related to BASE surface processing should be forwarded to Mr. Ferguson.

SECTION 4. GENERAL

Suggested background reading includes, "NOAA's Office of Coast Survey Adopts a Surface-Based Approach to High Density Hydrographic Data Analysis and Archiving, A Brief Overview", by LT Rick Brennan, NOAA, and "Implications of the Navigation Surface Approach for Archiving and Charting Shallow Survey Data", by Andrew Armstrong, Rick Brennan and Shepard Smith. Copies of the papers can be made available upon request. See Attachment One for additional background information.

SECTION 5. EFFECT ON OTHER ISSUANCES

This Directive supersedes the processing procedures and deliverables detailed in current versions of Project Instructions, Standing Instructions, Field Procedure Manual (FPM) and the NOS Hydrographic Surveys Specifications and Deliverables.

NOAA field units that implement BASE surface processing will submit to the Quality Assurance Branches the following deliverables:

1. CARIS Field Sheet (FS) to include:
   - original source BASE surface
   - finalized BASE surfaces with a naming convention indicative of the resolution
   - Critical Soundings layer
   - The HVFs that were used to convert and process the data
2. Descriptive Report (DR)
   - The DR should explicitly describe the finalized BASE threshold resolutions used (i.e. a table of depth ranges vs. BASE resolution)
   - explain variances from the pre-existing threshold guidelines listed in the draft FPM and SOP
3. Data Acquisition and Processing Report (DAPR)
   - the DAPR and DR must reflect and describe the new processing procedures, including the source and value of HVF entries
4. Full resolution CARIS HDCS files, PYDRO S-57 features and associated supporting files are still required.

Additional HSTDs will be issued as the process continues to evolve. If during the processing and verification of data there are immediate concerns that must be addressed, please contact HSD as soon as possible. Jeffrey Ferguson (jeffrey.ferguson@noaa.gov) will be the primary point of contact for all comments and questions on this Directive.

Distribution:
(1) All HSD Employees
(2) NOAA Ship RAINIER
(3) NOAA Ship THOMAS JEFFERSON
(4) NOAA Ship RUDE
(5) NOAA Ship FAIRWEATHER

Attachment One

New techniques for handling multibeam data have been developed at the NOAA funded Center for Coastal and Ocean Mapping and Joint Hydrographic Center (CCOM/JHC). The techniques use the power of the multitude of measurements and advanced error modeling obtained from modern multibeam echosounders to compute a statistically valid depth for a given spot on the sea floor.

To do this effectively, an error model is needed for all systems supplying measurements to compute a sounding (sound velocity probe, motion sensor, GPS, tide gages, etc.). Once this comprehensive error model is assembled, then all the inherent errors in each measurement can be propagated to each individual sounding. Once each sounding has an associated error, or Total Propagated Error (TPE), we can then compare each sounding in an objective manner with its neighbors.

In the past, when only a couple of soundings were obtained on each spot of the sea floor, it made sense to choose the shoalest. However, if we have dozens of soundings, we should use our knowledge of the inherent accuracy of each sounding (TPE) to determine the highest probability of the depth at a location. To fully benefit from the statistical power provided by oversampling, we can form a surface model of the sea floor, in this case a regular grid. The node spacing is driven by the highest resolution the data will support, primarily the type of sonar and water depth. For example, in depths less than 15 meters, we should achieve a grid resolution of 0.5 meter. Each node of the grid will have a computed depth composed of many soundings, each sounding weighted by its TPE and distance from the node. Each node will also include other attributes, such as, an associated uncertainty, standard deviation, density (number of soundings used in the computation), minimum depth and maximum depth.

It is important to note that the Hydrographer must always have the capability of over riding the depth computed by the algorithm and have tools available to check the relevance of depths. For instance, an echosounder return from the top of a submerged piling may be combined with soundings from the surrounding sea floor to compute a depth at the grid node that is deeper than the piling top. In this case, the Hydrographer will notice a problem due to the high standard deviation of the grid at that point. After review of the full resolution data, if appropriate, the sounding at the top of the piling will be selected as a special 'designated' sounding. This forces the grid node (and surface) to that sounding.

BASE Surfaces

The process of using high resolution attributed grids to process multibeam data is part of the newest CARIS HIPS release (version 5.4). CARIS implementation of the attributed grid concept is called Bathymetry with Associated Statistical Error (BASE) surface.

The first step in processing with BASE surfaces is to create a HIPS Vessel File (HVF). This is an essential component in calculating the Total Propagated Error (TPE) for each sounding. This file includes error estimates for each sensor, as well as offset measurements (and the potential error of those offset measurements). Examples of HVF files used by the THOMAS JEFFERSON and RAINIER, with references are available upon request. The examples may be used as a guide, but each vessel's HVF will be unique. The entries of the HVF are dependent on specific models of equipment installed on the vessel.

The THOMAS JEFFERSON (TJ) has been processing data using the new CARIS tools for over a year. They have worked closely with CARIS, troubleshooting the software, suggesting improvements and ensuring that the software can function in a 'real world' environment.

Primary Objective

The primary objective of developing a new pipeline for Hydrographic survey data which incorporates CARIS BASE surfaces is to streamline the ping-to-chart process to shorten the time required in getting sounding data to the chart. Without a change to the current processing paradigm, our ability to get the data to the end user faster, would be more difficult, especially with the impact of additional data from FAIRWEATHER, the time charter, increased contracting and outside source data.

The new tools when fully implemented should reduce the processing time required by field units, allowing surveys to get off the ships faster with a higher confidence that an area was properly and completely surveyed and that data meet accuracy and quality requirements.

Once in the Quality Assurance Branches, the new products will also allow the bathymetric data to be verified quickly and chart compilation from a final surface should be faster and more accurate than current methods.

Secondary/Parallel Objectives

Secondary objectives include creating a single, multiple-use product to support both nautical charting and other applications of the bathymetric data such as geology, essential fish habitat and ecosystem mapping, and coastal engineering and management. Additionally, the final BASE surface for a survey can be archived and distributed to provide products for uses other than nautical charting without significant reprocessing of the data.

Concurrent efforts underway to redefine the deliverables from a hydrographic survey used to update nautical charts will utilize BASE surface products. Currently, the final product of a hydrographic survey is a smooth sheet, which is a sounding plot decimated so that at the scale of the survey no soundings overlap. A typical 1:10,000-scale survey will have a single sounding every 50 meters.

Current products delivered to the Marine Chart Division (MCD) include a smooth sheet and H-drawing (compilation of the survey data at chart scale) as MicroStation drawing files. However, PHB has been working on an initiative to update these products in a more efficient manner utilizing gridded surfaces and the S-57 exchange format.

The primary deliverables from HSD to MCD will become a S-57 exchange set (H-cell) representing the chart revisions from a new hydrographic survey. An interim deliverable will be an S-cell, which is an S-57 version of a smooth sheet created in CARIS. Once fully implemented, the H-cell will replace the current production system which requires the drafting of a smooth sheet in MicroStation, and subsequent manual chart compilation in SCARS. The H-cell deliverable will be generated from BASE surfaces.

The H-cell initiative will eventually eliminate the MicroStation drafted smooth sheet as the deliverable used to revise NOAA charts (and thus reliance on MicroStation). It will also reduce the use of in-house customized software for the compilation of smooth sheets and chart revisions.

Official guidance on changing the deliverables to MCD will be provided under separate cover when appropriate. HSTD 2004-3 is intended to just change the processing procedures and data submission of NOAA hydrographic field units to the Quality Assurance Branches.

Testing of New Technologies

The Joint Hydrographic Center (JHC) developed the algorithms and ideas behind processing hydrographic data via TPE and gridded surfaces. JHC has conducted several tests of the concept using actual survey data in Snow Passage, Valdez, Woods Hole and Portsmouth. Several academic papers have been written. They have conducted many tests showing that the techniques are a valid, efficient and accurate tool for processing hydrographic data in support of nautical charting.

The THOMAS JEFFERSON has spent the last year or more processing data using early beta versions of HIPS' BASE surface processing routines and more recently with the final version of CARIS HIPS 5.4. They have found no major problems that would require them to 'reprocess' the data. In all instances, the BASE surface process provided meaningful results.

HSD has reprocessed a WHITING survey using the latest version of HIPS, for comparison to traditional processing methods. The final soundings agree very well. No major issues were found to discredit the BASE surface process.

The RAINIER has started to implement full HIPS 5.4 capabilities by dual processing several surveys. The new techniques allowed them to troubleshoot and fix problems in the data that were not noticeable with earlier processing procedures.

As the organization moves forward with the new technology, all hydrographers, cartographers and physical scientists both in the field and in the Processing Branches must take steps to ensure that accurate depths are compiled for charting. The accurate depths will not in all cases be the shoalest sounding available, but must be the most accurate depiction of the seafloor. All critical soundings and dangers to navigation must be analyzed, comparing the BASE surface nodes to the full resolution data to ensure that appropriate least depths are available for chart compilation.

Bathymetric Processing

Table of Contents

Document Scope

This document, in six sections, serves two main purposes: 1) to document the standard operating procedures used to generate, process, and review BASE surfaces and 2) to provide a fundamental level of understanding about the theories and ideas underlying those procedures.

1. HIPS Vessel File (HVF)
   The HVF is a list of sensors with their physical and calibration measured offsets, plus associated uncertainty estimates. The purpose of estimating the extent of the uncertainties is to quantify error and when necessary, reduce it.

2. TPE Calculation
   While it is beyond the scope of this document to explore the details of assigning an uncertainty to each piece of information that goes into making a sounding solution, this section does discuss how to calculate TPE in CARIS HIPS and some useful general concepts concerning TPE.

3. BASE Surface Generation
   After introducing the idea of representing bathymetry as a weighted-mean gridded model, rather than as a collection of shoal-bias excessed soundings, this section examines the uncertainty-weighed gridding method used by CARIS HIPS when generating BASE surfaces

4. Data Cleaning
   After contrasting the traditional "line-by-line" approach to data cleaning with the newer "surface-centric" approach and exploring the difficulties encountered in bridging the two, this section presents a few general ideas to keep in mind when cleaning data utilizing the various layers of a CARIS HIPS 5.4 BASE surface.

5. Finalize Surfaces
   Before discussing how to finalize BASE surfaces in CARIS HIPS 5.4, this section introduces assigning a final uncertainty to grid nodes, flagging "designated" soundings, and preserving the optimal resolution of data by "cookie cutting" out appropriate depth ranges.

6. Combine Surfaces
   Although generating combined surfaces is currently an official responsibility of the processing branch, it is useful for the ship to do so also in order to be able to produce sounding plots efficiently. This section discusses how CARIS HIPS combines two or more BASE surfaces into a separate BASE surface with a resolution no finer than that of the coarsest-resolution contributing surface.

1. HIPS Vessel File (HVF)

Prior to data acquisition the physical and calibrated offsets between the multibeam sonar and the inertial motion unit and the a priori uncertainty estimates of the survey equipment are entered into HIPS Vessel Files (HVF). The following section pertains only to the uncertainty entries in the HVF. In general the HVF will be updated, as needed, by either the Chief Survey Technician or the Field Operation Officer. All changes to the HVF must be thoroughly documented.

1.1 Total Propagated Error Entries

From CARIS HIPS and SIPS Vessel Editor Window:
Edit>Active Sensors, select "***TPE Values***."

Highlight ***TPE values*** from the sensor options listed and enter the following information:

Date, Time and Comments (Initials)
Enter ***Offset*** (physical measurements):
MRU to transducer
Navigation to transducer
Transducer roll.
Enter the ***StdDev**** (standard deviation):
Sensor errors, latencies
Offset measurement errors
Loading and Draft error
MRU mis-alignment errors.

Select the sonar ***Model*** from the drop down menu for ***Swath 1*** (and Swath 2-if dual transducers). This is a required entry for the BASE surface creation. If the sonar model is not listed in the drop down menu add the required information to the DeviceModel.XML, usually located in the C:\CARIS\HIPS\System folder.

Save the HVF, if you have an older version of the HVF (VCF) the new file will not overwrite the VCF however, the extension is not apparent later when you define vessels for a project. If you will be using both HVFs and VCF name the HVF, [Vessel_Sonar]_HVF.

** While it is beyond the scope of this document to explore the details of assigning an uncertainty to each piece of information that goes into making a sounding solution, it is useful to mention that the uncertainty values are reported at one sigma (68 % CI). The uncertainty estimates and supporting documentation for the FAIRWEATHER HVFs can be found in FA_TPE_Values_2004.xml.*

2. TPE Calculation

A prerequisite for generating BASE surfaces is that all soundings must have an associated total propagated error (TPE). TPE calculation consists of assigning a horizontal and vertical error to each sounding based on the uncertainty of each piece of information that goes into making that sounding solution. Examples of uncertainties include the following:

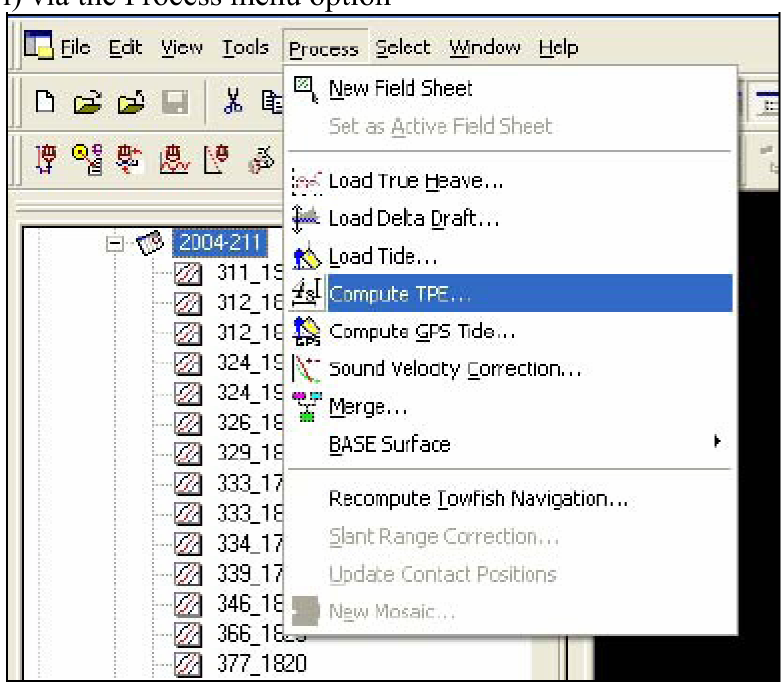
- *roll from the motion sensor*
- *positioning from the navigation system*
- *sound velocity information from a CTD (conductivity, temperature, and density) cast*
- *the sonar's bottom detection method*

The sources of the uncertainty values vary from manufacturers' specifications, to theoretical values, to field tested empirical observations. It is beyond the scope of this document to explore the details of assigning an uncertainty to each piece of information that goes into making a sounding solution.

2.1. Compute Total Propagate Error (TPE)

There are two ways to initiate the "Compute TPE" function:

i) via the Process menu option

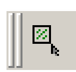


ii) via the "Compute TPE" button on the "Process" toolbar

Although there is no interactive dialogue box during the Compute TPE process, there is a window allowing a user to cancel the operation and a status bar window in the lower left.

3. BASE Surface Generation

A BASE surface is a representation of bathymetry with additional attributes, important among which is uncertainty. The notion of a BASE surface is a significant change in the way bathymetry is represented. Whereas bathymetry traditionally has been reported as a collection of shoal-biased excessed soundings (tailored for nautical chart production), a BASE surface represents bathymetry as a weighted-mean gridded model. Representing bathymetry as a model, versus a collection of down-sampled soundings, allows the full resolution of the source data to be preserved, i.e. data is not lost, and, in turn, allows the ship's product to be more valuable for a wider range of uses.

3.1. Create a Field Sheet 

The Field Sheet defines the geographical extents for the BASE surface, tiling, contours, etc. A field sheet must be created before a BASE can be made.

Create a Field Sheet

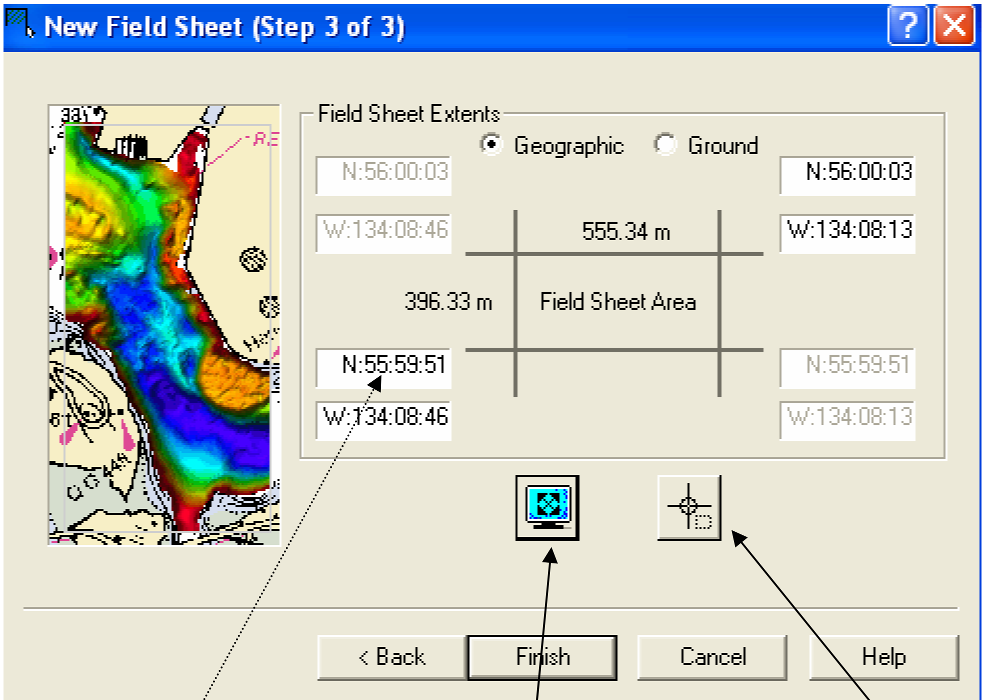
Process>New Fieldsheet

Name the Field Sheet; *H######*

Leave the default horizontal and depth resolution.

Define the datum and zone

Define the extent:

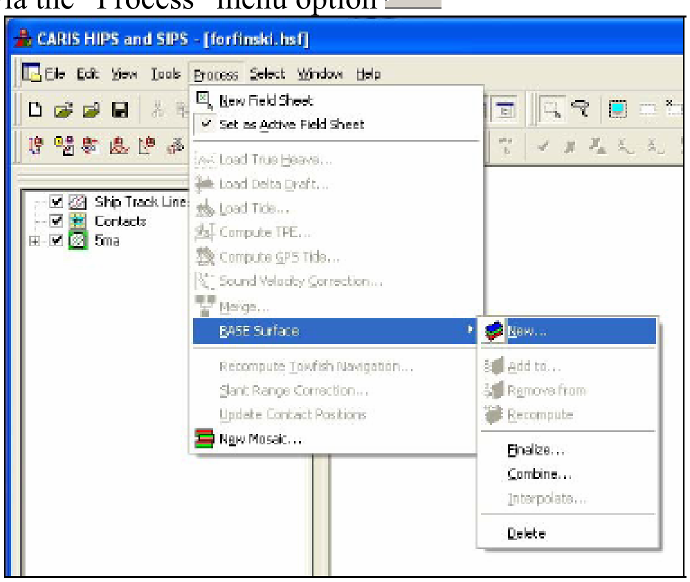


Type in the extents *or* Use the extents of the data on the screen *or* Click and drag extents

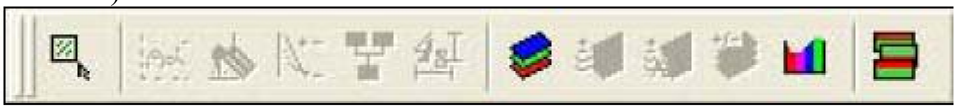
3.2. Start the BASE Surface Wizard

There are three ways to initiate the BASE Surface Wizard:

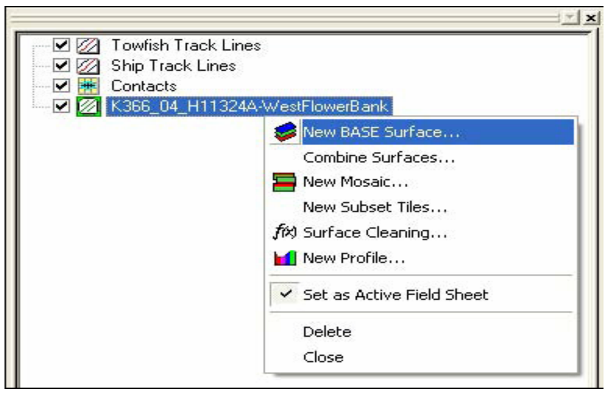
i) via the "Process" menu option 



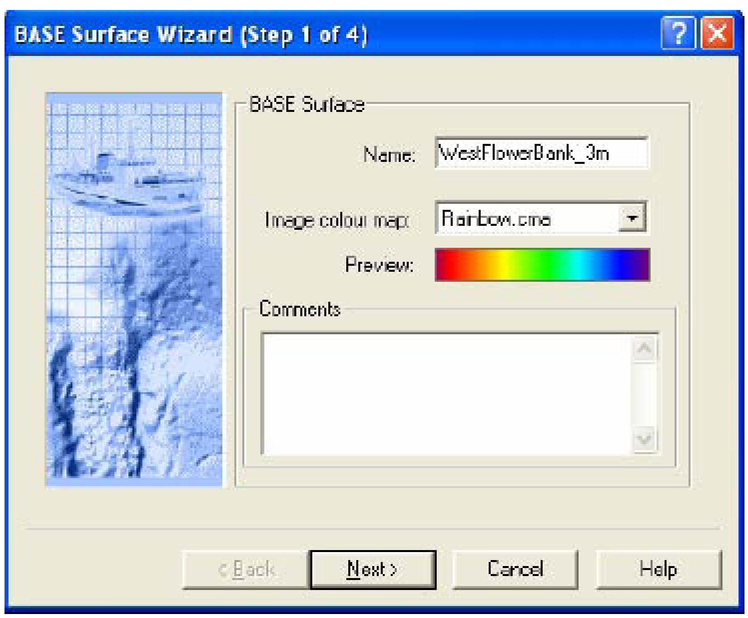
ii) via the "New BASE Surface" button on the "Process" toolbar



iii) via right-clicking on an existing fieldsheet in the session tab of the control window and selecting "New BASE Surface…".



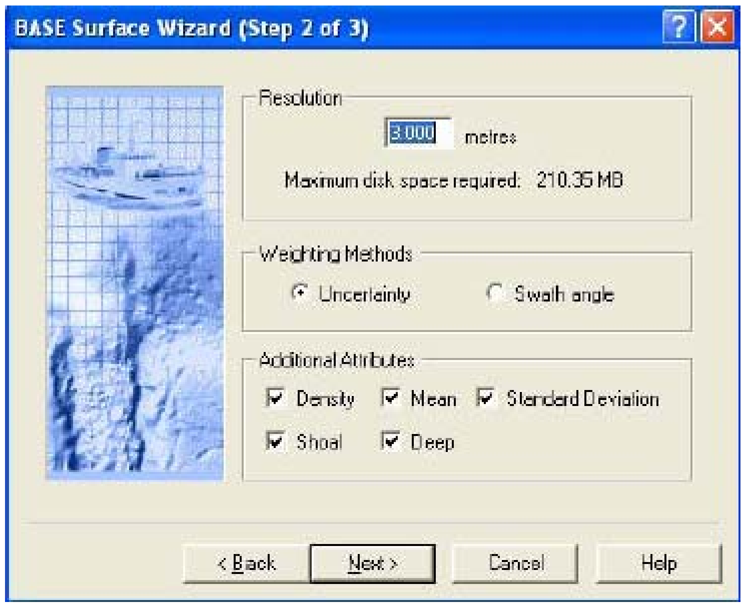
3.3. Specify BASE Surface Name and Color Map



Although the resolution of a BASE surface is recorded in the xml metadata file generated with every BASE surface, it's helpful to include the resolution in the name of a BASE Surface for easy reference.

Typical boat day BASE surface nomenclature:
Vessel_DayNumber_Resolution→ Example 1010_253_2m

3.4. Specify Resolution, Weighting Method, and Additional Attributes



3.4.1. *Resolution*

To preserve optimal data resolution, different depth ranges are gridded using different resolutions. Typically, deeper areas are gridded at a courser resolution than shoaler areas, where data density is typically greater. In practice, a BASE surface for each desired resolution is created for the entire survey area, and then during the finalize step, the appropriate depth range is "cookie cut" out (see Section 6).

Although the resolutions and depth ranges will vary from survey to survey, based on, among other factors, the sonars used and survey speed, a 2 meter resolution grid created during the batch process (See Appendix I) has been found to be a good starting point for determining what the cleaning resolution for the boat day should be set at.

3.4.2. *Weighting Method*

CARIS HIPS allows BASE surfaces to be generated using one of two weighting methods: swath angle weighting and uncertainty weighting.

NOTE: Although CARIS calls a swath angle-weighted grid a BASE surface, it does not contain an estimate of statistical error, as does an uncertainty-weighted BASE surface. In the rest of this document, "BASE surfaces" will refer to BASE surfaces generated using the uncertainty weighting method.

Swath Angle Weighting

Swath angle weighting is the weighting scheme used in CARIS HIPS 5.3 and earlier releases. Swath angle weighting involves 1) modeling each beam's footprint to determine its radius of influence and 2) weighting each footprint by 2 factors:

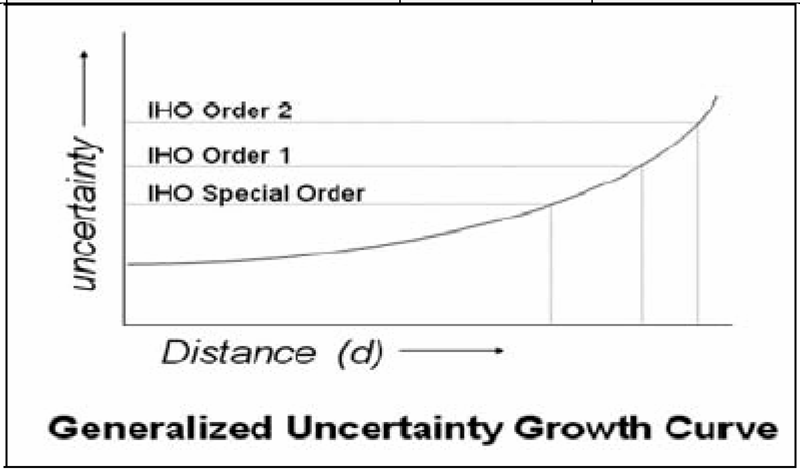
i- Range → The weight of a footprint is inversely proportional to its distance from a node.

ii- Swath Angle → A footprint is weighted by its grazing angle as defined in the file HIPS\System\GrazingAngleWeights.txt.

Uncertainty Weighting

Unlike swath angle weighting, uncertainty weighting does not model a beam's footprint. Rather, the weight and radius of influence for each sounding is based on that sounding's uncertainty (TPE).

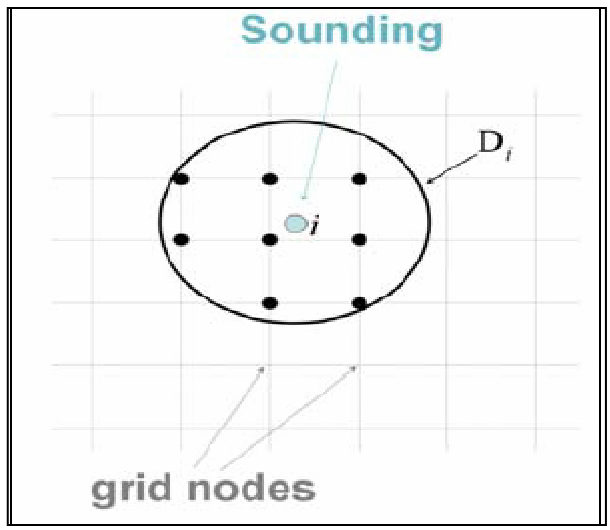
Determining the grid nodes to which a particular sounding will contribute weight (a sounding's radius of influence) is based on the idea of propagated depth-uncertainty (the vertical component of TPE). In general, soundings (observation points) do not coincide with grid nodes (estimation points). Soundings are propagated to grid nodes according to a power law that increases the vertical component of the sounding's TPE to account for this difference. The propagated uncertainty is a strong function of distance between observation and estimation points, d, but it also depends on the horizontal component of TPE and grid node spacing. A threshold of acceptable uncertainty is based on a user specified IHO order (see figure on top of next page).



Generalized Uncertainty Growth Curve

A sounding, i, will contribute weight to all of the grid nodes falling within domain D_i, which is determined by the propagated uncertainty mapping of observation point to estimation points, as described above (see figure to right).

The weight a sounding will contribute to a node is the inverse of the propagated uncertainty of that sounding, i.e. the lesser the uncertainty, the greater the weight.



A sounding's radius of influence

The depth at a given grid node, n, is the mean depth (weighted by propagated depth uncertainty) of the set N of soundings whose domain, D_i, contains n (see figure below). Likewise, the uncertainty at a given node is the mean uncertainty (weighted by propagated depth uncertainty) of all the soundings contained in set N.

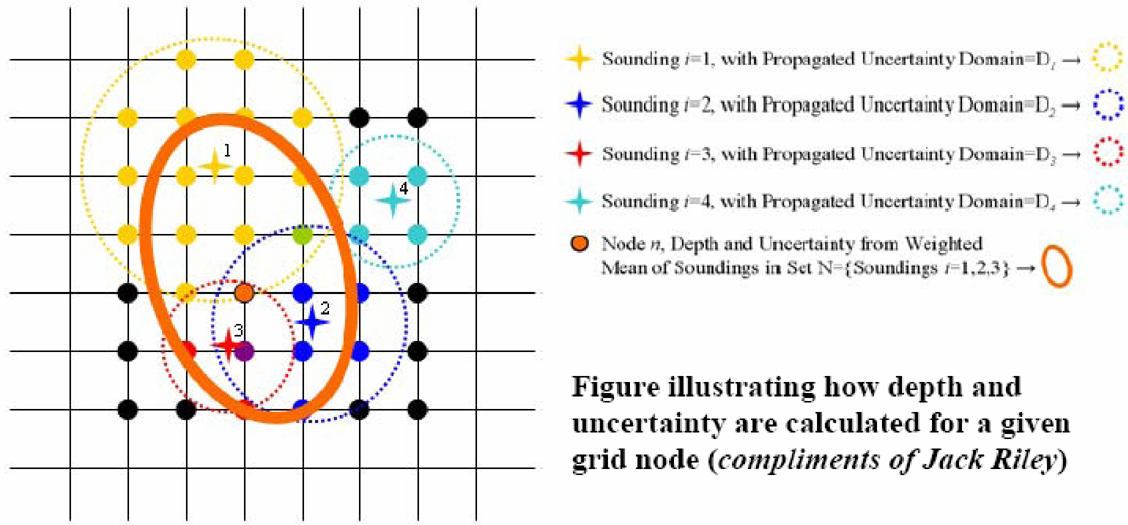
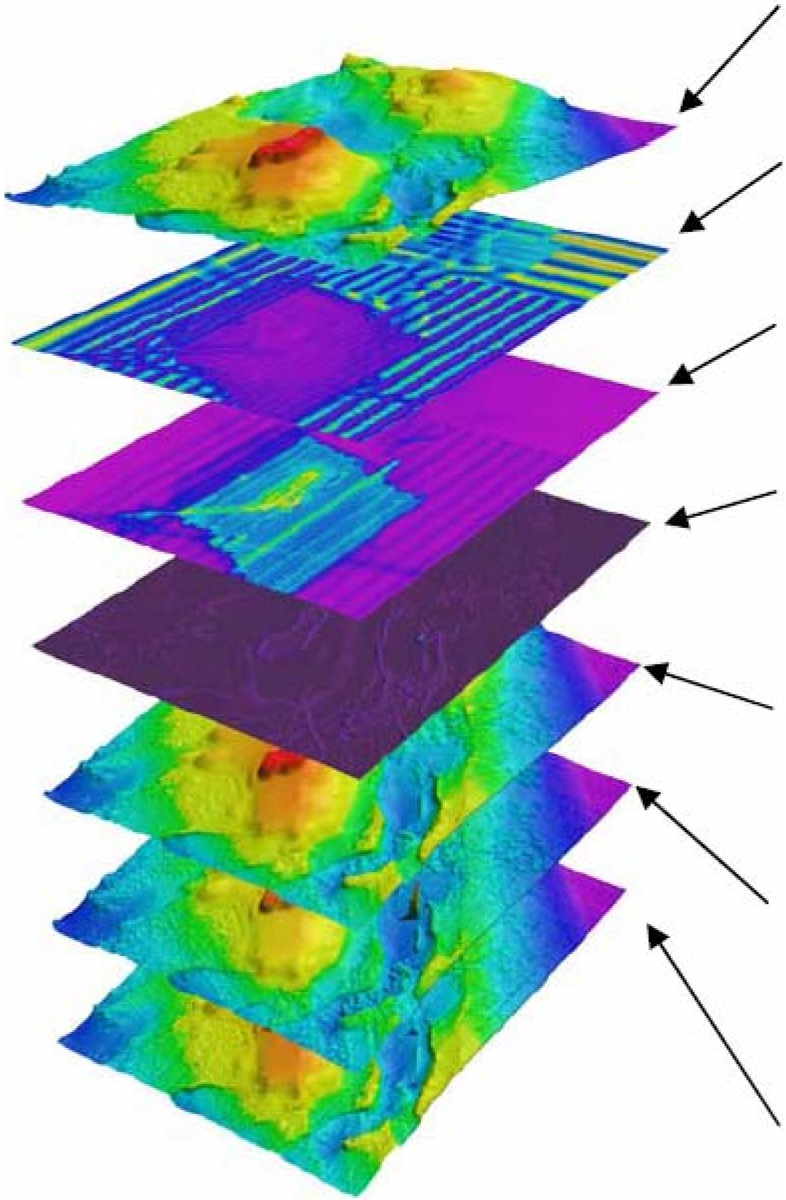


Figure illustrating how depth and uncertainty are calculated for a given grid node (*compliments of Jack Riley*)

3.4.3. *Layer Selection*

CARIS HIPS, by default, generates two layers, depth and uncertainty. The depth and uncertainty layers are weighted means, weighted by uncertainty. A user can also choose to generate five other layers, which report various statistics of the sample of soundings that contributed to a node: density, mean, standard deviation, shoal, and deep. See graphic next page.



Example of a BASE surface with all seven possible layers

The ***depth*** layer is the uncertainty-weighted bathymetry model.

The ***uncertainty*** layer is the uncertainty-weighted uncertainty model.

The ***density*** layer reports the number of soundings that contributed to each node.

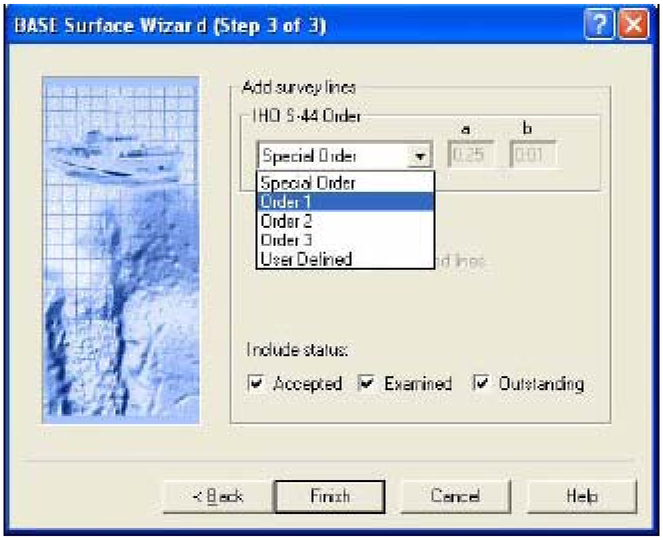
The ***standard deviation*** layer reports the standard deviation of all the soundings that contributed to each node.

The ***mean*** layer reports the average of all the soundings that contributed to each node.

The ***shoal*** layer reports the shoalest of the soundings that contributed to each node.

The ***deep*** layer reports the deepest of the soundings that contributed to each node.

3.5. Specify an Acceptable Uncertainty Threshold (Select IHO Order)



IHO Order

As was mentioned in the previous section, the specified International Hydrographic Organization (IHO) S-44 order serves as a maximum level of allowable uncertainty. Any sounding whose propagated uncertainty is greater than the allowable uncertainty will not be used in generating the grid.

The IHO Order that is selected here is dependant on water depth and survey purpose; generally NOS surveys are required to met IHO Order 1 accuracy tolerances. See *Appendix II* of this document for additional information IHO accuracy tolerances.

Along with every BASE surface, CARIS HIPS generates, in the same folder as the BASE surface, a corresponding xml-formatted metadata file that contains four sections:

SourceData → This section lists all the source HDCS line data.

DisplayParameters → This section lists the display parameters, such as the selected color map and shading parameters, of each of the layers in the BASE surface.

Information → This section records what computer user created the BASE surface, the date and time he/she created it, and what version of software was used.

SurfaceInformation → This section records information about the BASE surface as a whole, such as its coordinate system, resolution, dimensions, and the minimum and maximum of each of its layers.

4. Bathymetric Processing

Instead of the very time intensive, traditional method of cleaning data line by line, BASE surfaces, which incorporate soundings' TPE (total propagated error), allow processors to take a more efficient "surface-centric" approach to data cleaning. By viewing the depth layer in conjunction with other layers, particularly the uncertainty and standard deviation layers, processors can save time by targeting only the areas that need cleaning. After the appropriate edits have been made to the data and the BASE surface is regenerated, the BASE surface is then ready for the finalization process, which is discussed in the next section.

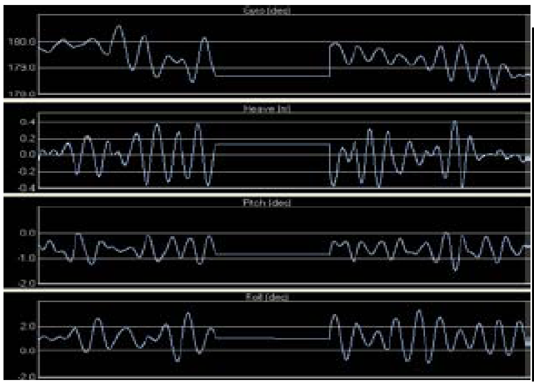
However, the transition from the traditional way of cleaning data to the more recent way has not been a single large leap. Although the foundation has been laid for a surface-orientated multibeam data processing pipeline, which gets away from looking at multibeam depth, attitude, and navigation data line by line as a matter of course, sheet managers are still "sub-setting" all the data as one would have traditionally done (albeit with perhaps a less stringent eye), because although the BASE surface implementation in CARIS HIPS 5.4 does minimize the influence of small, isolated bursts of noise, it does not have implemented CUBE "proper." Whereas CUBE "proper" formulates multiple hypotheses and then calculates a best guess of which hypothesis is the true bottom, the CARIS HIPS 5.4 implementation of TPE/BASE surface concepts will incorporate in its gridded bathymetry model all soundings that have an associated TPE within the acceptable limits of uncertainty. For example, whereas CUBE "proper" functionality might recognize a burst of noise from a school of fish near the surface as a separate bottom track, or hypothesis, and not incorporate those soundings into its final depth model, CARIS HIPS 5.4 would incorporate the noise into its final depth model (given that those soundings have not been rejected and have an associated TPE within the acceptable limits of uncertainty). The current processing procedures are a blend between new and old rather than a complete shift to the new.

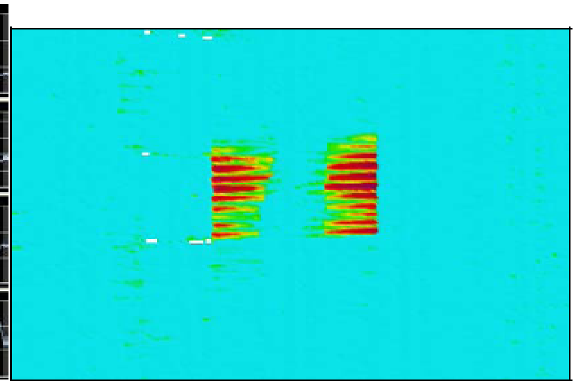
The basic idea behind a surface-centric approach to data cleaning is to systematically view the various BASE layers and investigate any anomalous features. Following are examples illustrating how a surface-centric approach to data cleaning can help target systematic and non-systematic errors that need to be cleaned or further examined.

4.1. BASE Surface Evaluation: Non-Systematic Errors

4.1.1. *Attitude Data Gap*

Rather than view attitude data line by line as a matter of course, BASE surfaces allow a processor to target only the areas that need cleaning or examination, which is illustrated in Figure 3. Further investigation of the along-track anomaly in the standard deviation layer of a BASE surface revealed a 42-second gap in the attitude data.

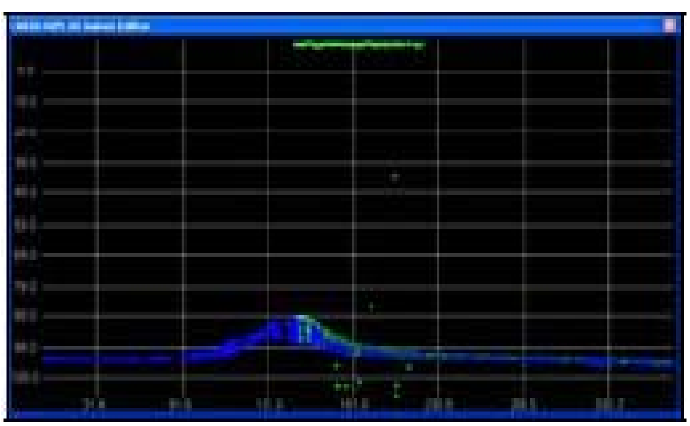




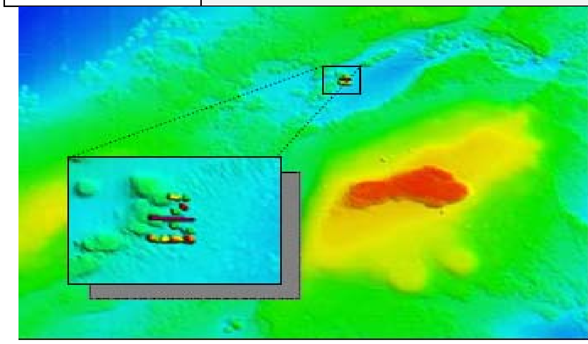
Standard Deviation Anomaly **Attitude Time Series Data**

4.1.2. *Depth Data "Blow Out"*

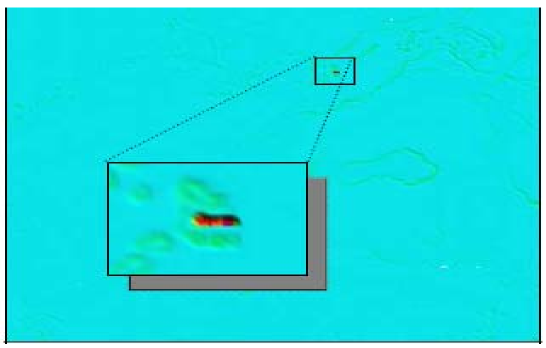
Although sheet managers, in reality, are still systematically reviewing entire surveys in subset mode (albeit with a less stringent eye), edits can be targeted by searching for anomalies in any of a BASE surface's layers. The following screen grabs illustrates how the shoal layer and an appropriately colored standard deviation layer can rather conspicuously reveal a blowout.



Depth data "blow out"



"Blow out" revealed in shoal layer

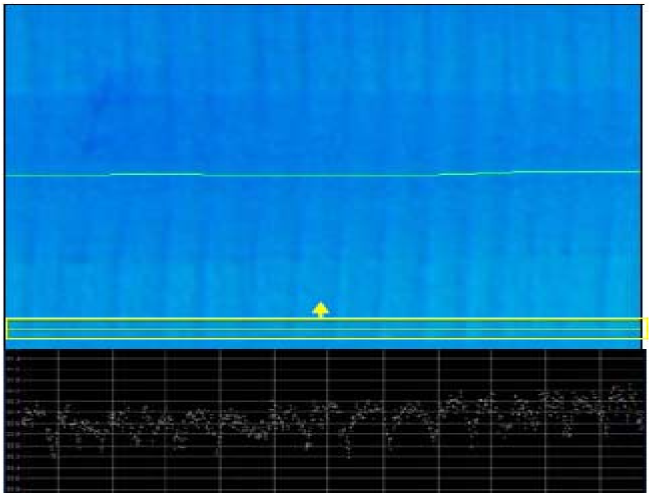


"Blow out"revealed in standard deviation layer

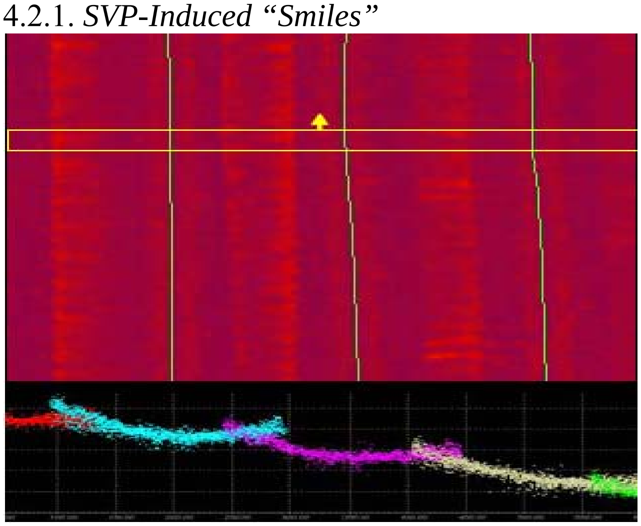
4.2. BASE Surface Evaluation: Systematic Errors

In addition to revealing isolated blunders, such as attitude data gaps and depth "blow outs", BASE surfaces are essential to identifying, visualizing, and quantifying systematic errors in data, such as svp-induced "smiles", tide busts, and inaccurate vessel configuration offsets, as illustrated below.

4.2.2. *Inaccurate Lever Arm*



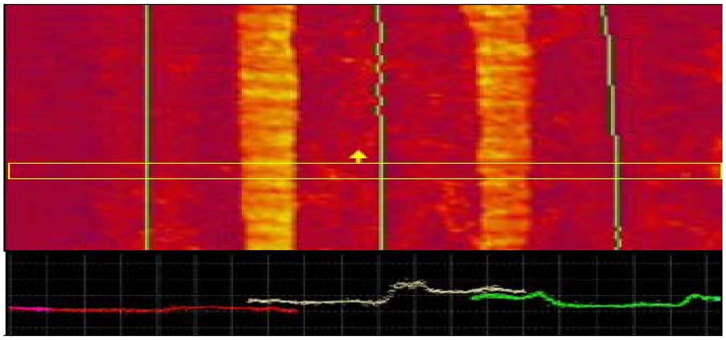
4.2.1. *SVP-Induced "Smiles"*



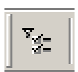
The outer beams of svp-induced "smiles" show up as along-track areas of relatively high standard deviation (the brighter red areas).

A possible inaccurate heave leaver arm manifests itself as a series of alternating across-track highs and lows in a depth layer

4.2.3. *Tide Error*



A tide error appears as two distinct stripes of relatively high standard deviation in the area of overlap.

4.3 Filters 

Processing of the bathymetric data will be dependant of the results of the grid. There are several filtering options, discussed below. By filtering after conversion the rejected data points can be viewed and reaccepted if deemed necessary.

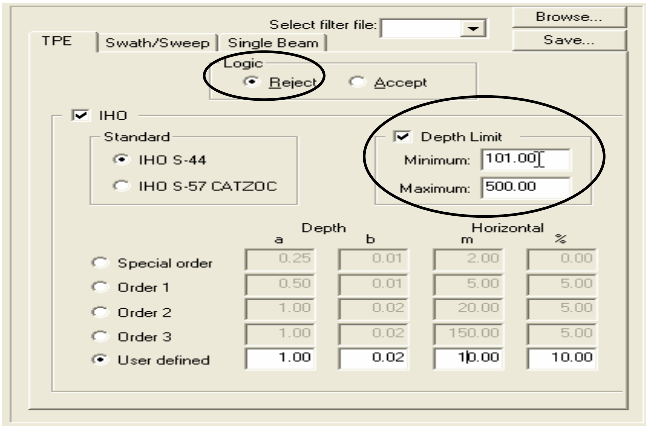
4.3.1. TPE

The TPE filtering option rejects (or accepts) soundings with uncertainty values that fall outside limits set by International Hydrographic Organization (IHO) standards. See Specification and Deliverables (page 62) for more detail on NOS accuracy tolerances. Filter lines after computing TPE.

Tools>Set Filters

Use Order 1 in 100m of water or less. Set the Depth Limit Minimum to 0 and Maximum to 100.

In depths greater than 100 m use "User defined" with the 'a' and 'b' error tolerance from Order 2 (1.00 and 0.023) and horizontal uncertainty of 5 meter + 5% of the water depth. Set the Depth Limit Minimum to 101 and Maximum to a value greater than expected maximum depth.

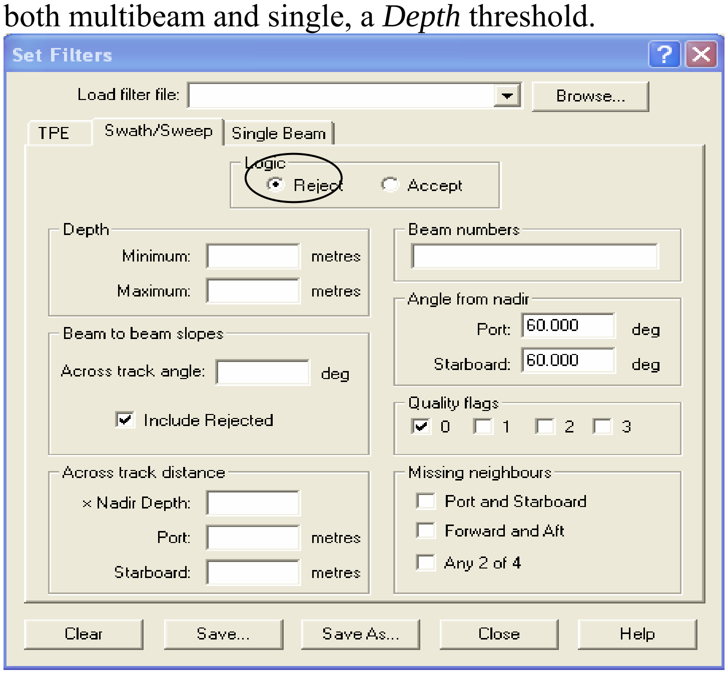


To calculate the error limits for depth accuracy, the constant depth error (a) and the factor of the depth dependent error (b) are combined with depth (d) and the depth dependent error (b * d) in the following formula:

Error limit for depth accuracy = $\pm\sqrt{a^2 + (b \times d)^2}$

4.3.2. Swath (Multibeam) and Single Beam Filtering

It may to be advantageous to filter based on sonar *Quality Flags*, *Angle from nadir* or, for both multibeam and single, a *Depth* threshold.



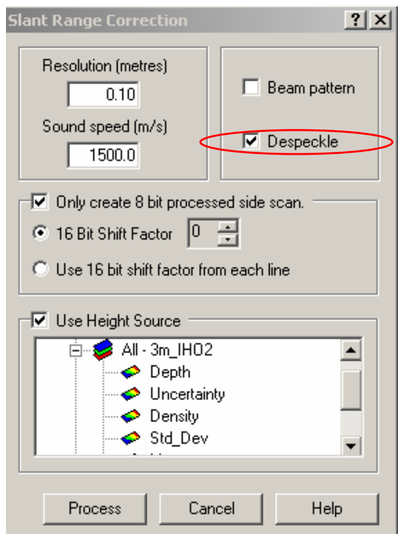
4.4 Object detection aided with side scan mosaic

In navigationally significant areas collected without acoustic backscatter, a review of the data must be done in line mode in addition to subset mode to aid in object detection.

If the multibeam data is collected with acoustic backscatter a mosaic should be reviewed in conjunction with the BASE surface to aid in object detection.

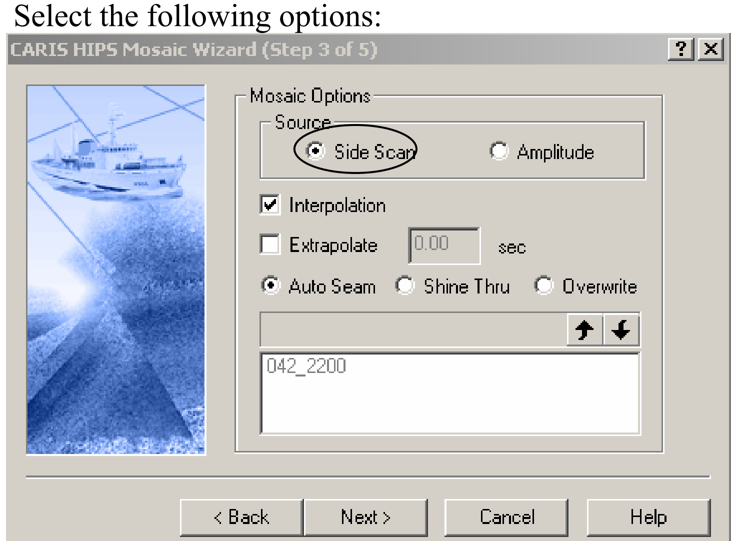
a) Slant range correct the data

- Create a ***Field Sheet***
- ***Process>Slant Range Correction***



Create a mosaic

- ***Process> New Mosaic***
- Select the following options:

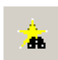


4.5 Subset Mode 

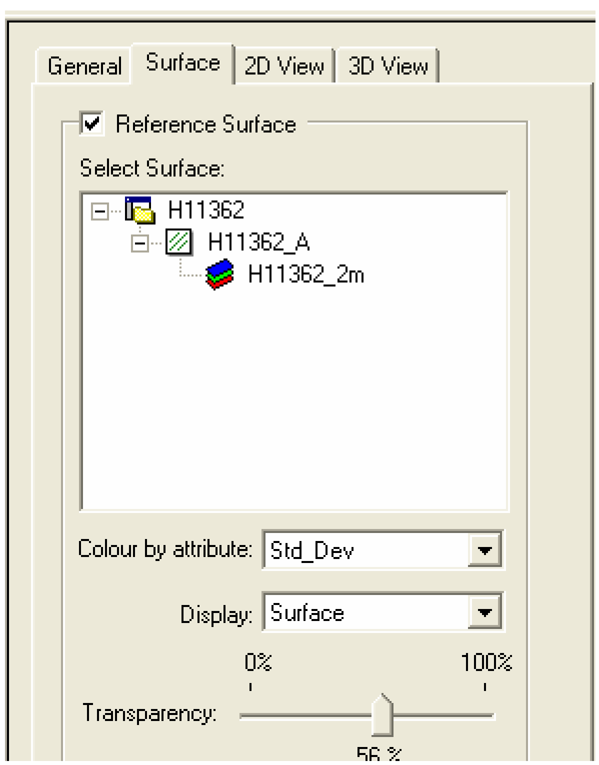
Data quality, based on the evaluation of the BASE surface, will greatly influence how the data will be processed. Currently, all data will be reviewed in subset mode. Noisy data will require further hydrographer evaluation and may necessitate line cleaning.

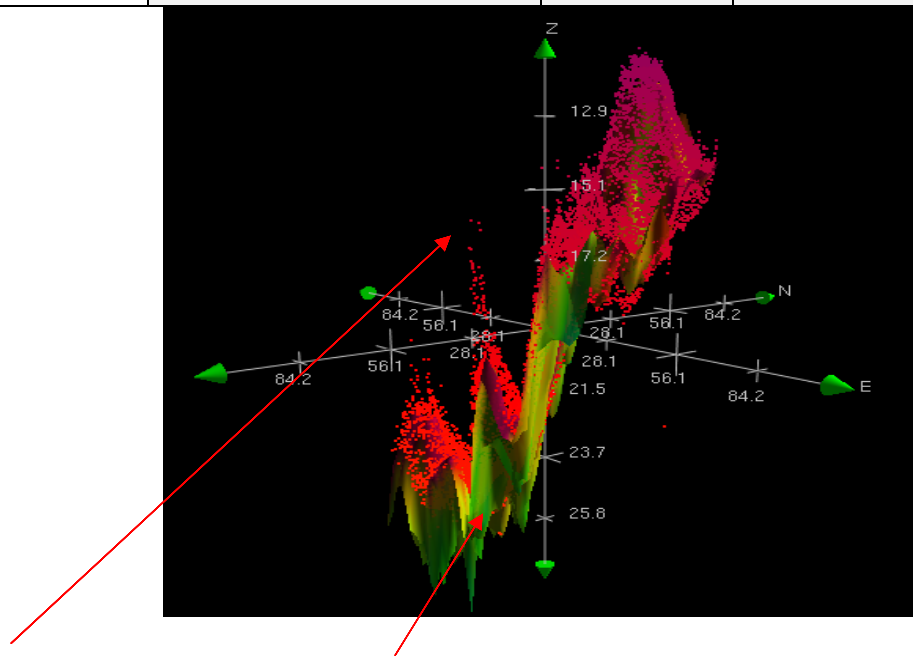
4.5.1 Designated Soundings

It may be necessary to flag a shoal sounding as "Designated" to ensure that it is preserved in the final combined BASE surface. The Designated Sounding depth value will be applied to the nearest node. To find the least depth highlight a cluster of soundings and use the Find Designated Sounding icon.



Determining whether a sounding should be flagged as "Designated" it is helpful to view the BASE surface with the HDCS data. The can be done by checking on *Reference Surface* on the *Surface* tab while in subset mode.





HDCS Data BASE Surface

5. Quality Control

The processes described below are reiterative by nature and it is not intended to be an exhaustive description of quality control procedures for bathymetric surveys but, it is limited in scope to reviewing the multibeam data in CARIS.

5.1 Display Critical Soundings

Depths that are flagged with Designated, Examined and Outstanding status flags can be displayed as a sounding layer in HIPS.

- ***View>Display Critical Sounding***

Since depths that are flagged as *Designated* generally represent least depths in navigationally significant areas, these soundings will be reviewed by the survey manager, assistant and Field Operation Officer as possible Dangers to Navigation (DtoN) submittals.

5.2 Field Sheet Editor

Contours and depths can be displayed in the HIPS session to aid in cleaning and evaluation. Contours and depths are reviewed on daily basis for anomalous depths. Please note that depths flagged as Designated will not be reflected in the depths and contours unless the BASE surface has been finalized (See Section 6).

In HIPS: ***File>Save Session***
Name the session

Tools>Field Sheet Editor

In FSE if the Contour and Sounding function is not available, re-open the Field Sheet

5.2.1. *Contours*

- ***Tools>Contours>New Contour Layer***
- Set the contour interval *(see Appendix 8 of NOS Specifications and Deliverables)*

5.2.2. *Depths*

- ***Tools>Soundings>New Soundings Layer***
- Selected the ***Depth*** Base layer

Select the following options:

5.2.3. *Selection Criteria*

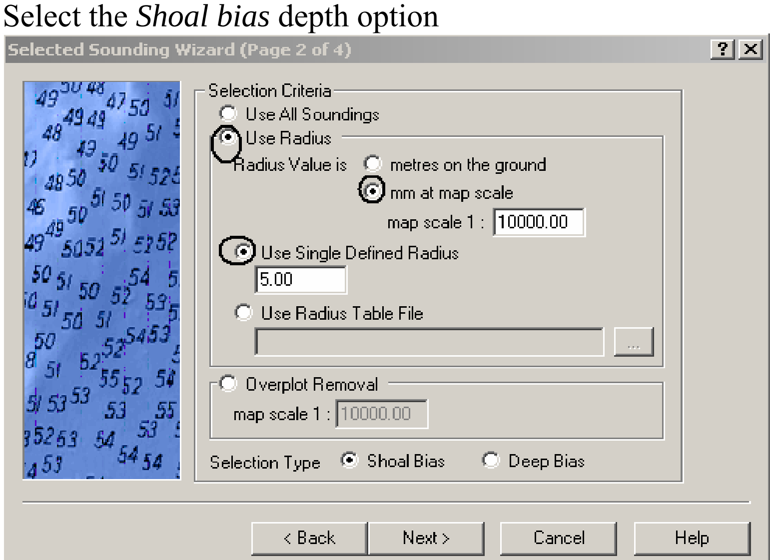
Selects the depth from a designated area. Select *Radius Value* and *mm at map scale,* enter the survey scale.

5.2.4. *Use Single Defined Radius*

Sets a standard minimum distance between soundings

5.2.5. *Selection Type*

Select the *Shoal bias* depth option



5.3 *Tiles*

- ***Tools>Tiles>Tiling***
- Selected the ***Tiling*** method
- Tile by ***Depth Tolerance*** of 5 meters (variable-dependant of depth range and density)
- Options: additional attribute ***StandardDeviation***
  User defined attribute (e.g. display all sounding that are less than 11 fathoms).
- The surface can be queried for information that will aid in cleaning and in QC/ QA such as querying for high standard deviations which may be associated with noise in the dataset. Query results can be reviewed in HIPS subset mode from Field Sheet Editor using the icon.
  - ***Tools>Tiles>Display Query***
    or
    Right click on the Tile layer in the information window

5.5 Danger to Navigation (DtoNs)
It is useful when examining the survey for significant least depths to generate a finalized BASE Surface that can be used to create contours and depths of a specific depth range. For example a depth threshold of zero to twelve fathoms can be used to aid in determining DtoNs. See Section 6.5 for defining depth thresholds.

6. Finalize BASE Surface

Finalizing BASE Surfaces serves three purposes:

1) To assign grid nodes a final uncertainty

A grid node's final uncertainty can be one of three options: 1) that node's a priori uncertainty-weighted uncertainty, i.e. predicted error, 2) the grid node's standard deviation, i.e. observed error, or 3) the greater of the two. Which option is selected will depend on what the user intends to report. NOAA Ship THOMAS JEFFERSON uses the "Greater of the two" option to maintain a conservative uncertainty estimate.

2) To apply designated soundings

In instances when a BASE surface does not accurately represent, due to the nature of the weighting algorithm, the least depth of a fine navigationally significant feature (such as a tall, narrow coral head or a shipwreck's mast), a sounding can be flagged as "designated" to force the nearest BASE surface grid node to honor the depth of that sounding.

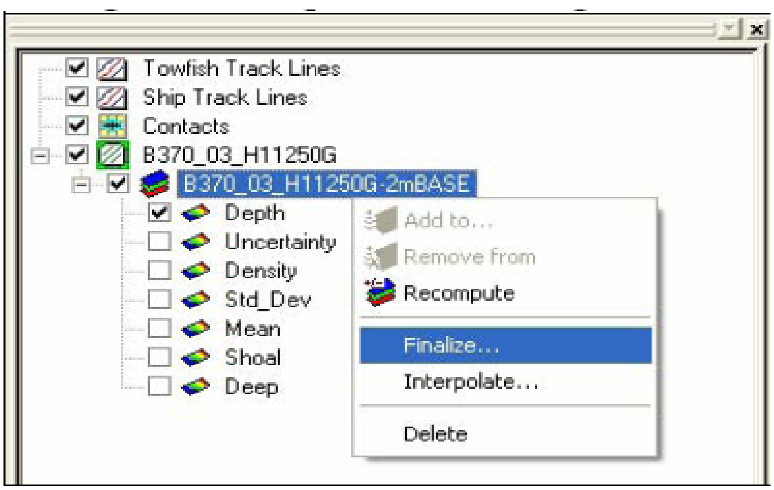
<u>*3) Define depth thresholds*</u>

A single-resolution grid covering an area may not necessarily be the optimal resolution for the entire area. To maintain the optimal resolution for a given depth range, the finalize process, in effect, "cookie cuts" out the desired depth range.

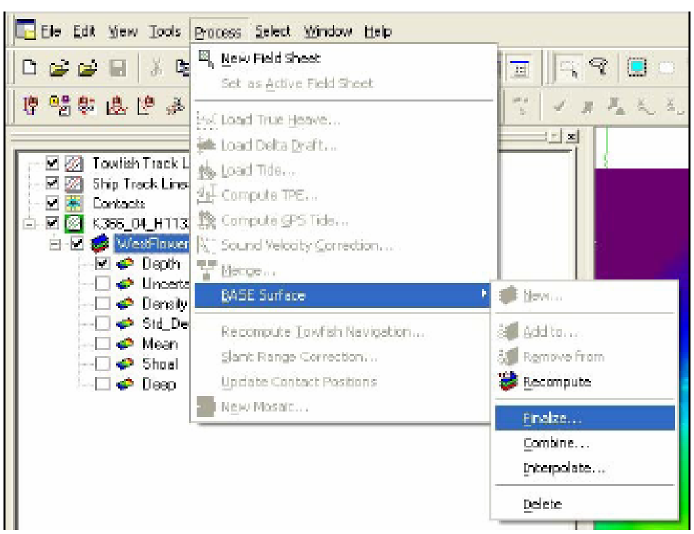
6.1. Open Finalize BASE Surface Dialogue

There are two ways to initiate the Finalize BASE Surface dialogue:

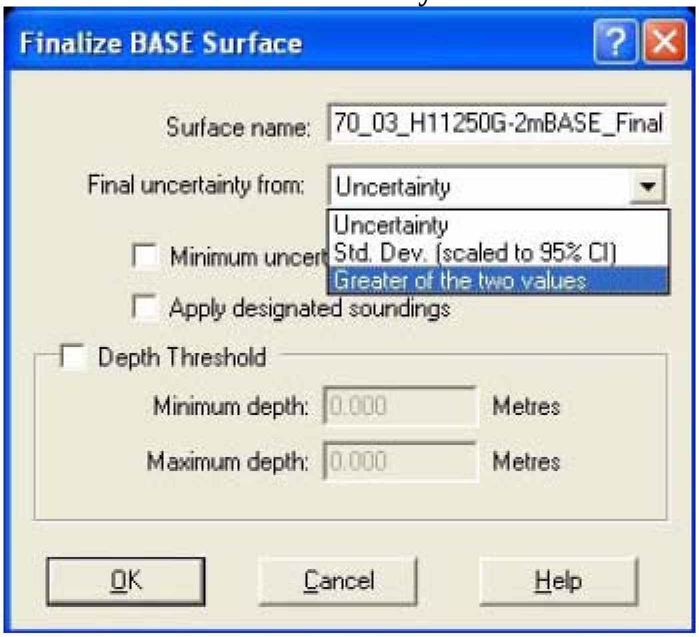
i) via right-clicking on an existing BASE surface



ii) via the "Process" menu option



6.2. Select Final Uncertainty Source

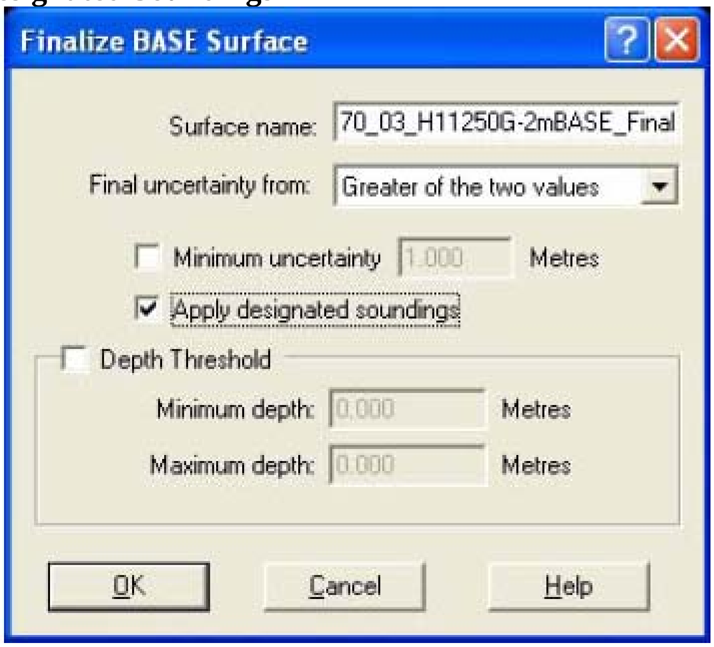


Select the *Greater of the two values option* 1) to maintain a conservative uncertainty estimate (in cases when the observed standard deviation is less than the a priori uncertainty-weighted uncertainty) and 2) to ensure that the observed error is used when it is greater than the predicted error (when the standard deviation is greater than the *a priori* uncertainty-weighted uncertainty).

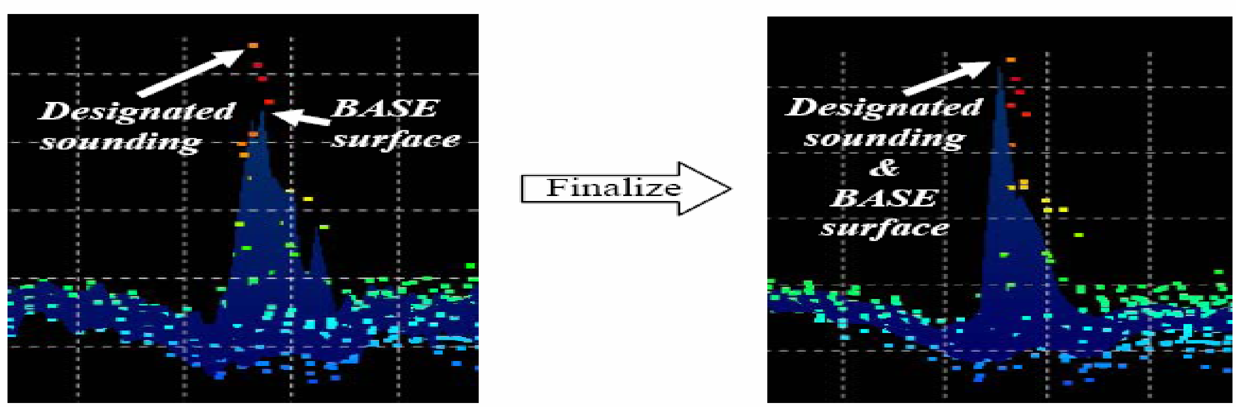
6.3. Specify "Minimum uncertainty" (if applicable)

The option to specify a "minimum uncertainty" is, for all intents and purposes, an obsolete concept, originally meant to provide a user a way to avoid uncharacteristically small uncertainty values in areas of very high data density; however, the uncertainty algorithm for which the minimum uncertainty option was intended is not the uncertainty algorithm currently implemented in CARIS HIPS and is no longer relevant to all but the most unusual and unlikely cases in which a user has reason to believe that the calculated TPE is inadequately low.

6.4. Apply Designated Soundings



Check the *Apply designated soundings* option to force the BASE surface to incorporate any soundings flagged as designated. During the finalize process, the nearest grid node to any "designated" sounding will be forced to have a depth of the "designated" sounding.



Pre-finalized BASE surface viewed in 2-d environment with soundings

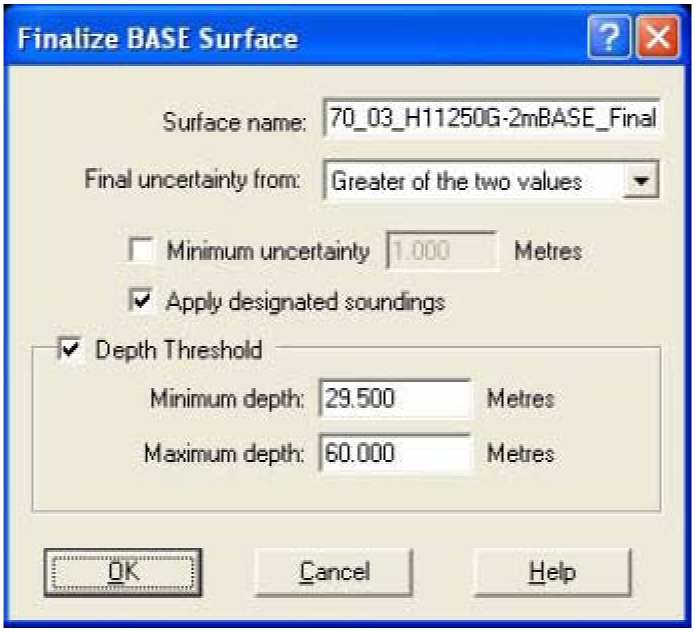
Finalized BASE surface viewed in 2-d environment with soundings

During the ongoing development of BASE surfaces and a BASE surface-orientated processing pipeline, there have been various schools of thought and questions concerning what soundings should be flagged "designated". Implemented procedures have included 1) flagging, as a matter of course, all items' least depths addressed in a descriptive report, 2) flagging only those "report" items' least depths whose model depth differs from their P/V/D/L/P/B, or HDCS, depth by more than a foot, and 3) flagging both chart and non-chart features' least depths whose model depth differs from their HDCS depth. Another idea that has arisen is to designate those features' soundings whose depths differ from the model by more than the acceptable IHO accuracy for soundings' depths; however, how such a comparison could be easily performed would also be open for discussion. Whatever specific guidelines are developed, comparing the model with the source soundings will now be significantly less thorny with the ability to view HDCS data and BASE surfaces together in a 2-d and 3-d environment with CARIS HIPS 5.4, Service Pack 1.

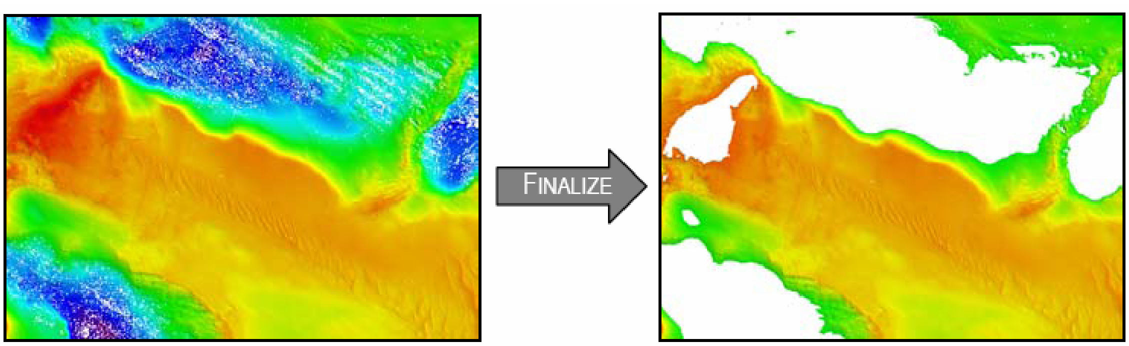
There has also arisen the question of which stage in processing should soundings be "designated" – for example, 1) in CARIS HIPS by the day/night processors or 2) in PYDRO by the sheet manager. Although the ability to flag soundings "designated" in both programs is beneficial, it's been suggested that the ideal stage at which to flag soundings "designated" is in CARIS HIPS, where a user is able to view all the source HDCS data and BASE surface in the same environment.

Another point that has arisen is that of having too many "designated" soundings. Although no model will always represent accurately the least depth of every fine navigationally significant feature, it should be representative a good portion of the time (or else one might question its usefulness). Having "too many" (admittedly a relative and ambiguous notion) designated soundings, i.e. too many cases where a model does not accurately represent what the hydrographer believes to be a least depth, is an indication that the resolution of the model is too course. By generating a new BASE surface with a finer resolution, the user is not "smoothing" the bottom as much and, in turn, is representing more accurately the least depth of features; however, the goal is to find a balance between resolution and data density.

6.5. Defining the Depth Threshold



If the survey area covers more than one desired depth range, specify the depth range to be "cookie cut" out. As is shown in the 2-meter resolution BASE surface below, relatively deep areas may not support a grid's resolution, whereas relatively shoal areas could be gridded with a finer resolution. To maintain the optimal resolution for a given depth range, the finalize process, in effect, "cookie cuts" out the desired depth range.



Pre-finalized 2-meter BASE surface including depths from 18-120 meters

Finalized 2-meter BASE surface including depths from 30-60 meters

The following resolutions and depth ranges have shown to be a good starting point when using a SIMRAD EM1002 in about 40-120 meters, a RESON 8101 in about 4-80 meters, and a RESON 8125 in about 4-50 meters:
Depth Threshold for Finalization of the BASE Surface
0.5-meter resolution → 0-15 meters depth
1.0-meter resolution → 14-30 meters depth
2.0-meter resolution → 29-60 meters depth
5.0-meter resolution → 59-150 meters depth
10.0-meters resolution → 149 & deeper

The depth ranges overlap by a meter to ensure that there are no gaps between adjacent BASE surfaces.

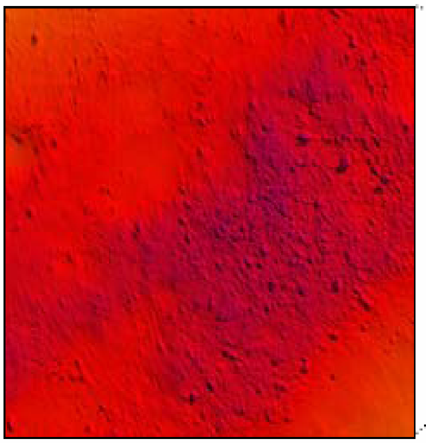
The BASE Surface deliverable will be five (as applicable) non-finalized BASE Surfaces. The Processing Branch will finalize the BASE Surface upon the application of smooth tides. To aid in processing at the Branch the nomenclature should include the depth range that the surface is able to support.

Example:
HXXXXX_DepthRange_Resolution →H12345_0-15_0p5m

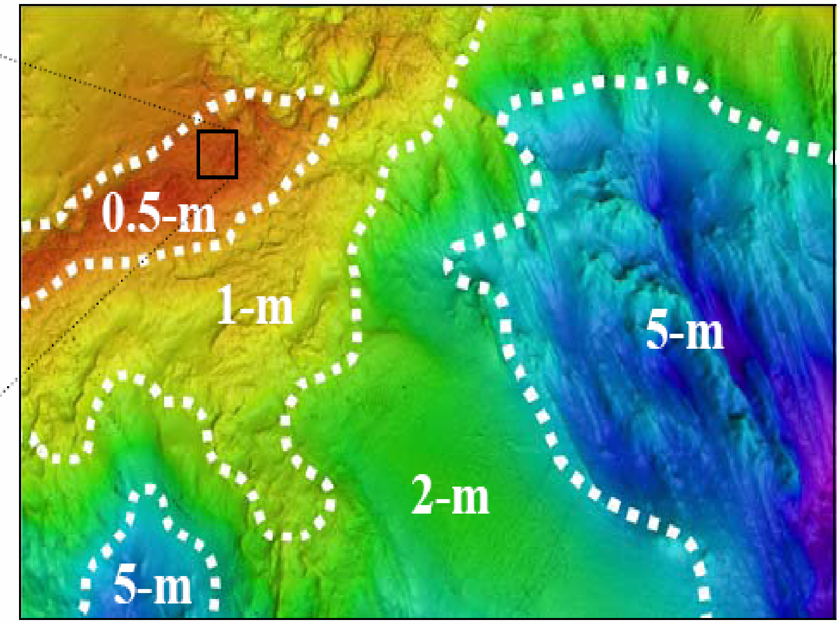
7. Combine BASE Surfaces

Generating combined surfaces, from which selected sounding layers can be generated, is currently an official responsibility of the processing branch; however, it is useful for the ship to do so also in order 1) to be able to produce sounding plots in CARIS without the problems associated with deconflicting soundings in areas of overlapping fieldsheets and 2) to be able to insert a survey's bathymetry model into PYDRO more efficiently than if multiple finalized surfaces were used. The usefulness of the combined surfaces functionality is of question since creating one surface at a particular resolution will generate the same results.

As illustrated on the next page, the combine function combines more than one BASE surface, with same or differing resolutions, into a new BASE surface that has a user specified resolution and maintains shoal depths.



Notice what happens to this area of the 0.5-meter resolution finalized BASE surface as a result of the combine function.

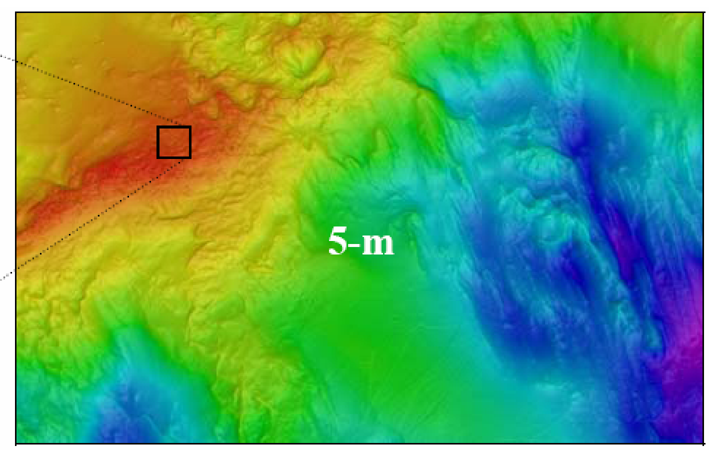


A collection of four separate finalized BASE surfaces, each with a different resolution: 0.5-m, 1-m, 2-m, and 5-m

⇩

(The combined BASE surface is on the next page.)

The area that was represented with a 0.5-m resolution BASE surface is now represented with a 5-m resolution BASE surface.

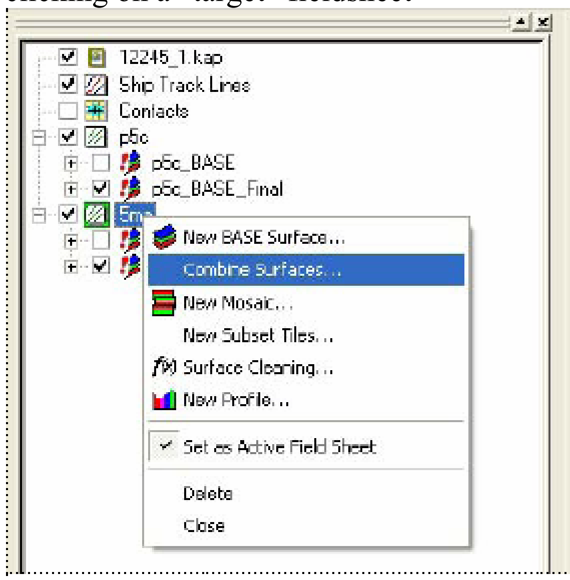


A single, combined BASE surface with a 5-meter resolution

7.1. Initiate the Combine BASE Surface function

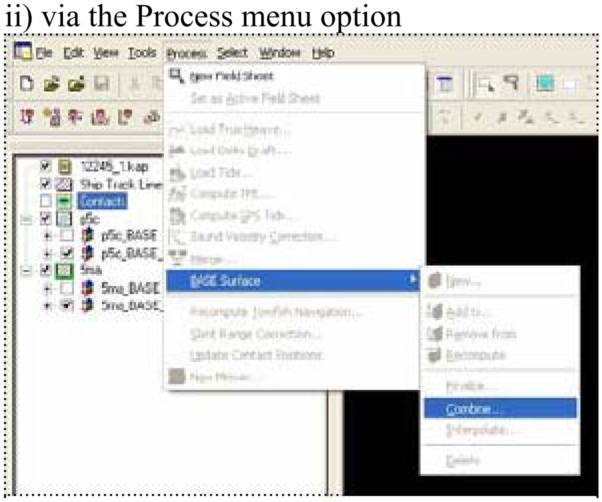
There are two ways to initiate the Combine Surfaces dialogue:

i) via right-clicking on a "target" fieldsheet

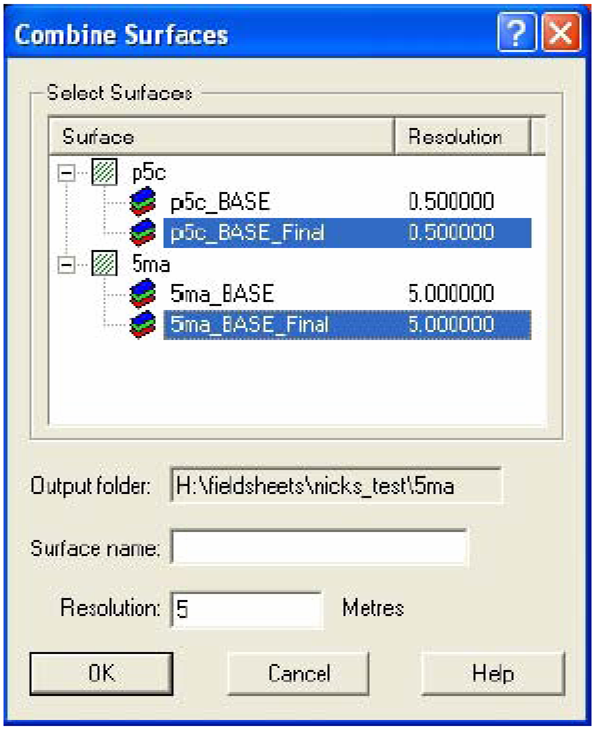


As the "target" fieldsheet is the geographical limits of the combined BASE surface, the fieldsheet should encompass all of the BASE surfaces intended to be combined. The BASE surfaces intended to be combined can be in the "target" fieldsheet, another fieldsheet, or various fieldsheets.

ii) via the Process menu option

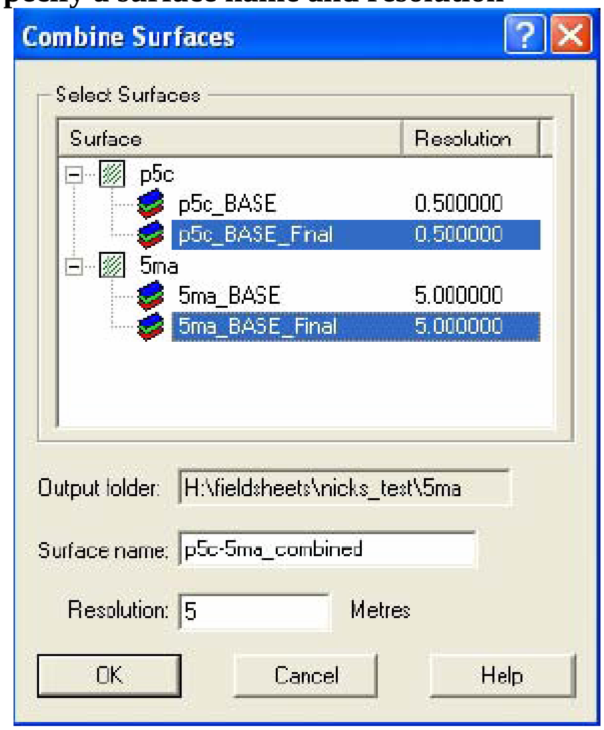


7.2. Select the surfaces to be combined



Select the desired BASE surfaces by expanding the Fieldsheet listing(s) and then highlighting the desired surfaces. The new combined surface will be output to the active Fieldsheet if the user initiated the Combine Surface dialogue via the "Process" menu option or to the clicked-on Fieldsheet if the user initiated the Combine Surface dialogue via right clicking on a Fieldsheet.

7.3. Specify a surface name and resolution



The resolution specified should be no finer than that of the **coarsest**-resolution contributing surface. CARIS HIPS deconflicts nodes using a simple shoal-biased algorithm in which each input node is snapped to the nearest output node, keeping the shoalest node.

8.0 Exporting BASE Surface(s)

The following processing procedures may vary from platform to platforms based on the software tools available.

8.1 Pydro

Inserting bathymetry

Pydro cannot directly access a BASE surface. CARIS intends to release an Application Programming Interface (API) that will allow direct access BASE data. The work around is to create a weighted grid in Pydro from the BASE surface.

Open Pydro

- ***Data>Inset>HIPS Weighted Grid***

Define the file path to the HDCS data

Define the "***Selection criteria for drawing on the chart***" 

- BUG v4.5.1-Double click on the ***CARIS Weighted Grid Data*** from the list
- Under the Selection window-***File>Close***

Pydro adds a '_HNS' to the file name of the imported BASE surface

Inserting Designated Soundings

Define the file path to the designated soundings

- ***Data>Insert>CARIS Line Features***
- Select the folder that contains the survey HDCS data

8.2 MapInfo

Run HydroMi

Define the path to HydroMi

- ***Tools>Tool Manager***
- ***Add Tool***
- Add title: Hydro Mi
- Location (normally): C:\Program Files\Python23\Pydro\Hydro_MI.MBX
- Check ***Loaded*** and ***Autoload*** from the main Tool Manager window

Insert the Pydro PSS

- ***Post-Survey>Draw Preliminary Smooth Sheet***

Select the PSS with the '.wgfsl' extension

Appendix I

Batch Processing

Batch Processing combines and automates numerous processing steps. The order in which the tasks are completed is important since the results of one step may be required for further processing to be accomplished. The following are the processing steps, in the order that they are performed, used to convert and apply correctors to the bathymetric data:

(01) Convert RAW

(02) SVP Correct

(03) Apply Predicted, Zoned Tides

(04) Load True Heave

(05) Merge

(06) Compute TPE

(07) Filter IHO 1 for <100m water depth

(08) Filter "User defined" (a=1.0, b=0.023, Hort. 10m+5%) for >100m water depth

(09) Add to BASE-(Generally at 2m resolution for coverage)

(11) Slant range correct (if sonar has backscatter)

(12) Mosaic side scan

Appendix II

IHO Orders

TABLE 1

Summary of Minimum Standards for Hydrographic Surveys

ORDER	Special	1	2	3
Examples of Typical Areas	Harbours, berthing areas, and associated critical channels with minimum underkeel clearances	Harbours, harbour approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200 m water depth	Offshore areas not described in Special Order, and Orders 1 and 2
Horizontal Accuracy (95% Confidence Level)	2 m	5 m + 5% of depth	20 m + 5% of depth	150 m + 5% of depth
Depth Accuracy for Reduced Depths (95% Confidence Level) (1)	a = 0.25 m b = 0.0075	a = 0.5 m b = 0.013	a = 1.0 m b = 0.023	Same as Order 2
100% Bottom Search	Compulsory (2)	Required in selected areas (2)	May be required in selected areas	Not applicable
System Detection Capability	Cubic features > 1 m	Cubic features > 2 m in depths up to 40 m; 10% of depth beyond 40 m (3)	Same as Order 1	Not applicable
Maximum Line Spacing (4)	Not applicable, as 100% search compulsory	3 x average depth or 25 m, whichever is greater	3-4 x average depth or 200 m, whichever is greater	4 x average depth

(1) To calculate the error limits for depth accuracy the corresponding values of a and b listed in Table 1 have to be introduced into the formula

$$\pm\sqrt{[a^2 + (b*d)^2]}$$

with
- a constant depth error, i.e. the sum of all constant errors
- b*d depth dependent error, i.e. the sum of all depth dependent errors
- b factor of depth dependent error
- d depth

(2) For safety of navigation purposes, the use of an accurately specified mechanical sweep to guarantee a minimum safe clearance depth throughout an area may be considered sufficient for Special Order and Order 1 surveys.

(3) The value of 40 m has been chosen considering the maximum expected draught of vessels.

(4) The line spacing can be expanded if procedures for ensuring an adequate sounding density are used (see 3.4.2)

Acronyms used in this guide

BASE — The Bathymetry Associated with Statistical Error (BASE) Surface. A georeferenced representation of the seabed derived from processed bathymetry and computed uncertainty (error) values. The algorithm applies soundings to the grid based on beam footprint size. A customizable weighting system allows more emphasis in the mean calculation to be placed on the inner nadir beams or on soundings with lower uncertainty values.

HVF — HIPS Vessel File. A vessel configuration file in XML format that consists of a list of sensors with their physical and calibration measured offsets, plus any error values. These are applied to the observed data during processing. The HVF supersedes the Vessel Configuration File (VCF).

TPE — Total Propagated Error. TPE is derived from a combination of all individual error sources and is used to calculate horizontal and vertical uncertainties for soundings.

The following people were instrumental in providing the information necessary to write this document: Brian Calder, Bill Lamey, Shep Smith, and Jack Riley.

S57 Shoreline Processing SOP

Table of Contents

0. Document Scope

This document outlines the new standard operating procedures for processing of shoreline data to S57 standards, from data transfer to export of S57 feature objects into Pydro and SVP and tide corrections in CARIS. For background information, see Suitcase Shoreline Presurvey SOP and Suitcase Shoreline Acquisition SOP.

1. Transfer data from field datalogger back to ship

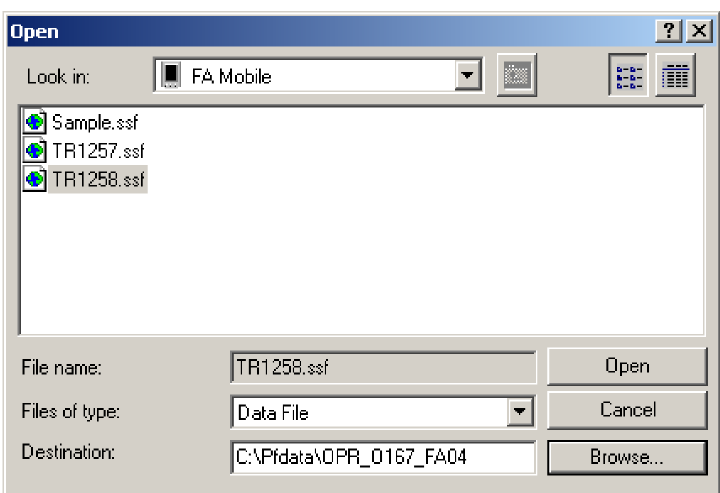
1.1. Boat sheets and DP forms

Boat sheets and DP forms are valuable pieces of data and must be kept track of and submitted as part of the DR. Completed DP forms should be filed in the appropriate sheet binder, and boat sheets should be stowed in a plastic sleeve in the back of the binder.

1.2. Data transfer

In Pathfinder Office, select Data Transfer from the Utilities menu. Then select a device from the pull-down menu. The icon in the upper right corner of the window indicates the status of Pathfinder's connection with TerraSync. If "Not connected" is displayed, click the button with the green checkmark to connect to TerraSync; the button with the red arrow disconnects.

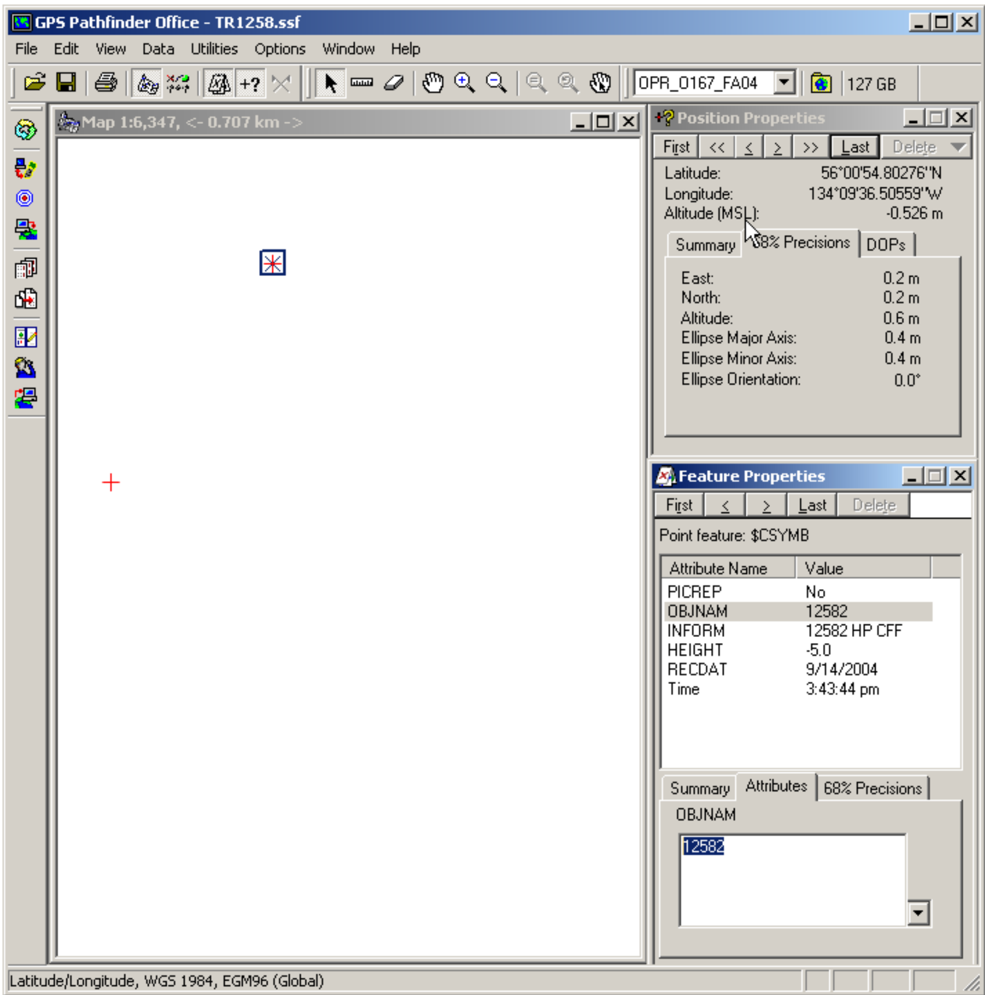
Click the Receive tab and then press Add and select Data File from the pull-down menu. Navigate to your data file. Click Browse in order to find your project folder; set this as your destination location. Click Open.



In the Data transfer window select Transfer All. Once the transfer is complete, press Close.

1.3. Open Data

Go to File→ Open. Navigate to your project folder, find your file, and click Open. You can now view and manipulate your data in three different windows: Map, Feature Properties, and Position Properties.



2. Edit attribution information in Pathfinder

Before exporting the shapefiles for use in Pydro, check to make sure that all information is correct, and that it matches any notes on the DP form. Scroll through all attribute fields for each point and make sure all information is correct.

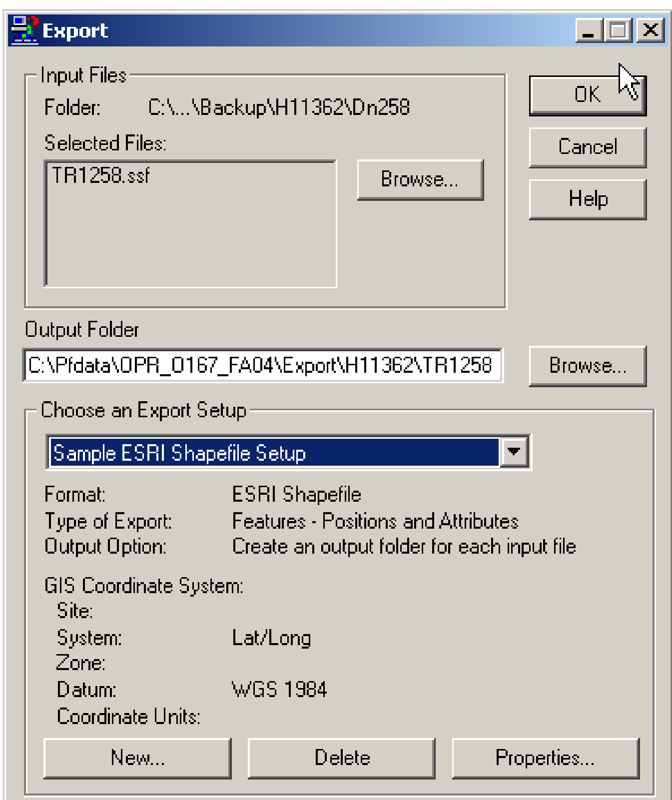
Clicking on a point in the Map window will automatically select it and bring up its attribution information in the Feature Properties and Position Properties windows. In each of these windows, the forward and back arrows can also be used to scroll between points. Double-clicking on a point in the Feature Properties window will automatically bring up its Attributes tab and allow you to edit the field. Make sure to save any changes you make.

NOTE: Currently, if converting the data into shapefiles, Pathfinder is unable to correctly export any DP's with a VALSOU or HEIGHT of a zero value; exporting points with VALSOU or HEIGHT = 0 will result in a null value and will import incorrectly in Pydro. Before exporting, any zero values should be changed to a slightly more conservative value, like observed depth = -0.01 m.

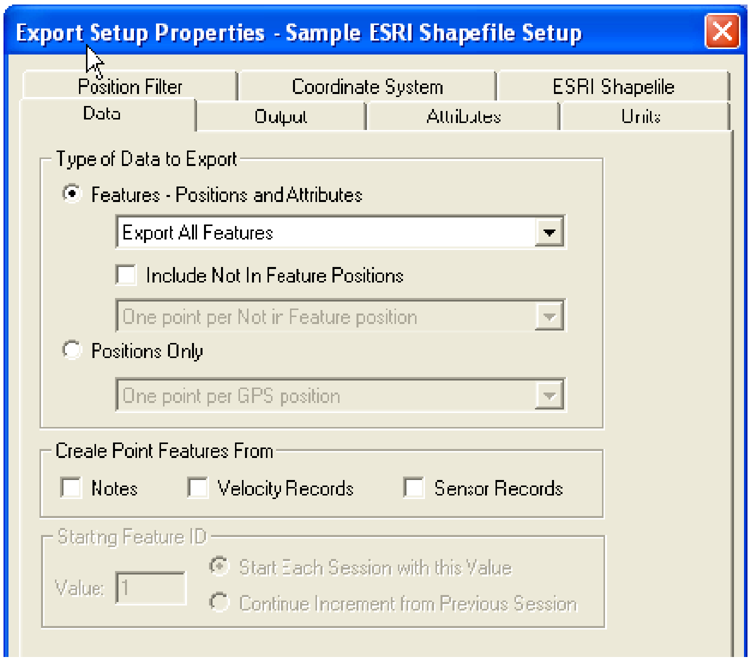
3. Process in Pydro

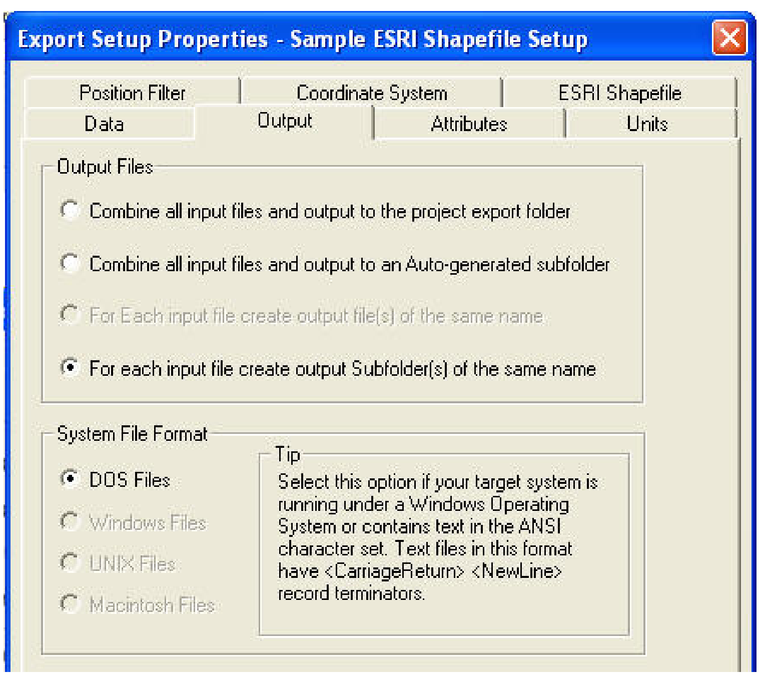
3.1. Export shapefiles to Pydro

When you're ready to export shapefiles to Pydro, choose Export from the Utilities menu. Select the Sample ESRI Shapefile Setup option under the pull-down menu called Choose an Export Setup, and click Browse in order to select your Output folder (the Export subfolder of your Pathfinder Office project folder). Press Browse in order to find the raw SSF Trimble data files you wish to export from the Pathfinder project Backup folder.

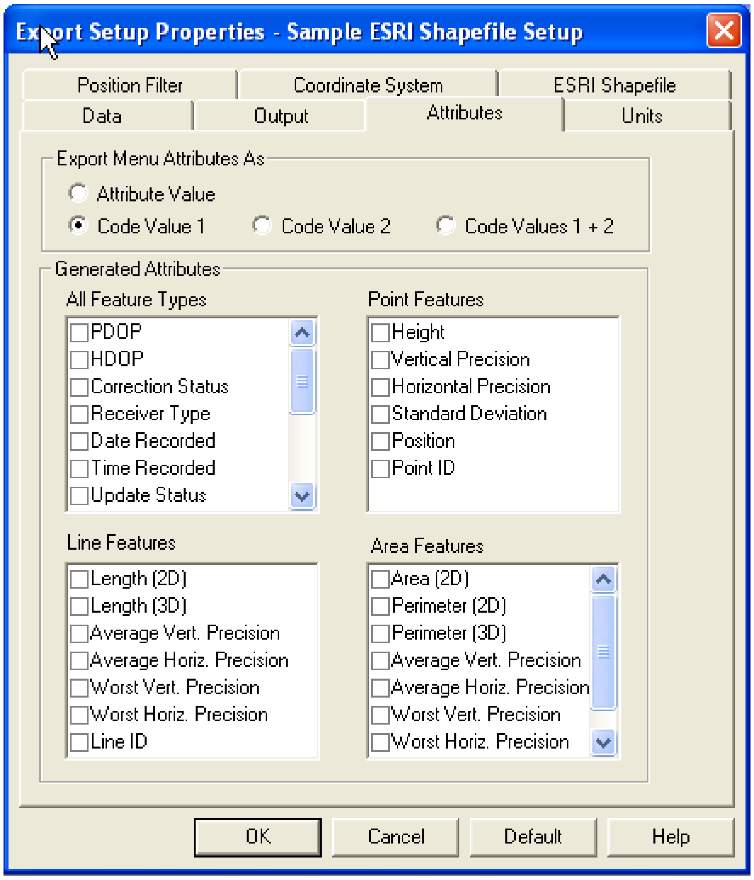


Click Properties and make sure all tabs are set according to the following examples:

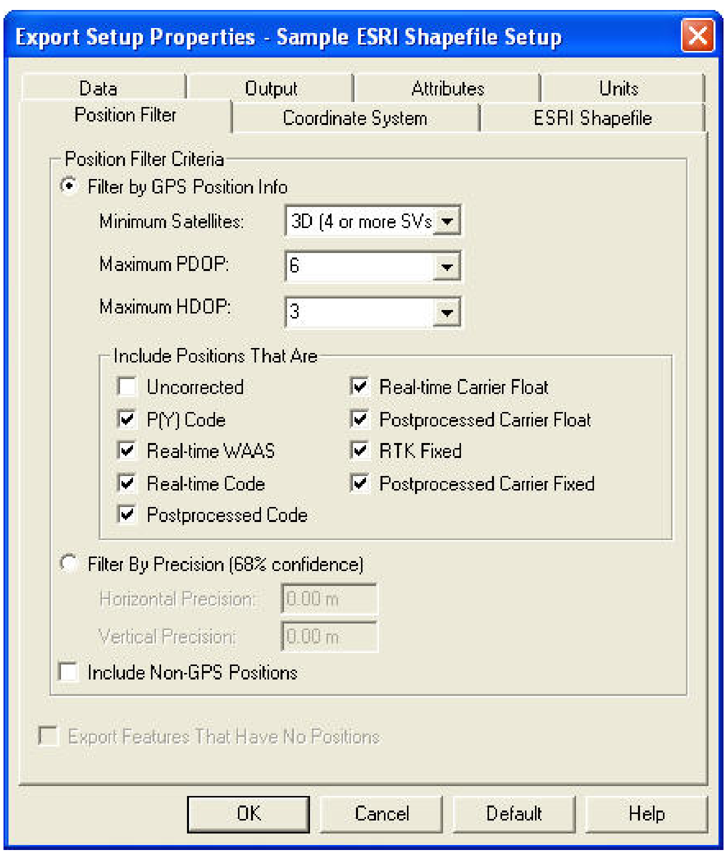




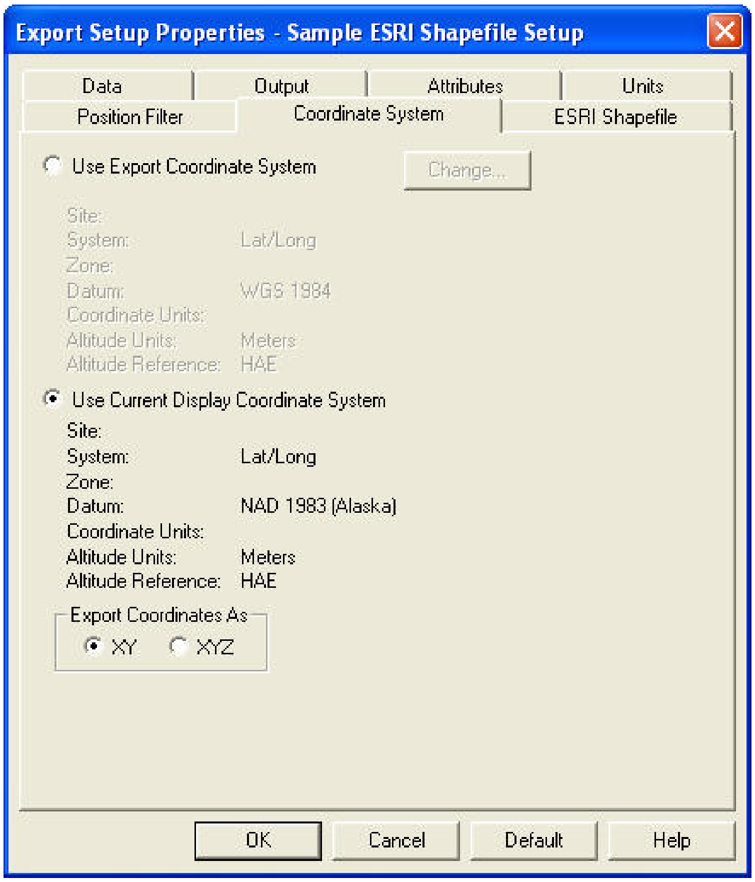
In the Attributes tab, Code Value 1 must be checked in the "Export Menu Attributes as" field so that Pydro can correctly interpret their S57 attribution.

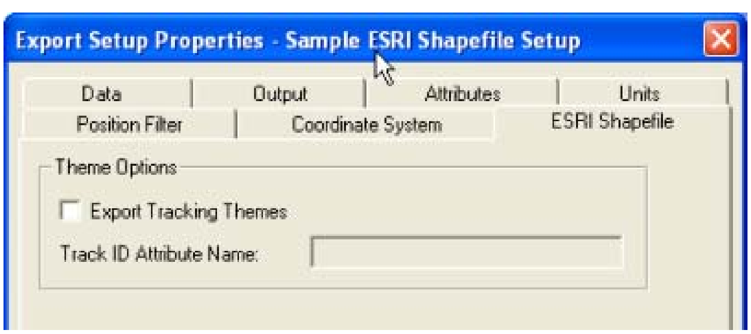


Export Setup Properties - Sample ESRI Shapefile Setup
Position Filter
Coordinate System
ESRI Shapefile
Data
Output
Attributes
Units
Units
Use Export Units
Change...
Distance Units: Meters
Area Units: Square Meters
Velocity Units: Meters Per Second
Use Current Display Units
Distance Units: Meters
Area Units: Square Meters
Velocity Units: Meters Per Second
Decimal Places
Lat/Long: 9
North/East: 3
Height: 3
Distance: 3
Area: 3
Velocity: 3
Precision: 1
Time: 3
Latitude/Longitude Options
Format: DDD.dddddd
Quadrant: +/-
Date/Time Options
Time Format: 12 Hour Clock
Date Format: MM/DD/YY



Export Setup Properties - Sample ESRI Shapefile Setup
Data
Output
Attributes
Units
Position Filter
Coordinate System
ESRI Shapefile
Position Filter Criteria
Filter by GPS Position Info
Minimum Satellites: 3D (4 or more SVs
Maximum PDOP: 6
Maximum HDOP: 3
Include Positions That Are
Uncorrected
P(Y) Code
Real-time WAAS
Real-time Code
Postprocessed Code
Real-time Carrier Float
Postprocessed Carrier Float
RTK Fixed
Postprocessed Carrier Fixed
Filter By Precision (68% confidence)
Horizontal Precision: 0.00 m
Vertical Precision: 0.00 m
Include Non-GPS Positions
Export Features That Have No Positions
OK
Cancel
Default
Help





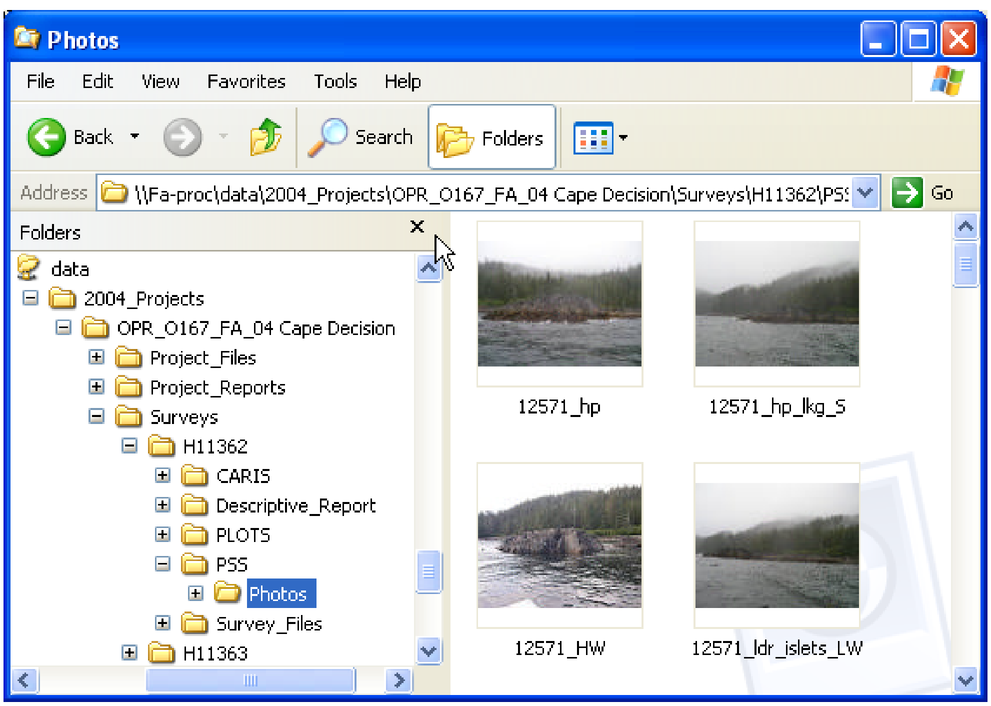
NOTE: One set of files (DBF, SHP, SHX) will be created per feature type ($CSYMB, UWTROC, WRECKS, etc.) so each file may contain one or many points, depending on how many DP's were given this feature name in the field.

After exporting points, open an explorer window of the Pathfinder Export folder, and find the files you just created. Rename each file, giving it the Trimble GPS unit and Julian Day Number (TR1*XXX*_ or TR2*XXX*_) as a prefix. Files must be uniquely identified in this manner before transfer into Pydro, otherwise the next DP of the same feature type will repeat the file name.

3.2. Prepare photos for DP's

Upload or scan any photos from the field and then erase them from the camera to avoid any future confusion. Name photos by their DP numbers and any other notes that will help the sheet manager and cartographers understand what the picture represents (i.e. the cartographer could interpret "12583_hp_toE" to mean that the photo is of the high point of DP 12583, and was taken towards the East).

If the subject of a photo is unclear or if multiple features are represented in the same picture, it may be useful to crop or label the picture with text and arrows in a photo editor. Save final copies of DP photos in a subfolder of the survey's PSS folder. It is fine to have multiple pictures for one feature, but any "fun" pictures from the day should be saved elsewhere.



3.3. Open or create a PSS

Open Pydro. If you are updating an existing PSS, open it through File→ Open→ Open PSS; if no PSS has yet been created, open the background chart you wish to use by choosing File→ Open→ Open BSB chart. Save the PSS with the survey name (i.e. H11362) to the project's PSS folder.

NOTE: Saving the PSS performs two processes; it writes a new line in the HDCS data and it creates a new PSS or overwrites an existing one. For this reason, be especially careful to use the existing PSS if there is one so you don't end up overwriting a session that already has DP's in it. Also, make sure that only one person at a time is updating a PSS so that the other's changes aren't lost.

3.4. Bring in DP's and GP's

Also refer to the Survey_PIC_Shoreline_SOP.doc for a step by step guide.

This process will change with pending Pydro updates (current version 4.9.3). Currently, to bring in your GPS positions, select Insert Generic GPs/DPs from the Data menu.

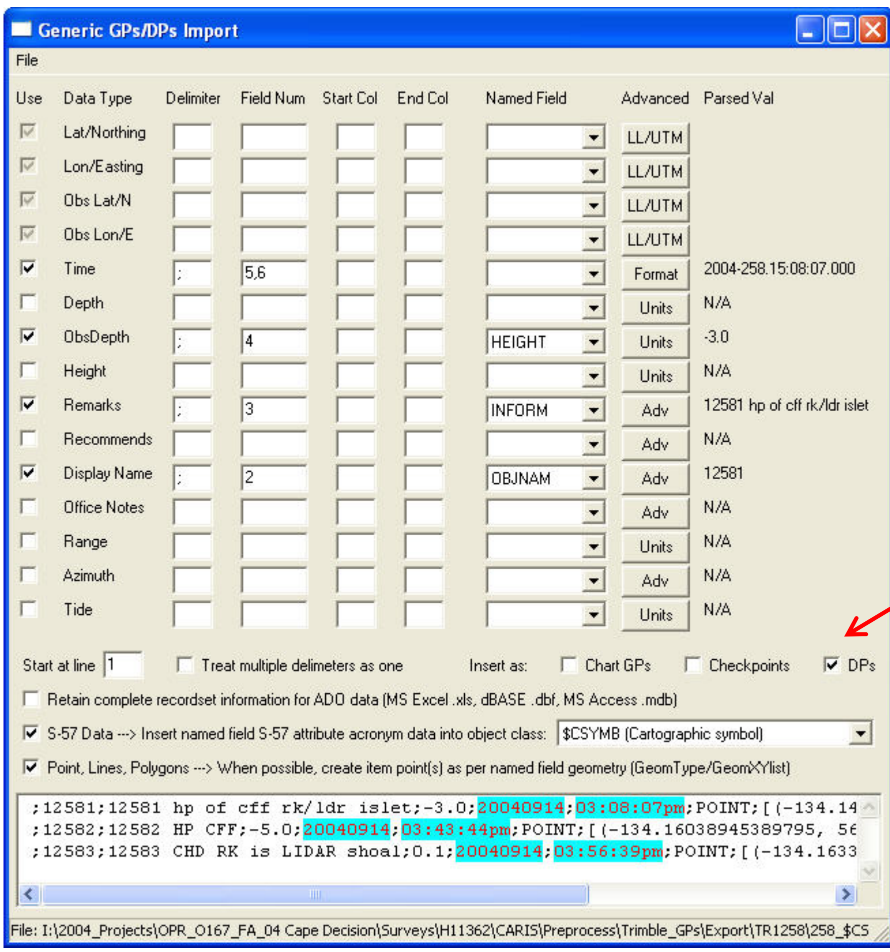
Templates have been created for UWTROC, $CSYMB, BCNSPP, SBDARE and MORFAC. To use these templates, select Open Template from the File menu and navigate to R:\Utilities\III_Pydro\Parser Templates and open the appropriate file. Data is then inserted into the smooth sheet by selecting Process File(s) from the File menu. Navigate to the Export subfolder of your project, and select the shapefile (.shp) of the feature that you exported from Pathfinder, then click Open. Repeat this process for each type of feature to be inserted.

If there are feature types to be inserted which do not have templates created, it is possible to create one. For each separate feature type: choose File→ Open data file, navigate to the Export subfolder of your project, and select the shapefile (.shp) of the feature that you exported from Pathfinder.

On the left-hand side of the screen, check the boxes of all rows you wish to populate with field data. In the pull-down menus on the right-hand side of the screen, find the attribute to be associated with each Data Type. After the attribute is set, the Field Delimiter and Field Num columns will automatically fill in with the appropriate values.

The Field Num column can also be filled in manually, which is desirable when two separate data dictionary attributes (i.e. RECDAT and Time) must be used in order to fill one of Pydro's Data Types (i.e. Time). Refer to the window at the very bottom of the screen that lists all attributes. Find the desired (i.e. time and date) entries and, counting the blank before the first semicolon as 1, determine the field numbers of the attributes and enter them in the Field Num column.

Most features are classified as DP's but SBDARE (bottom samples), FLODOC (floating docks), and fixed or floating ATON's (buoys, beacons, mooring facilities, etc.) are considered GP's. DP's and GP's are treated almost identically at this point, distinguished only by which checkbox in the lower right corner of the screen is checked.



Check this box for DP's

Do not check any boxes for GP's

3.4.1 Create a Generic DP or GP Import template

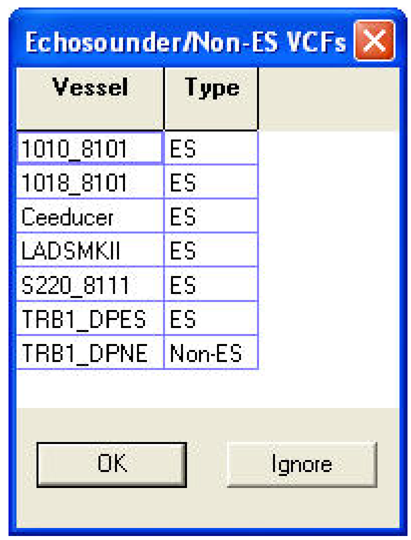
It may be useful to create an import template once all this information has been filled in. A separate template will have to be created for each feature object class, and the templates will only be usable as long the data dictionary has not been altered. To create a template, select File→ Save Template and specify

R:\Utilities\III_Pydro\Parser Templates as the destination folder. In the future, after a template already exists, the Open Data Files step may be skipped and Open Template used instead.

3.5. Process files

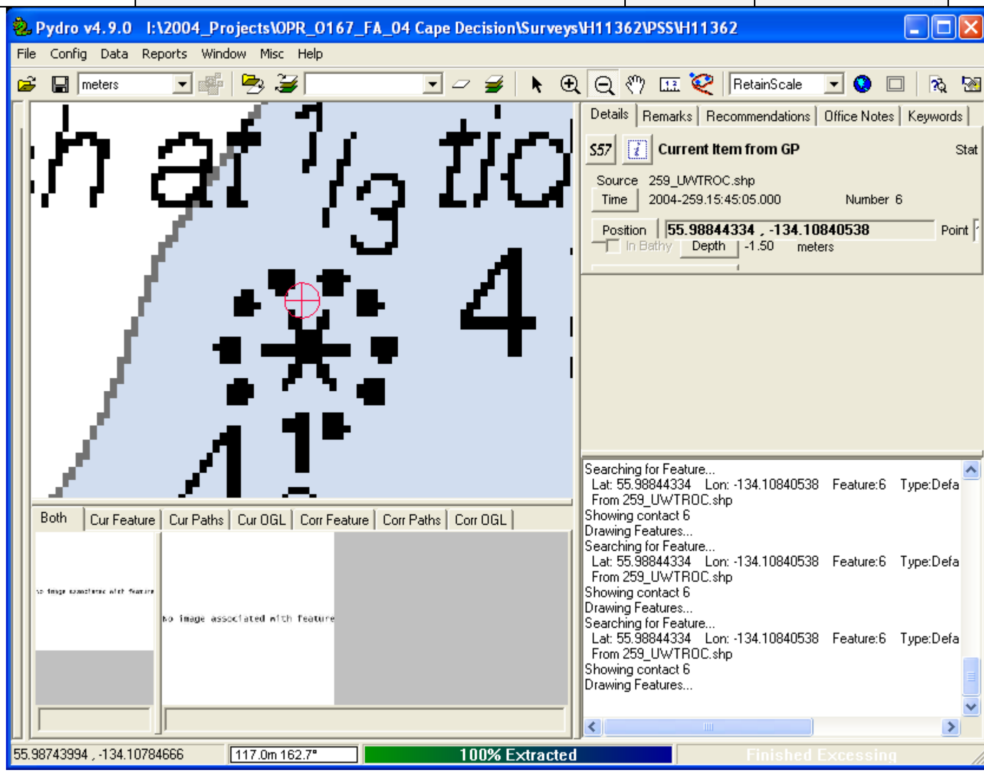
In the Generic GPs/DPs Import window, go to File/ Process file(s) and select one or more appropriate shape files. Click Open. If you are processing DP's, when prompted to 'Associate the incoming DPs with a HIPS/SIPS "Project"', select the CARIS\HDCS_DATA\H*XXXXX* folder of the current survey.

GP's do not need to be associated with a HVF (formerly VCF). However, when importing DP's, a window will pop up, asking you to select the vessel these points were taken from. All Trimble DP's will start with TRB1 or TRB2, depending on the unit, followed by _DPES for echosounder or _DPNE for nonechosounder. If unsure about the vessel or if DP's in the same file are of mixed vessel type, leave HVF as unassigned and edit vessels later.



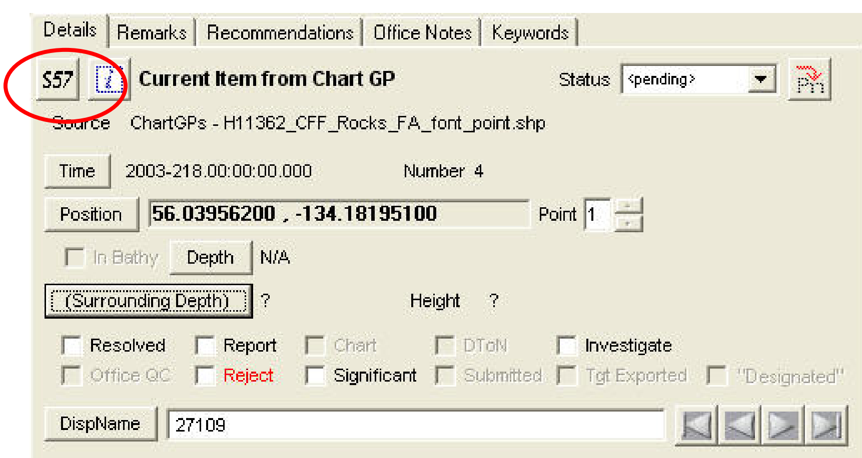
In Pydro, choose Config → DP Vessels and when asked to Browse to HIPS/SIPS VesselConfig folder, find the project's CARIS\HDCS_DATA\VesselConfig folder. In the following window select the correct vessel, paying close attention to ES (echosounder) or Non-ES (non echosounder) type:

To view your points, a background image must be loaded. Zoom in on a location, or randomly zoom in several times and then right-click → "Select closest feature." Echosounder and non-echosounder features alike will normally appear black; the currently selected feature will be red.

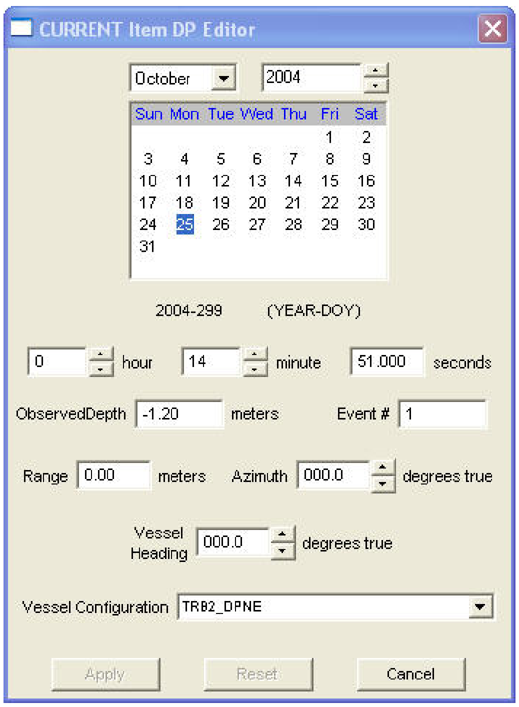


3.6. Remarks, recommendations, and flags

Any final updates or edits to S57 attribution should be made at this point. For GP's, click on the S57 button in the upper left-hand corner of the screen, make sure the correct Object Class is indicated, and use the Mandatory Attributes and Additional Attributes tabs to update any fields.



For DP’s, press the DP button next to the S57 button to open the DP Editor. In the window that pops up you can make limited attribution edits as well as change the Vessel Configuration for each individual DP:



After each feature has been checked any additional comments, such as disproval methods or disproval notes, should be added to the Remarks tab. For disprovals, check the Significant flag. If a DP needs additional work or investigation, flag Investigate. For charted items, include the chart # in the DP remarks (i.e. "Chd (17382) rk disproval" or "Chd (16701) rk hp new ldg”). Save the final PSS.

4. Apply correctors to DP’s in CARIS

Only DP’s will be brought into CARIS; GP’s do not need tide or SVP corrections. Both echosounder and non-echosounder DP’s will get tide-corrected but only echosounder DP’s undergo SV correction. Open CARIS HIPS/SIPS and set directory to the correct project through Tools → Options → Directories. Tide and SVP files should be recorded on the Detached Positions Log that will be submitted as part of the Descriptive Report for the project, in HXXXXX\Descriptive_Report\Separates\1_Logs\Detached_Positions.

4.1. Apply sound velocity (SVP) correctors

In CARIS HIPS, File → Open Project and open Project/Vessel/Day/Line. Select all echosounder DP's; from the Process menu, choose Sound Velocity Correction. Check "Load New SVP file" and then Select to find the SVP file that best fits the time and area the DP was taken in (for singlebeam, the cast and DP may have been taken a couple days apart). Choose the Set Profile selection method and choose Process.

4.2. Apply tide correctors

In the open project, select all DP's. Choose Process → Load Tide and click Multiple tide stations using tide zones; Select and navigate to the Zone Definition Files (ZDF) in the Predicted (or Observed if available) subfolder of the CARIS project's Tide folder. In the Load Tide window, choose Load.

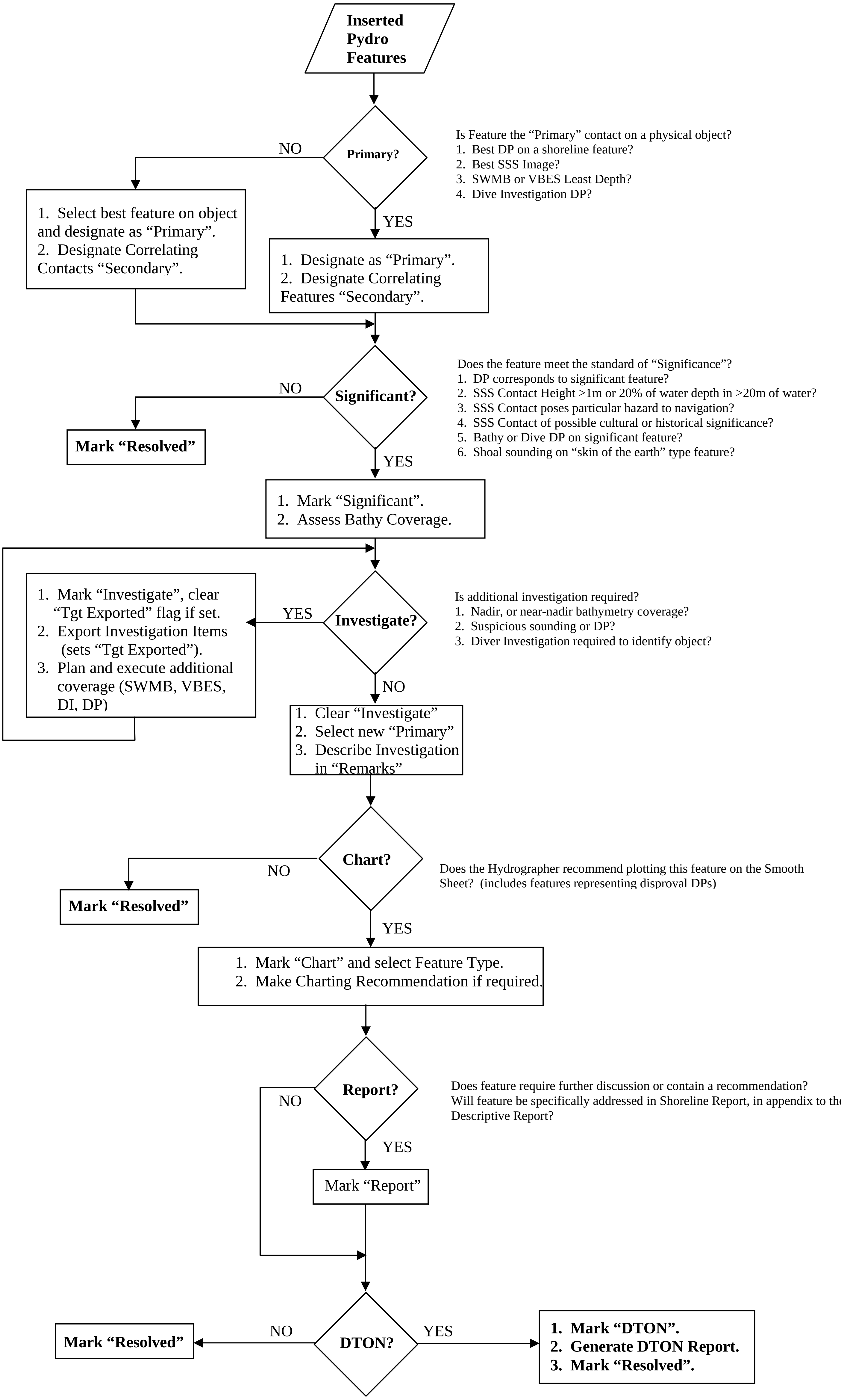
4.3. Merge

Select all DP's; Process → Merge. Exit CARIS.

5. Update Pydro Feature Log

In the Pydro Feature Log (*HXXXXX\Descriptive_Report\Separates\1_Logs\Detached_Positions*), note the HVF, Tide and SVP file applied to each DP or GP, as well as any comments of issues that arose during processing.

Back to top


Inserted Pydro Features
Primary?
Is Feature the "Primary" contact on a physical object?
1. Best DP on a shoreline feature?
2. Best SSS Image?
3. SWMB or VBES Least Depth?
4. Dive Investigation DP?
NO
1. Select best feature on object and designate as "Primary".
2. Designate Correlating Contacts "Secondary".
YES
1. Designate as "Primary".
2. Designate Correlating Features "Secondary".
Significant?
Does the feature meet the standard of "Significance"?
1. DP corresponds to significant feature?
2. SSS Contact Height >1m or 20% of water depth in >20m of water?
3. SSS Contact poses particular hazard to navigation?
4. SSS Contact of possible cultural or historical significance?
5. Bathy or Dive DP on significant feature?
6. Shoal sounding on "skin of the earth" type feature?
NO
Mark "Resolved"
YES
1. Mark "Significant".
2. Assess Bathy Coverage.
Investigate?
Is additional investigation required?
1. Nadir, or near-nadir bathymetry coverage?
2. Suspicious sounding or DP?
3. Diver Investigation required to identify object?
YES
1. Mark "Investigate", clear "Tgt Exported" flag if set.
2. Export Investigation Items (sets "Tgt Exported").
3. Plan and execute additional coverage (SWMB, VBES, DI, DP)
NO
1. Clear "Investigate"
2. Select new "Primary"
3. Describe Investigation in "Remarks"
Chart?
Does the Hydrographer recommend plotting this feature on the Smooth Sheet? (includes features representing disproval DPs)
NO
Mark "Resolved"
YES
1. Mark "Chart" and select Feature Type.
2. Make Charting Recommendation if required.
Report?
Does feature require further discussion or contain a recommendation?
Will feature be specifically addressed in Shoreline Report, in appendix to the Descriptive Report?
NO
YES
Mark "Report"
DTON?
NO
Mark "Resolved"
YES
1. Mark "DTON".
2. Generate DTON Report.
3. Mark "Resolved".

The Editor Notebook:
Controls, Text Fields, Status Levels, and Flags

Controls

- **S57 –** Opens S57 Editor.
  - Set HSD Carto Code and S57 Attribution (if desired).
  - Edit "Carto Text", which is exported to Microstation. This will be linked to first line of "Remarks" field in a future version.
- **Awois Editor –** Opens AWOIS Editor
  - Awois Item investigation to be updated by hydrographer, and submitted with completed survey, as part of the item investigation process.
  - This interface replaces need for separate MS Access process.
- **Pri –** Brings Primary correlating feature to "Current Feature" position. **Affected Charts –** Drop Down list of charts covering the position of the current feature. Requires CHAPP File from Marine Chart Division (which is distributed with Pydro). Ensures that hydrographer and evaluator are aware of all charts that must be compared with this surveyed item.

Text Fields

- **Remarks –** Hydrographer's description of the feature and investigation technique. Detached Position remarks and HIPS Side Scan Sonar Contact annotations are copied here when these data are inserted.
- **Recommendations –** The hydrographer's charting recommendation if selected as a Chart item. A recommendation is made for each chart affected. Recommendations for changes to MHW and complete disprovals only.
- **Office Notes –** Processing Branch comments on description and depiction recommendation of feature (concur / do not concur, etc).
- **Line / DB –** The data path to the CARIS line data source ("Line") or name of the Access database ("DB") source of the feature
- **Time –** System time at acquisition for bathymetric point features, or selection time for side scan contacts. Clicking "Time" button toggles display units. For Detached Positions, double clicking in data field opens DP editor.
- **Position –** Position of Feature, with range and azimuth applied to DPs. Clicking "Position" button toggles display units.
- **Depth –** Processed least depth on feature. For DPs and Bathy Features, this depth is that acquired at acquisition, corrected for requisite parameters through HIPS processing. For SSS Features, Depth is the least depth found within the Least Depth Grid Size specified in PSS Parameters. Clicking "Depth" button forces bathy search for "Least Depth" and"Surrounding Depth".
- **Surrounding Depth –** For SSS Features, the average depth in the Surrounding Depth "donut" set by Surrounding Depth and Least Depth search radii. This is used to define significance of the contact relative to local bathymetry.
- **Range –** Range to DP target, entered by hydrographer in Hypack or DP Editor.
- **Azimuth –** Direction to DP target in degrees relative to True North.
- **Observed Depth –** Depth associated with DP or Bathy Feature as acquired before correction in HIPS.
- **Display Name –** User editable feature name, originally set by hydrographer in feature source software (Hypack, CARIS). Future Upgrade: Clicking "Display Name" button will toggle display field between "Display Name", first line of "Remarks", and "Carto Text".

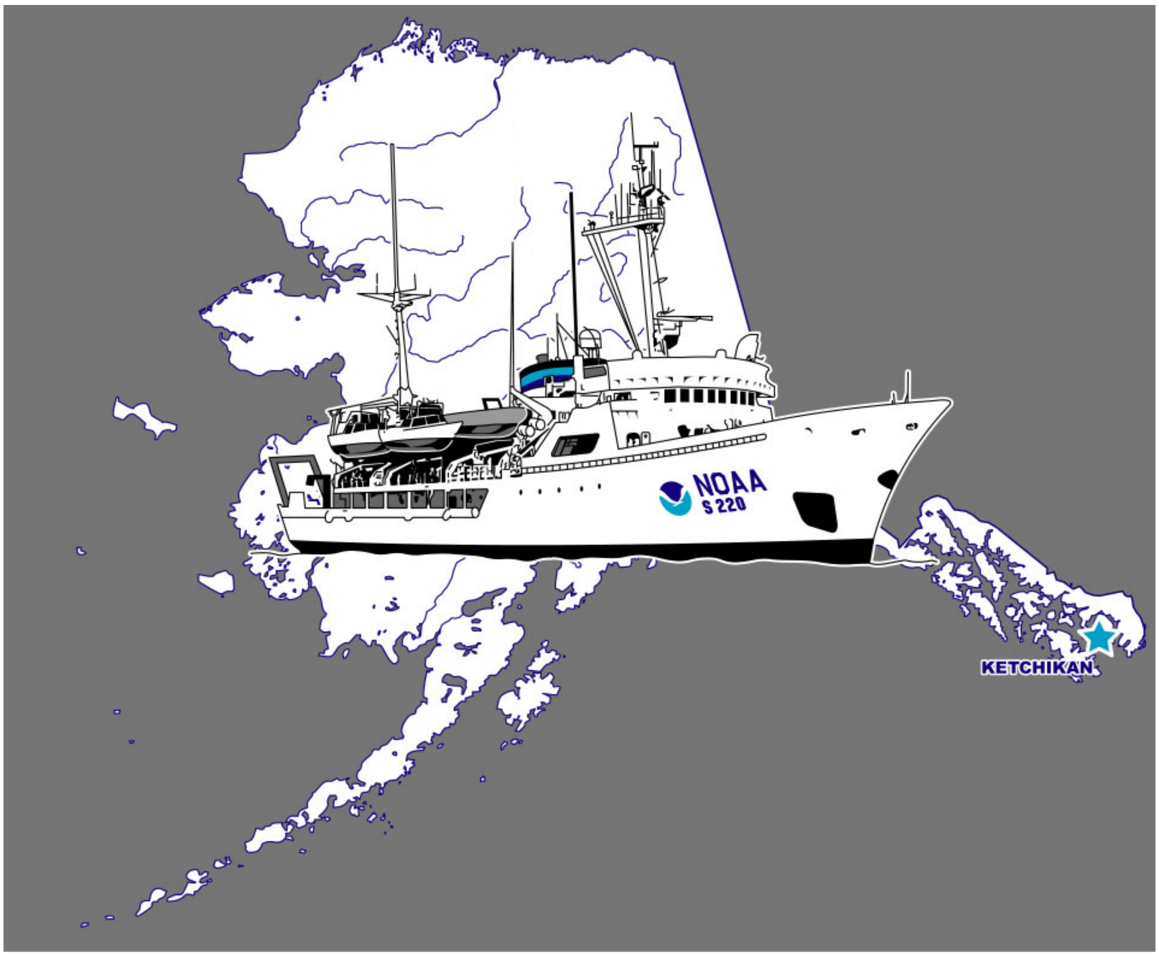
Status Levels

- **Pending –** Status not set. All features are "Pending" on import.
- **Primary –** The best Pydro feature available for any physical object. Typically, this is a bathy feature with least depth and position after an investigation is completed. Each physical object has only one "Primary" Pydro feature representation. Which feature is selected as "Primary" may evolve over the course of investigation.
- **Secondary –** Pydro features corresponding to the same physical object as the Primary, but of lesser quality (imagery, depth, position). Secondary features automatically assume attributes of their Primary.

Flags

- **Reject** - Should be used ONLY for mistakes; if data are re-acquired, a remark in the new feature shall reference the rejected feature.
- **Significant –** Features which meet standards for significance, generally related to feature representation indicating a physical object that is significant for IHO S-44 survey accuracy.
- **Investigate –** Feature requiring further investigation, typically additional SWMB coverage or a dive. "Investigate" shall be cleared once the hydrographer is satisfied with coverage. Features marked "Primary", and "Investigate", but not "Tgt Exported" will be exported on "Export Investigation Items".
- **Tgt Exported –** Feature for which a Hypack tgt has been exported, set automatically when "Export Investigation Items" is performed. Presence of this flag prevents repeat exports, and signifies to reviewers that the hydrographer planned an investigation.
- **Chart –** Feature recommended for application to the smooth sheet by the hydrographer. Only available for those features already selected as "Significant". This includes DPs which disprove the existence of currently charted features
- **DTON –** Feature selected by the hydrographer as a Danger to Navigation. Only available for those features already marked "Chart". Features marked "Primary" and "DTON", but not "Submitted" will be exported to the DTON .xml file.
- **Submitted –** Feature which has been exported as a DTON. Presence of this flag prevents duplicate DTONS.
- **Report –** Feature specifically addressed in the Descriptive Report.
- **In Bathy –** Forces depth from DP or Bathy contact into displayed soundings so that the final sounding set will include this depth.
- **Resolved –** A feature which the hydrographer has finished investigating, assessing, and describing. This is the final step in the field's analysis of the feature, and setting "Resolved" locks the previous flag settings (can be unlocked by un-checking "Resolved"). This indicates to the reviewer that the physical object has been described to the fullest extent by the hydrographer.
- **Office QC –** Feature which office personnel have verified.

SURVEY PIC SHORELINE DUTIES



Survey PIC Shoreline Duties

Table of Contents

0.0 Document Scope

This document is intended to guide sheet managers through shoreline processing. The SOP Shoreline_Processing.doc is also a useful reference.

1.0 Setting Up the Project

Before sending boats out in the field, it is important to know where to send them and what needs to be verified. The source shoreline files for the project will be translated to the appropriate format by the CST and made available to the sheet managers. Be sure to thank the CST for doing this.

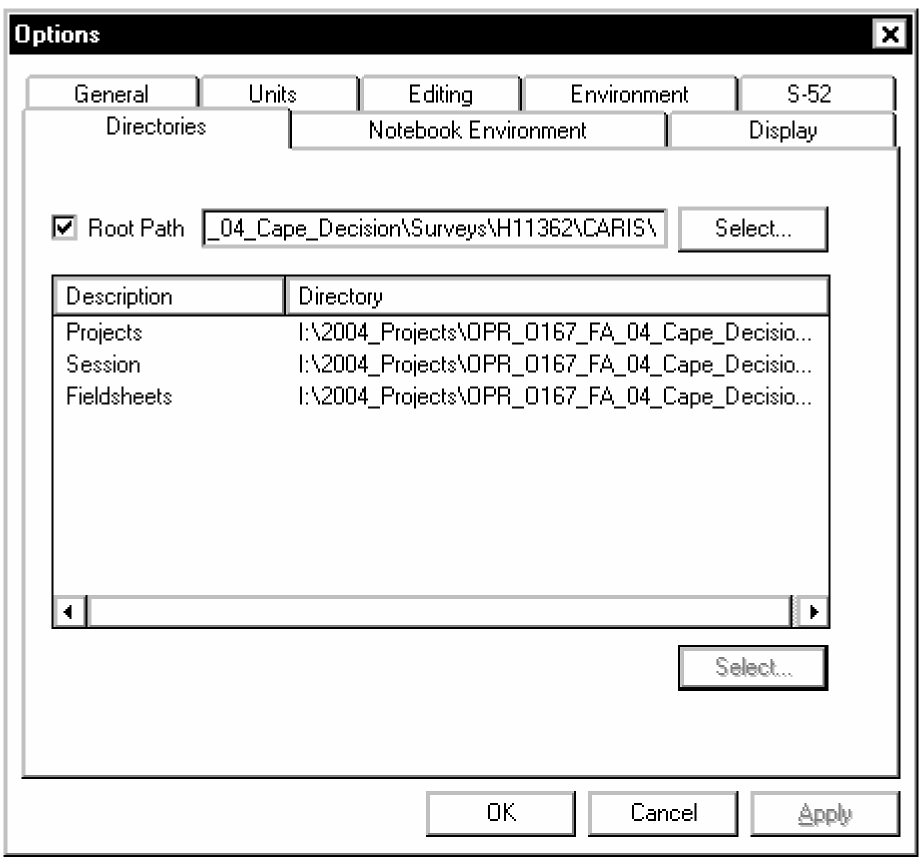
1.1 CARIS Notebook

Source shoreline files will be provided to the sheet manager in Notebook's .hob format with S57 attribution. Any additional items from the chart that should be addressed during verification will need to be digitized in Notebook.

SETTING THE DIRECTORIES

In order for CARIS Notebook to communicate properly with CARIS HIPS, the directories have to be properly set.

1. From the *Tools* menu, select *Options*.
2. Click on the *Directories* tab in the pop-up window.



3. Set the Root Path to the upper level CARIS folder associated with the survey. *I:\200#_Projects\OPR_O###_FA_0#\Surveys\H#####\CARIS*
4. The *Projects* directory should point to the *CARIS HDCS* folder for the survey.
5. The *Session* directory should point to the *CARIS Session* folder. This will allow HIPS sessions to be opened into Notebook for reviewing shoreline data with a BASE surface in the background.
6. The *Fieldsheets* directory should point to the *CARIS Fieldsheets* folder. Individual fieldsheets can be opened in Notebook for review.
7. Click on the *Environment* tab of the *Options* window.
8. In order to view the HIPS BASE surfaces properly, the color maps in Notebook have to match those of HIPS. Change the *Image Colour Map Directory* directory to match those of the HIPS system. (Not currently working in Notebook 2.2 Beta)
9. If pictures are going to be inserted in Notebook, the *Multimedia Folder* directory must be set to map the folder where the pictures are stored. This directory is also under the *Environment* tab of the *Options* window. (Not currently working in Notebook 2.2 Beta)
10. Once all directories have been properly set, click *Apply* and then *OK*.

OPENING SOURCE SHORELINE FILES

1. From an explore window, browse to the raw data folder for the project on the H: drive and locate the *X###_CFF_Shoreline.hob* file.
2. Save a copy of this project wide .hob file as *H#####_CFF_Shoreline.hob* in the *Notebook Files* folder for the sheet.
3. Open CARIS Notebook.
4. From the *File* menu, select *Open*, or click on the icon in the toolbar.
5. Browse to the *Notebook_Files* folder and select the *H#####_CFF_Shoreline.hob* file.
6. Click *OK*. The file should appear in the *Layers* tab.
7. Open the survey sheet limits and use it to edit the source shoreline, deleting any features outside the limits. Make sure not to trim out too much, especially with line features.
8. Save the changes to the layer.

CREATING EDIT LAYERS

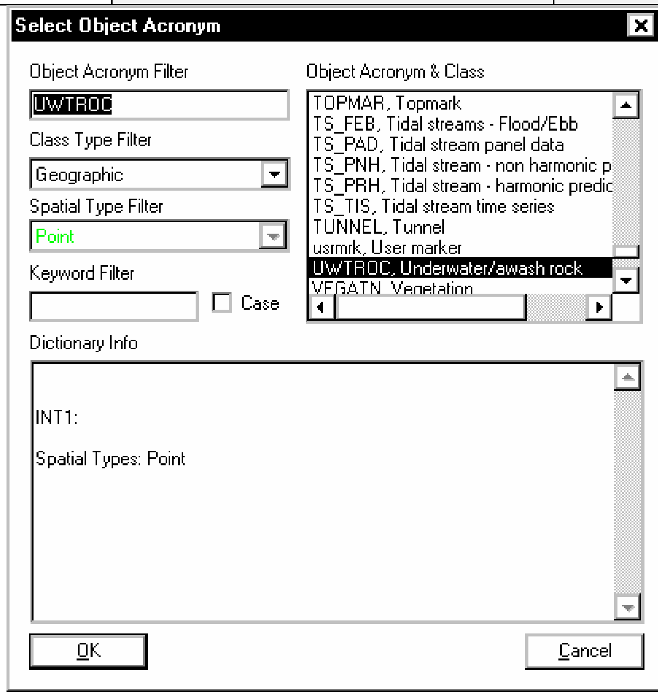
Editable layers are used for digitizing charted items or adding new shoreline features.

1. From the *File* menu, select *New Edit Layer*, or click on the button in the toolbar.
2. Browse to the *Notebook_Files* folder and create a new .hob file, named *H#####_CHD_Shoreline.hob*
3. Digitize any items from the chart to the *CHD_Shoreline.hob* layer, such as rocks or AtoNs that need to be addressed in the field and are not represented in the source shoreline files.
4. After acquiring some shoreline data, another layer named *H#####_Shoreline_Updates* will need to be added.

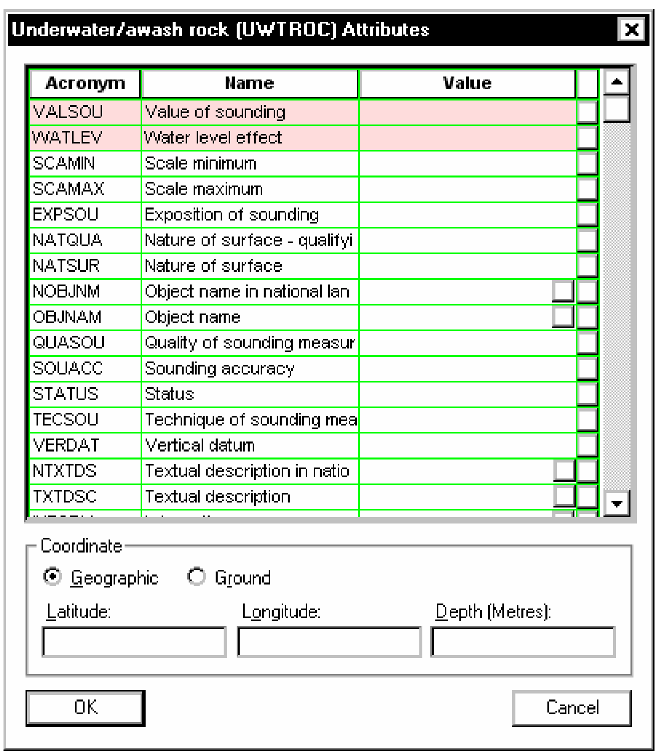
DIGITIZING FEATURES

1. In the *Layers* tab, select the layer to be edited and *Set As Active Digitize Layer* from the *Edit* menu.
2. Select the appropriate digitizing tool from the toolbar (point, line or area).

3. When a digitizing tool is selected, a *Select Object Acronym* window will appear. Choose the appropriate acronym from the list (UWTROC, $CSYMB, WEDKLP, etc) then click *OK*.



4. An *Attributes* window will appear. Fill in any required fields, which will appear red, and any desired optional fields, then click *OK.*

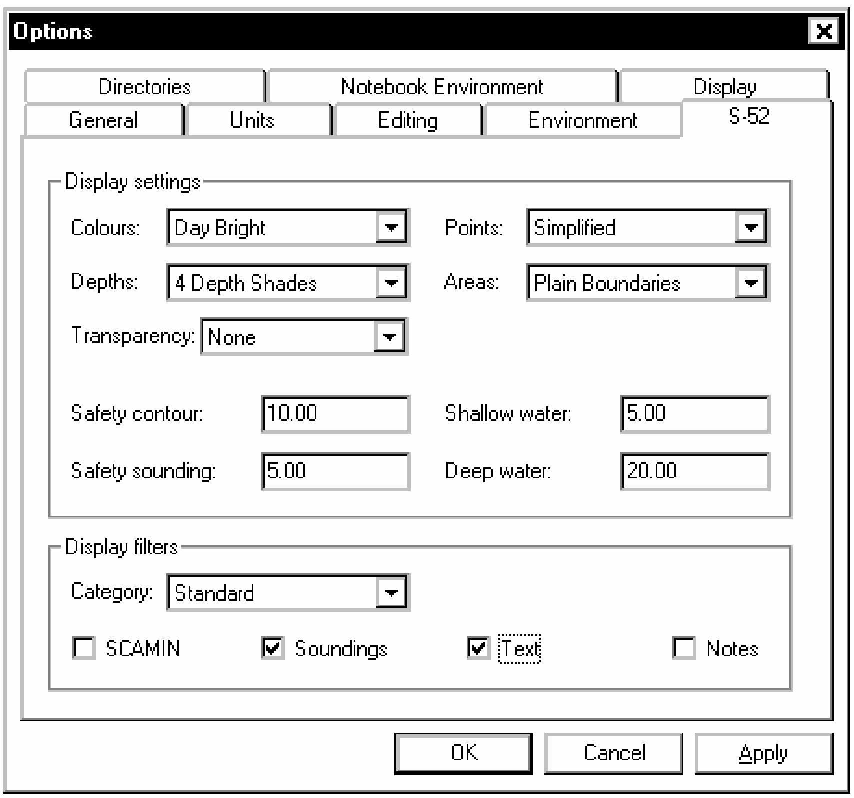


5. The cursor symbol will change. Click on the desired position for the digitized object, line or area.
6. To end a digitized line or area, right click on the last point dropped and select *End Line*, or *Close Line*.
7. Digitized features can be moved or edited using the *Edit Feature* tool in the toolbar.

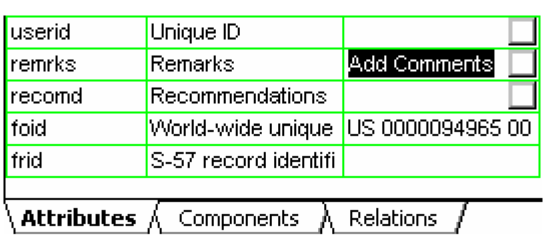
TURNING ON TEXT DISPLAY

Some text from Object ID, Inform and Remarks fields can be displayed with the digital data. It is not currently possible to select which text is displayed. It is either on or off.

1. Go to the *Tools* menu and select *Options.*
2. Select the *S52* tab.
3. There are several check boxes at the bottom of the window. Turn on the *Text* option, then click *OK*.



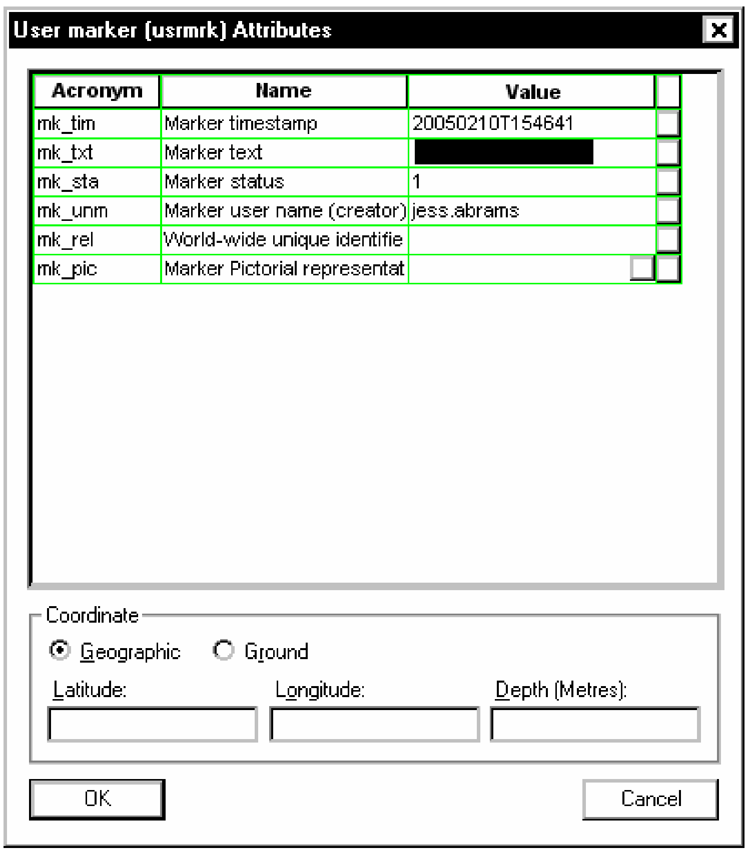
4. Text can be added to a feature by selecting it, then adding the desired comment to the *remrks* field. This ability to add text will be used in place of a marker layer for point features.



MARKER LAYERS

Marker layers are not stand alone layers. They must be attached as a child layer to an Edit layer. Marker layers will be used to transfer notes made in the field from the boat sheet to line features in CARIS Notebook.

1. Highlight the parent layer to which a marker layer will be added (e.g. CFF or Lidar).
2. From the *File* menu, select *New Marker Layer*, or simply click the *M* icon in the tool bar.
3. A new Marker layer will appear in the *Layers* tab, with the same name as the parent layer. Select the Marker layer and *Set As Active Layer*.
4. Right click on the associated parent layer and *Set as Snap Target.*
5. Choose the appropriate digitizing tool (usually point).
6. An *Attributes* window will open and comments can be entered in the *Marker text* field.



Attributes of the marker:

mk_tim: Marker timestamp Displays the date and time captured automatically from the computer

mk_txt: Marker text User text, description, recommendation, comment, etc., populated during entry

mk_sta: Marker Status Value is a number: 1. Active, 2. Dismissed, 3. Closed, 4. Unknown

mk_unm: Marker User Name Capture of the user account id. Can be changed later

mk_rel: *Related feature ids* Capture of the FOIDs when objects on the parent layer are selected

mk_pic: Marker picture file A multi-media file can be attached to the marker

7. Once the text has been entered and other fields set as desired, click *OK* and the digitizing tool will appear.
8. Hold down the left mouse button and the shift key. Position the mouse over the desired location and release. This will snap the marker to the object being marked.
9. To display the text of the markers in the *Display* window, follow the steps for Turning on Text Display above, but check the *Notes* box in the S52 window.

CAPTURING A FOID
If a marker layer is attached to a parent layer that contains S-57 objects, it is possible to capture the Feature Object Identification (FOID), which is the S-57 worldwide unique ID, and snap to the source object. A reference FOID can only be captured on the parent layer of a marker. This is not a necessary procedure, but if you need to do it, here's how.
1. From the *Edit* menu, select *New Feature.*
2. Choose *Create Marker Reference from Superselection* when using just a single object highlighted in the worksheet window, or *Create Marker Reference from Selection* for several objects, or the entire parent layer.
3. Follow Steps 1-4 above, to create a new Marker layer for the desired S-57 layer.
4. Highlight the parent layer in the *Layers* window, then select the desired object (superselection) or objects (selection) from which to capture the FOID.
5. Follow Steps 5-8 above to complete the marker.

PRINTING A BOAT SHEET
Once all preliminary shoreline data is in the Notebook session, a boat sheet will need to be printed. The crew on the shoreline boat will write useful information on the boat sheet that will be transferred into Notebook by the sheet manager. The process for printing a boat sheet is yet to be determined. Hopefully, the Publication Designer from Notebook can be used to create a template for this. For now, refer to R:\Utilities\I-FA_SOP\1_Presurvey\Shoreline\Printing Boat Sheets.doc

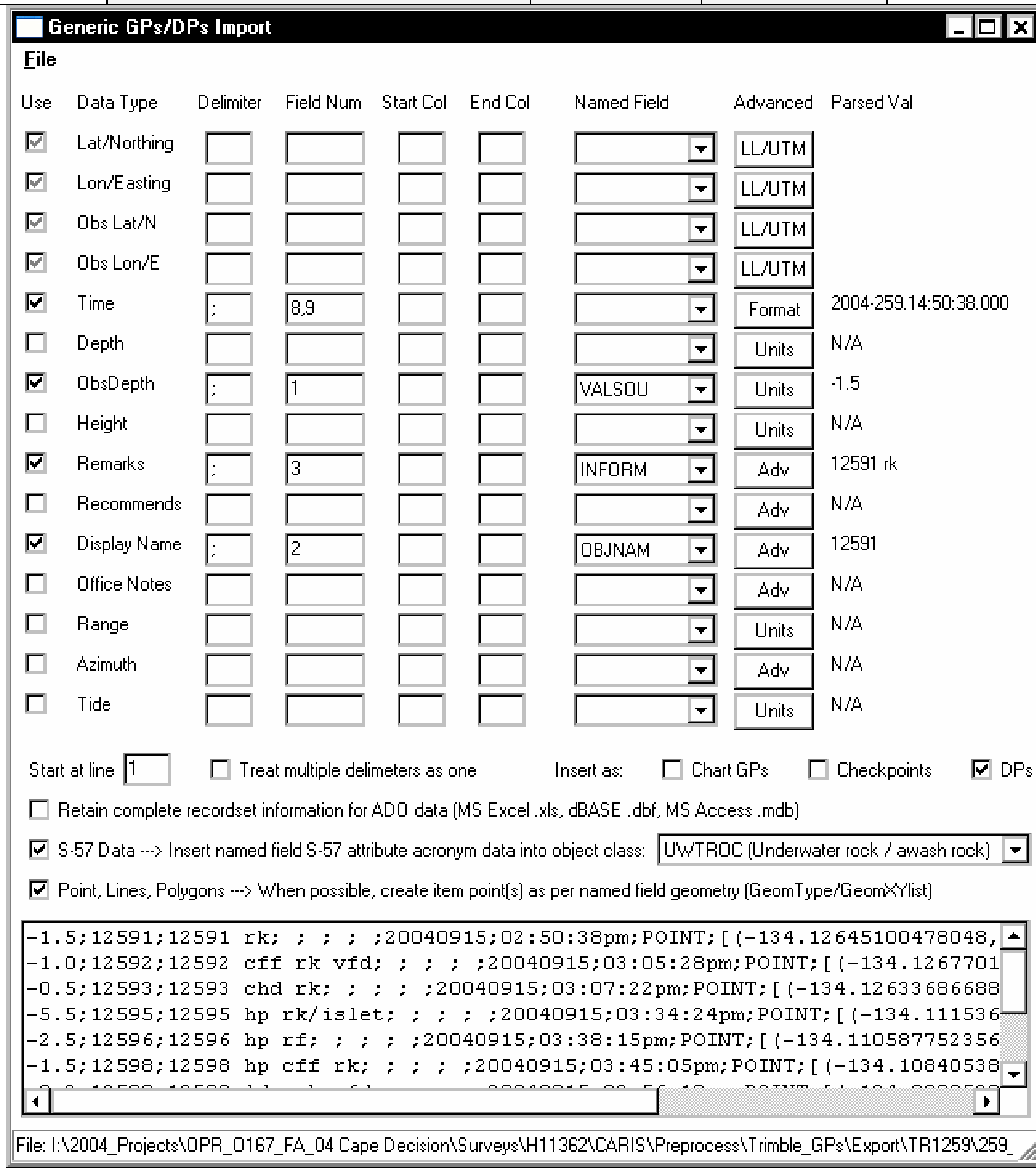
2.0 Post Acquisition Duties

After acquiring shoreline data in the field, it will need to be transferred to Pydro and CARIS Notebook for processing. These steps need to be done immediately, while the ship is still in the survey area.

2.1 Pydro

Open the PSS for the survey, or create a new one if one does not exist. Be sure all metadata is entered and correct.

INSERTING GPs AND DPs
Positions recorded in the field must be imported into Pydro for processing. The boat crew will be responsible for transferring the Trimble files to the appropriate folder.
1. From the Pydro *Data* menu, select *Insert > Generic GPs/DPs*.
2. In the pop up window, go to the *File* menu and select *Open template.*
3. Browse to *R:\Utilities\III_Pydro\ Parser Templates* and open the appropriate template file (e.g. $CSYMB or UWTROC). Some fields in the *Import* window will be filled in automatically.

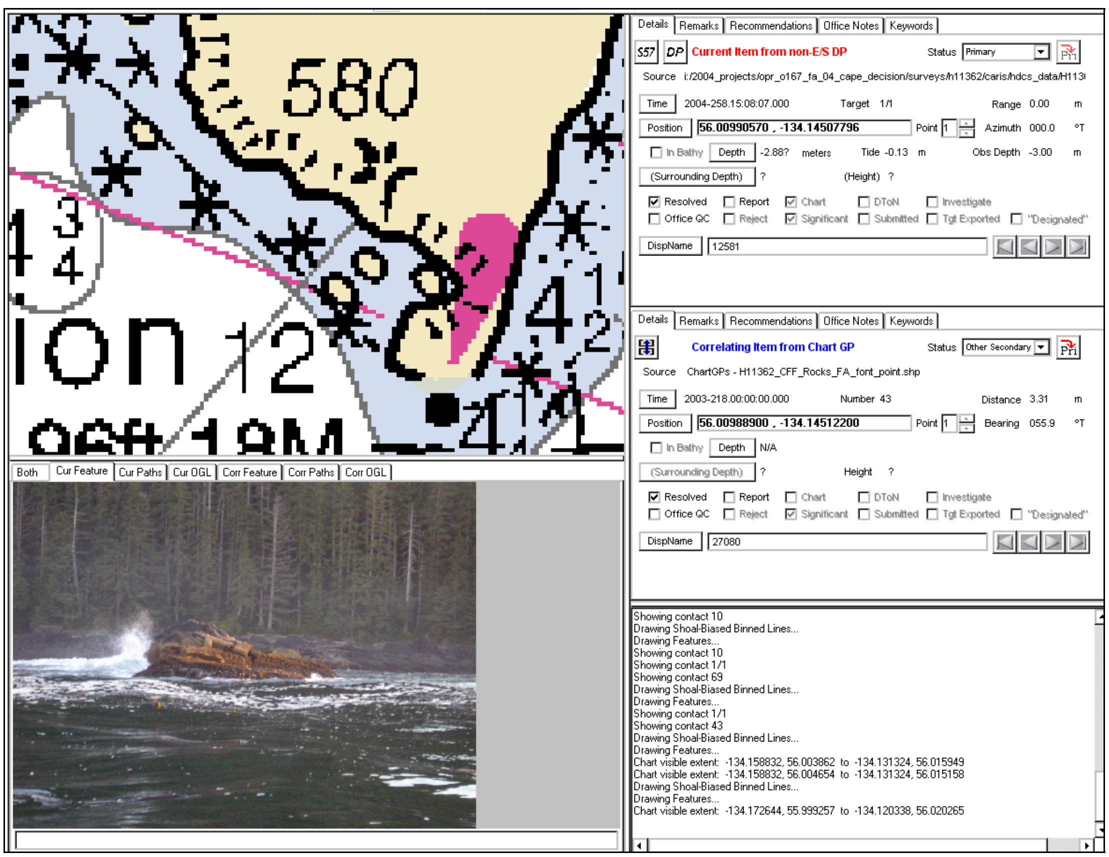


4. Go to the *File* menu and select *Open data file*.
5. Browse to the folder where the Trimble files were saved. *I:\200X_Projects\OPR_XXXX_FA_0X \Surveys\H#####\CARIS\Preprocess\Trimble_GPs\Export\TRX_DDD*
6. Open the desired .shp file.
7. From the *File* menu, select *Process file(s)* and open the shape file used in Step 6. This seems redundant, but insures proper processing.
8. When importing DPs, Pydro will ask for an associated CARIS project. Point to the H##### folder within the HDCS Data folder for the project.
9. Repeat Steps 6 & 7 for all new .shp files.

10. Fill in the Pydro Feature Log for each file inserted. The template is located at R:\Utilities\II_Forms_Lists_and_Templates\2_Acquisition and Processing\Shoreline. Save a copy in *Descriptive_Report > Separates > 1_Logs > Detached_Positions*.
11. When all features have been imported, close the *Import* window and save the PSS. The field unit used to acquire the DP's should appear as a vessel in the associated HIPS project. Tide and SV correctors will be applied as described in section 3.1 below.

ADDING IMAGES

1. Photos taken in the field should be saved in one *Photos* folder, within the survey PSS folder.
2. To associate a photo with a DP, select a feature and click on the *Cur Feature* tab below the chart.
3. Right-click in the blank space and choose *Add Image(s).*
4. Navigate to the *Photos* folder, highlight the appropriate image(s), and select *Open*. Once an image is displayed under the *Cur Feature* tab, the paths of all images can be displayed under the *Cur Path* tab.
5. Alternatively, images can be added by having the *Photos* folder open and dragging and dropping the images into the *Cur Feature* window.



6. To toggle between images, right-click in the image window with either the *Cur Path* or *Cur Feature* tab activated, and choose *Next Image*.
7. To remove an image, right-click and select *Remove Image*.

CHECK FOR COMPLETENESS

1. Check to make sure all items on the boat sheet and DP forms have been addressed. Insure that all remarks in Pydro are correct.
   NOTE: The Range and Bearing values recorded on the DP forms are also entered into TerraSync, which automatically updates the position. These fields in Pydro should be zeroes.
2. Check to make sure all AWOIS items have been addressed.
3. Make sure anything marked investigate has been investigated and that all HW VBES and SWMB disprovals have been obtained.
4. Use the Pydro decision tree to check flags and update Recommendations, especially with disproval methods and notes. Refer to *R:\FA_SOP\3_Processing\Pydro\Pydro Logic_SOP.doc*.
5. Update Pydro session flags to *Chart*, *Significant* and *Primary* prior to leaving the acquisition area.
6. Start marking things that will be addressed in the DR as *Report* and update the Recommendation tabs.
7. Refer to *R:\FA_SOP\3_Processing\Pydro\Pydro Logic_SOP.doc* & *The Editor Notebook_SOP.doc* for more information. It might also be helpful to look at the example shoreline report:
   \\Fa_process_3\Primary Drive\Survey\OPR_O112_RA_02\H11121\Descriptive_Report\Appendices\Shoreline\H11121_Shoreline_Report.pdf

EXPORTING XML DATA

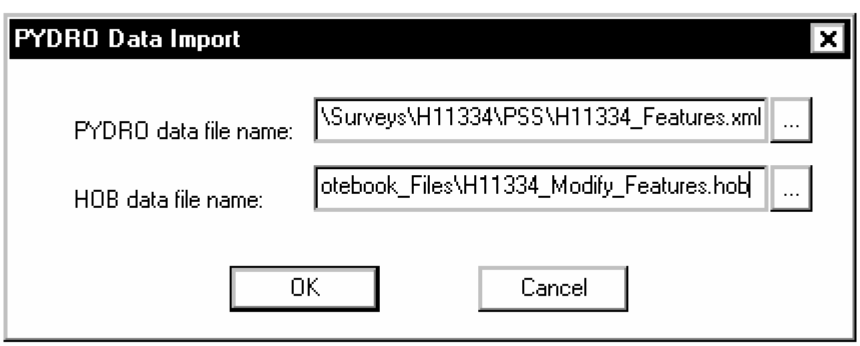
1. From the *Data* menu, select *Export > XML Feature Data*.
2. Set the filter to export only Primary features and click *OK*.
3. Save the file as *H######_Features.xml* in the PSS folder for the survey. This file will be imported to CARIS Notebook for processing.

2.2 CARIS Notebook

IMPORTING PYDRO FEATURES

CARIS Notebook can read features directly from the Pydro .xml file, exported as described in the Pydro section above. If some features do not import, it is possible that they are not attributed correctly. Refer to the S57 Attribution section below.

1. From the *Tools* menu, select *PYDRO Data Import*.
2. In the *PYDRO data file name* field, browse to the location of the *Features.xml* file.
3. In the *HOB data file name* field, browse to the *Notebook_Files* folder and create a new .hob file called *H######_Features.*

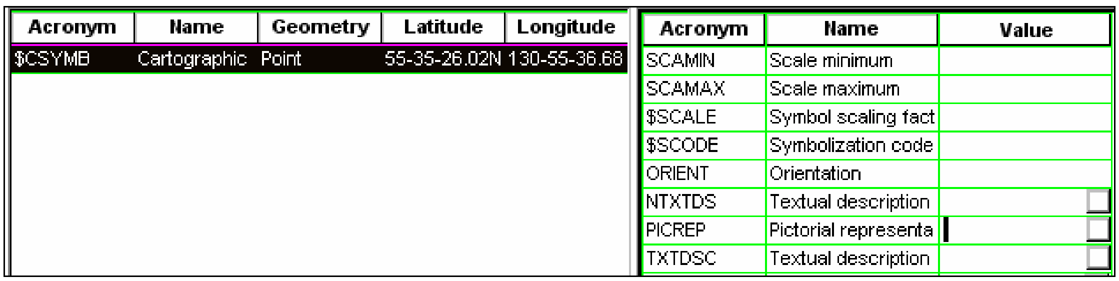


4. Click *OK*. The features should appear in the Display window of CARIS Notebook. **NOTE:** Bottom samples will not appear unless the text is set to display, as described in the Turning on Text Display section above.
5. Separate features into Add, Modify and Delete layers.

ADDING PICTURES TO EDIT LAYERS

This process will hopefully be eliminated in future versions of Pydro, which will automatically export the pictures associated with each feature in the .xml file. Currently the Multimedia directory cannot be set in Notebook 2.2 Beta, so this process does not work at all.

1. Make sure the *Mulitmedia Folder* directory is mapped to the folder containing the pictures to be inserted. See the Setting the Directories section above. Doesn't work in 2.2 Beta.
2. Set the appropriate layer as editable.
3. Select the item with which the picture will be associated. The feature information will appear in the *Selection* tab at the bottom of the window.
4. Under the *Acronym* label, look for a *PICREP* option (cartosymbols have it, underwater rocks do not) and click on the … browse box.



Acronym	Name	Geometry	Latitude	Longitude
$CSYMB	Cartographic	Point	55-35-26.02N	130-55-36.68

Acronym	Name	Value
SCAMIN	Scale minimum	
SCAMAX	Scale maximum	
$SCALE	Symbol scaling fact	
$SCODE	Symbolization code	
ORIENT	Orientation	
NTXTDS	Textual description	
PICREP	Pictorial representa	
TXTDSC	Textual description	

5. The *Multimedia Browser* window will pop up. Browse to the appropriate picture, then click *Add* and *OK*.

ADDING SHORELINE NOTES

Any notes made on the boat sheet in the field will need to be added to the Notebook session.

1. For point features, add text such as "CFF RK NTD" directly to the *remrks* field of the digitized object. Refer to the Turning on Text Display section above.
2. Adding comments to carto-symbols or line features, such as "CFF FOUL VRD", or "LDR LW NTD", will require a Marker layer. Refer to the Marker Layer section above.

ADDING SHORELINE UPDATES

1. Create a new edit layer named *H######_Shoreline_Updates*. Refer to the Creating Edit Layers and Digitizing Features sections above.
2. Add any new features to this layer, such as fouls, ledges, shoaling or new high water lines which are not on the current chart, or in the source files. Add comments to a Marker layer for the line features, as described above. Do not add new point features to this layer. These should have DP's associated with them and brought into the *Features* layer using the *Pydro Data Import* described above.

3.0 Processing Duties

These are things that can be done as time allows and do not necessarily have to be completed while the ship is still in the survey area.

3.1 CARIS HIPS

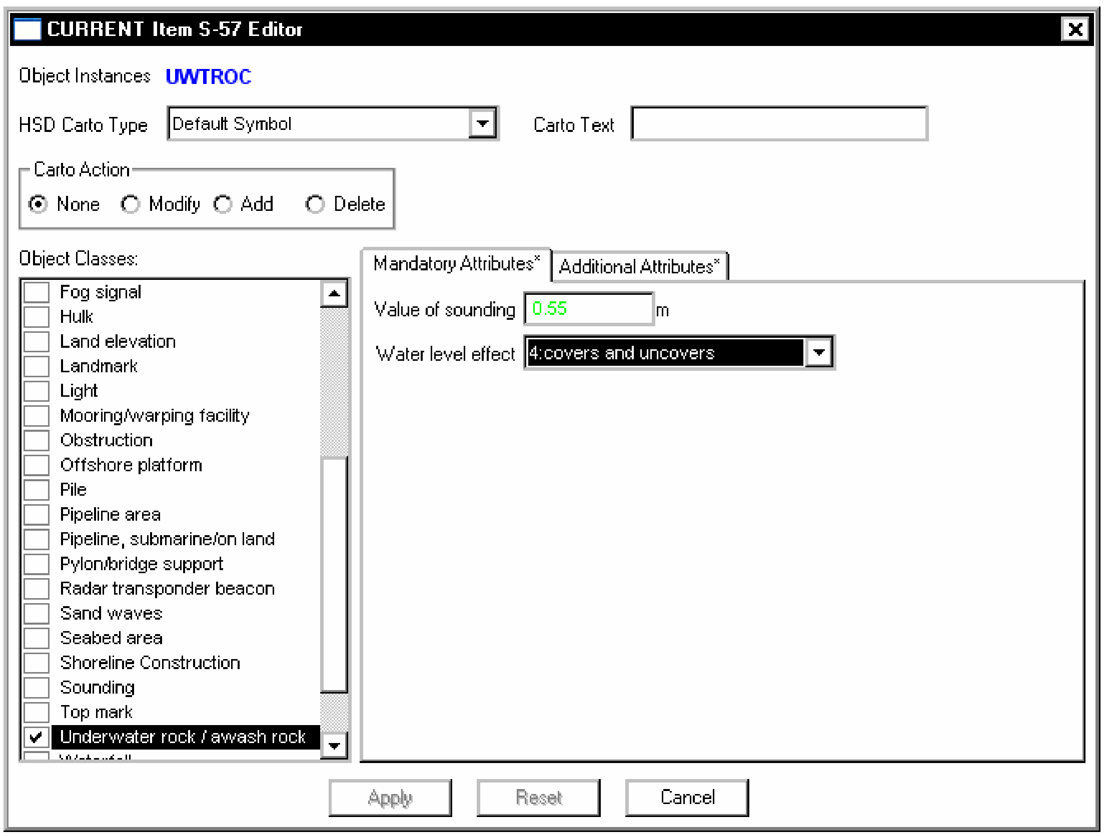
APPLY CORRECTORS

1. Open a project in HIPS and open the DPs and GPs.
2. Apply observed tides to all items.
   NOTE: Zoned tides can only be applied to files containing more than one position. A single tide station must be applied to any single DP or GP.
3. Apply SVP correctors to any echosounder DPs. If necessary, use a nearby cast taken during hydrography.
4. Merge all data.

3.2 Pydro

S57 ATTRIBUTION

1. Under the *Details* tab, click the *S57* button to open the *S57 Editor*.
2. A window will open with the information for the selected item.



3. Check that the *Object Instances* displays the correct object type (e.g. UWTROC, $CSYMB, etc).
4. Left click on the appropriate object type in the *Object Classes* box. It should already have a check mark in the box next to it.
5. Information will appear in the *Mandatory Attributes* box. Fill in the appropriate information.

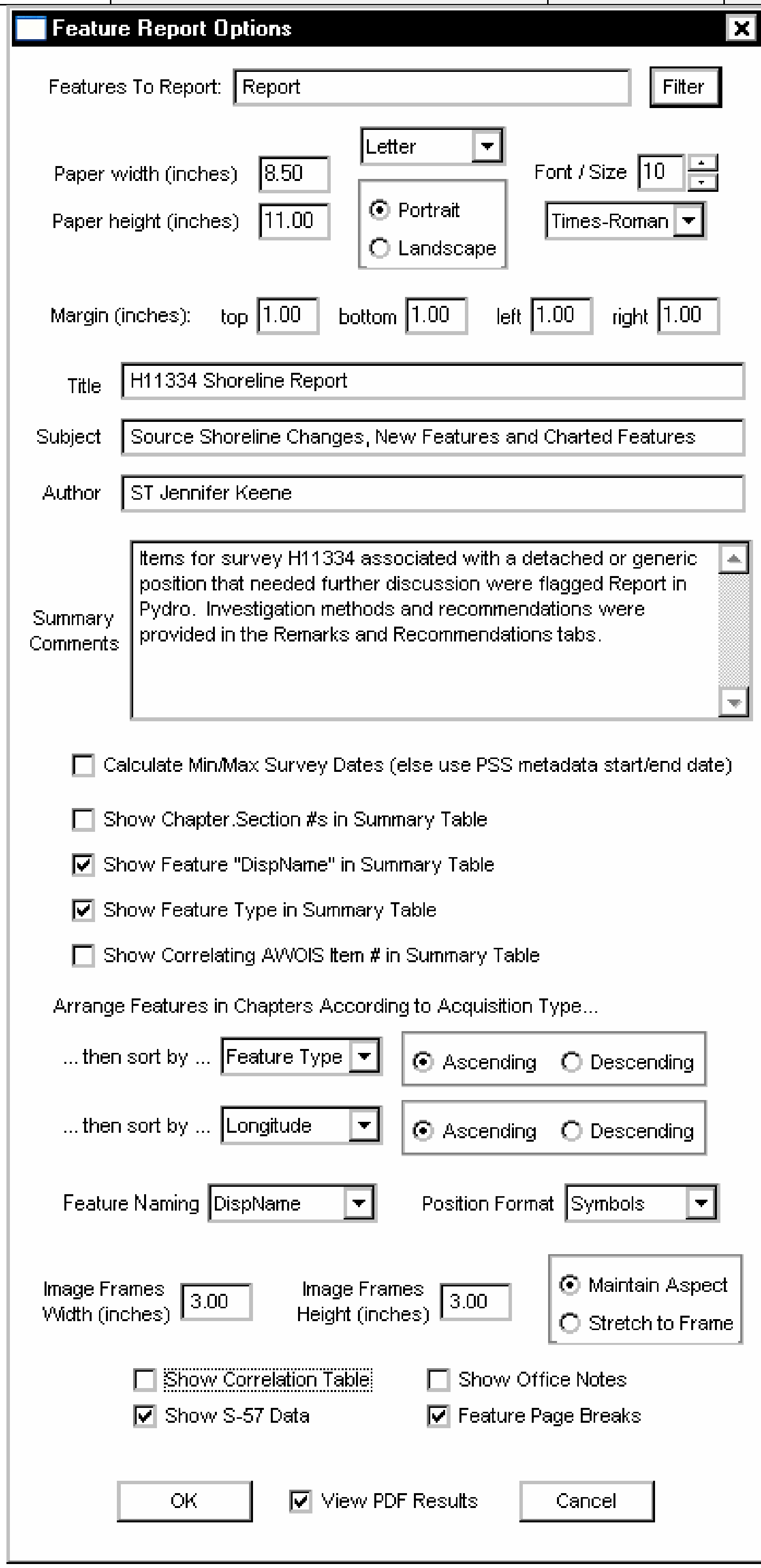
6. Click *Apply*.
7. Repeat this process for all features in the PSS.

REVIEW FEATURES

1. Compare the items inserted in Pydro with the DP/GP log. Make sure the log is completely filled out and up to date.
2. Check S57 attribution of all items and correct if necessary.
3. Add chart numbers to chart items (e.g. CHD (17424) RK DSP).
4. Add Light List numbers to ATONs
5. Address and update AWOIS items using the Pydro Editor function.
6. Use the Pydro Features Tree to edit flags and update Recommendations, especially with disproval methods and notes. Pydro flags should be updated to *Chart*, *Significant* and *Primary*. Check the *Report* flag if an item needs to be addressed in the DR. (This should already be done, but do it now if not complete.)
7. Any item flagged as *Report* should have the surveying information in the *Remarks* tab and any necessary recommendations entered under the *Recommendations* tab.
8. Check the DP Forms in the project binder. Make sure they are completely filled out and match the information entered in Pydro.
   NOTE: The distance and bearing entered in TerraSync as noted on the DP form will not appear in Pydro. The position is automatically updated.
9. Scan the finalized DP forms and save as a single PDF in:
   I:\OPR_XXXX_FA_0X\Surveys\H#####\Descriptive_Report\Separates\1_Logs\Detached_Positions.
10. Mark items as *Resolved* once they have been completely finalized.
11. The features will need to be re-exported after all correctors have been applied and S57 attributions made. Refer to the Exporting XML Data section above.

CREATE A SHORELINE REPORT

1. From the *Reports* menu, select *For List of Items.*
2. In the pop-up window, set the filter to Report.
3. Fill in the fields as shown below, with a short text description for the report.



Feature Report Options
Features To Report:
Report
Filter
Letter
Paper width (inches)
8.50
Font / Size
10
Paper height (inches)
11.00
Portrait
Landscape
Times-Roman
Margin (inches):
top
1.00
bottom
1.00
left
1.00
right
1.00
Title
H11334 Shoreline Report
Subject
Source Shoreline Changes, New Features and Charted Features
Author
ST Jennifer Keene
Summary Comments
Items for survey H11334 associated with a detached or generic position that needed further discussion were flagged Report in Pydro. Investigation methods and recommendations were provided in the Remarks and Recommendations tabs.
Calculate Min/Max Survey Dates (else use PSS metadata start/end date)
Show Chapter.Section #s in Summary Table
Show Feature "DispName" in Summary Table
Show Feature Type in Summary Table
Show Correlating AWOIS Item # in Summary Table
Arrange Features in Chapters According to Acquisition Type...
... then sort by ...
Feature Type
Ascending
Descending
... then sort by ...
Longitude
Ascending
Descending
Feature Naming
DispName
Position Format
Symbols
Image Frames Width (inches)
3.00
Image Frames Height (inches)
3.00
Maintain Aspect
Stretch to Frame
Show Correlation Table
Show Office Notes
Show S-57 Data
Feature Page Breaks
OK
View PDF Results
Cancel

4. Click *OK* and save the file to the *Shoreline* appendix of the DR.

3.3 CARIS Notebook

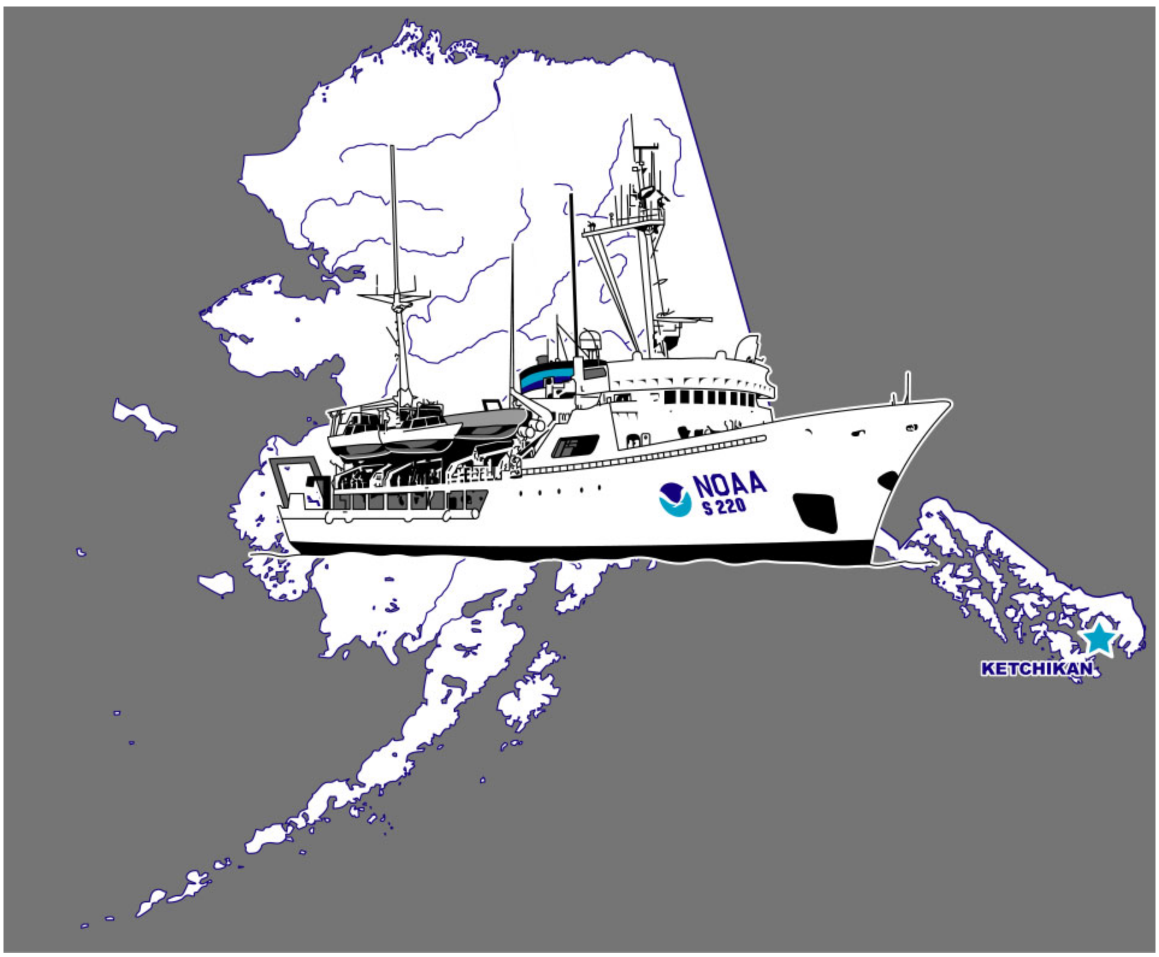
REVIEW WITH BASE SURFACE

1. From the *File* menu, select *Open Session*.
2. Select the appropriate CARIS HIPS session for review. The session should contain BASE surfaces, contours and soundings.
3. Open all Notebook files necessary for review.
   NOTE: Files must be opened individually. Choosing to open a Notebook session will close the HIPS session.
4. Individual fieldsheets can also be opened into Notebook as further reviewing tools.
5. Review shoreline remarks and features with SWMB surfaces with contours and depths to make sure there are no conflicts (i.e. SWMB over CHD (17324) RK NTD).

FINALIZING

1. Import the final .xml features from Pydro to the *H######_Features.hob* file. Make sure all old files are deleted or over written. Add, Modify, Delete layers?
2. Check that the *H######_Shoreline_Updates.hob* file is correctly attributed and complete.
3. Make sure all notes, shoreline additions and edits have been entered from the boat sheet to the appropriate layer. Refer to the Post Acquisition section above.
4. Delete any outdated or extra layers from the final Notebook session.

Survey Management



SURVEY MANAGEMENT

Table of Contents

0.0 Document Scope

This document is meant to be used as a guideline for survey managers to insure that surveys are completed properly. There is a general order to this list. Some things have to be done in order, while others, like the Coast Pilot, DR and Final Fieldsheet prep can be started in advance. This document can be used in conjunction with the QC Checklist. The two should match fairly closely beginning with the Post Acquisition section.

1.0 Survey Planning

Survey planning begins before arriving at the survey area and continues throughout the project.

1.1 Project Instructions

Read and understand the project letter instructions, located here:
I:\200X_Projects\OPR_XXXX_FA_XX\Project Files\Instructions\Letter Instructions\OPR-XXXX-XX.doc

1.2 Manager Responsibilities

The survey manager is responsible for creating polygon files, a shoreline workspace, boat sheets, setting up projects on the launches (including suitcase shoreline and ship if necessary for your survey). In addition, the Survey Manager is responsible for directing the daily work schedule (polygon plans and chartlets) of launches assigned to acquire data on the survey. See:
R:\Utilities\FA_SOP\0_Management\File Management\Survey File Management
R:\Utilities\FA_SOP\1_Presurvey\Shoreline\Shoreline_Presurvey.doc & Printing Boat Sheets.doc
R:\Utilities\FA_SOP\1_Presurvey\AWOIS_Presurvey\ AWOIS_Setup.doc
R:\Utilities\FA_SOP\1_Presurvey\Creating_DelphMap_Projects_SOP.doc
R:\Utilities\FA_SOP\2_Acquisition\Shoreline\Shoreline_Guidelines

Remember to update your near shore polygons using the shoreline buffer, shoreline updates and new features to determine the inshore limit of hydro. Review polygons with shoreline data so you don't accidentally send a SWMB boat over a new rock, or into an area that is too shoal. Also, use the Ceeducer depths that were collected to edit your polygons.

DO NOT send multibeam boats inshore of the eight meter curve until shoreline verification has been run in that area. Once shoreline has been run, export your new features from Pydro into Isis for use by the multibeam boats during near shore acquisition.

1.3 Survey Log

Keep a survey log in addition to the daily acquisition and processing logs to note any problems during the survey, or deviations from the DAPR. This will be useful when writing the DR.

2.0 Post Acquisition

These steps are intended to be followed both during acquisition and immediately after data acquisition has been completed for the survey.

2.1 Quality Control and Assessment of Soundings

During acquisition of data, the Sheet Manager is responsible for analyzing the quality of the soundings and insuring coverage and sounding density. Before leaving the survey area, the Sheet Manager must review the BASE child layers in subset mode, checking for sound velocity and tide problems, as well as checking for ample coverage, especially over navigationally significant areas. Unverified observed tides are usually available within a day or two and can then be applied to the data.

It may be beneficial to create a subset tile layer in CARIS to keep track of areas that have been reviewed. This review is not cleaning in subset. It's just a quick look in subset mode for lines that may not have been cleaned properly, holidays, SV, tide and other problems with the data. Have the BASE surfaces open in CARIS and use different sun illumination angles. Problem areas will look suspect.

2.2 Check for Immediate DTON's

Look for any items in the bathymetry which are extremely navigationally significant. These items should be brought to the attention of the FOO and the CO immediately, so they can be added to the relevant charts as soon as possible. Otherwise, the regular DTON review occurs at the end of post processing.

2.3 Document Deviations from DAPR

Any deviations from the DAPR should be recorded in the survey log, or the acquisition and processing logs. Changes to the HVF, or other unusual steps taken during data acquisition or processing should be noted and explained in the DR. Be familiar with the DAPR for the project.

2.4 Shoreline

Insure that shoreline verification is conducted in accordance with the Letter Instructions and that adequate annotations are made to allow for complete description of the shoreline environment. Review Pydro and Notebook sessions, photos and DP forms for completeness prior to leaving the survey area. Pydro PSS features should be completely addressed and with the Chart, Significant, Primary and Report flags checked where applicable. See:
R:\Utilities\FA_SOP\3_Processing\Shoreline\Survey _PIC_ Shoreline _SOP.doc
R:\Utilities\FA_SOP\3_Processing\Pydro\Pydro Logic.doc & The Editor Notebook.doc

2.5 AWOIS Items

Insure that all AWOIS items listed for the survey are either verified or disproved through methods listed on the AWOIS database technique section. Update the AWOIS database using Pydro. If there are questions about which method is best for a particular item, consult the FOO, CST or an SST.

2.6 Coast Pilot Updates

The Coast Pilot should be updated while still in the survey area. Don't put it off! Reference depths, bottom samples and shoreline information as needed to update relevant paragraphs. See:
R:\Utilities\FA_SOP\4_Deliverables\Coast_Pilot\Coast Pilot Survey PIC Instructions.doc

2.7 Smooth Tide Request

Request for Smooth Tides letters should be drafted and submitted as soon as a survey is completed. These requests do not need to wait until all data processing is complete or the DR has been written. See:
R:\Utilities\FA_SOP\4_Deliverables\SmoothTides\Smooth Tides Request.doc

2.8 Create Survey Outlines

It may be necessary to make two or three outlines for the survey, depending on whether VBES and / or SSS are submitted as well as SWMB. The table named H#####_Survey_Outline.tab should outline all data. If only SWMB is being submitted, only one table is needed. For step by step instructions on creating tables, see:
R:\Utilities\FA_SOP\4_Deliverables\Survey_Outline\Survey_Outlines_2004.ppt

If the survey has VBES or SSS, there will need to be an outline around the VBES coverage named H#####_VBES_Outline.tab and an outline around the SSS coverage named H#####_SSS_Outline.tab, as well as the SWMB outline, named H#####_SWMB_Outline.tab.

All of the outline files should be saved in:*I:\Projects\ OPR-XXX-FA-0X\Surveys\HXXXXX\ Descriptive_Report\Appendices\Survey_Outlines*

2.9 Apply Observed Tides to CARIS Data

Check the observed tide file to be applied to the data. Make sure that all acquisition days are included in the tide file. Be sure that there is a buffer of one extra day at the end of the file, or before any gaps in acquisition days. This will cover any data collected after midnight GMT.

Using CARIS, open the file in Tide Editor to insure that it looks OK. Look for fliers and for problems with the data, such as a shift up or down in one section of the data, or any discontinuities. Alert the tides people if you see a problem, so it can be corrected. If you can't find, or don't know which tide file to use, check with the tides people.

At the end of acquisition, reload the observed tides with the zone file to all lines and DPs.

2.10 Review Sound Velocity Files

1) Check all SVPs, using CARIS Sound Velocity Editor to look for any fliers or other problems with the cast.
2) Display SVP Positions in CARIS with the SWMB data open.
3) From HDCS_Data folder, select the folder for one line from each boat day. Use a text editor to compare the SVP file listed to the cast that the acquisition log query lists as being applied.
4) Male sure that all casts listed in the acquisition logs have been copied to the appropriate folders to be applied to the data.
5) Produce a list of all CTD casts performed during the survey to be included with the DR. Use the template located at: *R:\Utilities\Templates\SV_Cast_Example.doc*

2.11 Re-Merge CARIS Lines

Check the CARIS H#####_QC session to make sure that it contains all SWMB lines. There should not be any DP files in the subset cleaning session. Re-merge all lines once observed tides have been applied.

2.12 Query All Lines

Query all HDCS lines and save the results in the H#####_Data_Query.xls, in the Acquisition and Processing folder of the DR Separates . Check that the appropriate tide file has been applied and that the SV profile makes sense as far as time and position. Compare this query with the original queries recorded in the acquisition and processing logs and investigate any discrepancies.

3.0 Post Survey

These steps outline the process for final review of data before submission.

3.1 Quality Control and Data Review

The Survey Manager must review the entire survey area in subset mode, using the H#####_QC session. Refer to:
R:\Utilities\\FA_SOP\Processing\CARIS\Bathy_Processing

It may be helpful to create a subset tile layer for the entire survey to keep track of which areas have been checked. This requires a surface that is up to date and contains all SWMB lines. The CARIS session should not include any DPs or BSs. The recommended tile size for a 1:10,000 scale survey is 20m. Bigger than that causes overlap between subsets to be too large and smaller is not necessary.

3.2 Designate Soundings

Use CARIS Subset Editor to review the data with a BASE surface in the background. Designate soundings in areas where the surface doesn't match the highest point of the data. Refer to: *R:\Utilities\\FA_SOP\Processing\CARIS\Bathy_Processing*

Depth Threshold BASE Surfaces must be finalized in H#####_QC session for designated soundings to take effect and become critical soundings that will be submitted with data.

3.3 Depth Checking for Flyers

Using CARIS Fieldsheet Editor, create contours and soundings in the H#####_QC session. Review the entire survey area and check areas with bulls eye contours or questionable depths using subset or line mode.

3.4 Chart Comparisons

Review depths in CARIS with the appropriate chart in the background. Write up results in the DR. Also, check the latest Local Notice to Mariners for the most recent updates to the chart.

3.5 DTONs

For information on selecting DTONs, refer to:
R:\Utilities\FA_SOP\4_Deliverables\DTONs\Selecting DTONs.doc

Select any possible DTONs in CARIS and mark soundings as outstanding or designated. Insert the item as a HIPS/SIPS Line Feature in Pydro and check the DTON flag. Also, new DPs/GPs can be possible DTONs, so review the new features and check the DTON flag if applicable. E-mail the FOO to review the possible DTONs in the PSS.

Once the DTONs have been approved by the FOO, continue with the instructions given in: *R:Utilities\FA_SOP\4_Deliverables\DTONs\DTONS_Procedure_XML.ppt*

Make sure all Remarks and Recommendations tabs have been filled in and then create an .xml of the DTONs. Have the FOO review the .xml and e-mail it to MCD, CC-ing the Sheet Manager. A digital copy of the e-mail should be kept in the DTON appendix for the DR. This folder should also include the H#####_DTON.xml and the H#####_DTON_Report.

3.6 Field Products

A CARIS Notebook session should be created for the survey, which includes all shoreline and bottom sample data. For the proper procedures, refer to:
R:\Utilities\FA_SOP\3_Processing\Shoreline\Survey_PIC_Shoreline_SOP.doc

3.7 Create Depth Threshold BASE Surfaces

The H#####_QC session should contain all SWMB lines, but none of the DP or BS files. The fieldsheet can contain any BASE surfaces which were used during processing, but should also contain finalized BASE surfaces, with the appropriate depth thresholds. Refer to the Digital Submission Checksheet for suggested depth ranges and resolutions.

The H#####_Final CARIS session should contain a field sheet with non-finalized BASE surfaces. These surfaces should be named to reflect the resolution and depth ranges used for the finalized surfaces in the QC session.

3.8 Preliminary Smooth Sheet (PSS session in Pydro)

Open the PSS in Pydro. Use the Data Stats function to make sure that the data is not stale or outdated. Check the shoreline and bottom sample DPs to insure that the appropriate flags are checked, the Remarks and Recommendations tabs are filled in as necessary and that correctors have been properly applied. The DP forms should be scanned and the electronic copies saved in: *I:\200X_Projects\OPR_XXXX_FA_0X \Surveys\HXXXXX\Descriptive_Report\Separates\1_Logs\Detached_Positions\HXXXXX_DP_Forms.pdf*

3.9 AWOIS

After all AWOIS items have been reviewed and resolved in Pydro, create an AWOIS report, using the Report function of Pydro. Save the digital copy in the DR Appendix 3 AWOIS folder.

3.10 Descriptive Report

In the DR, the Survey Manager describes what, where, why, when, how and with whom the survey was conducted. The DR is a legal document and can be brought up in court to prove (or disprove) the accuracy of the survey. Go to the template:
I:\200X_Projects\OPR-XXXX-FA-0X\Surveys

Save a copy to the survey folder:
I:\200X_Projects\OPR-XXXX-FA-0X\Surveys\H#####\Descriptive_Report
and name it H#####_Descriptive_Report. Use the survey log and acquisition and processing logs to write about any issues encountered, or deviations from standard processes.

3.10.1 Shoreline

Disprovals and anything ambiguous, about which further information would be helpful to the cartographer, should be flagged for Report in Pydro. Most shoreline discussion items will be in Pydro, if something was not positioned or could not be brought in as a GP, it will need a paragraph in the DR to address the item. A general write-up on how shoreline was conducted, what programs and processes were used, and any deviations from shoreline procedures outlined in the DAPR should be included in the shoreline section of the DR.

3.10.2 Junction and Prior Survey Comparisons

Examine Junctions and Prior surveys in CARIS subset mode or Fledermaus (if possible). Measure the distance for a general difference range and note if agreement was good or not. Major discrepancies should be investigated and addressed in DR.

3.10.3 Digital Images

Limits of Hydrography.jpg and Junctions.jpg are created in MapInfo with the survey limit displayed. These images should be saved to the survey Misc folder, NOT in the Descriptive Report folder. Insert the images directly into the DR. The digital images do not get submitted separately.

3.10.4 Cross Line Analysis

Review a portion of your crossline areas in subset mode to get a general idea of how your data is matching up. Discrepancies need to be investigated and written about in the DR if necessary.

With all SWMB lines inserted into Pydro by type (Mainscheme or Checkline), use the built in function in Pydro to determine the mileage. Then calculate the percentage of cross lines to mainscheme and report it in the DR. If requirements were not met, be sure to include an explanation.

3.10.5 Discussion of Issues and Deviations from Standards

It is important to discuss any problems with the data, or processes that were done differently than those described in the DAPR.

3.10.6 Cover and Title Pages

Copy the templates from:
R:\Utilities\Templates
into the DR folder for the survey. Fill in all fields with information from the project letter instructions and acquisition and processing logs.

3.11 DR Appendices

3.11.1 DTONs

Refer to the DTON section (3.5) above.

3.11.2 Geographic Names

The Geographic Names form 76-155 will only need to be filled out if there are new geographic names in the survey area. Save a copy of the form to the Geographic Names appendix folder and name it H#####_Geographic_Names.xls.

The names will also need to be added as marker text in a new edit layer in CARIS Notebook, named H#####_GeoNames.hob. This will go into the Final Fieldsheets\Notebook Files folder.

Make a note in the DR referring to the Geopgraphic Names form in the Appendices andthat the names were included in the CARIS Notebook session.

3.11.3 Survey Outline

Refer to the Survey Outline section (2.8) above.

3.11.4 Smooth Tide Request

Refer to the Smoot Tide Request section (2.7) above.

3.11.5 Shoreline Report

Use the report generating function in Pydro to produce a H#####_Shoreline_Report.pdf from the features flagged Report in the PSS.

3.11.6 AWOIS

Refer to the AWOIS section (2.5) above.

3.12 DR Separates

3.12.1 Acquisition and Processing Logs

Clean up the binder. It should contain only official paperwork, boat sheets, acquisition logs and DP forms. Remove any personal items and unnecessary paperwork, such as polygon plans, PODs, etc. Check that all DP forms are in the notebook.

The digital folder should contain all acquisition and processing logs as well as the survey log.

3.12.2 Side Scan Contacts

Not applicable at this time.

3.12.3 Sound Velocity Data

Make a list of all CTD casts, using the template located at: *R:\Utilities\Templates\SV Cast Example.doc*. Save the file into the appropriate Separates folder and name it H#####_SV.doc

4.0 Submission

4.1 Check Coverage and Accuracy Requirements

The coverage requirements for the survey are specified in the project letter instructions. Check the data to make sure the requirements were met. If they were not, be sure to make a note in the DR about what kind of coverage was achieved and why letter instructions could not be followed.

The accuracy standards are as stated in the Specifications and Deliverable, unless otherwise noted in the project letter instructions. Be sure the data meets standards and discuss any problems in the DR.

4.2 File Management

Please remove/delete all extraneous files from the I drive. This includes temp files, delete_me files, etc., which were used during processing but are no longer needed once the survey is approved. Once the necessary files are copied into the Field Products folder, the survey files folder and its contents can be deleted. Delete any non-official field sheets, surfaces and sessions from the I drive. It should contain two sessions: H#####_QC and H#####_Final for each survey. The H#####_Final session should contain a H#####_Final fieldsheet, named with the official non-finalized depth threshold and resolution BASE surfaces. The H#####_QC session and fieldsheet can contain any surfaces, fieldsheets, contours, depths, etc. that were used during the review and QC of the survey. Just tidy it up for submission. Anything else is extraneous and can be deleted. Please note that the I drive can and will be cleaned up after the data has been submitted.

4.3 Quality Control Review

When the field products, DR, Appendices/Separates and QC Checklist are complete, have a reviewer (FOO, CST, SST) go through the QC Review Checklist prior to submitting the survey to the FOO for approval.

4.4 Submit to FOO

Submit the survey to the FOO for review and approval.

Hydrographic Survey Quality Control Checklist

Survey: HXXXXX ________ Project: OPR-XXX-FA-XX __________ Survey PIC: ____________________

Bold underlines require a date and initials of when item was completed.
Refer to Survey Management SOP for detailed instructions to complete these steps.

Post Acquisition - review of data

________ Quality Control of survey area in subset prior to departure from field (SV, Tide, Holidays, Noise)
- ________ BASE surfaces reviewed
- ________ Survey area reviewed in subset mode
- ________ Review Acquisition and Processing logs for issues/problem data

________ Check for immediate DTONs
- ________ Immediate DTONs submitted

________ Document special circumstances/problems and HVF changes/deviations from DAPR as occurred for DR
- ________ Issues listed in HXXXXX_Survey_Log.doc
- ________ Issues explained in DR

________ Shoreline acquisition & boat sheet/Notebook review
- ________ All items addressed (all data including CFF, Chart, Lidar, and new items)
- ________ AWOIS investigations complete

________ Pydro
- ________ DPs/GPs/Bottom Samples reviewed/flagged/S57 attributed
- ________ Pictures labeled correctly, in one folder, & inserted
- ________ AWOIS.mdb inserted

________ Coast Pilot review & write up with edits completed

________ Smooth Tides Request (*.mif/mid and times of Hydro)
- ________ Produced, Submitted, Archived [Digital-copy (letter, times, & mif/mid) in Appendix VI Smooth Tide Req fldr]

________ Survey Outline
- ________ Produced, Submitted, & Archived (digital-copy in Appendix I Survey Outline folder)

________ Observed Tides
- ________ Observed tide file verified & checked for gaps/flyers (txt in Notepad, .tid in Caris Tide Editor)
- ________ Applied to lines
- ________ Applied to DPs

________ Verify Sound Velocity files
- ________ SVP files compared in digital acquisition logs vs. I drive – all should match
- ________ Each cast profile reviewed individually in CARIS
- ________ SV cast positions displayed in CARIS (check for gross error)
- ________ SV cast list produced (digital copy in Separates III SV Profile List folder)
- ________ SV acquisition/processing deviations from the DAPR are noted in the DR.

________ Data re-merged in CARIS after observed tides have been re-applied.

________ All lines re-inserted into HXXXXX_QC session, for BASE/subset review (not DP lines)

________ Data queried in CARIS (compare to digital acquisition logs)
- ________ Query all lines in CARIS
  - ________ Save query to H#####_Data_Query log
  - ________ Compare query to SVP file in HDCS line directory (random sample)
  - ________ Tide and SVP files applied are correct and most current (observed or verified)
- ________ Problems/discrepancies investigated
- ________ Vessel speeds queried in CARIS and reviewed
  - ________ Vessel speeds meet object detection requirements for relevant depths

Post Survey - post spatial (subset) review of data

- ____ Quality Control of cleaning performed by others and general QC of survey area
  - ____ Complete Subset Review (include looking at rejected and BASE child layers)
    - ____ Subset tiles created for review process
  - ____ Review all examined soundings (to designate, mark outstanding, or reaccept)
  - ____ Data checked for systematic errors (Std deviation child layer especially useful)
  - ____ Data issues discussed in DR if present
- ____ Designate soundings in areas where surface does not accurately represent the bottom
  - ____ # of Designated Soundings
- ____ Depth checking for flyers (CARIS Field Sheet Editor)
  - ____ Contours & Soundings generated (CARIS Field Sheet Editor)
- ____ Chart comparisons completed and documented in DR
  - ____ Local Notice to Mariners checked for recent updates
  - ____ Chart edition & date corrected through included in DR
- ____ DTONs (Dangers to Navigation)
  - ____ Selected (marked outstanding in CARIS and inserted as CARIS Line Feature)
  - ____ Reviewed by FOO
  - ____ Pydro session updated/.xml produced
  - ____ FOO emailed
  - ____ Submittal email/DTON Report archived (digital copies in Appendix II DTON folder)
- ____ Field Products—Notebook and file management
  - ____ All .shp files are in appropriate projection and name to include attribute description
  - ____ All .hob files are in the Notebook session, named properly, & are in the Field Products/Notebook folder
  - ____ Extraneous files are removed from the Field Products folder
- ____ CARIS Fieldsheets & Sessions cleaned up and submission ready
  - ____ HXXXXX_QC Fieldsheet & Session tidied up
    - ____ Depth Threshold BASE surfaces finalized to produce critical soundings
    - ____ Use Finalized (clipped by depth range) surfaces to assess coverage requirements were met
  - ____ Non-Finalized BASE Surfaces produced (in HXXXXX_FINAL Fieldsheet & Session)
    - ____ BASE surfaces include Depth Threshold ranges and resolutions
- ____ Pydro
  - ____ PSS data IS NOT Stale or Outdated
  - ____ All features resolved, flagged correctly and S57 attributed
  - ____ DP forms match PSS & scanned into DP Log folder
  - ____ Correct Vessels were selected for all data
  - ____ Correctors were applied properly
  - ____ Remarks/Recommendations completed in Pydro
  - ____ AWOIS items finalized
    - ____ AWOIS Report produced and archived (digital copy in Appendix III AWOIS folder)
- ____ Descriptive Report completed
  - ____ Shoreline Processes described in DR
  - ____ Shoreline Report produced in Pydro and archived (digital copy in folder)
  - ____ Junction comparisons completed and documented in DR
  - ____ Prior surveys were reviewed because of special issues ____________________
    - ____ Did the issues require an explanation in the DR
  - ____ Cross-line (SWMB) comparisons completed and documented in DR
    - ____ Required quantity of XLs met. If not, addressed in DR.
    - ____ SWMB Cross-line comparisons completed in subset mode in CARIS
  - ____ Special circumstances/problems/issues/HVF changes/deviations from DAPR documented in DR
    - ____ Does the data meet specifications? Include an answer to this with any write-up.
  - ____ Cover & Title sheets produced (digital copy in folder)
  - ____ Appropriate Appendices completed and included with digital data
  - ____ Separates completed and included with digital data

Submission

_____ Coverage requirements were met.

- _____ If not, addressed in DR.

_____ Accuracy requirements were met.

- _____ If not, addressed in DR

_____ Digital folders cleaned up

- _____ HXXXXX_FINAL Fieldsheet folder contains only official Non-Finalized BASE Surfaces
- _____ Sessions & Fieldsheets open in CARIS and are not outdated

_____ Content of all submission folders (CARIS, DR, Field Products, & PSS folders) checked for completeness and suitability

_____ Data checks

- _____ HVFs match current DAPR (check HVF database for which applies)
  - _____ If not, addressed in DR.

_____ Hydrographic Survey Quality Control Review Checklist completed

List name of reviewer _____

Date completed _____

_____ All data and DR submitted to FOO for approval

The quality and completion of all tasks are the responsibility of the Sheet Manager (OIC) (meaning if someone else completed a task, the OIC has verified the accuracy).

Standard field surveying and processing procedures were followed in conducting the above mentioned survey.

The digital data and supporting records have been fully reviewed and are considered complete and adequate for review and approval.

_____	_____	_____
Sheet PIC Name Printed	Sheet PIC Signature	Date

Field Operations Officer (FOO) Review

_____ Data and DR are approved

- _____ Descriptive Report & Appendices reviewed
  - _____ Shoreline Report reviewed
- _____ Pydro/Notebook Sessions reviewed
- _____ Processed HDCS Data reviewed in Fledermaus

_____	_____	_____
FOO Name Printed	FOO Signature	Date

Hydrographic Survey Quality Control Review Checklist

Survey: ________ Project: ________ Survey Reviewer: ________

Bold underlines require and date and initials when item is completed.

____ Descriptive Report reviewed
- ____ Special circumstances/problems/issues/HVF changes/deviations from SysCert/DAPR documented in DR
  - ____ Were data requirements met?

____ Quality Control Checklist reviewed

____ Logs reviewed
- ____ Digital Acquisition & Processing Logs
- ____ Pydro Feature Log
- ____ Survey Log

____ Quality and flyer check of depths/surfaces (review in CARIS w/ HXXXXX_QC Session & Fieldsheets)
- ____ Subset (include looking at rejected) – just need to look at around 10% of area
  - ____ Shoals and Navigationally Significant areas reviewed
- ____ Contours & Depths checked
- ____ Designated soundings reviewed
- ____ Errors discussed in DR if present

____ CARIS DP/BS line query
- ____ DPES lines are SVP/Tide/Merged
- ____ DPNE lines are just Tide/Merged

____ Outside Review of Shoreline & Pydro session
- ____ All features resolved
- ____ Remarks/Recommendations make sense
- ____ AWOIS Items resolved sufficiently
- ____ Files in Notebook folder open in CARIS Notebook
- ____ Review Notebook shoreline files with Caris Map .des from BASE surface for survey

____ DTONs (Dangers to Navigation)
- ____ Reviewed/Verified

____ Chart comparisons reviewed
- ____ Ensure chart edition and date corrected through included in DR

____ Coverage and accuracy requirements were met
- ____ If not, addressed in DR.

____ Check that all lines are in HXXXXX_FINAL CARIS session
- ____ Session & Fieldsheet open correctly
- ____ HXXXXX_FINAL Fieldsheet folder contains official Depth Threshold BASE surfaces
- ____ Depth Threshold BASE surfaces open correctly and are not outdated

Digital Data Submission Checklist

OPR-A###-FA-##

HXXXXX Survey X

CARIS

Fieldsheets

- ______ HXXXXX_FINAL (Non-Finalized BASE Surfaces)
  - ______ HXXXXX__0to20_1m
  - ______ HXXXXX__19to60_2m
  - ______ HXXXXX__59to150_5m
  - ______ HXXXXX__149to250_10m
  - ______ HXXXXX__249toXXX_15m

Naming convention: HXXXXX_DepthRange_Resolution(m)

List all Non-Finalized BASE Surfaces - the number of surfaces submitted is dependent on the depth range of the data and the finest resolution the data can support.

- ______ HXXXXX_QC (Working fieldsheet used throughout the survey for coverage and qc)
  - (The following are examples of possible files)
  - ______ Preliminary Finalized BASE Surfaces
  - ______ Subset Tiles
  - ______ Depths and Contours

HDCS_Data

- ______ HXXXXX (processed CARIS HDCS data)
- ______ VesselConfig (only vessels that apply to this survey)

Preprocess

- ______ ISIS (raw XTF data and True Heave from ISIS)
- ______ SVP_raw (raw SV data from Velocwin)
- ______ Trimble (raw data from TerraSync & exported SHP files from GPS PathFinder)

Session

- ______ HXXXXX_FINAL.hsf (CARIS session)
- ______ HXXXXX_QC.hsf (CARIS session)

SVP

(processed CARIS SVP data files separated by vessel)

- ______ 1010
- ______ 1018
- ______ S220

Tide

- ______ Observed .tid and .zdf (Tide files applied to the data at the time of submission)

DESCRIPTIVE REPORT

- ______ HXXXXX_DR.doc, HXXXXX_DR.pdf (the final Descriptive Report)

Appendices

Survey Outline

- ______ HXXXXX_Survey_Outline.tab (survey outline of hydrography)
- ______ HXXXXX_SWMB.tab (multibeam coverage)

DTON

- ______ HXXXXX_DTON.xml (XML of DTONs exported from Pydro)
- ______ HXXXXX_DTON_Report.pdf (report produced in Pydro)
- ______ HXXXXX_DTON_email.txt (copy of submission email)

AWOIS

- ______ HXXXXX_AWOIS.mdb (Include only items that apply to this survey)
- ______ HXXXXX_AWOIS_Report.pdf (report produced in Pydro)

Shoreline

- ______ HXXXXX_Shoreline_Report.pdf (report produced in Pydro)

Quality Control

- ______ HXXXXX_QC_Checklist.doc
- ______ HXXXXX_Review_Checklist.doc
- ______ HXXXXX_Submission_Checklist.xls

Smooth Tide Request

- ______ HXXXXX.pdf (Smooth Tides Request & Abstract Times of Hydro)
- ______ HXXXXX.mif/mid files

Supplemental Correspondence

- ______ HXXXXX_Correspondence.xxx (digital copies of emails, request & correspondence)

Separates

Logs

Acquisition & Processing

- ______ HXXXXX_1010_8101_Log.xls
- ______ HXXXXX_1010_8101_Log.xls
- ______ HXXXXX_S220_8111_Log.xls
- ______ HXXXXX_S220_8160_Log.xls
- ______ HXXXXX_Survey_Log.doc

Detached Positions

- ______ HXXXXX_Pydro_Feature_Log.xls
- ______ HXXXXX_DPForms.pdf (Scanned DP forms)

Sound Velocity

- ______ HXXXXX_SV_Cast_List.doc (contains filename, lat, lon, & depth)

FIELD PRODUCTS

Final Fieldsheet

Notebook Files

- _____ Source shoreline shapefiles
- _____ HXXXXX_Shoreline_Updates.hob
- _____ HXXXXX_Shoreline_Notes.hob
- _____ HXXXXX_Charted_Shoreline.hob
- _____ HXXXXX_Features.hob (hob file created from xml import)
- _____ HXXXXX.hsf (Notebook session)

PR and Constituent Products

- _____ Include all products that were provided to constituents

PSS (Pydro Preliminary Smooth Sheet)

- _____ HXXXXX.PSS
- _____ Images (Non-SSS contact images associated with Pydro features, named w/unique identifier)
- _____ HXXXXX_S57Features.xml

HXXXXX Contents

- _____ size
- _____ number of files
- _____ number of folders

_____ Survey data included in transmittal list text file

Analog Data Submission checklist

HXXXXX   Sheet X

__________ Digital Data on Hard Drive (listed on Digital Data tab)

__________ Shoreline boatsheets

__________ DP Forms

__________ Daily acquisition forms