W00185

NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey HYDROGRAPHIC

Field No.

Registry No. W00185

LOCALITY

State American Samoa

General Locality Tutulia Island

Sublocality Pago Pago Harbor

2006

CHIEF OF PARTY

Micah Tinkler, NAVOCEANO

LIBRARY & ARCHIVES

DATE

NOAA FORM 77-28
(11-72)

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

REGISTER NO.

HYDROGRAPHIC TITLE SHEET

W00185

INSTRUCTIONS - The hydrographic sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the office.

FIELD NO.

State: American Samoa

General Locality: Tutulia Island

Sublocality: Pago Pago Harbor

Scale: N/A

Date of Survey: 05/05/2006 -05/07/2006

Instructions Dated: None

Project No.: OSD-PHB-06

Vessel: Beachcraft King Air 200, Tail Number C-FBCN

Chief of Party: Micah Tinkler

Surveyed by: Tinkler, Sauks, Johnson, Bonisteel

Soundings taken by echo sounder: Optech Inc. SHOALS 1000T

Graphic record scaled by: N/A

Graphic record checked by: N/A

Evaluation by: Faulkes

Automated plot by: N/A

Verification by: K. Brown

Soundings in: Fathoms at MLW

REMARKS: Time in UTC. UTM Projection Zone 2 South

Revisions and annotations appearing as endnotes were

generated during office processing.

As a result, page numbering may be interrupted or non-sequential

All separates are filed with the hydrographic data.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF COAST SURVEY
Pacific Hydrographic Branch
Seattle, Washington 98115-6349

July 24, 2009

MEMORANDUM TO: Captain John E. Lowell, NOAA
Chief, Marine Chart Division

THROUGH: Jeffrey Ferguson
Chief, Hydrographic Surveys Division

FROM: Gary C. Nelson Gary C. Nelson 2009.07.24 08:50:24 -07'00'
Acting Chief, Pacific Hydrographic Branch

SUBJECT: Approval Memorandum for W00185
Pago Pago Harbor, American Samoa

The Pacific Hydrographic Branch has completed an evaluation and chart application of Outside Source Data from the Naval Oceanographic Office (W00185). The primary objective of this survey was to acquire hydrographic (Lidar) data to satisfy requirements of NGA and COMPACFLT.

I have reviewed the data, reports and compilation to the chart. The data quality was good. The Lidar lines were flown at 2x2 meter spot spacing with the goal of 200% coverage. The conditions near Pago Pago were excellent for Lidar, low turbidity. However, NOAA standards for object detection have not been proven for Lidar. As a result, no shoal soundings where superseded with the data. Since the quality of the Lidar was excellent, PHB has recommended some adjustments to the charted reefs and ledges (see DR endnotes).

Within the 2008 NOAA Hydrographic Survey Priorities (NHSP), Pago Pago Harbor is listed as a "Priority 2" area. Except where noted in the Evaluation and Quality Assurance Memorandum survey W00185 provided adequate depth information to update NOAA charts in near shore areas. However, due to the lack of full coverage in the priority area and the possible lack of object detection throughout the survey, it is recommended that the area remain a "Priority 2" area.

As full bottom coverage and object detection requirements could not be verified, the survey area should be classified as Category of Zone of Confidence (CATZOC) "B" if used to update ENC survey area classification (Seafloor Coverage: Full seafloor coverage not achieved; uncharted features, hazardous to surface navigation are not expected but may exist. Typical Survey Characteristics: Controlled, systematic survey to standard accuracy.).

cc: Chief, HSD Operations Branch N/CS31

FILE: AS_ROS.doc
UPDATED: 21 September 2006
BY: Jamie Bonisteel

NAVAL OCEANOGRAPHIC OFFICE
Stennis Space Center, Mississippi

Report of Survey

Territory of American Samoa

Vessel: CHARTS Aircraft
Detachment: CHARTS Team
Dates of Survey: 05-07 May 2006
Technical Specification: None Provided
Archive Number: 06H3A05
Hydrographic Area: Pago Pago Harbor
Topographic Areas: Pago Pago International Airport
Personnel:

SURVOP	SURVOP Dates	Senior NAVOCEANO Representative	Data Manager	N4 Lead	Surveyors
04-CHARTS-07	05-07 May 06	Micah Tinkler	Jamie Bonisteel	Jamie Bonisteel	Jamie Bonisteel

AirCrew	Pilot	Co-Pilot	Mechanic	Fugro Surveyors
Kenn Borek	Andre Cormier	Raven Ares	Garth Robson	Emilie Sauks, Derek Johnson

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1.0 General Information

1.1 Scope of Report

NAVOCEANO personnel and contracted surveyors conducted survey operations within Territory of American Samoa. This report specifically addresses the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) survey and should be considered complimentary to any other reports such as the American Samoa Data Processing Report.[1]

1.2 Requirements

This survey was conducted in support of specific validated requirements of NGA and COMPACFLT. Data collection included the acquisition of the following types of information: Hydrographic and topographic lidar data, digital imagery, navigation data, investigation of hazards and aids to navigation. The collected data will support the production of updated high-resolution nautical charts, high and medium density Digital Terrain Elevation Databases (DTED), and safe navigation of U.S. and coalition forces operating in the area, humanitarian assistance, disaster relief, coastal zone development and harbor expansion projects.

1.3 Survey Standards

1.3.1 International Hydrographic Organization (IHO)

This survey was planned and conducted to meet IHO Order 1 standards (see IHO Special Publication 44, IHO Standards for Hydrographic Surveys).[2]

1.3.2 United States Army Corps of Engineers (USACE)

The topographic portion of this survey was conducted according to guidance used by USACE including:

- USACE publication EM-1110-1-1003, NAVSTAR Global Positioning System Surveying.
- USACE EM -1110-1-1005, Topographic Surveying.
- USACE publication EM-1110-1-1000, Engineering and Design - Photogrammetric Mapping.

Some of the significant requirements include:

- Topographic spot density at a maximum of 2.0 by 2.0 meters.
- Vertical elevation accurate to +/- 30 cm (2 sigma).
- Horizontal positioning accurate to +/- 3 m (2 sigma).
-

- The topographic lidar data of sufficient density to produce 1 meter contours.
- Topographic data collected with 200% coverage by flying lines at 65% overlap.
- Topographic data collected at or near the land water interface.

1.4 Survey Areas

1.4.1 Hydrography

The hydrographic surveys were conducted over Pago Pago Harbor.[3] Images of the surveyed area are located in Section 6.1

1.4.2 Topography

Topographic data was collected over Pago Pago International Airport[4]. Pictures of the topographic survey area are located in Section 6.2.1

1.5 Extraneous Activities Affecting the Survey

The survey was affected by numerous extraneous activities including:

- Commercial flight schedules to transport survey personnel to and from American Samoa
- Inability to adjust gain on downlooking DuncanTek RGB camera. Over-exposed sunglint images failed to compress and were discarded by the system.
- Weather (wind, rain, low cloud ceilings)
- GPS week rollover (every Saturday, 1300 local)

1.6 Flight History

A total of three flights were conducted between 5 and 7 May 2006. A summary of these flights are listed below in Table 1.6.

GMT Date	Start/End (GMT)	Line Type	Number of Lines
05 May 06	20:52/01:56	T/H	15/34
06 May 06	03:07/05:54	H/T	25/3
07 May 06	18:24/20:24	H	16

Table 1.6. Summary of CHARTS hydrographic and topographic flights. “Type” refers to hydrographic (H) or topographic (T) lines.

2.0 Geodetic Control

2.1 Time

All data was initially collected in Universal Time Coordinated. Times were converted to GPS time after processing by adding 14.000 seconds. GPS time will be used as the reference time for all data.

2.2 Horizontal Datum

WGS84 was used for all data collection.

2.3 Vertical Datum

All soundings and elevations were collected using WGS84 Ellipsoid.

2.4 Station Descriptions

Control established by GPS satellite surveying techniques was completed in accordance with geometric (three-dimensional) geodetic survey standards set by the Federal Geodetic Control Committee in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, 1 August 1989.

The station description and datasheet for the geodetic control in American Samoa can be found in Appendices A.1.

2.4.1 Base Station Information

The base station (STN-022) was established in 1966 by the U.S. Coast and Geodetic Surveys personnel and resurveyed in May 1994 by NOAA's National Geodetic Survey personnel. This base station was used for all hydrographic and topographic surveys in American Samoa covered by this ROS. Datasheet for STN-022 is found in Appendix A.1. Photographs of STN-022 are shown in Figures 2.4.1a, 2.4.1b, and 2.4.1c. Collection information is listed in Tables 2.4.1a and 2.4.1b.

Figure 2.4.1a. STN-022. The benchmark is a standard disk set in the top of a 3 foot diameter concrete post. The disk is stamped---satellite triang. station 022 1966.

Figure 2.4.1b. STN-022 setup at 2.053 meters with view towards the north.

Figure 2.4.1c. STN-022 setup with view towards the south with building and fence obstructions. This location may have experienced some elevation masking or multipath issues due these obstructions.

GPS Receiver Type	Trimble
GPS Receiver Model	4700
GPS Receiver S/N	0220240177
Antenna Type	Trimble Zephyr Geodetic
Antenna S/N	12482193
Ellipsoid	WGS84
Latitude	14 19 54.363 S
Longitude	189 17 08.807 E
Ellipsoid Height	37.133 m

Table 2.4.1a. Collection information for STN-022 is listed above.

Date (Local)	GMT Start/End
05 May 06	21:30/03:15 (06 May 06)
06 May 06	03:45 (07 May 06)/07:10
07 May 06	19:04/21:15

Table 2.4.1b. STN-022 GPS base station collection times are listed above.

2.4.2 New Geodetic Control

No new geodetic control was established during this survey.

2.5 Datum Shifts

No vertical or horizontal datum shifts were made in the field. See the American Samoa Data Processing Report for detail on the reduction of data to chart and map datum.[5]

2.6 Kinematic GPS Data Collection and Processing

The aircraft is positioned in flight using a combination of a Novatel GPS receiver and an Applanix POS/AV-410. During each flight, GPS data is simultaneously recorded on board the aircraft and at a GPS base station. The frequency of recording is two records per second on the aircraft and one record per second at the GPS base station. Simultaneous GPS fixes from the base station and the aircraft are processed by Applanix POSPac V4.1 or V4.2. POSPac calculates a corrected aircraft position for each one-second epoch by the post-processed kinematic GPS method. In flight, the POS/AV measures aircraft accelerations in three dimensions at 200 Hz. This data is later combined with the post-processed GPS solution using POSPac by calculating the aircraft attitude and position between GPS fixes. The final kinematic aircraft positions are then applied to the laser shot data in SHOALS GCS by Auto Processing.

3.0 Digital Survey System

3.1 System Components

3.1.1 Aircraft

Manufacturer: Beachcraft
Model: King Air 200
Serial Number: BB007
Tail Number: C-FBCN

3.1.2 Laser / Transceiver

Manufacturer: Optech Incorporated
Model: SHOALS 1000T
Serial Number: 002

Topographic laser
Manufacturer: Northrop Grumman Component Technologies
Model: Unknown

Serial Number: Unknown
Wavelength: 1064 nm
Pulse repetition rate: 10 kHz

Hydrographic Laser
Manufacturer: Cutting Edge Optronics, Inc.
Model: Unknown
Serial Number: Unknown
Wavelength: 532 nm
Pulse repetition rate: 1 kHz

3.1.3 GPS Receiver

Manufacturer: Novatel
Model: Unknown
Serial Number: Unknown

3.1.4 GPS Antenna

Manufacturer: NavCom
Model: NavCom
Serial Numver: AT27753

3.1.5 Primary GPS Receiver (in POS/AV)

Manufacturer: NovAtel
Model: Millennium GPS Card
Serial Number: Unknown

3.1.6 Primary GPS Antenna

Manufacturer: NovAtel
Model: 512
Serial Number: Unknown

3.1.7 POS/AV

Manufacturer: Applanix Corporation
Model: 410
Serial Number: Unknown

POS AV Absolute Accuracy Specifications (RMS):

Navigation Mode	DGPS	Real Time Kinematic	Post-Processed Kinematic
Position (m)	0.5 - 2	0.1 - 0.3	0.05
Velocity (m/s)	0.05	0.01	0.005
Roll & Pitch (deg)	0.015	0.015	0.008
True Heading (deg)	0.05	0.04	0.015

3.1.8 Digital Camera

Manufacturer: Duncan Tech
Model: DT4000
Serial Number: Unknown

3.1.9 Field Processing Software

Software used during field processing is listed in Table 3.1.9.

POSPac V4.1 or 4.2
Optech Shoals GCS V6.01 or 6.02
Fledermaus V6.1.b or 6.1.5 Professional
Area Based Editor V

Table 3.1.9. Field data processing software.

4.0 Calibrations

4.1 Positioning Systems

No formal calibrations of the Novatel receivers were conducted in the field. However, the consistency of sequential GPS positions were verified during the application of kinematic corrections from the base station to the aircraft data. Bathymetric data associated with invalid fixes was not processed. Cross check lines orthogonal to production lines and sixty percent overlap on production lines were used to monitor the repeatability (precision) of the navigation and laser systems. Gross differences in horizontal or vertical positioning of the aircraft were obvious in the three-dimensional renderings (Fledermaus and Area Based Editor) of the data. In such cases the navigation methods used on the suspect flight lines were investigated and corrected.

4.2 CHARTS Positioning Quality Control

During survey operations the operator continuously monitored position quality in the air. Flight lines were re-flown if any of the following specifications are exceeded:

- Position Dilution of Precision exceeds 3.
- The semi-major axis of the positional error ellipse exceeds 3.5 m at the 95% confidence level.
- The minimum number of satellites being tracked for continued sounding is less than 4 healthy SV's.
- The minimum elevation for SV is less than 100 from the horizontal.

4.3 CHARTS System Calibration

Optech installed CHARTS System 2 prior to the American Samoa survey. A discussion of system calibration methods is found in the "SHOALS Calibration Summary".[6] System 2 was calibrated immediately prior to the installation, and the calibration report is found in the System 2 Calibration Report".[7]

4.3.1 Hard Target Test

A "hard target" test is accomplished by firing the lasers against a known baseline distance using a calibrated jig. The test is performed for each receiver of the surface and bottom channels. Any observed error is eliminated through adjustment of appropriate parameters. The hard target test is described in the Timing Calibration section of Appendix B.1.

4.3.2 In Flight Calibration

Prior to surveying (and after any equipment changes) CHARTS system undergoes an in-flight calibration to determine small system offsets. These offsets include the position of the scanner mirror frame relative to the optical axes of the system and aircraft attitude (roll, pitch and heading) as defined by the Inertial Navigation System. The in-flight calibration is accomplished by flying over a calm, flat area in the field. An average of the water surface is derived by the system, and then a calibration program developed by the National Ocean Service derives the angular offsets assuming that the sea surface is flat. The offsets are applied to the collected data, and successful plotting of a flat-water surface indicates that the angles were correctly derived. In flight calibration procedures are described in the Angular Calibration section of Appendix B.

4.3.3 Survey System Offsets/Alignment

The survey system offsets for System 2 are listed in Appendix C. During each installation of the laser system and motion sensors are optically aligned, and the offsets measured with respect to the phase center of the GPS antenna. The measured offsets are contained in the "STATIC" file that is written to the survey plan. During initialization of the data collection system the STATIC file is written to the daily data tape. During processing the offset values are extracted from the tape along with the navigation data applied during post processing.

5. 0 Tides and Tide Gages

5.1 Tide Gages

The NOAA tide gage installed in American Samoa (seehttp://tidesandcurrents.noaa.gov/station_info.shtml?stn=1770000%20Pago%20Pago,%20AMERICAN%20SAMOA) has been operational since September 6, 1948 and is referenced to Mean Low Water. This was used to determine tidal datums and benchmark datum offsets previously established for this gage.[8]

For surveys of American Samoa the KGPS base station receiver was placed over a previously installed benchmark STN022. (See Appendix A for further detail).

5.2 Preliminary Tidal Zoning

Not applicable.

5.3 Final Tidal Zoning

Not applicable.

5.4 Tidal Data Collection

Not applicable.

5.5 Tidal Corrections

Not applicable.

5.6 Application of Tides

The lidar data was collected with respect to the WGS84 ellipsoid (i.e. the "soundings" and "elevations" are really distances between the ellipsoid and the measurement). Depths and elevations for this project will eventually be referred to chart datum (Mean Low Water) and map datum (MSL) when a final "datum-to-ellipsoid" zoning scheme is determined.[9] See American Samoa Data Processing Report.

5.7 Currents and Tidal Streams

No tidal currents or streams were measured.

6. 0 Data Collection and Processing

6.1 Hydrography

Hydrographic survey area for American Samoa is shown in Figure 6.1a and 6.1b.

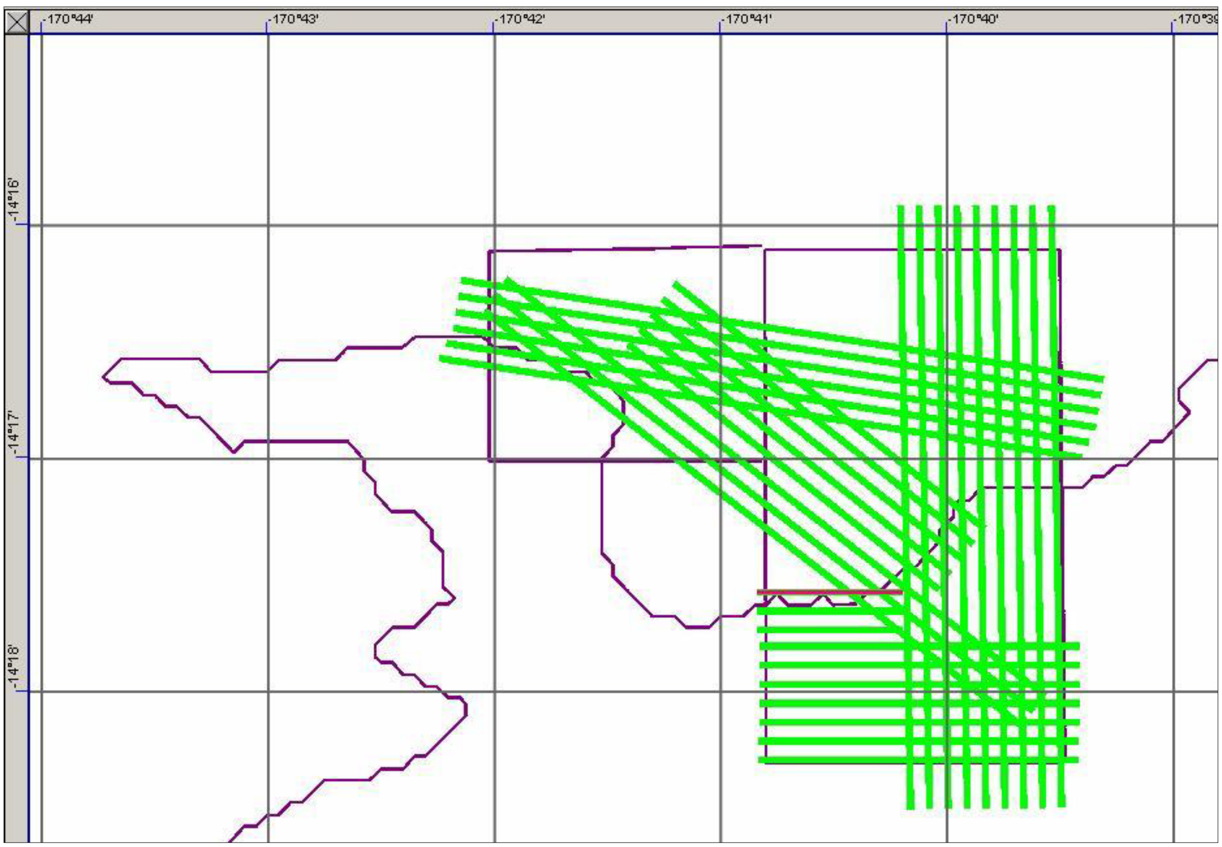

Figure 6.1a. 100% coverage in survey area for American Samoa over Pago Pago Harbor on 05 May, 2006.

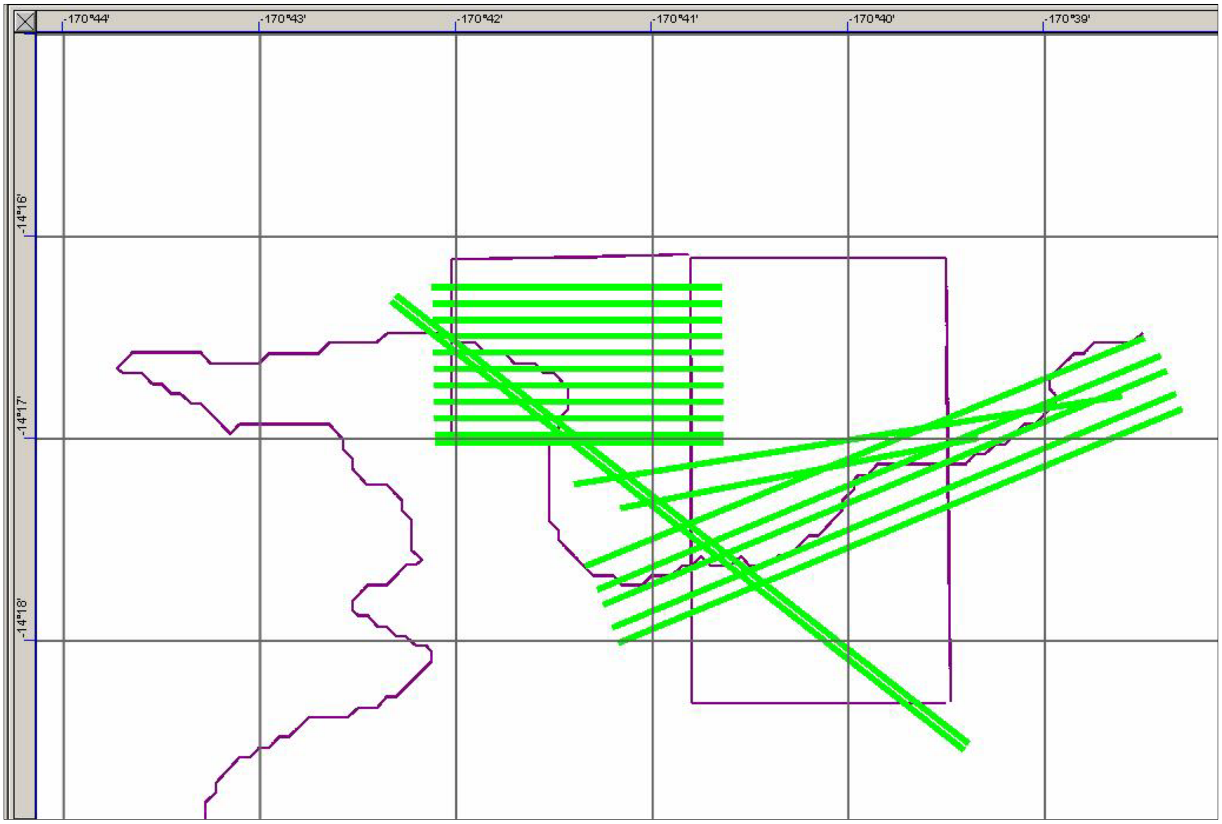

Figure 6.1b. Completes 200% coverage in survey area for American Samoa over Pago Pago Harbor on 06 May, 2006.

6.1.1 Units

All depths and elevations were reported as distance from the WGS84 ellipsoid in meters.

6.1.2 Sounding Development and Coverage

Characteristics of the hydrographic cross check and production lines are shown in Table 6.1.2.

Line type	Altitude	Speed	Shot Spacing	Line Spacing	Swath Width	Overlap
Hydro Cross-check	400 m (AGL)	126 kts	4 X 4 m	340 m	215 m	none

Hydro Production	400m (AGL)	126 kts	4 X 4 m	60 m	215 m	65 %

Table 6.1.2. System 2 hydrographic crosscheck and development line characteristics. 100% production lines were flown to deal with steep terrain and weather conditions. 200% then flown on subsequent day to superimpose onto the area of 100% coverage. Flight on 07 May, 2006 was used to cover any holidays in 200% coverage.

Crosscheck and production lines were planned using GCS software and world vector shoreline data. In situ observations were utilized to alter survey line planning as needed to accomplish the mission. Line spacing and overlap ensured each area was surveyed to a minimum of 200%. Percentage of coverage was checked using Fledermaus and Area Based Editor. Any holidays were re-flown to achieve a minimum of 200% coverage.

6.1.3 Field Data Processing

Field processing of hydrographic data included applying precise navigation to the laser shots, automatically extracting depths from the laser return waveforms and manual data editing. POSPac was used to apply kinematic GPS corrections derived from the base station to the POS-AV and GPS data collected on the aircraft. Once the laser shots were precisely navigated depths were extracted from the raw laser wave forms using Optech's SHOALS GCS software. The output of this process is the Hydrographic Output File (HOF), consisting of the position, depth and status (i.e. accepted, rejected, questionable, depth-swapped, etc.) of each laser shot. SHOALS GCS software was then used to create a "Pure File Magic" (PFM) file. Fledermaus software was used to visualize the data and to change the status of the flags in the HOF file. Fledermaus was also used to recover rejected soundings from very shallow (~1.5 to 2.0 meters) water (Shoreline Depth Swap), to extract rejected soundings from near shore areas that were flown in a land-to-water direction (Reverse Processing), and to accept or reject suspect soundings. Once the data was processed using SHOALS GCS software a second PFM file was created using Area Based Editor (ABE) software. ABE was used to search for known targets (wrecks, shoals, rocks and aids to navigation) in the data, to compare the data with Geo-Tiff images of NOAA charts and to view the data in slices. It should be noted that during the entire processing sequence no sounding data was deleted; only the status flags were changed in the HOF file.

6.1.4 Corrections to Soundings

Soundings were collected referenced to the WGS84 ellipsoid. See the American Samoa Data Processing Report for more information on reduction of data to chart datum.

6.1.5 Agreement with Prior Surveys

Not applicable.

6.1.6 Agreement with Existing Charts[10]

Chart affected by this survey include:

NOAA Chart 83484, Pacific Ocean Samoa Islands
Date: March, 1993
Edition: 9
UTM grid zone: 2S
Horizontal datum: WGS84
Chart Datum: MLW[11]

Most recent chart 83484 edition: edition 11, July/06 (NM:7/15/2006) (LNM:7/11/2006)

6.1.7 Aids to Navigation

Aids to navigation (ATON) for Pago Pago Harbor were extracted from NGA website (see USCG Light List, Vol. VI, 2005, corrected through U.S. Notice to Mariners No. 15/2005 (03 April 2005). Additional NTM corrections were added through 21/2006. The positions of the ATONs were converted to .pts files, imported into ABE software and displayed as circles overlaid on the lidar bathymetry data. Each ATON was shown to be verified (listed position correct), not verified (not seen in the digital down-look imagery or in the lidar data) or observed (seen in down-look imagery but not positioned with lidar data). A summary of the ATON investigation is found in “AS_ATONS.xls”.[12]

6.1.8 Obstructions

See American Samoa Data Processing Report.

6.2 Topography

6.2.1 Survey Areas

Topographic survey area shown in Figure 6.2.1.

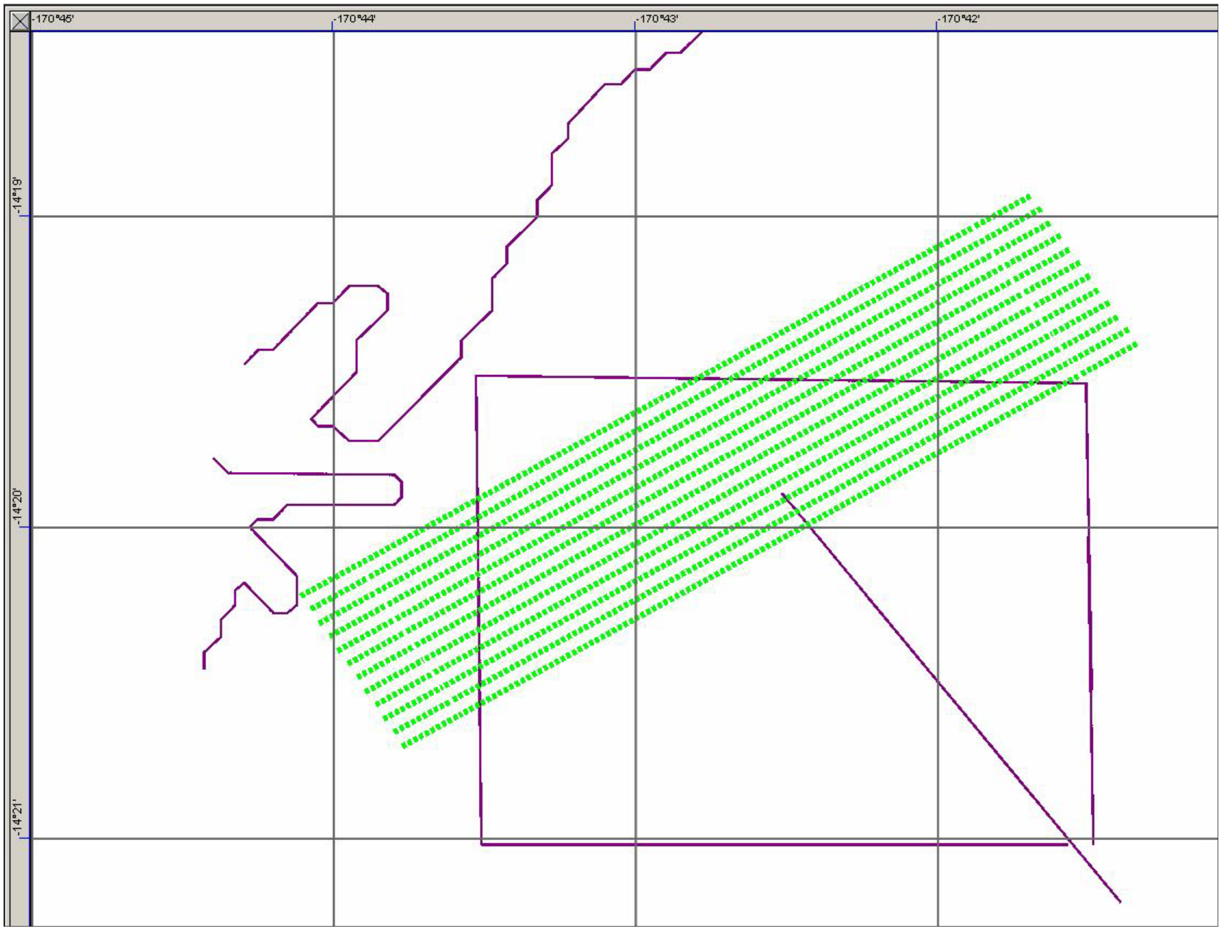

Figure 6.2.1 American Samoa International Airport topographic survey area.

6.2.2 Units

All elevations are reported as distance from the WGS84 ellipsoid in meters.

6.2.3 Elevation Development and Coverage

Topographic flights were conducted on 05-06 May, 2006. Details of these flights are listed in Section 1.6. Characteristics of the topographic and development lines are shown in Table 6.2.3. To reduce flight time 60% overlap on each line was used. Line spacing and overlap ensured each area was surveyed to a minimum of 200%. Percentage of coverage was checked using Fledermaus and any holidays were re-flown. No crosscheck lines were flown for this topographic survey area; although the two flights on separate days ensured data quality.

Line Type	Altitude	Speed	Shot Spacing (along X cross track)	Line Spacing	Swath Width	Overlap
Topo Production	600 m (AGL)	155 kts	1.3 X 1.7 m	~150 m	246 m	60 %

Table 6.2.2. System2 topographic development line characteristics. Adjacent lines were flown in opposite directions.

6.2.4 Field Processing

Field processing of topographic data included applying precise navigation to the laser shots, automatically extracting elevations from the laser returns and manual data editing. POSPac was used to apply kinematic GPS corrections derived from the base station to the POS-AV and GPS data collected on the aircraft. Once the laser shots were precisely navigated, elevations were extracted from the raw laser shots using Optech's SHOALS GCS software. The output of this process is the Topographic Output File (TOF), consisting of the position, elevation and status (i.e. accepted, rejected, questionable, etc.) of each laser shot. Fledermaus software was used to visualize the data and to change the status of the flags in the TOF file. Fledermaus was also used to reject elevations from water returns and to edit obvious errors in the data.

Software used during field processing is listed in Table 6.2.4.

POSPac V4.1
Optech Shoals GCS V6.01
Fledermaus V6.1.4.b Professional
Area Based Editor V

Table 6.2.4. Field topographic data processing software.

6.2.5 Corrections to Elevations

Elevations were measured by the aircraft as distances from the WGS84 ellipsoid. Elevations for this project will be referred to the map (vertical) datum (Mean Sea Level). Reduction of elevations to map datum is discussed in the American Samoa Data Processing Report.

Topographic data collected with airborne lidar includes both "first" and "last" returns. First returns are reflections from objects above the earth's surface (vegetation, power lines); second returns are ground reflections. Due to the density of vegetation in some areas surrounding the topographic survey areas very few second returns were recorded over those areas. It should be noted that the .pfm elevation files are composed of returns from trees and vegetation as well as returns from hard surfaces (true earth or structures).

6.2.6 Agreement with Prior Surveys

Information from prior topographic surveys was not available.[13]

7.0 Accuracy and Resolution of Soundings (Hydrographic Mode)

Optech (personal communications, November-December 2004) provided horizontal and vertical error budget information. The error budgets discussed below pertain to depths referenced to the WGS84 ellipsoid, the positioning system operating in KGPS mode and with flight parameters shown in Table 6.1.2.

7. 1 Horizontal Accuracy

An example of the horizontal error budget for the CHARTS system operating with KGPS for soundings in 50 meters of water is shown in Table 7.1.

Error Source	Error	Resultant horizontal error (m)
Height (m, 1 sigma)	0.10	0.04
Roll (deg, 1 sigma)	0.008	0.06
Pitch (deg, 1 sigma)	0.008	0.06
Heading (deg, 1 sigma)	0.015	0.04
Scan angle encoder (deg, 1 sigma) 1	0.02	0.22
Antenna lever arm (m, 1 sigma)	0.05	0.07
Calibration (deg, 1 sigma)	0.010	0.11
Laser pointing (deg, 1 sigma)	0.02	0.16
IHO allowable depth error (1 sigma) at 50 m (m) 2	0.41	0.11
Propagation error (factor) 3	0.015	0.75
Surface beam steering(m, 1 sigma) 4	0.23	0.06
KGPS position (m, 1 sigma)	0.15	0.29
CHARTS total RMS horizontal error (m, 1 sigma)	--	0.81
CHARTS total RMS horizontal error (m, 95% confidence)	--	1.60
IHO allowable horizontal error (m, 95% confidence)	--	7.50

Table 7.1. Horizontal error budget for hydrographic data collection in 50 meters of water using flight parameters shown in Table 6.1.2.

Notes: 1. The scan angle of the two steering mirrors is digitized with an error of 0.02 degrees. 2. This is the horizontal error that may be present if the depth error was at the IHO 1-sigma maximum (0.41 meters) for a 50 meter sounding. 3. The propagation error factor is caused by beam spreading in the water column. As it is a "factor" it is multiplied by the depth—i.e. 50 m x 0.015 = 0.75 m. 4. This uncertainty is due to random steering of the pulse by surface waves. The horizontal error budget for the CHARTS system for all depths up to 50 meters is shown in Figure 7.1.

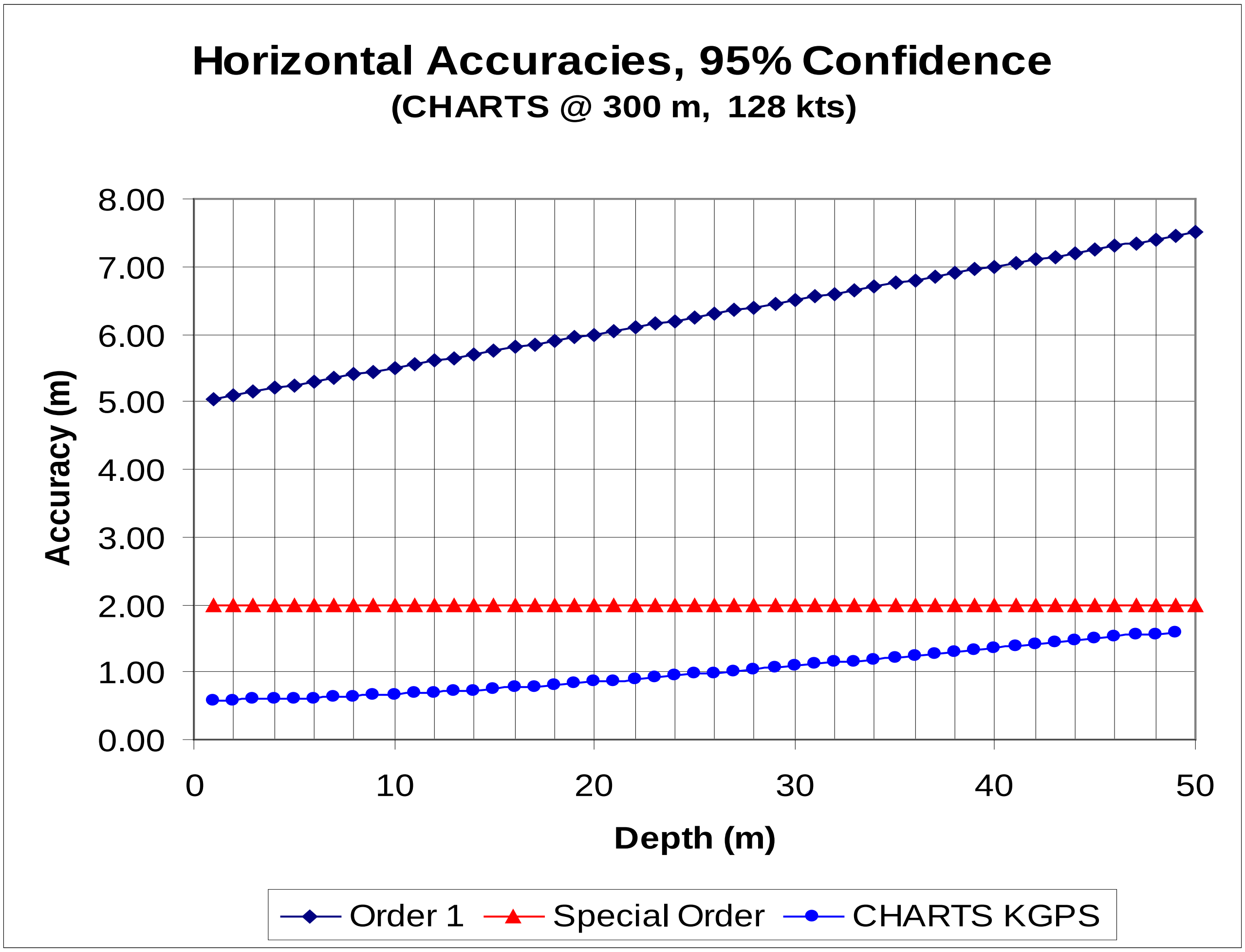

Figure 7.1. CHARTS system horizontal error budget for hydrographic data collection between 0 and 50 meters of water using flight parameters shown in Table 6.1.2.

7. 2 Vertical Accuracy

An example of the vertical error budget for the CHARTS system operating with KGPS for soundings in 50 meters of water is shown in Table 7.2. The 95% confidence level for depth is calculated as:

$$|\Sigma(\text{Bias Errors})-(\text{Constant Bias})| + 1.96(\Sigma\text{Random Errors})$$ [1,2]

Notes:
[1]Errors in the determination of the tidal datum are not included in this error budget.
[2]10 cm used for the error in the KGPS trajectory. If the trajectory vertical accuracy is better than this, then the overall error would be lower. For example, a 5 cm error in the trajectory would lower the total error for shallow water (less than 5 m) from 29 cm in the table to 24 cm. This meets the USACE General Survey standard but, Optech cannot guarantee this for all cases.

23/02/2006														
DEPTH ERRORS FOR SHOALS HYDRO														
Off Nadir Angle (deg)	20													
Constant Bias (m)	0.08													
Altitude (m)	400													
Depth (m)	1	2	3	4	5	10	15	20	25	30	35	40	45	50
Vertical Random Errors (m, 1 sigma)														
System Random Error	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Ellipsoid-to-laser Vertical Error (KGPS only)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Wave Beam Steering Error (10 kt wind)	0.00	0.01	0.01	0.02	0.02	0.05	0.07	0.09	0.11	0.14	0.16	0.18	0.20	0.23
Total Random Error (m, 1 sigma)	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.23	0.25	0.27
Vertical Bias Errors (m)														
System Bias Error	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Water Propagation Induced Bias Error	0.06	0.06	0.06	0.06	0.06	0.08	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23
Total Bias Error (m)	0.08	0.08	0.08	0.08	0.08	0.09	0.11	0.12	0.14	0.16	0.18	0.20	0.22	0.24
Total Vertical Error, KGPS (95% confidence)	0.29	0.29	0.29	0.29	0.29	0.31	0.34	0.38	0.42	0.47	0.52	0.57	0.63	0.68
IHO Order 1 Spec (95%)	0.50	0.50	0.50	0.50	0.50	0.52	0.54	0.56	0.60	0.63	0.68	0.72	0.77	0.82

Table 7.2. Vertical error budget for hydrographic data collection in 50 meters of water using flight parameters shown in Table 6.1.2.

The System Random error in Table 7.2 includes such factors as the range measurement, the amplifiers, wave heights, pulse location calculation and also the vertical error associated with the pointing of the laser beam. The two random errors of the KGPS trajectory (10 cm) and the vertical component were kept separate due to the steering of the beam from the wave surface.

The System Bias error includes thermal effects, range calibration, and the error in detecting the air water interface. The major bias for a hydrographic laser is the bias induced by the water propagation which depends on many factors. We have kept this error minimized in the SHOALS design by using a constant off nadir angle for the beam. The algorithm also attempts to correct for this bias with the use of a depth dependent parameter. However, there still remains an uncertainty and this is the bias shown in Table 7.2.

The vertical error budget for the CHARTS system for all depths up to 50 meters is shown in Figure 7.2.

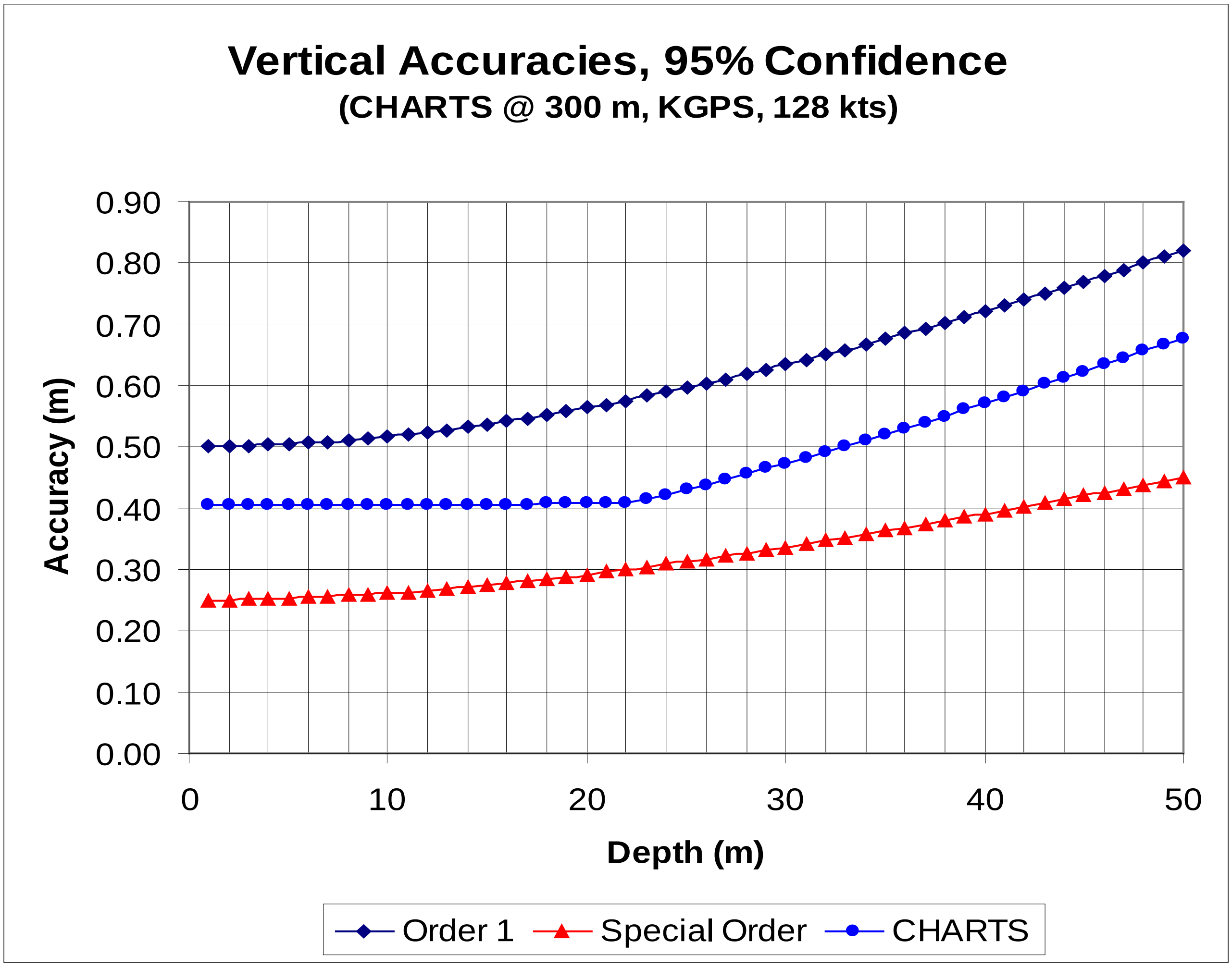

Figure 7.2. CHARTS system vertical error budget for hydrographic data collection between 0 and 50 meters of water using flight parameters shown in Table 6.1.2.

7. 3 Tide Corrections

No tide corrections were applied to the data. Soundings were collected referenced to the WGS84 ellipsoid. Depths for this project will eventually be referred to the chart datum (Mean Low Water) when the distance between the ellipsoid and the chart datum is established. See the American Samoa Data Processing Report for more information.[14]

7.4 IHO Standards

It can be seen from Table 7.1 and Figure 7.1 that CHARTS data meets IHO horizontal accuracy requirements for all depths up to 50 meters. Vertical error budgets discussed in section 7.2 pertain to depths referred to the WGS84 ellipsoid. While the absolute accuracy (with respect to the WGS84 ellipsoid) is high, whether the data meets IHO standards can only be determined after the distance from the WGS84 ellipsoid to chart datum is applied to the data (see American Samoa Data Processing Report).[15]

7.5 CHARTS Lidar Target Detection

Based on target detection probability curves produced by NOAA, all areas meet IHO Order 1 target/object detection requirements at the 95% confidence level for depths from 7 m to 20 m with single-flight coverage. At depths deeper than 20 m, signal-to-noise ratio limitations greatly reduce target detection capability, particularly for small objects less than 2 meters. During testing of the CHARTS system targets of 2 meters and larger were detected 100% of the time in depths between 5 and 30 meters. Based on these tests the lidar system meets IHO Order 1 target detection requirements and multiple coverage greatly reinforces this capability.

8.0 Accuracy and Resolution of Elevations (Topographic Mode)

Optech (personal communications, 28-30 November 2004) provided horizontal and vertical error budget information. The error budgets discussed below pertain to depths referenced to the WGS84 ellipsoid, the positioning system operating in kinematic mode and with flight parameters from Table 6.2.3.

8.1 Horizontal Accuracy

An example of the horizontal error budget for the CHARTS system in topographic mode is shown in Table 8.1.

Error Source	Error	Resultant horizontal error (m, 1 sigma)
Height (m, 1 sigma)	0.10	0.04
Roll (deg, 1 sigma)	0.008	0.07
Pitch (deg, 1 sigma)	0.008	0.07
Heading (deg, 1 sigma)	0.015	0.04
Scan angle encoder (deg, 1 sigma)1	0.02	0.24
Antenna lever arm (m, 1 sigma)	0.05	0.07
Calibration (deg, 1 sigma)	0.010	0.12
Laser pointing (deg, 1 sigma)	0.02	0.17
KGPS position (m, 1 sigma)	0.15	0.29
CHARTS total RMS horizontal error (m, 1 sigma)	--	0.38
CHARTS total RMS	--	0.74

horizontal error (m, 95% confidence)		
USACE allowable horizontal error (m, 95% confidence)	--	3.00

Note:
1. The scan angle of the two steering mirrors is digitized with an error of 0.02 degrees.

Table 8.1. Horizontal error budget for topographic data collection in 50 meters of water using flight parameters in Table 6.2.3.

8.2 Vertical Accuracy

The vertical error budget for the CHARTS system operating in topographic mode is shown in Table 8.2. The 95% confidence level for elevation is calculated as:

$$|\Sigma(\text{Bias Errors})-(\text{Constant Bias})| + 1.96(\Sigma\text{Random Errors})^{1,2}$$

Notes:
[1]The error in the determination of the vertical datum (MSL) is not included in this error budget.
[2]10 cm used for the error in the KGPS trajectory. If the trajectory vertical accuracy is better than this, then the overall error would be lower. For example, a 5 cm error in the trajectory would lower the total error for shallow water (less than 5 m) from 29 cm in the table to 24 cm. This meets the USACE General Survey standard but, Optech cannot guarantee this for all cases.

VERTICAL ERRORS FOR SHOALS TOPO (23/02/2006)				
Off Nadir Angle (deg)	17			
Altitude (m)	300	500	700	1000
Vertical Random Errors (m, 1 sigma)				
System Random Error	0.07	0.08	0.10	0.12
Ellipsoid-to-laser (KGPS only)	0.10	0.10	0.10	0.10
Total Random Error (m, 1 sigma)	0.12	0.13	0.14	0.16
Vertical Bias Errors (m)	0.02	0.02	0.02	0.02
Total Vertical Error, KGPS (95% confidence)	0.26	0.27	0.29	0.33

Table 8.2. Vertical error budget for topographic data collection in using flight parameters in Table 6.2.3.

The Vertical Bias errors in Table 8.2 for the topographic laser subsystem include thermal and calibration terms.

The System Random Errors in Table 8.2 comprise such factors as the range measurement, the amplifiers, and the vertical component error due to the error in the laser beam pointing.

8.3 USACE Standards

Topographic elevations use Mean Sea Level (MSL) for the vertical datum. While the absolute accuracy (with respect to the WGS84 ellipsoid) is high, whether the data meets USACE standards can only be determined after the distance from the WGS84 ellipsoid to vertical datum is applied when the American Samoa Data Processing Report is available.

9.0 Navigational Aids

Lists of navigational aids, wrecks and obstructions are provided in the American Samoa Data Processing Report.

10.0 Photography

Digital overlapping, down-look images were taken at a rate of one per second, providing at least one image per laser shot. While not of photogrametric quality (neither orthometric nor orthorectified) these images were used to identify features observed in the lidar data. On the completion of the project these images shall be mosaiced (see American Samoa Data Processing Report). Individual images and the final mosaic shall be submitted to NAVOCEANO along with other hydrographic data.

11.0 References

11.1 U.S. Department of Commerce. National Oceanic and Atmospheric Administration, National Ocean Survey. "National Ocean Survey Hydrographic Survey Specifications and Deliverables," Apr. 1999.

11.2 U.S. Federal Geodetic Control Committee. "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Version 5.0 (Preliminary)", National Oceanic and Atmospheric Administration, Rockville, MD, National Geodetic Survey, May 1988. (Reprinted and corrected Aug 1989).

11.3 Naval Oceanographic Office. "Hydrographic Smooth Sheet Specification," Ver. 2.2. Bay St. Louis, Stennis Space Center, MS.

11.4 Naval Oceanographic Office. “Hydrographic Field Chart Specification,” Ver. 2.0. Bay St. Louis, Stennis Space Center, MS.

11.5 Naval Oceanographic Office. "Hydrographic Procedures". Bay St. Louis, Stennis Space Center, MS, 1990.

11.6 United States. Oceanographer of the Navy. "Guide to Marine Observing and Reporting", N.O. Publication 606, Washington, DC, Defense Mapping Agency Hydrographic/Topographic Center, 1983.

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11.8 Monaco. International Hydrographic Bureau. "IHO Standards For Hydrographic Surveys, Classification Criteria For Deep Sea Soundings, and Procedures For Elimination of Doubtful Data", Special Publication No. 44, 4th Edition, 1998.

11.9 U.S. Department of Commerce. National Oceanic and Atmospheric Administration, National Ocean Survey "Side Scan Sonar Manual", by LCDR D.H. Peterson, NOAA and LCDR A.A. Armstrong III, NOAA, Charting and Geodetic Services, 1988.

11.10 IHO Standards for Hydrographic Surveys Special Publication No.44, Fourth Edition, Monaco, 1998.

11.11 “Maritime Claims Reference Manual,” DOD 2005.1-M January 1996.

11.12 “The Commander’s Handbook on The Law of Naval Operations,” NWP 1-14M, Formerly NWP 9 (Rev. A), October 1995.

11.13 “Department of the Navy (DON) Information Security Program (ISP) Regulation,” SECNAVINST 5510.36, Exhibit 8A, 17 March 1999.

11.14 Naval Oceanographic Office. “Responsibility and Authority of the Senior NAVOCEANO Representative,” NAVOCEANOINST 3120.2B, 10 October 1994.

11.15 Naval Oceanographic Office. “Survey Operations Reporting Procedures,” NAVOCEANOINST 3140.5C, 17 June 1995.

11.16 Naval Oceanographic Office . “Administrative Procedures,” Chapter 4, Mail Procedures, NAVOCEANOINST 5218.3B, 16 May 1996.

11.17 United States Army Corps of Engineers. “Engineering and Design – Photogrammetric Mapping,” USACE publications EM 1110-1-1000, 01 July 2002.

11.18 United States Army Corps of Engineers. “NAVSTAR Global Positioning System Surveying,” USACE publication EM 1110-1-1003, 01 July 2003.

11.19 United States Army Corps of Engineers. “Topographic Surveying,” USACE publication EM 1110-1-1005, 31 August 1995.

12.0 Appendices

Appendix A. Datasheet for KGPS base station locations.

A.1 STN-022 KGPS Geodetic Report

See STN-022_2002_datasheet.txt.

Appendix B. CHARTS System Calibration

B.1. Timing Calibration

Timing calibration utilized by the CHARTS program had developed a symptom termed “double banding”, whereby the absolute timing of the system separated itself into distinct populations --- one level offset to longer timing from the correct value, and one offset to shorter timing values. Various attempts were made to characterize this problem, and indeed to work around its effects, but these were largely unsuccessful because this is a fundamental problem internal to the digitizer and there appears to be no robust method to recover data which exhibits the double banding problem.

The following table presents the hardware changes which are critical to the timing calibration of the system, the delta_time values (“hardware” timing constants) used during data collection within this time period, and the delta_t_soft values (“software” timing constants) used to compensate collected data whenever the modification of delta_time values lagged behind.

During the hard target testing, subsequent analysis showed that the target times for the laser power/timing test mode should be:

sys_param_version: 1.109

timing_cal_primary: 88.82
timing_cal_secondary: 88.35
timing_cal_ir: 89.61
timing_cal_raman: 88.55

All tests performed subsequently, in order to re-calibrate the system timing following the replacement of timing-critical hardware, were done by reference only. That is only the “hardware” timing parameters, or delta_time values, were changed to bring the system timing into agreement with the hard target tests. Since the physical timing path for the laser power/timing test did not change, the system timing could be adjusted merely to maintain these target values by comparative laser power/timing tests performed just prior to and just subsequent to any hardware changes. Therefore the target numbers for the laser power/timing test mode have been preserved throughout the time period listed in the table above.

B.2. Angular Calibration

Initial indications were that the existing angular calibration values did not flatten the water surface to the extent required for the highest quality data production. There was a slight "crown" to the average water surface, and a very slight tilt across the swath. While the existing calibration values could be used with a fair degree of success, it was decided to revise the angular calibration parameters to yield a truly flat average water surface.

These data were analyzed to yield values of the pitch, vertical and horizontal misalignment angles which would preserve the sum of (pitch + vertical) misalignment values at +0.111 degrees, in order that the absolute elevations derived by the hydro system would be maintained between the existing and new calibration sets.

reference the calibration contained within, are written as below:

sys_param_version: 1.109

IMU_sensor_pitch_offset: -1.209
rcvr_horiz_misalign_angle: -0.036
rcvr_vert_misalign_angle: 1.261
scan_x_yaw_misalign_angle: -0.315

B.3. Camera Calibration

sys_param_version: 1.109

camera_boresight_roll: -0.175
camera_boresight_pitch: 0.766
camera_boresight_heading: -1.398

B.4. Deep Bias Calibration

The deep bias parameters are used to ensure agreement between the deep and shallow channels for derived depths in the so-called "overlap" region between 8 and 13 meters. The GCS processor performs an automatic calculation to determine the deep bias parameters, given appropriate input data

sys_param_version: 1.109

primary_bias_200: 0.0, 0.0
primary_bias_300: -0.004, 0.015
primary_bias_400: 0.009, 0.026

Appendix C. System 2 Parameter File

Parameter file version 1.109 was provided by Optech on in March, 2006. All data collected in RMI used this parameter file for data processing.

See system_params_02.txt for review.

Revisions Compiled During Office Processing and Certification

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[1] Filed with survey records
[2] SHOALS LIDAR data acquired in this survey does not meet NOAA HSSDM requirements (equivalent to IHO Order 1) for object detection. The capability of LIDAR to meet NOAA object detection requirement is still unproven and questionable.
[3] In several areas the lidar data was sparse and therefore not used for the SS sounding set. The meta areas created only cover areas with good lidar coverage.
[4] Topograhic data was removed from the SS sounding set and not used in the HCell. Only data seaward of the MHW on chart 83484 was used in the HCell. As no ENC exists in the survey area, the MHW line on the raster was digitized and used as the shoreward extent of meta areas.
[5] The chart datum used for survey was Mean Low Water. The difference between MLW and MLLW is 0.018m (0.06 ft).
[6] Report not included with survey data.
[7] Report not included with survey data.
[8] No tidal data was applied to the data. The data was surveyed to the WGS84 ellipsoid and reduced to MLW by subtracting the difference between a CGS BM ellipsoid height and the BM height above chart datum (related to the Pago Pago tide gauge) from the raw lidar elevations. At this time, this is not a NOAA approved method of reducing soundings to chart datum.
[9] See note 3.
[10] In two areas the coral reef line was adjusted based on the lidar hydrography. The coral reef on the south side of Breakers Point (14-17-26S, 170-39-43W) was extended based on negative lidar depths. On the opposite side of the harbor at Fagaalu (14-17-28S, 170-40-54W) where lidar hydrography showed depths of 4 to 10 fathoms, the coral reef line was shifted inshore. We recommend making the changes based on the following factors: The lidar depths in other areas of the survey showed good agreement with the charted coral reefs. The water clarity in the area is ideally suited for lidar. The lidar lines were flown using 2x2 meter spot spacing with the goal of 200% coverage. However as lidar does not meet NOAA's object detection requirements and there are some small "holidays" in the data, it is recommended that no lidar depths be charted and only intertidal blue tint be shown in the area previously showing the coral reef.
[11] Do not concur. Chart datum is MLLW.
[12] File not included with survey data.
[13] Concur
[14] See note 3
[15] Although the error analysis shows the data meets IHO Order 1 requirements, SHOALS LIDAR data acquired in this survey does not meet NOAA HSSDM requirements (equivalent to IHO Order 1) for object detection. The capability of LIDAR to meet NOAA object detection requirement is questionable. The data should be used to chart soundings and depth curves representing general bathymetric trends, and new shoals and features that are not currently depicted on NOAA chart 83484. The data should not be used to supersede shallower charted soundings and least depths over wrecks, rocks, obstructions or coral reefs. The charted shoreline should be retained as charted.

W00185 HCell Report

Kurt Brown, Physical Scientist
Pacific Hydrographic Branch

Introduction

The primary purpose of the HCell is to provide new survey information in International Hydrographic Organization (IHO) format S-57 to update RNC 83484.

HCell compilation of survey W00185 used Office of Coast Survey HCell Specifications Version 3.0 and HCell Reference Guide Version 1.0.

1. Compilation Scale

Depths for HCell W00185 were compiled to the largest scale charts in the region, 83484, 1:15,000. The density and distribution of soundings from W00185 were selected to emulate the distribution on chart 83484.

2. Soundings

A survey-scale sounding (SOUNDG) feature object layer was built from the 5-meter combined surface, **Samoa_5m**, in CARIS BASE Editor. A shoal-biased selection was made at 1:7500 scale for chart 83484. The resultant sounding layer contains depths ranging from -0.3 to 47 meters.

In CARIS BASE Editor soundings were manually selected from the high density sounding layers and imported into a new layer created to accommodate chart density depths. Manual selection was used to accomplish a density and distribution that closely represents the seafloor morphology.

3. Depth Areas and Depth Contours

3.1 Depth Areas

The extents of the highest resolution BASE Surface together with the extents of the soundings layer were used to digitize the hydrographic extents, which were then used to create the single, all encompassing depth area (DEPARE). A single depth range from -1.577 to 35 meters were used for the depth area and includes the intertidal area.

3.2 Depth Contours

Depth contours at the intervals on the largest scale chart are included in the W00185_SS HCell for MCD raster charting division to use for guidance in creating chart contours. The generalized metric and feet equivalent contour values are shown in the table below.

Chart Contours in Fathoms	Metric Equivalent of Chart Contours	Metric Equivalent of Chart Contours NOAA Rounded	Actual Value of Chart Contours

0	0	0.2286	0.75
5	9.144	9.3726	5.75
10	18.288	18.5166	10.75
20	36.576	37.9476	20.75
30	54.864	56.2356	30.75

Contours delivered in the W00185_SS file have not been deconflicted against shoreline features, soundings and hydrography as all other features in the W00185_CS file and soundings in the W00185_SS have been. This results in conflicts between the W00185_SS file contours and HCell features at or near the survey limits. Conflicts with M_COVR, M_QUAL, DEPARE, and with DEPCNT objects representing MLLW, should be expected. HCell features should be honored over W00185_SS.000 file contours in all cases where conflicts are found.

4. Meta Areas

The following Meta object areas are included in HCell 11498:

M_QUAL
M_COVR

Meta area objects were constructed on the basis of the limits of the good lidar data. In several areas the lidar data was sparse and the compiler excluded these areas from the limits reflected in the meta areas. (See 3.1 *Depth Areas*.)

5. Features

No shoreline features were submitted with the survey.

In the two areas where the coral reef extents were adjusted, the new coral reef extents are represented by new SBDARE areas. The seaward extents of the areas represent the new coral limit and the inshore limit was clipped to the survey limits for simplicity in creating the areas. The new coral areas should be extended from the point where the SBDARE areas intersect with the charted coral reef, disregarding the inshore limits of the areas.

There were no DTONs reported from survey W00185.

There were no AWOIS items in the limits of the survey.

6. S-57 Objects and Attributes

The W00185_CS HCell contains the following Objects:

SOUNDG	Chart scale soundings
DEPARE	All-encompassing depth area and intertidal areas
M_COVR	Data coverage Meta object
M_QUAL	Data quality Meta object
$CSYMB	Blue notes

The W00185_SS HCell contains the following Objects:

DEPCNT	NOAA rounded contours at chart scale intervals
SOUNDG	Soundings at the survey scale density

7. Blue Notes

Notes to the RNC and ENC chart compilers are included in the HCell as $CSYMB features with the Blue Note information located in the INFORM field. The NINFOM field is populated with the charting disposition

8. Spatial Framework

8.1 Coordinate System

All spatial map and base cell file deliverables are in an LLDG geographic coordinate system, with WGS84 horizontal, MHW vertical, and MLLW (1983-2001 NTDE) sounding datums.

8.2 Horizontal and Vertical Units

<u>Fathoms and Feet Verbiage</u> (Section 9.2 Horizontal and Vertical Units – Hcell Report)

During creation of sounding sets in CARIS BASE Editor, and creation of the HCell in CARIS S-57 Composer, units are maintained as metric with millimeter resolution. NOAA rounding is applied at the same time that conversion to chart units is made to the metric HCell base cell file, at the end of the HCell compilation process.

A CARIS environment variable, uslXsounding_round, controls the depth at which rounding occurs. Setting this variable to NOAA fathoms and feet displays all soundings equal to or greater than 11 fathoms as whole units. Depths shoaler than 11 fathoms are shown in fathoms and feet.

In an ENC viewer fathoms and feet display in the format X**.**YZZZ, where X is fathoms, Y is feet, and ZZZ is decimals of the foot. For fathoms and feet between 0 and 10 fathoms 4.5 feet (10.75 fms), soundings round to the deeper foot if the decimals of the foot are X**.**Y75000 or greater. For fathoms and feet deeper or equal to 11 fathoms, soundings round to the deeper fathom if feet and decimals of the foot are X**.**45000 (X**.**Y75000) or greater. Drying heights are in feet and are rounded using arithmetic methods. In an ENC viewer, heights greater than 6 feet will register in fathoms and feet using the above stated rules.

<u>S-57 Composer Units</u>
Sounding Units: Meters rounded to the nearest millimeter
Spot Height Units: Meters rounded to the nearest meter

Chart Unit Base Cell Units
Depth Units (DUNI): Fathoms and feet
Height Units (HUNI): Feet (or fathoms and feet above 6 feet)
Positional Units (PUNI): Meters

9. Data Processing Notes

9.1 Junctions

W00185 does not junction with any surveys.

10. QA/QC and ENC Validation Checks

W00185 was subjected to QA checks in S-57 Composer prior to exporting to the HCell base cell (000) file. The millimeter precision metric S-57 HCell was converted to a chart units and NOAA rounding applied. dKart Inspector was then used to further check the data set for conformity with the S-58 ver. 2 standard (formerly Appendix B.1 Annex C of the S-57 standard). All tests were run and warnings and errors investigated and corrected unless they have been approved by MCD as inherent to and acceptable for HCells.

11. Products

11.1 HSD, MCD and CGTP Deliverables

- W00185 Base Cell File, Chart Units, Soundings compiled to 1:15,000
- W00185 Base Cell File, Chart Units, Soundings compiled to 1:7,500
- W00185 Descriptive Report including end notes compiled during office processing and certification, the HCell Report, and supplemental items
- W00185 Survey Outline to populate SURDEX

11.2 File Naming Conventions

• Chart units base cell file, chart scale soundings	W00185_CS.000
• Chart units base cell file, survey scale soundings	W00185_SS.000
• Descriptive Report package	W00185_DR.pdf
• Survey outline	W00185_Outline.gml & *xsd

11.3 Software

CARIS HIPS Ver. 6.1	Inspection of Combined BASE Surfaces
CARIS BASE Editor Ver. 2.2	Creation of soundings and bathy-derived features, creation of the depth area, meta

	area objects, and Blue Notes; Survey evaluation and verification; Initial HCell assembly.
CARIS S-57 Composer Ver. 2.0	Final compilation of the HCell, correct geometry and build topology, apply final attributes, export the HCell, and QA.
CARIS GIS 4.4a	Setting the sounding rounding variable for conversion of the metric HCell to NOAA charting units with NOAA rounding.
CARIS HOM Ver. 3.3	Perform conversion of the metric HCell to NOAA charting units with NOAA rounding.
HydroService AS, dKart Inspector Ver. 5.1	Validation of the base cell file.
Newport Systems, Inc., Fugawi View ENC Ver.1.0.0.3	Independent inspection of final HCells using a COTS viewer.

12. Contacts

Inquiries regarding this HCell content or construction should be directed to:

Kurt Brown, Physical Scientist, PHB, Seattle, WA; 206-526-6839; Kurt.Brown@noaa.gov.

APPROVAL SHEET
W00185

Initial Approvals:

The survey evaluation and verification has been conducted according to branch processing procedures and the HCell compiled per the latest OCS H-Cell Specifications.

Digitally signed by
Kurt Brown
Date: 2009.07.24
08:52:45 -07'00'

The survey and associated records have been inspected with regard to survey coverage, delineation of the depth curves, development of critical depths, S-57 classification and attribution of soundings and features, cartographic characterization, and verification or disproval of charted data within the survey limits. The survey records and digital data comply with OCS requirements except where noted in the Descriptive Report and are adequate to supersede prior surveys and nautical charts in the common area.

Gary C. Nelson
For Russ Davies
2009.07.24 08:55:39
-07'00'

I have reviewed the HCell, accompanying data, and reports. This survey and accompanying digital data meet or exceed OCS requirements and standards for products in support of nautical charting except where noted in the Descriptive Report.

Gary C. Nelson
2009.07.24
08:56:07 -07'00'

Digitally signed by David Scharff
DN: cn=David Scharff, o=OCS,
ou=NOAA,
email=david.scharff@noaa.gov,
c=US
Reason: AWOIS and Surf Check
complete
Date: 2009.07.27 16:45:04 -04'00'