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Data Acquisition & Processing Report

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Project No. S-P909-RA-06

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State Alaska

General Locality Offshore – Vicinity of Semidi Islands

2006

CHIEF OF PARTY

Commander Guy T. Noll, NOAA

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DATE

Data Acquisition and Processing Report
NOAA Ship RAINIER (s221)

S-P909-RA-06
Offshore – Vicinity of Semidi Islands, Alaska
Hydrographic Letter Instructions dated June 16, 2006
Chief of Party: Commander Guy T. Noll, NOAA

A. EQUIPMENT

This Data Acquisition and Processing Report describes both the survey equipment used and the standard methods for acquisition applied to the equipment used. Not necessarily all equipment described within this report was used during data acquisition for all sheets of this project. Data were acquired by the following RAINIER survey launches:

Hull Number	Vessel type
S221	231 foot steel hydrographic ship

Vessel S221 was used to acquire shallow-water multi-beam (SWMB) data and sound velocity profiles. No unusual vessel configurations or problems were encountered on this project. Vessel descriptions and offset measurements are included in the 2006 NOAA Ship RAINIER Hydrographic Readiness Review Package.

One category of echosounder system was utilized for project S-P909-RA-06. The individual system(s) chosen for use in a given area were decided at the discretion of the Hydrographer using the guidance stated in the Standing Project Instructions, the Hydrographic Letter Instructions, and the Field Procedures Manual, and depended upon the limitations of each system, the bottom topography, the water depth, and the ability of the platform vessel to safely navigate the area. These systems are described in the following section.

A complete description of all echosounder systems, positioning, and attitude sensors in addition to a complete inventory and list of serial numbers is located in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package.*

Sounding Equipment:

1. ELAC 1050D MKII Shallow and Intermediate-Depth Multibeam

S221 (RAINIER) is equipped with a hull-mounted SeaBeam/Elac (Elac) 1050D MKII, which is a dual frequency (180 kHz, 50 kHz), high-resolution multibeam echo sounder system for shallow- and intermediate-water depths. Each frequency uses two flat-faced transducers, one starboard and one port, for a total of four transducers in the transducer housing. Each set of transducers, starboard and port, are mounted at a 38° angle from horizontal. During data acquisition only one frequency at a time is active. Echosounding is achieved using a Rotating Directional Transmission (RDT) method where sound is directed utilizing the directional gain of the complete transducer array. Sonar transmission occurs across adjacent sectors in a 3-step "subfan" process. Out of each of the 3 subfans within a sector, the receiving beamformer calculates 3 slightly overlapping beams each 1.5^{o} wide with a spacing of 1.25^{o}, for a total of 9 beams per sector. There are 7 fanwidth settings possible, the maximum of which (153.5º) utilizes 7 sectors, for a maximum total of 126 beams within a "virtual swath." RAINIER personnel typically operate the Elac 1050D on a swath width of 131º (116 beams) or 108º (90 beams), depending on water depth, sea state, data quality, and coverage requirements. The Elac 1050D was operated exclusively on 50 kHz for this project, as shipboard testing has shown this frequency to produce less noisy, more accurate soundings than the 180 kHz band in water depths greater than 100m.

Because the RDT beam forming method described above requires three ping cycles to fully ensonify the coverage swath, the Elac 1050D cannot meet the coverage and object detection requirements specified in the NOS Hydrographic Surveys Specifications and Deliverables currently in effect while maintaining a reasonable survey speed. Hydrographic Surveys Division has been informed of this deficiency, and RAINIER will continue to operate this legacy system until funds are available for its replacement. In the interim, the Elac 1050D is not utilized to obtain full bottom coverage in water depths less than 100 m.

Side Scan Sonar:

1. Multibeam Echosounder Backscatter

The ELAC SWMB systems used aboard S221 provides a very low-resolution digital SSS record of the multi-beam swath. This SSS imagery is primarily used during processing of the multibeam sounding data to aid in determining whether anomalous soundings are true features or noise. It generally does not have sufficient resolution for small object detection, but the shape of objects and their strength of return can greatly increase the confidence in processing results.

Positioning Equipment:

1. Applanix POS MV 320

Vessel S221 is equipped with a TSS POS/MV 320 (version 4) Position and Orientation Sensors to measure and calculate position. The POS/MV is a GPS-aided inertial navigation system, which provides a blended position solution derived from both an Inertial Motion Unit (IMU) and an integrated GPS receiver. The IMU and GPS receiver are complementary sensors, and data from one are used to filter and constrain errors from the other. This inter-dependence results in higher position accuracy and fewer errors than either system could produce by itself. Position accuracy is displayed in real time by the POS/MV software and was monitored to ensure that positioning accuracy requirements as outlined in the NOS Hydrographic Surveys Specifications and Deliverables were not exceeded. In addition, the POS/MV software displays HDOP and number of satellites used in position computation. Data acquisition was generally halted when an HDOP of 2.5 was exceeded or the number of satellites available dropped below four. However, because positional accuracy can be maintained by the POS/MV through short GPS outages with the help of the IMU, data acquisition was not halted during short periods of time when the HDOP and number of satellites used exceeded stated parameters.

Attitude Measurement Equipment:

1. Applanix POS MV

RAINIER is equipped with a TSS POS/MV Model 320 Position and Orientation System – Marine Vessel (POS/MV) sensors, which provide accurate navigation and attitude data to correct for the effects of heave, pitch, roll and heading. The POS generates attitude data in three axes (roll, pitch and heading) to an accuracy of 0.05^{o} or better. Heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement for movements that have a period of up to 20 seconds. The Heave Bandwidth filter was configured with a damping coefficient of 0.707. The cutoff period of the high pass filter was determined by estimating the swell period encountered on the survey grounds. These values ranged from 8 s (flat water) to 20 s (long period ocean swell), with values of 8 or 12 s typical.

Applanix “TrueHeave” values were also recorded. The TrueHeave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. At this time, TrueHeave cannot be applied to Elac bathymetry because the Elac systems cannot be accurately time synchronized to the POS MV. See Section C. below for additional information.

Software:

Rainier recorded Elac multi-beam echosounder data, along with position and attitude data, using Elac’s Hydrostar Online software. Data were logged in the Hydrostar exchange format (XSE) produced by version 3.4.0.1 of the Hydrostar software.

All SWMB data were processed using the CARIS Hydrographic Information Processing System (HIPS) and Hydrographic Data Cleaning System (HDCS) software version 6.0 for the Microsoft Windows environment.

Coastal Oceanographic’s HYPACK MAX was used for vessel navigation and line tracking during acquisition of SWMB data. HYPACK MAX was also used to quick mark targets that were processed as detached positions using Pydro supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP).

Sound velocity profiles were computed from raw pressure, temperature, and conductivity measurements using the program VelociWin, supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP).

A complete list of software and versions is included in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package*. Software updates were applied throughout the project to improve productivity and data quality. As software patches became available, they were tested by the Field Operations Officer, Chief Survey Technician, or other designated crew member. If tests resulted in satisfactory performance, the updates were installed on all affected workstations and tracked in a version control spreadsheet.

B. DATA PROCESSING AND QUALITY CONTROL

Project Management Overview

RAINIER’s data processing and quality control procedures are described in detail in the flow diagrams included in Appendix I. Roles, responsibilities, and the generalized project accomplishment procedure are summarized in this section.

Project Planning

Project Instructions received from Hydrographic Surveys Division (HSD) are reviewed by the Chief of Party (Commanding Officer), Field Operations Officer (FOO), and Chief Survey Technician (CST). Preliminary questions are addressed to HSD for clarification. The FOO then develops survey limits for each assigned sheet, and in consultation with the CO and CST, assigns each survey to a sheet team.

The sheet team is composed of as many as three people: The **Survey Manager** has responsibility for completion of the survey, including planning, data acquisition and processing, quality control, and creation of deliverables. Depending on the complexity of the survey, the Survey Manager is typically a commissioned officer, survey technician, or physical scientist with 6 months to 2 years experience. **Survey Assistants** and/or **Survey Mentors** may also be assigned if required. **Survey Mentors** are assigned to particularly difficult survey areas or in the case of a less experienced Survey Manager.

Mentors serve as intermediaries between the survey manager and the FOO, advising the Manager on survey planning and reviewing data and deliverables. Mentors generally have at least a year and a half of experience, and have demonstrated proficiency as Survey Managers themselves. **Survey Assistants** are junior commissioned or civilian personnel with less than one year's experience. They assist the Survey Manager with planning and data processing, and receive training from the Manager and Mentor. Notwithstanding the delegation of this authority to junior personnel, the FOO remains responsible to the Chief of Party for efficient, accurate, and thorough completion of all projects assigned to RAINIER.

The Sheet Team reviews the Project Instructions, all other relevant guidance[1], and all available prior survey and source data. Prior survey bathymetry, if available, is used as a guide for planning survey lines to achieve the coverage required by the letter instructions. If shoreline verification is required for the survey, prior source data (Remote Sensing Division source, prior hydrographic survey data, LIDAR if available, and charted items) are compiled and deconflicted. The resulting survey data acquisition plan is reviewed by the FOO prior to implementation.

<u>Data Acquisition</u>

Field operations are planned by the FOO to utilize the appropriate platforms and sensors to meet the requirements of the survey team's acquisition plan. In the case of launch-based hydrography, actual data acquisition and field quality control is accomplished by a qualified **Launch Team.** At a minimum, this team will include a **Coxswain** (Person-In-Charge) and **Hydrographer-In-Charge** (HIC). The Coxswain is a member of the ship's crew who has met all requirements of coxswain certification for the vessel in use, and has been qualified by the Commanding Officer (CO) in consultation with the Chief Boatswain. The coxswain is responsible for the safe operation of the launch and the safety of the embarked personnel and equipment. The Hydrographer-In-Charge is a member of the ship's crew who has met the requirements for HIC qualification for the surveying techniques to be employed, and has been so qualified by the FOO in consultation with the CST and Chief of Party. The HIC is responsible for directing survey operations and operating survey equipment to efficiently complete the vessel's assigned mission and ensure data quality. Both Coxswains and HICs will generally have at least one year's experience prior to qualification for these positions. Additional qualified **Launch Crewmembers** may be assigned to a vessel as required for training purposes and/or to assist the HIC and Coxswain with survey operations.[2]

Each survey day begins and ends with a short meeting of personnel involved in that day's operations. Prior to deploying launches, the Commanding Officer and FOO brief the launch crews to ensure that they are aware of all safety issues, operational considerations, and mission for the day. The launch HICs are debriefed by the FOO in the evening to provide a first hand account of the days activities, any unusual features discovered, and any problems with data acquisition or launch systems.

<u>Data Processing</u>

Initial data processing at the end of each survey day is the responsibility of the **Night Processing Team**, or launch crew if no night processing team is assigned. The Night Processing Team is typically composed of two crewmembers, one with at least a year's experience, and one junior member in training. Daily processing produces a preliminary product in which all gross data problems have been identified and/or removed, and thus can be used by the Survey Team to plan the next day's operations. The Night Processors complete a data pass down log to inform the survey manager and FOO of any notable features or systematic problems in the day's data.

[1] "NOS Hydrographic Surveys Specifications and Deliverables", "OCS Field Procedures Manual", "Standing Project Instructions", and Hydrographic Surveys Technical Directives.

[2] For more information on personnel qualification standards, see NOAA Administrative Order 217-103, NMAO Small Boat Policy, and RAINIER Standing Orders.

Final data processing and analysis is the responsibility of the Survey Team. While "ping-by-ping" data editing is not required, the Team will review the survey in its entirety to ensure that the final products reflect observed conditions to the standards set by the relevant OCS guidance. Bathymetric surfaces are reviewed with the best available correctors applied to ensure that all data quality problems are identified and resolved if possible, and all submerged features are accurately represented. Shoreline verification (if applicable) and feature data are reviewed in the context of this bathymetry. Survey documentation (including the Descriptive Report) are generated in conjunction with this review process.

Review and Quality Control

While quality control reviews are present throughout survey planning, data acquisition, and data processing, the final, complete review is accomplished once acquisition is complete and preliminary deliverables have been produced. Draft survey products are first reviewed by the Survey Mentor (if assigned) to check that RAINIER standard practice has been followed, all applicable guidance has been observed, and all products meet specifications. Draft surveys are then forwarded to the CST and FOO for data review. The CST's review focuses on features and shoreline verification (if applicable), while the FOO's review focuses on bathymetric products. Feedback is passed back to the Manager, who makes the required changes. This process is repeated until the FOO is satisfied that all products are ready for review by the Chief of Party (CO). The CO reviews all products for consistency with ship and Coast Survey policy, and may also review constituent data to ensure data quality. The CO's comments are passed back through the FOO to the Survey Manager as necessary to address any issues encountered. Finally, once the survey is finalized, the data products are packaged by the CST for submittal to OCS.

Multi-beam Echosounder Data

Shallow-water multi-beam data were monitored in real-time using the 2-D and 3-D data display windows in HydroStar for Elac 1050D MKII. Adjustable user parameters common for all sonars are range scale, power, gain, and pulse width. Swath width and bottom slope type are additional user parameters used during acquisition for the Elac sonar systems. These parameters may be adjusted as necessary to ensure the best bathymetric data quality. Since full bottom coverage is not required for this project, no effort was made to adjust vessel speed to ensure the along-track coverage required for object detection. Additionally the sonar swath width for mainscheme lines was acquired in 153º mode, rather than the usual 131º to minimize gaps between lines.

RAINIER's primary bathymetric data review and quality control tool is the CARIS CUBE (Combined Uncertainty and Bathymetry Estimator) surface as implemented in HIPS version 6.0. The CUBE algorithm generates a surface consisting of multiple hypotheses that represent the possible depths at any given position. The CUBE surface is a grid of estimation nodes where soundings values are computed based on the horizontal and vertical uncertainty of each contributing sounding as follows:

- Soundings with a low vertical uncertainty are given more influence than soundings with high vertical uncertainty
- Soundings with a low horizontal uncertainty are given more influence than soundings with a high horizontal uncertainty.
- Soundings close to the node are given a greater weight than soundings further away from the node.

As soundings are propagated to a node, a hypothesis (possible depth value) is developed for the node. If a sounding's value is not significantly different from the previous sounding then the same or modified hypothesis is used. If the value does change significantly, a new hypothesis is created. A node can contain more than one hypothesis.

Any individual soundings uncertainty, or Total Propagated Error (TPE) is derived from the assumed uncertainty in the echosounder measurement itself, as well as the contributing correctors from sound speed, water levels, position, and attitude. TPE values for tide and sound velocity must be entered for each vessel during TPE computation (see table #1). Tide values measured uncertainty value is the RSS of the error estimates associated with each six minute tidal value. The tidal value zoning is given in the Letter Instructions for each project at the 95% confidence level, and includes the estimated gauge measurement error, tidal datum computation error, and tidal zoning error. Since this tidal error value is given for 2 sigma, the value must be divided by two before it can be entered into CARIS (which expects a 1 sigma value). Sound speed value measured is always 0.5 m/s, the error for the SeaBird 19plus. Sound speed value surface for flat face transducers like the Reson 8125 and the Elac 1180 on 1016 and 1015 is 0.3 m/s, the error of the Digibar Pro. All other launches that have no sound speed correctors ant the transducer face use a value of 0.0 m/s. All other error estimates are read from the Hydrographic Vessel File (HVF) and Device Model file.

The exact behavior of CUBE is determined by the values set in the CUBE Parameters File (CUBEParams.xml). RAINIER uses parameters which have been tuned by Hydrographic Systems and Technology Programs (HSTP) personnel to optimize performance of the CUBE algorithm in typical Alaskan bathymetry. This modified file is stored in the central CARIS VesselConfig directory, and is submitted with each survey.

Vessel	Tide values measured	Tide values zoning	Sound speed values measured	Sound speed values surface
S221_Elac1050D_LF	0.01	0.13	0.50	0.00

Table #1 (TPE Values for Tide and Sound Velocity)

The HVF contains all offsets and system biases for the survey vessel and its systems, as well as error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements. In addition, the HVF specifies which type of sonar system the vessel is using, referencing the appropriate entry from the Device Model file. The default CARIS DeviceModels.xml has been extended by Coast Survey personnel to include error estimates for the Elac 1180 and 1050D multi-beam and Knudsen 320m and Ross 950 vertical beam echosounders.[3] This modified DeviceModels.xml file is include with the digital data submission.

Following acquisition, multi-beam sonar data were processed using the CARIS HIPS and SIPS Batch Processor. The batch processor runs a user defined script which accomplishes the following standard tasks without user intervention:

1. Convert the “raw” Reson XTF or Elac XSE data to the HDCS data format.
2. Load predicted tides.
3. Load and apply sound velocity files.
4. “Merge” data to apply position, attitude, vessel offsets, and dynamic draft correctors to bathymetry and compute the corrected depth and position of each sounding.
5. Compute TPE.
6. Filter data according to the following criteria:

[3] Although the error estimates for NOAA-specific equipment were derived from manufacturer data and empirical experience, CARIS HIPS currently uses a set of generic, conservative uncertainty estimates when computing TPE for non-standard echosounders, regardless of the contents of the DeviceModels.xml file. CARIS has indicated that they intend to extend the set of standard echosounders to include those used by NOAA and other surveyors in the near future, so the RAINIER-specific error model has been retained for potential recomputation of TPE at that time.

a. Reject soundings with poor quality flags, (0 for Reson and 3 for Elac).
b. Reject soundings with TPE greater than the horizontal and vertical error limits specified in the NOS Hydrographic Surveys Specifications and Deliverables:

Horizontal Error > ±(5m + 5% of depth)

Vertical Error $> \pm\sqrt{\left[a^2 + (b * d)^2\right]}$, where “a” and “b” are defined as

Depth range	Depth a	Depth b
0-100m	0.500	0.013
Greater that 100m	1.000	0.023

7. Create a temporary Boat-Day CUBE surface in the “Hxxxxx_Processing” field sheet.

The naming convention for these “temporary” CUBE surfaces is “Launch Number_DnXXX” (Example: “1006_Dn095”). Typically these daily CUBE surfaces are created with resolutions between 2 and 10 meters. When selecting the boat-day CUBE surface resolution, the hydrographer attempts to match the final resolution called for the by the Field Procedures Manual (see Table 1, below) as closely as possible for the depth range encountered that day.

The following options were selected when CUBE surfaces were created:

- **Surface Type** – CUBE
- **IHO S-44 Order** – Order 1
- **Include status –** check Accepted, Examined and Outstanding
- **Disambiguation method -** Density & Locale (this method selects the hypothesis that contains greatest number of soundings and is also consistent with neighboring nodes).

Preliminary, daily data cleaning is performed using the Boat-Day CUBE surface as a guide for "directed editing". Depth and Standard Deviation models derived from the boat-day surface are viewed with appropriate vertical exaggeration and a variety of sun illumination angles to highlight potential problem areas. Based on this analysis the most appropriate cleaning method is selected as follows:

- Subset Mode is the default tool selected due to its ability to quickly compare large numbers of soundings with adjacent or overlapping data for confirmation or rejection. Subset mode also excels with the assessment of possible features, disagreement between overlapping lines, and crossline comparison. The image designer can be used to visually enhance patterns and anomalies in CUBE surfaces, especially the standard deviation CUBE surface.
- Swath Editor is useful for burst noise, multipath, and other "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode. Additionally, when it was felt that the quality of the data was reduced due to environmental conditions such as rough seas or extreme variance in sound velocity, data were filtered on a line by line basis to a lesser swath width to ensure data quality.
- Both modes (but particularly Swath Editor) are used as a training aid to help novices learn how the various sonars operate, and provide feedback to the acquisition process.

With the advent of CUBE, it has become possible to adjust the CUBE surface directly by selecting the correct hypothesis to use. Although this method is available, it is standard practice on RAINIER to clean soundings in the traditional method until the CUBE algorithm selects the correct hypothesis.

After initial cleaning is complete, the Boat-Day CUBE Surface is reviewed by the Survey manager and Mentor. At no point does the launch crew re-compute the Boat-Day CUBE surface which could result in obscuring mistakenly rejected features behind a now “smooth” CUBE surface. Final review is left to the Mentor who inspects areas with questionable shaded depth models and/or high standard deviation to ensure that no actual features were cleaned out. The use of large tiles is encouraged to track coverage of problems areas without the need to re-compute the CUBE Surface. The Manager is responsible for accepting the data and adding it to the appropriate production CUBE surface in the "HXXXXX" Field Sheet. Specific data quality factors are discussed in the Descriptive Report for each survey.

The production CUBE surface is used to ensure bottom coverage and plan additional lines. In addition the production CUBE surface is used to compare adjacent lines and crosslines, for systematic errors such as tide or sound velocity errors, sensor error, sonar errors (consistent bad beams), vessel configuration problems, and noise. Any irregular patterns or problems are reported immediately to the FOO and the Survey manager so that remedies can be found and applied before more data are acquired.

As the last step to finalize survey data, multiple CUBE surfaces are gridded using different resolutions for different depth ranges in accordance with the Field Procedures Manual. Under ideal circumstances, gridding should be done at the finest resolution that the data density will support. This theoretical maximum resolution is often defined as three times the beam footprint size for a particular echosounder and depth combination. In practice, RAINER adheres to the guidance of the Field Procedures Manual (see Table 1, below), which includes suggested resolutions as a function of depth. These suggested resolutions are based on assumed sonar system selections for each depth regime and practical data processing limitations. Typically, deeper areas are gridded at a coarser resolution than shoaler areas where the data density is greater.

On occasion, the resolution of the CUBE surface may not be sufficient to capture the high point of a bathy feature. In less than 20m of water, any feature where the most probable accurate sounding was shoaler than the CUBE surface by greater than one half the allowable error under IHO S-44 Order 1 was considered inadequately captured by the CUBE surface. In greater than 20m of water, this allowable error was expanded to the full Order 1 error allowance at that depth. Although this may occur on irregular shoals or rock pinnacles, man-made features such as piles and wrecks are of particular concern. These features have very slender high points that extend far above the surrounding seafloor as well as the CUBE surface. To ensure that these features are properly represented, the shoalest point is flagged “designated” in CARIS. During the “finalization” process, the CUBE surface is forced to honor all soundings which have been flagged “designated”. In the case of a survey where the high points of many features are not being captured by the CUBE surface, (i.e. a boulder field), the hydrographer may decide to produce higher resolution CUBE surfaces to ensure that these features are being honored. Any such deviations from the Field Procedures Manual will be noted in that survey’s Descriptive Report.

Unfortunately, at the time this document was generated, the multiple resolution option for creating a CUBE surface was not properly working. To circumvent this problem, single resolution CUBE surfaces were generated to be “cookie cut” and then reassembled to create the final CUBE surface from which depths are derived. This step can occur only after navigationally significant cultural features such as piles and wrecks have been flagged as “designated” so that the CUBE surface will honor that sounding when the surface is finalized. If final approved water levels have not been received and applied to the data prior to submission, it is necessary for the field unit to submit both a finalized and un-finalized copy of each CUBE surface. This dual submission is required since CARIS does not allow tides to be applied to CUBE surfaces that have already been finalized and thus PHB would not be able to apply final approved water levels.

Another shortcoming exists in CARIS that limits CUBE surfaces to a maximum of approximately 25 million nodes. This upper bound is imposed to keep CUBE surface processing within the 2 GB of physical memory installed on most RAINIER workstations. Exceeding this limit has been shown to dramatically increase processing time and software crashes as the system swaps data to and from virtual memory. This node limit is generally not a problem at the coarser resolutions, but surveys requiring 1m & ½ m resolution surfaces often must be subdivided into several field sheets to keep the respective CUBE surfaces under this limit. The field sheet layout and CUBE surface resolutions are described for each survey in the Descriptive Report.

Each resolution-specific field sheet and its CUBE surface share a unique name, according to the following convention:

H<registry #>_<resolution in meters>M_<letter designation, if necessary>

(EX: "H12345_2M" refers to the two-meter resolution surface of survey H12345 and "H54321_1M_C" would be the third field sheet necessary to cover the area of H54321 at one-meter resolution.)

Once the collection of field sheets accurately represent the surveyed bottom and it is certain that no further edits will be made, each CUBE surface is finalized using the resolution and depth ranges specified in the Field Procedures Manual Version 2.1 (see table 1). All CUBE surfaces are then combined at the coarsest resolution used to create the final combined CUBE surface. The final, combined CUBE surface should be named Hxxxxx_Final_Combined_Xm and be created in the survey wide field sheet Hxxxxx.

Depth Range Filtering	Final CUBE Surface Resolution
0 - 15 m	0.5 m
14 – 30 m	1 m
29 – 60 m	2 m
59 – 150 m	5 m
149 m +	10 m

Table 2 Depth range vs. CUBE surface resolution

These final CUBE surfaces are sun-illuminated from different angles and examined for coverage and as a final check for systematic errors such as tide, sound velocity, or attitude and/or timing errors. The final CUBE surface submitted in the fieldsheet serves to demonstrate that both SWMB coverage requirements are met and that systematic errors have been examined for quality-assurance purposes.

As a quality control (QC) measure, a number of cross-lines greater than 5% of mainscheme lines were run on each survey and manually compared to the mainscheme lines in CARIS subset mode. This qualitative QC comparison is discussed in the descriptive report for each survey.

Vertical Beam Echosounder Data

No Vertical Beam Echosounder data were collected for project S-P909-RA-06.

Feature Data

No shoreline verification data or bottom samples were collected for project S-P909-RA-06.

Pydro Depth Extraction

The final, combined CUBE surface is inserted into Pydro by selecting **Data > Insert > HIPS BASE/Weighted grids.** The PSS parameters **Localized Bathy-Grid Least Depth Size**, **Localized Bathy-Grid Surrounding Depth Size**, and **Localized Bathy-Grid Resolution** were left on their default values (15, 35, and 5 respectively). The resultant data is then excessed in Pydro using a 3-millimeter character size, ensuring that the largest spacing between selected soundings would not exceed 5 millimeters at survey scale. Data processing flow diagrams are included in Appendix I of this report.

Pydro Processing & Reports

Pydro was used to manage, attribute, and generate the Requests for Approved Water Levels included with the survey.

CARIS Notebook

No shoreline verification was conducted for project S-P909-RA-06.

C. CORRECTIONS TO ECHO SOUNDINGS

Sound Velocity

Sound velocity profiles were acquired with SeaBird Electronics SeaCat SBE19 and SBE 19Plus Conductivity, Temperature, and Depth (CTD) profilers (S/N 219, 281, 4039, 4114, 4343, and 4443). Raw conductivity, temperature, and pressure data were processed using the program VelocWin version 8.8 which generated sound velocity profiles for CARIS in the .SVP format. VelocWin was also used to generate sound velocity profiles for Elac acquisition in the *.SVA* format. Calibration reports and dates of the SeaCat profilers are included in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package*.

In contrast to the minimum of one cast for every four hours of SWMB acquisition called for in the Standing Project Instructions and the NOS Hydrographic Surveys Specifications and Deliverables Manual, RAINIER collected SV casts only every 5-8 hours. This deviation from standard procedure was due to the fact that S-P909-RA-06 is a navigable area hydrographic survey that does not require full bottom coverage. Since the stated goal of this project was to have the RAINIER collect data while transiting through the area without sacrificing significant amounts of time from other projects, the decision was made to minimize SV cast frequency in favor of transit speed.

The Elac 1050D SWMB system utilized on vessel S221 is a beam-steered flat-faced transducer system which produces the best results when SV correctors are applied to both the transducer-water interface and the water column itself. Although there were plans to install a Seabird SBE-45 thermosalinograph (TSG) to collect sound speed measurements from the vicinity of the transducer head, it was not yet working for project S-P909-RA-06.. To correct beam-steering in the water column, the *.SVA* file produced by VelocWin was input into the HydroStar acquisition software and is used until replaced with another *.SVA* file.

Sound velocity profiles for CARIS were concatenated by vessel in order of ascending time/date and saved in the same directory as the individual SVP files for each vessel. A naming convention of H*xxxxx_vvvv*_SVP.SVP was used where H*xxxxx* is the sheet's registry number and *vvvv* is the vessel's hull number (Ex: **H11292_1006_SVP.SVP** is the concatenated SVP file for hull number 1006 for sheet H11292). This concatenated file was then applied to all HDCS data collected by that particular vessel with the option **Previous in time** selected under the **Profile Selection Method**.

Vessel Offsets and Dynamic Draft Correctors

The table below shows when the vessel offsets and dynamic draft correctors used for this project were last determined. A full description of the methods and results employed for each vessel is included in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package.*

Vessel Hull Number	Date of Static Draft and Transducer Offset Measurements	Method of Settlement and Squat Measurement	Date of Settlement and Squat Measurement	Location of Settlement and Squat Measurement
S221	April 2003 & March 2006	OTF*	March 1999	Port Angeles, WA

*OTF: "On-the-fly" GPS techniques

For the 2006 field season, RAINIER's vessel offset measurements were conducted by NGS personnel and these values were submitted with the 2006 Hydrographic Readiness Review Package.

Dynamic draft and vessel offsets corrector values are stored in the HIPS Vessel Files (HVFs). Survey platforms with more than one acquisition method have a separate HVF associated with each individual acquisition system aboard. Each of these HVFs contain sensor offset and dynamic draft correctors that pertain to this single acquisition system. Sensor offset and dynamic draft correctors were applied to bathymetric data in CARIS during post-processing. Vessel offset diagrams and dynamic draft tables are included in included in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package*. The HVFs themselves are submitted with the digital HDCS data.

The following table lists each HIPS Vessel File used for this project:

HVF name	Survey Vessel & System Type
S221_Elac1050D_LF	Ship hull S221, SWMB using hull mounted Elac 1050D MKII

Heave, Pitch, Roll and Heading, Including Biases and Navigation Timing Errors

Attitude and Heave data were measured with the sensors described in Section A, and applied in post-processing during SVP Correct and Merge in CARIS HIPS.

RAINIER utilizes a data time synchronization method known as "precise timing" as described in Section 3 of the OCS Field Procedures Manual. This synchronization significantly reduces latency magnitude and variability, producing data which is both horizontally and vertically more accurate.

RAINIER utilizes a heave filter integration method known as "TrueHeave" as described in Section 3 of the OCS Field Procedures Manual. This dramatically reduces the filter settling time as compared to the traditional heave filter, almost completely eliminating the need for steadying up on lines before logging can begin.

TrueHeave data was logged throughout the survey day, independent of line changes. Each vessel's TrueHeave files were saved in the "POS" folder of the CARIS preprocessed data drive (ex: H:\OPR-O112-RA-06_Sitka\H11128\POS\1016\DN148 contains TrueHeave data collected by vessel 1016 on day number 148 for sheet H11128). After regular CARIS data conversion this TrueHeave file was separately loaded into HIPS, replacing the unfiltered heave values recorded in the raw XTF data.

An offset between the time stamps of TrueHeave data and the XSE data as converted in CARIS prevented TrueHeave from being applied to any Elac data. Even though this TrueHeave data could not be used it was retained in the hope that CARIS might one day solve this time stamp problem. At the time of this writing no such time stamp fix exists.

Timing and attitude biases were determined in accordance with Section 1 of the Field Procedures Manual, and are described in the *2006 NOAA Ship RAINIER Hydrographic Readiness Review Package*.

All vessel offsets, dynamic draft correctors, and system bias values are contained in CARIS HIPS Vessel Files (HVFs) and were created using the program Vessel Editor in CARIS. These offsets and biases are applied to the sounding data during processing in CARIS.

Water Level Correctors

Soundings were reduced to Mean Lower-Low Water (MLLW) using verified observed final approved water levels from station Sand Point, AK (945-9450) using the tide file 9459450.tid. The final approved water level data from this reference station was applied to the survey depths in CARIS using height ratio and time correctors from the CO-OPS provided zone definition file (H11588CORF.zdf).

Refer to the Horizontal and Vertical Control Report for specific information on the tidal gauges used in during this project and individual Descriptive Reports for further information regarding water level correctors specific to each survey.

D. APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were followed during this project. All operations were conducted in accordance with the Office of Coast Survey Field Procedures Manual (May 2006 edition), NOS Hydrographic Surveys Specifications and Deliverables (June 2006 edition), and all HSD Technical Directives issued through November 2006. All departures from these standard practices are described in this Data Acquisition and Processing Report and / or the relevant Descriptive Reports.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Guy Noll
I am approving this document
2007.03.12 15:14:12 -07'00'

Approved and Forwarded: ______________________

Guy T. Noll
Commander, NOAA
Commanding Officer

In addition, the following individual was also responsible for overseeing data acquisition and processing of this project:

James B Jacobson
2007.03.12 16:08:14 Z

Chief Survey Technician: ______________________

James B. Jacobson
Chief Survey Technician, NOAA Ship RAINIER

LT Benjamin K. Evans, NOAA
I have reviewed this document
2007.03.13 00:22:58 Z

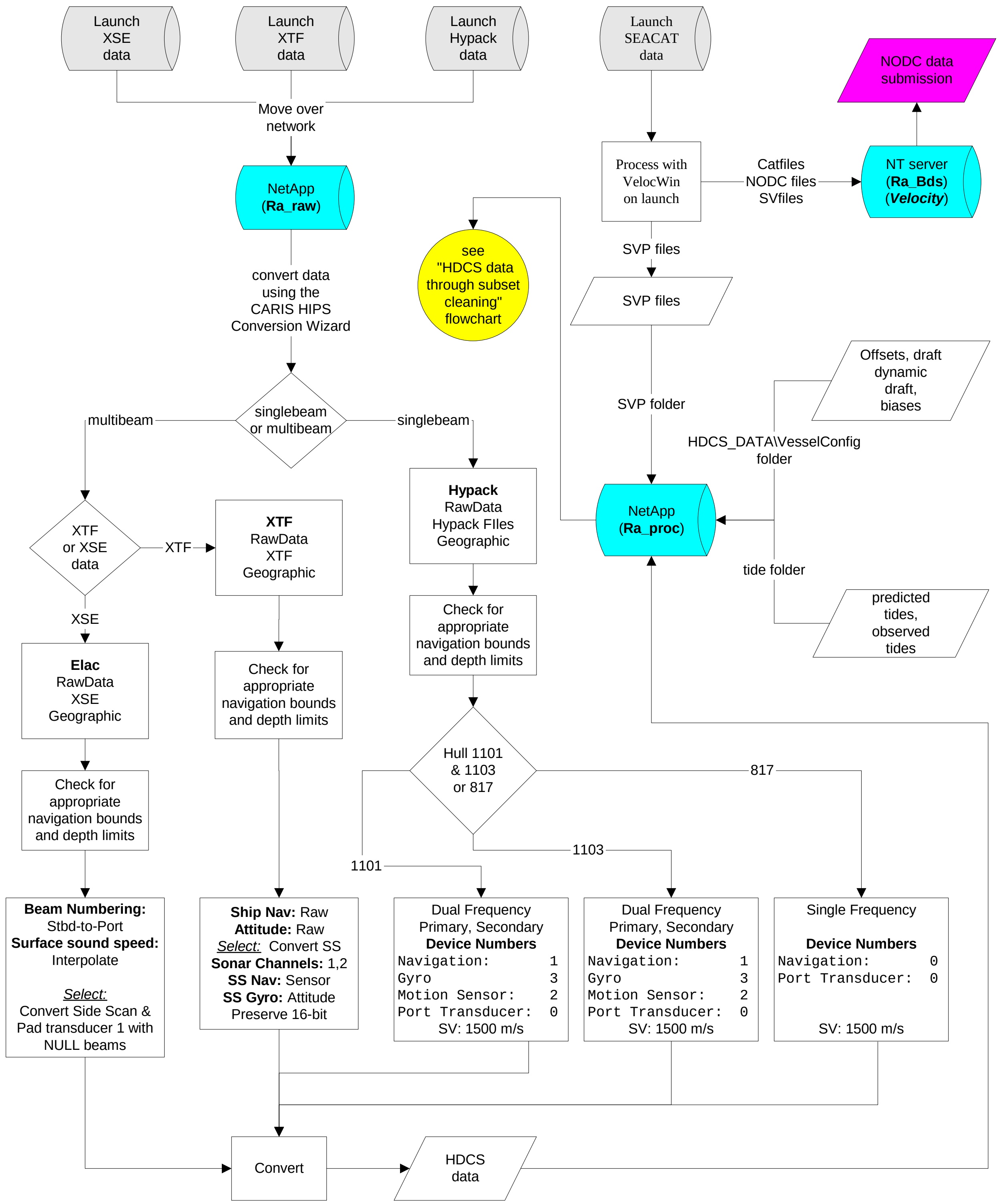
Field Operations Officer: ______________________

Benjamin K. Evans
Lieutenant, NOAA

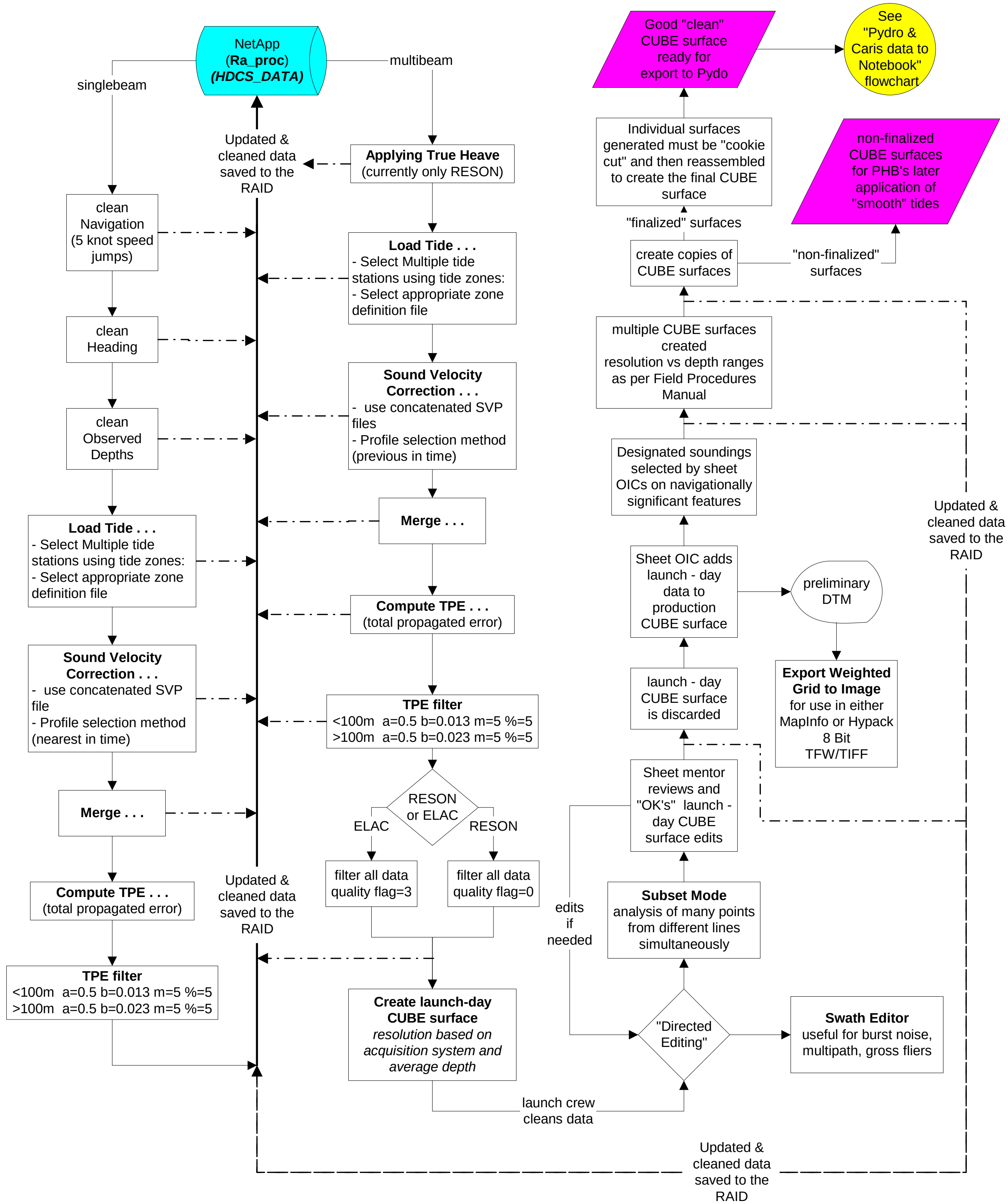
APPENDIX I

Data Processing Flow Diagrams

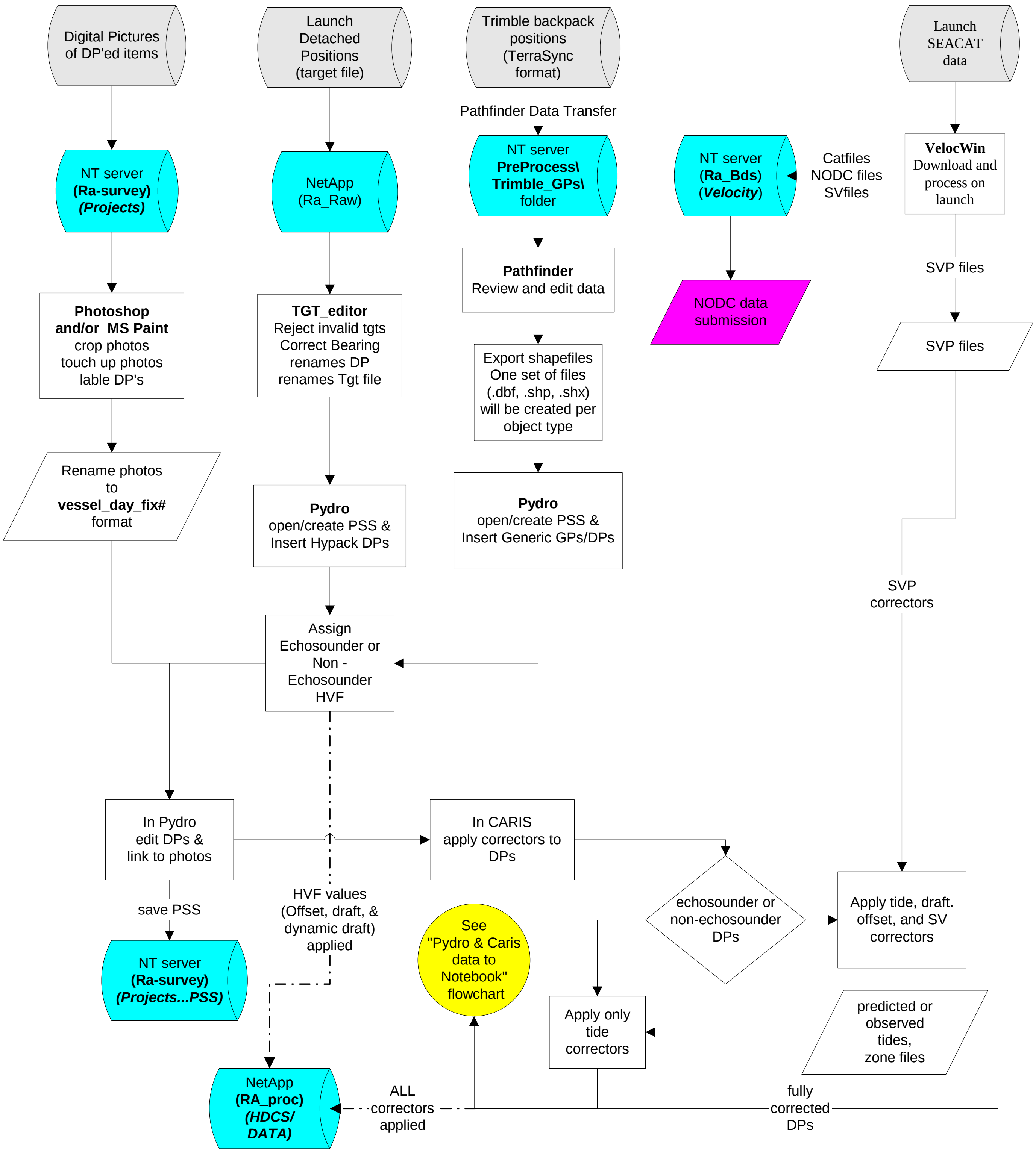
Raw sounding data to HDCS



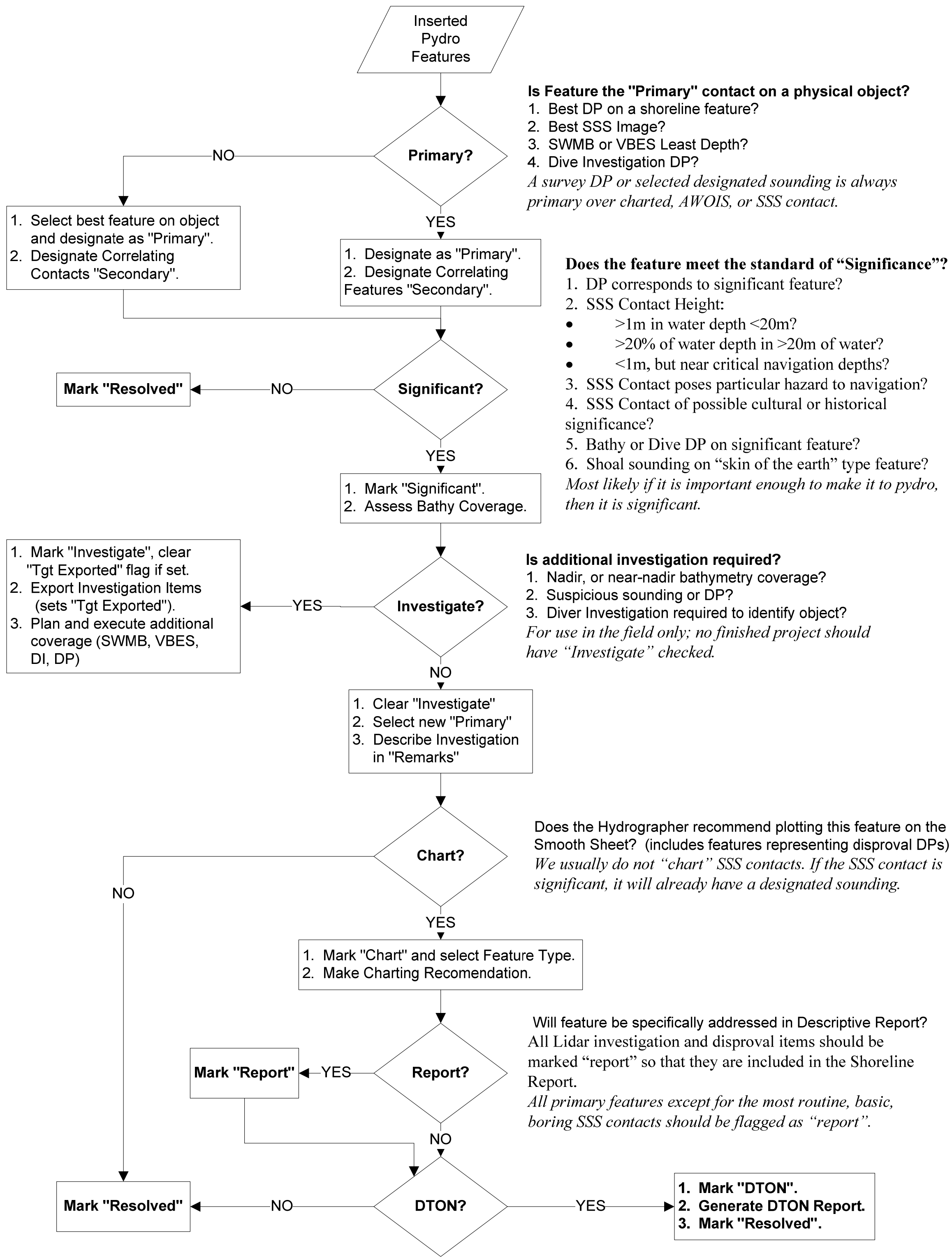
HDCS data through subset cleaning



Detached Position processing
(Raw DP's to Pydro)



Detached Position and Side Scan contact processing in Pydro



Pydro & Caris data to Notebook