W00203

NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey **LIDAR Survey**
Field No. **W00203**

LOCALITY

State **Massachusetts**

General Locality **Chatham**

2007

CHIEF OF PARTY

JALBTCX

NOTE: This survey was provided to NOAA by the Joint Airborne Lidar Bathymetric Technical Center of Expertise (JALBTCX). As such, no traditional Descriptive Report was provided. The following two documents are provided to serve as the report of survey. The first report compiled by T3 Global Strategies Corporation, provided Fugro Earthdata, outlines the horizontal control network established for the LiDAR flight lines. The second report is compiled by Fugro Pelagos, Inc. and describes the acquisition, processing, and quality control for the survey. These documents are followed by the Atlantic Hydrographic Branch's H-Cell Report which outlines our compilation procedures and any special points of interest that Coast Survey's Marine Chart Division cartographers should pay special attention.

REPORT OF GPS SURVEY
NE LiDAR CONTROL
MASSACHUSETTS COASTAL AREA

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September 2007

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REPORT OF SURVEY
LiDAR CONTROL, MASSACHUSETTS COAST

INTRODUCTION

Fugro Earthdata and Fugro Pelagos contracted with T3 Global Strategies to perform a ground control survey in support of LiDAR mapping of the coastal area of Massachusetts. Approximate locations of the LiDAR control points were selected by Fugro Earthdata. T3 Global Strategies surveyed the control points using the Global Positioning System (GPS). The LiDAR control points were selected where there was open, relatively flat terrain; primarily maintained grass or areas with sparse vegetation.

The maps below show the project area. The black lines show the LiDAR flight line coverage. The new LiDAR control points are indicated by the blue circles. The yellow squares show locations of existing National Spatial Reference System (NSRS) benchmarks that were used for vertical control. The red dots show the locations of Continuously Operating Reference Stations (CORS) that were used.

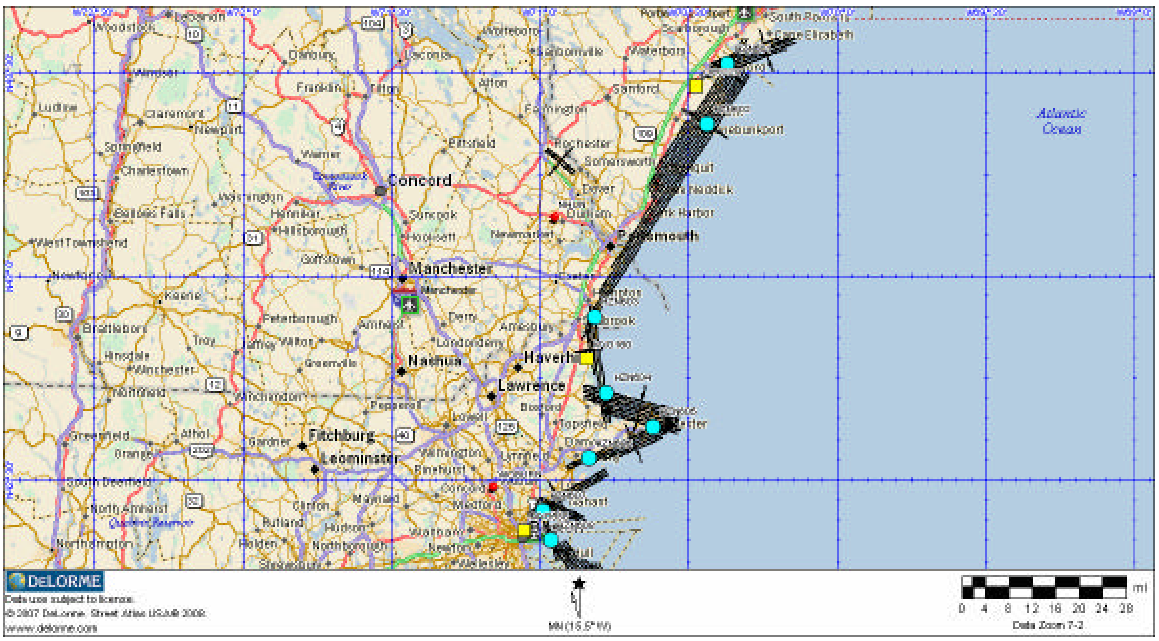

Figure 1 Project Area (North Area)

Figure 2 - Project Area (South Area)

CONTROL

The control for this project consisted of stations of the National Spatial Reference System (NSRS). Three Continuously Operating Reference Stations (CORS) and six benchmarks were used to control the network surveyed for this project. The table below lists the NSRS stations that were used:

PID	Station Name	H order	V order
OC0229	S 161	B	1
MY0160	J 36	1	1
MY0588	TRI STA	B	1
LW1544	844 6493 TIDAL 10	1	1
AB2629	CHATHAM LIGHT USCG	A	1
AB7938	W 56	1	1
DI0876	ACUSHNET 5 CORS ARP	CORS	-
DI1075	U NEW HAMPSHIRE CORS ARP	CORS	-
AJ4072	MTS WOBURN COOP CORS ARP	CORS	-

The horizontal datum used was the North American Datum of 1983, NSRS 2007 adjustment (NAD 1983 NSRS2007). The vertical datum used was the North American Vertical Datum of 1988 (NAVD 1988).

NEW STATIONS

The approximate locations of the new control stations were selected by Fugro Earthdata, taking into account the flightline layout and accessibility. There were a total of 16 new LiDAR control stations surveyed. The table below summarizes these stations:

Station	Description
HZN601	beach grass area
HZN602	mowed grass area
HZN603	mowed grass area
HZN604	gravel road/parking area
HZN605	grass/marsh area
HZN606	mowed grass area
HZN607	grass area
HZN608	grass median
HZN609	field area
HZN610	field area
HZN611	marsh/field area
HZN612	grass area
HZN613	mowed grass area
HZN614	beach grass area
HZN615	field area
HZN616	mowed grass area
070148Y	Temporary GPS base
070148Z	Temporary GPS base

GPS OBSERVATIONS

Trimble dual frequency receivers were used in a static differential mode to measure the interstation vectors. Observations were made on days 256, 257, and 258 of 2007. Each day, a base station was established in the area to be surveyed. This base receiver collected data throughout the entire day. Secondary receivers was then used to visit each new station, and data was collected at each of these new stations for a minimum of 15 minutes, ranging up to 98 minutes, depending on distance from the base and amount of obstructions to the satellite signal present. Figure 3 shows the network configuration.

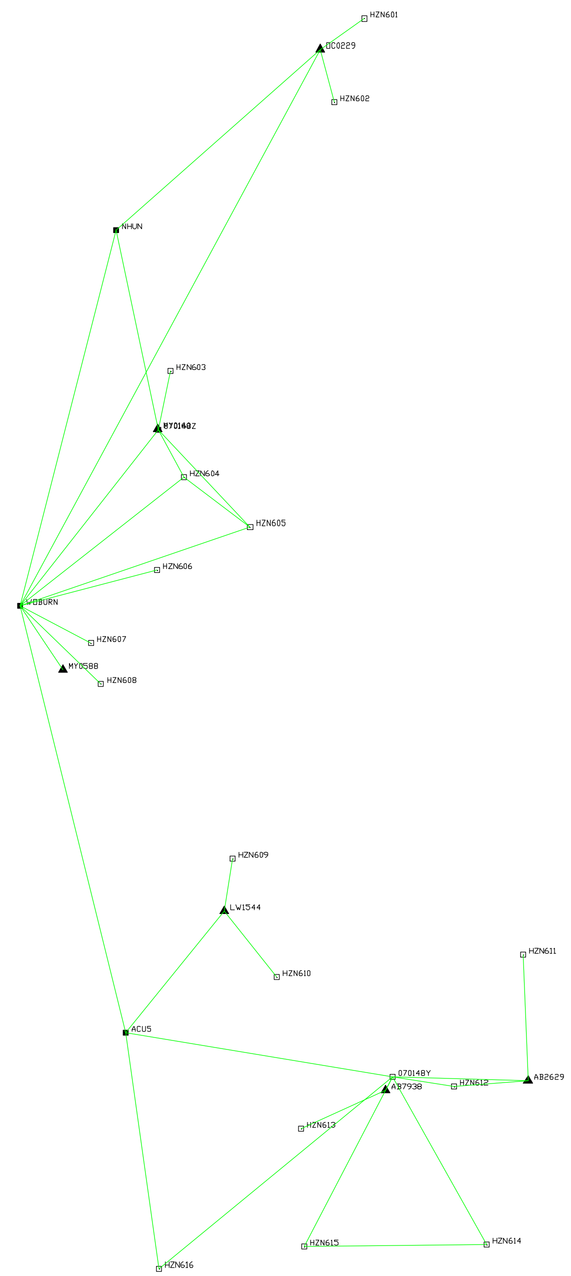

Figure 3 - Network Configuration

The table below summarizes the GPS observations:

Station	Julian Day	UTC start	UTC stop	Duration (min)	Filename
OC0229	256	16:52:45	19:39:00	166	29492560.DAT
070148Z	256	21:05:30	23:42:30	157	29492561.DAT
HZN601	256	17:44:45	18:05:15	21	36652560.DAT
NZN602	256	18:50:45	19:10:15	20	36652561.DAT

Station	Julian Day	UTC start	UTC stop	Duration (min)	Filename
MY0160	256	21:20:45	21:35:45	15	36652562.DAT
HZN603	256	22:03:15	22:20:15	17	36652563.DAT
HZN604	256	23:05:30	23:25:15	20	36652564.DAT
MY0588	256	15:40:45	16:06:15	26	51132560.DAT
HZN608	256	17:29:45	18:15:15	46	51132561.DAT
HZN607	256	19:06:30	19:51:00	45	51132562.DAT
HZN606	256	20:53:30	21:52:30	59	51132563.DAT
HZN605	256	22:38:45	23:23:30	45	51132564.DAT
070148Y	257	11:14:45	23:42:45	748	29492570.DAT
AB7938	257	11:53:30	12:13:15	20	36652570.DAT
HZN614	257	17:12:15	18:21:15	69	36652571.DAT
AB2629	257	22:58:30	23:34:45	36	36652572.DAT
HZN616	257	13:25:00	14:53:15	88	51132570.DAT
HZN615	257	17:18:00	18:33:00	75	51132571.DAT
HZN612	257	23:21:00	23:35:30	15	51132572.DAT
AB2629	258	10:46:45	11:42:00	55	36652580.DAT
HZN613	258	12:53:15	13:20:15	27	36652581.DAT
LW1544	258	14:28:15	16:06:00	98	36652582.DAT
HZN611	258	11:14:30	11:42:00	27	51132580.DAT
AB7938	258	12:56:45	13:19:00	22	51132580.DAT
HZN610	258	14:49:45	15:08:45	19	51132582.DAT
HZN609	258	15:47:45	16:05:15	17	51132583.DAT
ACU5	256	15:00:00	23:00:00	480	acu52560.07o
NHUN	256	13:15:00	23:59:45	645	nhun2560.07o
WOBURN	256	13:00:00	23:59:55	660	wmts2560.07o
ACU5	257	12:00:00	23:43:30	703	acu52570.07o
ACU5	258	14:00:00	16:59:45	180	acu52580.07o

No equipment problems or other problems were encountered during the observations.

GPS DATA PROCESSING

The data was downloaded from the GPS receivers and processed using the *WAVE* (*W*eighted *A*mbiguity *V*ector *E*stimator) processor in Trimble Geomatics Office, version 1.6. The single baseline method was used. The broadcast ephemeris was used and all baselines were processed as integer bias fixed solutions. The table below summarizes the results of the baseline processing:

From Point Name	To Point Name	Slope Distance	RMS	Ratio	Ref Var
WOBURN	HZN605	47125.383m	0.013m	27	1.283
WOBURN	OC0229	122433.696m	0.016m	24.3	1.492
WOBURN	070148Z	43316.578m	0.011m	22.4	0.881
WOBURN	HZN604	40331.914m	0.010m	28.6	0.809
WOBURN	MY0588	14933.866m	0.014m	17.8	1.386
WOBURN	HZN608	21813.529m	0.009m	37	0.623
WOBURN	HZN607	15496.039m	0.014m	13.2	1.342
WOBURN	HZN606	27447.565m	0.011m	8.8	0.989
WOBURN	NHUN	75116.919m	0.013m	31.5	1.269
HZN605	070148Z	25882.926m	0.010m	43.1	0.589
HZN605	HZN604	15977.046m	0.013m	18.1	1.098
OC0229	HZN601	10394.003m	0.012m	16.9	0.925
OC0229	HZN602	10619.909m	0.013m	10.6	1.227
OC0229	NHUN	52772.337m	0.013m	23.9	1.199
070148Z	MY0160	131.839m	0.003m	29.3	0.860
070148Z	HZN603	11656.020m	0.009m	23	0.630
070148Z	NHUN	39570.709m	0.013m	8.4	1.194
070148Z	HZN604	10493.499m	0.010m	39.1	0.644
WOBURN	ACU5	85200.727m	0.012m	46.5	1.150
AB2629	HZN612	14394.867m	0.010m	25	0.715
AB2629	070148Y	26211.881m	0.012m	25.1	0.989
HZN612	070148Y	11986.057m	0.014m	20.8	0.936
070148Y	AB7938	2918.567m	0.010m	12.2	9.114
070148Y	HZN614	37249.304m	0.010m	34	0.732
070148Y	HZN616	58507.542m	0.018m	3.8	1.639
070148Y	ACU5	52412.225m	0.010m	32	0.675
070148Y	HZN615	37040.210m	0.009m	26.9	0.623
HZN614	HZN615	35401.543m	0.009m	28	0.624
HZN616	ACU5	46139.596m	0.011m	26	0.892
LW1544	HZN609	10249.048m	0.018m	18.4	1.951
LW1544	HZN610	16367.830m	0.014m	11.6	2.314

From Point Name	To Point Name	Slope Distance	RMS	Ratio	Ref Var
LW1544	ACU5	30377.669m	0.019m	10.8	3.553
AB2629	HZN611	24401.198m	0.013m	11.9	1.370
HZN613	AB7938	17983.485m	0.011m	18	1.403

In general, indicators of high confidence in baseline results includes a ratio greater than 3.0, an rms of less than 0.02, and a variance under 5, preferably close to 1. All of baselines processed had acceptable indicators.

LEAST SQUARES ADJUSTMENTS

The data was adjusted using STAR*NET, a least squares adjustment program from Starplus Software. The processed baselines were parsed to form an input file. No scaling of the apriori baseline statistics was done. Station errors (HI and centering) of 0.005 m were also included. Geoid separations for each station were interpolated using the GEOID03 model.

The first adjustment held the CORS **NHUN** fixed horizontally (latitude and longitude), and benchmark **MY0160 (J 36)** was constrained vertically (orthometric height). The estimated error factor for this adjustment was 1.223.

The misclosures (in meters) at the other control points were as follows:

Station	dN	dE	dZ
WOBURN	-0.0063	0.0052	0.0520
OC0229	-0.0206	0.0074	-0.0267
MY0160	-0.0133	0.0033	0.0000
MY0588	-0.0132	0.0114	0.0678
NHUN	0.0000	0.0000	0.0269
LW1544	-0.0179	0.0342	0.0765
AB2629	0.0070	0.0294	-0.0152
AB7938	-0.0069	0.0475	0.0137
ACU5	0.0029	0.0124	0.1023

The control all agrees very well for a network of this size, both horizontally and vertically. The output from this adjustment is included in appendix A.

The final adjustment held all of the control fixed horizontally and the benchmarks fixed vertically (CORS were fixed horizontally only). The estimated variance error was 2.269. The output from this adjustment is included in appendix B. The following table lists the Station Coordinate Error Ellipses (95.000 percent):

Station Coordinate Error Ellipses (Meters)
Error Ellipses are Scaled by Total Error Factor
Confidence Region = 95%

Station	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Elev
WOBURN	0.000001	0.000001	0-00	0.018861
OC0229	0.000001	0.000001	0-00	0.000000
MY0160	0.000001	0.000001	0-00	0.000000
MY0588	0.000001	0.000001	0-00	0.000000
NHUN	0.000001	0.000001	0-00	0.024416
LW1544	0.000001	0.000001	0-00	0.000000
AB2629	0.000001	0.000001	0-00	0.000000
AB7938	0.000001	0.000001	0-00	0.000000
ACU5	0.000001	0.000001	0-00	0.020955
070148Y	0.020083	0.019880	176-35	0.019181
HZN614	0.037959	0.037845	179-18	0.032992
HZN615	0.037953	0.037841	178-52	0.032976
HZN616	0.030059	0.029843	8-18	0.029073
070148Z	0.019936	0.019757	162-59	0.021844
HZN603	0.045060	0.044553	159-48	0.041485
HZN604	0.027364	0.026431	166-07	0.028813
HZN611	0.040770	0.039802	30-06	0.035328
HZN612	0.031105	0.030284	165-51	0.028159
HZN605	0.027283	0.026366	168-08	0.028782
HZN613	0.041020	0.040152	155-08	0.040039
HZN609	0.044320	0.041489	157-25	0.041177
HZN610	0.042668	0.041538	174-47	0.041856
HZN601	0.040073	0.040028	161-25	0.038920
HZN602	0.040618	0.040359	177-43	0.036517
HZN606	0.039683	0.039620	134-47	0.039037
HZN607	0.040156	0.040022	165-10	0.038782
HZN608	0.039601	0.039522	42-44	0.038471

SUMMARY

A geodetic control network was established along the coast of Massachusetts in support of a LiDAR mapping project. The points established have an accuracy of ±0.04 m relative to NAD 83 (NSRS2007) and NAD 83.

NAD 1983 NSRS2007/NAVD 1988 Adjusted Coordinates

Adjusted Positions and Ellipsoid Heights (Meters)

Station	Latitude	Longitude	Ellip Ht	Geoid Ht
WOBURN	42-29-00.949010	71-09-28.650610	9.8830	-27.5540
OC0229	43-27-52.276130	70-28-25.380340	23.4916	-26.3324
MY0160	42-47-46.527680	70-50-34.150090	-23.9694	-26.9044
MY0588	42-22-25.097780	71-03-12.766410	-24.9857	-27.6817
NHUN	43-08-33.179490	70-57-06.863300	9.1384	-26.8469
LW1544	41-57-34.125780	70-39-44.753620	-25.2050	-28.2470
AB2629	41-40-18.272180	69-56-56.974770	-15.7966	-28.0786
AB7938	41-39-05.274900	70-16-47.363810	-23.5740	-28.1450
ACU5	41-44-36.796960	70-53-13.027350	6.5525	-28.9525
070148Y	41-40-29.547940	70-15-50.050300	-16.8870	-28.1034
HZN614	41-23-04.902883	70-02-24.385579	-26.1287	-28.5707
HZN615	41-22-36.800131	70-27-47.511650	-24.8316	-28.7491
HZN616	41-20-00.850613	70-47-51.747172	-2.8373	-29.3605
070148Z	42-47-44.600957	70-50-28.971862	-24.0188	-26.9030
HZN603	42-53-55.995638	70-48-55.354903	-22.4510	-26.8241
HZN604	42-42-49.302722	70-46-40.127369	-24.3638	-26.8357
HZN611	41-53-28.249516	69-57-48.015986	-13.6009	-27.7757
HZN612	41-39-36.701115	70-07-16.739003	-22.5182	-28.0915
HZN605	42-37-47.819768	70-37-09.679328	-25.3906	-26.7779
HZN613	41-34-57.200145	70-28-30.281571	-17.4910	-28.3133
HZN609	42-03-03.111571	70-38-43.106636	-26.0805	-28.0204
HZN610	41-50-44.897592	70-32-12.851709	-12.5109	-28.2195
HZN601	43-31-10.113798	70-22-11.011701	-21.8104	-26.1924
HZN602	43-22-20.876871	70-26-18.242355	-21.2093	-26.2811
HZN606	42-33-05.032200	70-50-12.369422	-19.7391	-26.9501
HZN607	42-25-19.188388	70-59-20.192622	-26.0600	-27.4486
HZN608	42-21-02.736437	70-57-45.970246	-22.4128	-27.6101

UTM Zone 19 North Adjusted Coordinates (Meters)

Station	N	E	Elev
WOBURN	4705728.0512	322638.8051	37.4370
OC0229	4813455.9566	380787.8920	49.8240
MY0160	4739836.7992	349297.4444	2.9350
MY0588	4693304.7190	330925.3361	2.6960
NHUN	4778494.1523	341269.5622	35.9853
LW1544	4646613.7978	362231.9757	3.0420
AB2629	4613766.3246	420989.7304	12.2820
AB7938	4611871.0815	393430.6144	4.5710
ACU5	4623024.5678	343097.9731	35.5051
070148Y	4614450.5364	394794.4327	11.2164
HZN614	4581985.1913	413035.3650	2.4421
HZN615	4581629.5162	377644.7660	3.9174
HZN616	4577346.3886	349571.6433	26.5231
070148Z	4739774.7954	349413.7790	2.8842
HZN603	4751185.1264	351787.4064	4.3731
HZN604	4730554.2588	354420.4956	2.4719
HZN611	4638142.8509	420082.4581	14.1748
HZN612	4612656.4382	406642.1201	5.5733
HZN605	4720993.6959	367218.2026	1.3873
HZN613	4604480.1614	377040.7218	10.8223
HZN609	4656733.2201	363846.1635	1.9399
HZN610	4633798.1205	372408.7958	15.7086
HZN601	4819415.6062	389300.5018	4.3820
HZN602	4803182.4794	383468.2760	5.0718
HZN606	4712635.1282	349201.1852	7.2110
HZN607	4698548.0600	336370.3073	1.3886
HZN608	4690587.6575	338340.8725	5.1972

SHOALS-1000T LiDAR SURVEY

Regional Coastal Mapping 2005 - 2007

Northeast
Maine to Rhode Island

Survey Report

Fugro Document No: FP-6284-002-RPT-01-00
EN Project Number: C-05-056

Applicable to:	**Fugro Pelagos, Inc.**
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REPORT CERTIFICATION FOR

SHOALS-1000T LiDAR SURVEY

Regional Coastal Mapping 2005 - 2007

Northeast
Maine to Rhode Island

FP-6284.002-RPT-01-00

This issue of the report has been approved by:

1.	Vice President Coastal Mapping and LiDAR Services	David Millar
2.	Project Manager	Mark MacDonald

This report has been distributed to:

1.	Eddie Wiggins JALBTCX 7225 Stennis Airport Rd, Suite 100 Kiln, MS 39556	1 Digital Copy

The following versions of this report have been issued:

REV	DATE	DESCRIPTION			
0	9/24/08	Report Issued	ES	JM	MM

APPENDIX A : GROUND CONTROL EQUIPMENT

APPENDIX B : FUGRO EARTHDATA REPORT OF GPS SURVEY

APPENDIX C : GROUND CONTROL SUMMARY LOGS

APPENDIX D : STATION DESCRIPTIONS AND NGS DATASHEETS

APPENDIX E : AIRCRAFT SPECIFICATIONS

APPENDIX F : SHOALS-1000T EQUIPMENT SPECIFICATIONS

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1 INTRODUCTION

Fugro Pelagos, Inc. was contracted by the Army Corps of Engineers (USACE) to obtain existing conditions of the beach and near shore from the area along the Atlantic coastline from just North of Portland, Maine, through New Hampshire and Massachusetts to Rhode Island, including Martha's Vineyard, Nantucket and Block Island (Figure 1-1).

The survey was in support of the Joint Airborne Lidar Bathymetric Technical Center of Expertise (JALBTCX) National Coastal Mapping Program and was performed in conjunction with the CHARTS Regional Coastal Mapping survey program.

Figure 1-1 Survey Location

The survey acquisition operations collected information from the following sources:

- Bathymetric and Topographic LiDAR data from the SHOALS-1000T system.
- Topographic LiDAR data from the Fugro EarthData ALS-50 system.
- Digital Aerial Photography from the SHOALS-1000T.
- Satellite imagery from the DigitalGlobe QuickBird sensor.
- Dual frequency static GPS at ground control stations

The SHOALS-1000T acquisition operations took place from October 19 to December 2, 2005 and April 26 to June 11, 2007. Fugro EarthData collected topographic LiDAR from Jun 30 to Jul 17, 2007. Satellite imagery encompassed data from April 11, 2002; March 29, April 29, September 7, September 20, and October 8, 2004; May 2, May 12, May 25, July 13, September 5 and September 18, 2005; May 25, 2006; June 23, August 3, August 29, September 8, September 13, October 22, and December 25, 2007; January 25 and May 20, 2008.

GPS data were collected during all LiDAR acquisition surveys.

All times quoted in this report are local time (EST), unless otherwise stated.

1.1 SURVEY EXTENTS AND SPECIFICATIONS

Bathymetric LiDAR data were acquired from the shoreline edge seaward for 1000 m or to laser extinction. Topographic LiDAR data were surveyed from the shoreline edge inland for 500 m. The shoreline definition was obtained from the CHARTS project planning and effort was made to corroborate it with NOAA nautical charts.

The SHOALS-1000T bathymetric LiDAR was operated to achieve 5m x 5m spot spacing flying at 400m altitude and speed-over-ground of approximately 162 knots. Cross check lines were flown perpendicular to the coastline every 20 km. The flight lines over the land/water interface and intertidal areas were flown within 2 hours of high tide in order to provide sufficient overlap between the bathy and topo LiDAR data. The SHOALS-1000T topographic LiDAR was operated at 2m x 1m spot density at a nominal altitude of 430 m and 140 knots speed-over-ground. Topographic flight lines were flown twice in reciprocal directions to achieve 200% coverage. Both bathymetric and topographic lines were spaced to achieve 30 m sidelap. Positioning accuracy specifications for both bathymetric and topographic LiDAR were +/- 0.30m (2 sigma) vertical elevation and +/- 0.20m (2 sigma) horizontal.

Fugro Pelagos, Inc. subcontracted Fugro EarthData to do the topographic survey in 2007. Fugro EarthData surveyed the inland area for RCM-01, RCM-02 and RCM-03 (Figure 1-2) using LH Systems ALS-50 LiDAR system. Fugro EarthData met Fugro Pelagos' specifications for the topographic survey. Table 1-1 describes ALS-50 LiDAR system specifications.

Table 1-1 ALS-50 LiDAR system flight specifications

Field of View	35 Degrees
Altitude:	5500 ft (1670 m) AMT
Scan Rate:	40 Hz
Airspeed:	130 knots
Average Post Spacing:	1.25 m
Average Swath Width:	1036 m
Intensity Mode:	4+3
Total Flight Lines:	116
Number of Lifts:	8

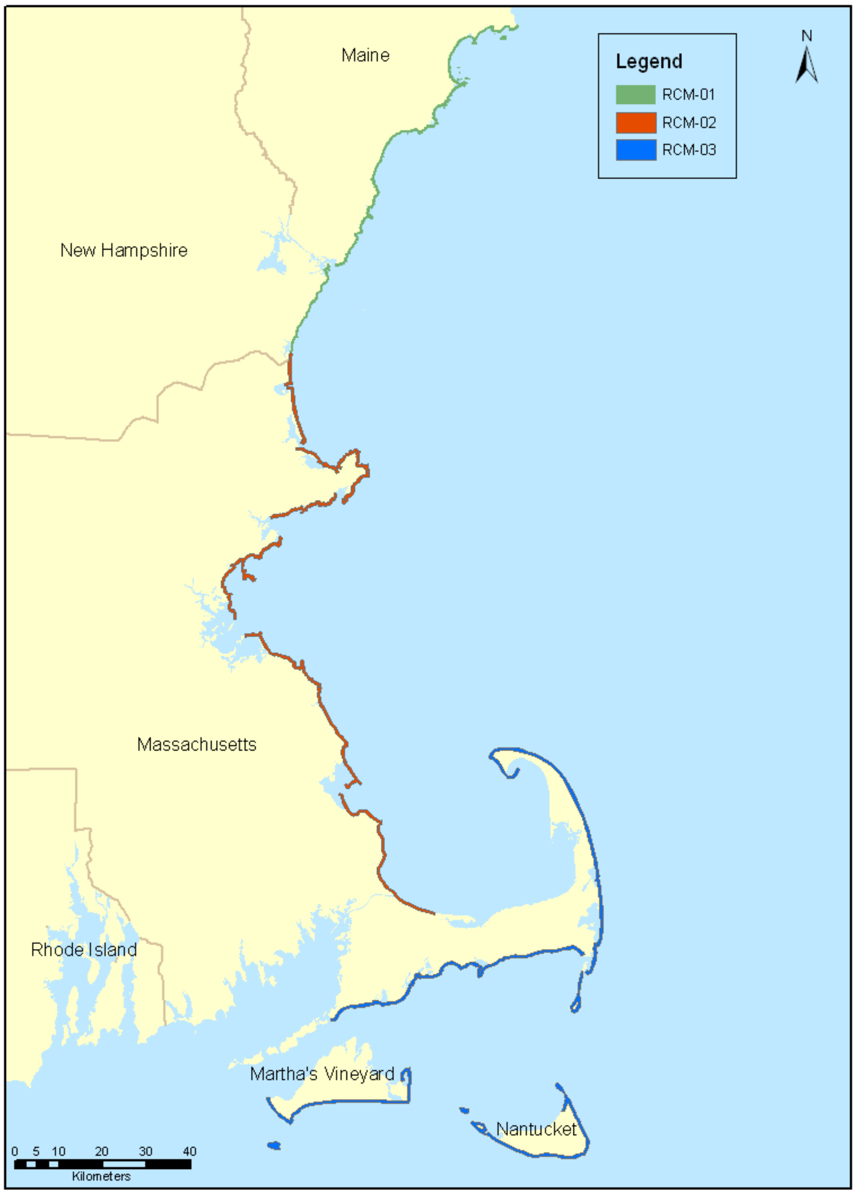


Figure 1-2 Fugro EarthData Topographic Coverage

Fugro Pelagos, Inc. subcontracted Land Info Worldwide Mapping LLC (Highlands Ranch, CO) to supply high-resolution ortho-rectified DigitalGlobe QuickBird satellite imagery for the entire survey area. The imagery covers both hydro and topo LiDAR survey extents.

The total coastline was broken down into four SHOALS GCS projects. Table 1-1 lists the project numbers, area of coverage, LiDAR acquisition modes used, and the approximate coastline length on each project. The total length of coastline surveyed was approximately 826 km. The total surveyed area was approximately 1730 km^2.

Table 1-1. SHOALS_GCS projects

Number	Area of Coverage	LiDAR survey modes	Coastline Length (km)
RCM_NE_01	New Hampshire and Maine	ALS-50 Topo SHOALS-1000T Hydro	153.5
RCM_NE_02	Massachusetts	ALS-50 Topo SHOALS-1000T Hydro	225.2
RCM_NE_03	Cape Cod, Nantucket, Martha's Vineyard	ALS-50 Topo SHOALS-1000T Hydro	336.4
RCM_NE_04	Rhode Island and Block Island	SHOALS-1000T Topo SHOALS-1000T Hydro	111.3

2 DATA ACQUISITION

FPI temporary processing offices for this survey moved along the coast as were necessary for efficient operations. Operations were based out of the Courtyard by Marriott in Islip, NY, and Best Western and Marriott in Portsmouth, NH, in 2005. In 2007, operations were from the Hilton Garden Inn in Plymouth, MA and the Hampton Inn, Portsmouth, NH.

Ground control personnel moved along the coastline every day early in the morning to control point locations. Communications with ground control crew were maintained through mobile phones. At the end of the day, ground personnel delivered the data back to the field office, or if situated further away on the coast, digitally transmitted the data and logs to a centralized FTP site to allow data access for field office processors.

The base airports for operations were Long Island MacArthur Airport (ISP) and Pease Airport (KPSM) in 2005, and Plymouth Municipal Airport (KPYM) and Pease Airport in 2007.

2.1 PROJECT DATUM

The LiDAR real-time positioning corrections were supplied by the Omnistar DGPS in the NAD83 datum. Project control was referenced to NAD83 and all data were post-processed in this datum (Table 2-1). The data was projected to UTM Zone 19 North in meters for mapping purposes (Table 2-2).

The vertical datum for the project was NAVD88 with units in meters. All data referenced to NAD83 derived ellipsoid heights were converted to NAVD88 orthometric heights using the GEOID03 geoid model.

Table 2-1 Chart Datum

Datum	NAD83
Spheroid	GRS80
Semi-major Axis	6378137.000
Semi-minor Axis	6356752.3141
Inverse Flattening (1/f)	298.257222101

Table 2-2 Survey Projection

Projection	UTM
Zone	19 N
Central Meridian (C.M.)	69° W
False Easting	500000 m
False Northing	0 m

2.2 GROUND CONTROL

Dual-frequency GPS data were acquired for the duration of each survey flight on ground control points. The GPS data were used to post-process a Kinematic GPS (KGPS) solution for the airplane position every second. Thales Navigation Z-Max surveying systems were used at all locations. Detailed specifications for all ground control equipment may be found in **Error! Reference source not found.**.

The area coverage of each control GPS station was set to a maximum radius of 30 km to achieve a good accuracy compromise of the kinematic ambiguities resolution. Control GPS stations were therefore spaced at distance intervals less than 60 km and more commonly less than 50 km.

On every control point, two identical GPS receivers were installed. The primary GPS receiver was set on the actual control monument while a secondary (back up) GPS receiver was placed on a temporary survey mark (nail, wooden peg) a short distance away. This procedure was followed to avoid potential loss of GPS data in the event that the primary GPS station experienced fault or damage.

The report of GPS survey prepared by Fugro EarthData for their topographic operations may be found in **Error! Reference source not found.**.

2.2.1 HORIZONTAL CONTROL

All horizontal control points used in this project are NGS published monuments. Effort was made to recover control monuments with a position quality of Class B or better; however, there were regions with lack of minimum quality published monuments. In such cases, First Order marks were occupied and tied to higher order quality when processed with OPUS. Ground Control Summary Logs may be found in **Error! Reference source not found.**. The summary logs were used on a daily basis to compile the observation dates, antenna heights, OPUS solution coordinates and published coordinates.

Station Description Sheets for all monuments used in the positioning processing, along with the NGS datasheets for all recovered and observed control monuments, may be found in **Error! Reference source not found.**.

2.2.2 VERTICAL CONTROL

The vertical control points in the project were in large majority NGS published monuments with a quality of at least First Order Class I and II. On those regions with unreliable or inexistent monuments a lower quality Order monument was occupied and tied to a higher quality when processed with OPUS.

Published NAVD88 datum elevations were converted to NAD83 ellipsoid heights for baseline processing using the GEOID03 geoid model.

2.3 AIRBORNE SURVEY

A Beechcraft King Air 90 equipped with a SHOALS-1000T Bathymetric and Topographic LiDAR System was used for the project (Figure 2-1). Technical specifications for the plane are located in **Error! Reference source not found.**. Detailed equipment specifications for the SHOALS-1000T are available in **Error! Reference source not found.**.

Figure 2-1 Beechcraft King Air 90.

2.3.1 AIRCRAFT MOBILISATION

The aircraft was mobilized at Bridgewater, Virginia on August 14, 2005 and April 17, 2007. The airborne component of the SHOALS-1000T consisted of three separate modules. The lasers and camera were housed in a single package that was bolted to a flange above the aircraft camera door. An equipment rack, containing the system cooler and power supplies, was installed aft of the laser. The operators console was attached to the seat rails forward of the power supply. The console was installed so the operator was facing forward. All hardware was located on the starboard side of the aircraft. Equipment installation required about 2 hours.

Ground truth data were flown in San Diego on July 6-11, 2005 and at Lake Ontario, Canada, on April 20-24, 2007 to ensure all calibration and offset values were valid. The values were used in the SHOALS-associated software in order to obtain true LiDAR elevations.

2.3.1.1 OFFSET MEASUREMENTS

The only offset measurement required during system mobilization was from the POS AV Inertial Measurement Unit (IMU) to the POS AV GPS antenna. The IMU was completely enclosed within the laser housing. The offsets from the IMU to the common measuring point (CMP) on the outside of the housing were known constants.

Offsets were measured using a total station. An arbitrary base line was established along the port side of the aircraft. Ranges and bearings were measured from the total station to the CMP on the top of the laser housing. Additional measurements were made to the sides and top of the housing to determine its orientation. A final measurement was made to the center of the POSMV GPS antenna. The IMU to POS AV GPS offsets were calculated using the known IMU to CMP offsets. A summary of the offset measurements may be found in Table 2-3. The offsets from the IMU to the POS AV GPS antenna were entered into the POS AV console prior to survey.

Table 2-3 Aircraft Offsets for 2005 and 2007.

2007 OFFSET	X	Y	Z
IMU to CMP	+0.073	-0.230	-0.415
CMP to POS AV GPS Antenna	+1.796	-0.162	-0.877
IMU to POS AV GPS Antenna	+1.869	-0.392	-1.292
2005 OFFSET	**X**	**Y**	**Z**
IMU to CMP	0.073	-0.230	-0.415
CMP to POS AV GPS Antenna	+1.300	-0.155	-0.855
IMU to POS AV GPS Antenna	+1.373	-0.385	-1.270

2.3.2 POSITIONING

Aircraft positioning was determined in real time using a OmniStar DGPS system. However, final positions were determined using a post-processed Kinematic GPS solution (Section 3.2.2).

The primary position GPS antenna was a NovAtel 512 airborne L1/L2, which was connected to a NovAtel Millennium GPS card residing in the POS AV (Section 2.3.3).

An AeroAntenna AT-3065-9 antenna was used to acquire differential corrections. Two differential receivers were available: the OmniSTAR 3100LM and a CSI MBX-3S Coast Guard beacon receiver. The OmniSTAR was the primary source of differential corrections for this project.

Dual frequency GPS data were also acquired with the NovAtel Millennium card in the POS AV. These data were used in post-processing, along with the dual frequency ground control data to provide a KGPS solution.

2.3.3 SENSOR ORIENTATION

The Applanix POS AV 410 measured orientation (roll, pitch and heading). The system consists of a POS AV computer with a NovAtel Millennium GPS card, an Inertial Measuring Unit (IMU), and one NovAtel 512 airborne L1/L2 GPS antenna.

The IMU is permanently mounted within the SHOALS-1000T sensor. It uses a series of linear accelerometers and angular rate sensors that work in tandem to determine orientation.

The orientation information is used in post-processing to determine position of the laser spots. However, analog data from the POS AV is also used during acquisition to maintain a consistent laser scan pattern.

2.3.4 LIDAR SYSTEM

The SHOALS-1000T was used to acquire bathymetric and topographic LiDAR data at a rate of 1 kHz and topographic LiDAR data exclusively at 10 kHz.

Background theory on bathymetric LiDAR can be found in the paper, "*Meeting the Accuracy Challenge in Airborne LiDAR Bathymetry*" (Guenther, et al.[1]). In general, the laser outputs a

[1] *"Meeting the Accuracy Challenge in Airborne LiDAR Bathymetry", Gary C. Guenther, A. Grant Cunningham, Paul E. LaRocque, David J. Reid*

green and infrared beam. The infrared beam is used to detect the water surface and does not penetrate this. The green beam penetrates the water and detects the seafloor. The green beam also generates red energy when excited at the air/water interface. This is known as Raman backscatter and can be used to detect the sea surface. Distances to the sea surface and seafloor are calculated from the times of the laser pulses, using the speed of light in air and water.

Topographic LiDAR principles are in essence the same as the bathymetric LiDAR but in a more simplified operation. The scattering of the infrared beam as it hits the ground is detected directly by the receiver sensor to calculate the distance from the sensor to the ground that will produce a ground elevation once the accurate position of the airplane is determined.

Data received by the airborne system were continually monitored for data quality during acquisition operations. Display windows showed coverage and information about the system status. In addition, center waveforms at 5Hz were shown. All of this information allowed the airborne operator to assess the quality of data being collected.

In addition to LiDAR data, a DuncanTech DT4000 digital camera was also used to acquire one 24-bit color photo per second. The camera, mounted in a bracket at the rear of the sensor, captures imagery of the area being over flown, and can be used during post-processing.

2.3.4.1 LIDAR CALIBRATION

A LiDAR in-flight calibration was performed in post-processing using data acquired prior to this project. This “raster pattern” calibration is used in the determination of the small offsets of the scanner mirror frame relative to the optical axes of the system. To calculate the angular offsets, an average of the water surface is derived by the system. The raster pattern calibration required flying reciprocal straight lines over a relatively calm water surface for at least 5 minutes, into and against the waves. In addition, ground truth data were acquired over Oshawa runway (near Toronto, Ontario), and these were used to determine system biases.

2.3.5 CHALLENGES ENCOUNTERED

No major technical problems with the LiDAR system were experienced in 2005. In 2007, the topographic laser was inoperative so Fugro EarthData was subcontracted in order to fill in the remaining topo coverage. Overall, operations ran smoothly for both bathymetric and topographic LiDAR acquisition; however, there were some production delays and difficulties. Weather conditions, such as rain, fog, low clouds and strong winds; water conditions, such as poor water clarity, white caps, glassy water surface; and the timing of tidal cycles all impaired the survey effort.

3 DATA PROCESSING

Data were processed at the temporary office base in Long Island, NY and Portsmouth, NH in 2005, and in Plymouth, MA and Portsmouth, NH in 2007. After survey acquisition was complete, data processing and the creation of final products continued in Fugro Pelagos' San Diego office. The overall processing and operations flow for this project is shown in Figure 3-1.

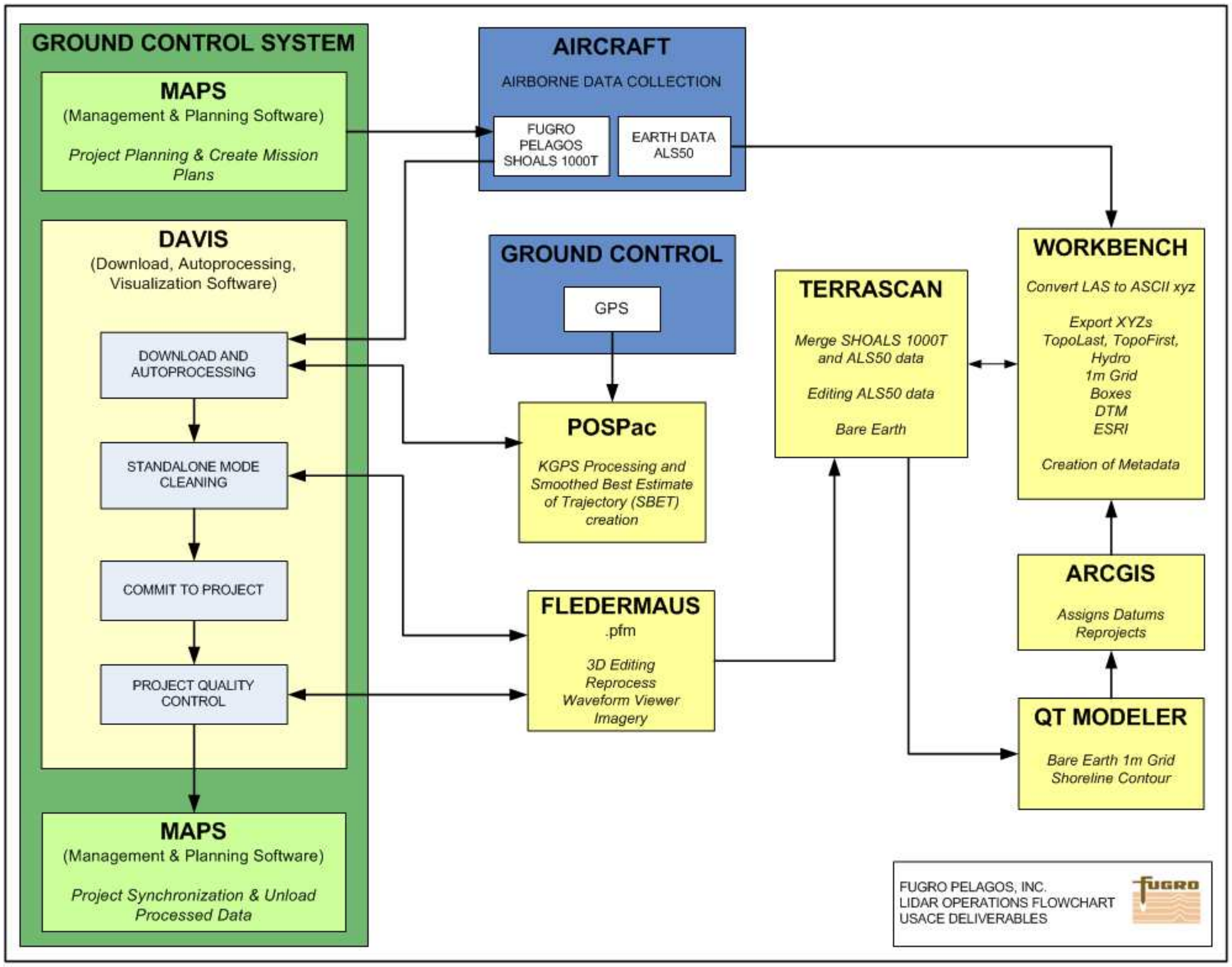


Figure 3-1 LiDAR Operations Flowchart

3.1 GROUND CONTROL

Dual frequency GPS data collected at each ground station were converted to RINEX format, and uploaded to the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) (http://www.ngs.noaa.gov/OPUS/) for static post-processing. The data were processed by the OPUS using automatically selected data from the Continuously Operating Reference Stations (CORS) network. Solutions were returned via e-mail and logged in the Ground Control Summary Logs (**Error! Reference source not found.**).

As a principle, high order position quality from NGS published coordinates was observed for positioning control. Published coordinates were compared against averaged OPUS coordinates to validate usage. Large discrepancies (difference values >0.07 m) were analyzed closely and, given the case, the OPUS coordinate was used for the positioning control processing. This was particularly true when a multi-station KGPS solution produced higher-than-expected residual values when a questionable published coordinate was used. The Ground Control Summary Logs for each individual station indicated when the published or OPUS coordinates were used. A list of control monuments used on each project is presented in Table 3-1. In some cases, the control point data was unsatisfactory for data collection due to multipath or equipment failure so the secondary point was used instead.

Table 3-1 Control monuments used for ground control GPS stations.

Project No.	Name	NGS Control Monuments used (PID)
RCM_NE_01	New Hampshire and Maine	AI5537 AB2631 OC0478 OC0229 OC0229secondary AJ2697 AJ2697secondary
RCM_NE_02	Massachusetts	AJ4048 AA7161 AJ4037 MY2749 AB7938
RCM_NE_03	Cape Cod, Nantucket, Martha's Vineyard	AB7938secondary AB2629 AJ4051 AB3245 AI5592 LW5817
RCM_NE_04	Rhode Island and Block Island	AA7164 AI5561 LW0254 LW1756 LW5587 LW5637 LW0891 LW0505 LW0505secondary

3.2 LIDAR DATA

All SHOALS-1000T data were processed using the Optech's Ground Control System (GCS) on Windows XP workstations. The GCS includes links to Applanix POSPac software for GPS and inertial processing, and IVS Fledermaus software for data visualization and 3D editing.

The GCS was used to process the KGPS and inertial solutions, apply environmental parameters, auto-process the LiDAR waveforms, apply the vertical datum offsets, edit data and export accepted data to an ASCII file.

3.2.1 PRE-PROCESSING

Once data had been downloaded to DAViS (Download, Auto processing and Visualization Software), hardware related calibration information was verified in the GCS. A list of the calibration values used may be found in **Error! Reference source not found.**.
In addition to the hardware values, some default environmental parameters were also set. Surface detection method was set to use the IR channel initially. If no IR pick was found then the Raman would be used.

3.2.2 KGPS PROCESSING

For every mission, a new project was set up in POSPac, Version 4.2. POS data downloaded from the airborne system were extracted from DAViS into the POSPac project.

Using POS GPS, GPS data from the airplane and ground control base station were converted from the NovAtel and RINEX GPS formats respectively, to the POS GPS GPB format. The KGPS data were then post-processed using the selected control point coordinates as the master control coordinates. Single and multi-station KGPS solutions were used according to the geographic extents of the mission flight dataset. In general, an optimal KGPS solution should present a small separation difference between forward and reverse solutions when combined, ideally <0.10 m.

POSPac then used the post-processed GPS positions to post-process the POS orientation data and refine the inertial solution. The final solution was exported to a SBET file, which was then used by the GCS during LiDAR auto processing.

Before auto processing in the GCS, a KGPS zone was defined. KGPS zones were used to apply vertical datum offsets. Since data were processed in NAD83, no offset was applied at this stage.

3.2.3 AUTO PROCESSING

Once calibration values were set, environmental parameters selected, KGPS zones defined and KGPS data processed, the LiDAR data may be auto processed using the GCS. The auto processing routine contains a waveform processor to select surface and bottom returns from the bathymetry data, and land surfaces from the bathymetric laser. In addition, it contains algorithms to determine position for each laser pulse.

The auto process algorithms obtained inputs from the raw data and calculated a height, position and confidence for each laser pulse. This process, using the set environmental parameters, also performed an automated first cleaning of the data, rejecting poor land and seafloor detections. Questionable soundings were flagged as suspect, with attached warning information.

Data were then imported into a Fledermaus project in PFM format file to allow data inspection and editing in a 3-D environment.

3.2.4 DATA VISUALIZATION & EDITING

Data visualization and editing was done using Fledermaus. Fledermaus displays a gridded surface (PFM) of the entire project in 3-D (Figure 3-2). Bathymetric and topographic data types were edited separately and then combined for correlation. Any areas with questionable soundings/elevations were then reviewed using the 3D area-based editor. The 3D editor opens up a smaller subset of data, displaying each individual elevation in 3D (Figure 3-3). Gross fliers were manually rejected. Other data of uncertain quality requiring more examination were reviewed using the waveform window, which displays shallow and deep channel bottom selections, and IR and Raman surface picks (Figure 3-4). Other metadata such as confidence and warnings are also incorporated into the viewer. In addition, the camera image associated with the laser pulse was also displayed.

Other SHOALS specific tools, such as swapping a sounding falsely recognized as land to water, were used inside Fledermaus.

In most cases, manual editing was used to remove obvious anomalies in the data mostly due to temporal targets such as people, beach umbrellas, vehicles, boats, surf, sediment plumes in the water column, and some vegetation.

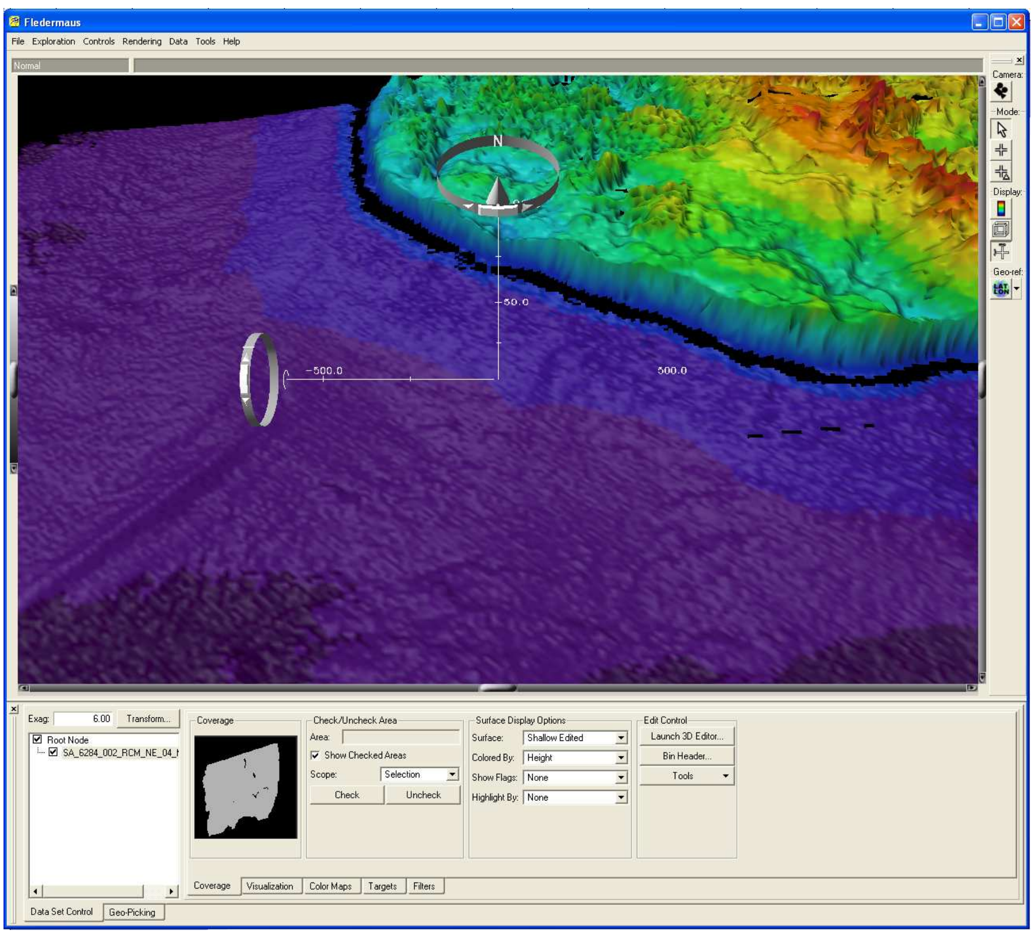


Figure 3-2 Viewing a Project Surface in Fledermaus

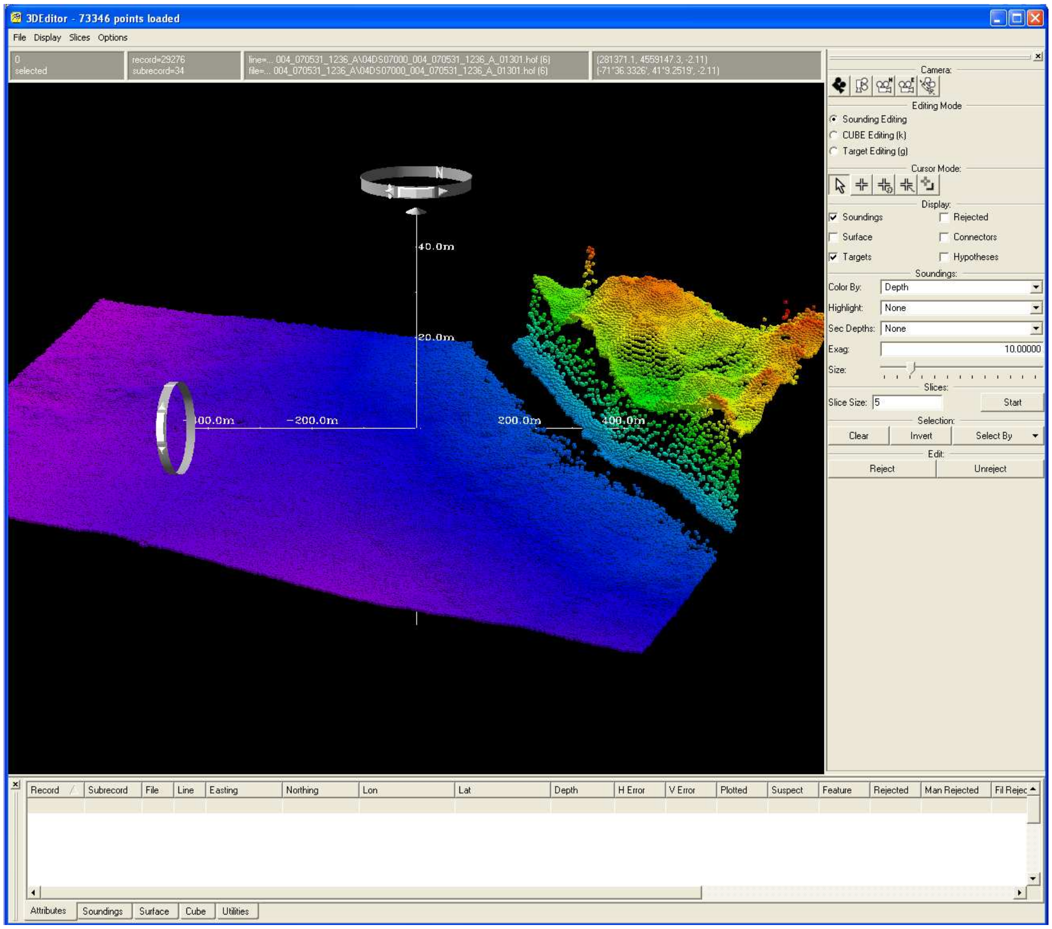


Figure 3-3 Fledermaus 3D Editor

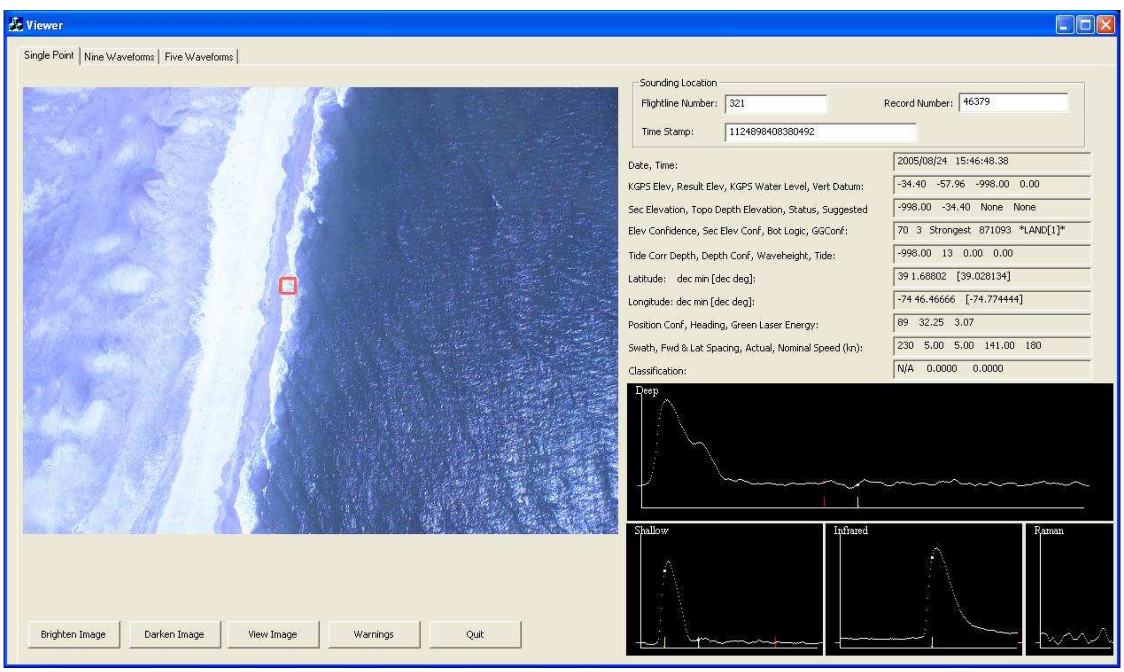


Figure 3-4 Waveform Viewer

3.2.5 ALS-50 LIDAR DATA PROCESSING

3.2.5.1 Flight Line Data Acquisition/Quality Control Check

LiDAR data and the IMU files were processed together using EarthData LIDAR processing software. The data set for each flight line was checked for project area coverage, data gaps between overlapping flight lines, and tension/compression areas (areas where data points are more or less dense than the average project specified post spacing). Based on this check it appears the entire project area is covered without gaps.

3.2.5.2 Boresighting Process

Pre-processing of LiDAR corrects for rotational, atmospheric, and elevation differences that are inherent to LiDAR data sets. This process is called boresighting. LiDAR data was collected for bi- and cross-directional flight lines over the airport prior to and after acquisition of the project area. Using an iterative process that involves analyzing raster difference calculations the Omega, Phi, Kappa angle corrections of the LiDAR instrument were determined. The corrections were applied to the LiDAR data set for the project area.

3.2.5.3 Vertical Accuracy Check

Extensive comparisons were made of vertical and horizontal positional differences between points common to two or more LiDAR flight lines. This was done for the airport bore-sight testing area and the project area. All flight lines (airport and project) were within project specifications for vertical accuracy.

3.2.5.4 LiDAR Intensity Check

An intensity raster for each flight line was generated. The raster was checked and verified that intensity was recorded for each LiDAR point.

3.2.5.5 Vertical Bias Correction

LiDAR has a consistent vertical offset. LiDAR ground points were compared to independently surveyed and positioned ground control points at both the airport bore-sight area and the project area. Based on the results of these comparisons, the LiDAR data was vertically biased down to the ground.

3.2.5.6 Project Ground Control Check

Comparisons between on-site ground survey control points and LiDAR data yielded the following results:

Vertical Accuracy (RMSE)	0.067 m
Standard Deviation	0.069 m
Mean Difference	0.007 m

3.2.6 TERRASCAN EDITING AND EXPORT

After the SHOALS-1000T data were edited, all remaining accepted data were exported using Workbench into USACE ASCII format in NAD83 UTM 19N, ellipsoid elevation in meters. The bathy, topo first return and topo last return were all exported into separate files. The data were then ready to be merged with the topographic ALS-50 data from Fugro EarthData.

Fugro EarthData supplied unedited ALS-50 topographic data in LAS file format. These files were converted into ASCII xyz using a subroutine in Workbench. The xyz files were then imported into a Terrascan project. Any false topo data over the water surface was reclassified so that it would not be included in the final deliverables (Figure 3-5). The data were then exported out of Terrascan in USACE ASCII format and clipped into boxes using Workbench.

Both SHOALS-1000T and ALS-50 data were imported into a new Terrascan project, sorted both into boxes and into separate classes (topo, bathy hydro, bathy land). The data were then checked for continuity and edited using Terrascan. Once complete, all data were exported from Terrascan in ASCII xyz format.

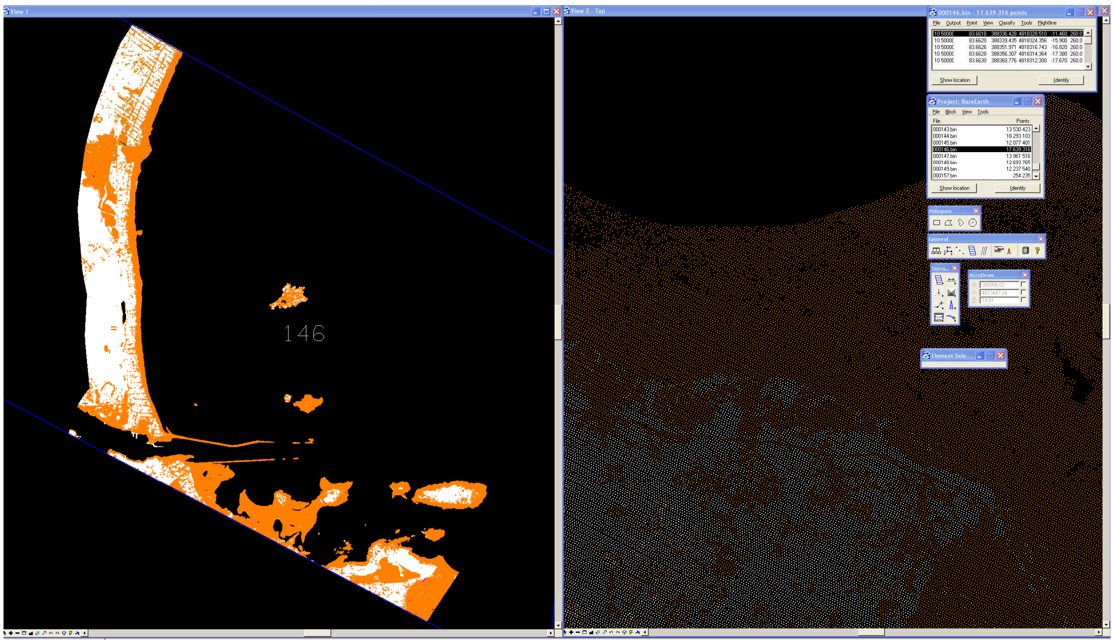


Figure 3-5 Editing data in Terrascan

3.2.7 CREATION OF ASCII AND 1 M RASTER FILES

Workbench was used in order to create the final ASCII and 1 m raster file products. The xyz format data supplied by Terrascan were run through Workbench, which provided USACE required fields and delivered buffered and non-buffered boxes in NAD83 NAVD88 and in UTM zone 19N. At the same time, it supplied 1m raster TIFF format files using the topo last return and bathy data, ESRI format files, Digital Terrain Models (DTMs) and associated metadata.

3.2.8 CREATION OF BARE EARTH PRODUCT

The bare earth product creation involved several steps. The xyz data files were imported into Terrascan and a bare earth macro was run on the data to export the data into bare earth files. The macro essentially reclassified the data in an iterative process depending on the number of adjacent datapoints, which left bare earth in its original class, and vegetation and buildings in a separate class. The bare earth classified points were exported. These files were then converted from NAD83 to NAVD88 using Workbench.

The bare earth files were then imported into Quick Terrain Modeler, which created the 1m gridded surface. QT Modeler outputs the grid nominally in WGS84 UTM zone 19N, so the grid files were exported into GeoTIFF format and brought into ArcGIS to change the datum name back to NAD83. The TIFF files were then reprojected using ArcGIS from the NAD83 UTM zone 19N projection to the geographic coordinate system NAD83 NAVD88m.

Metadata were created for bare earth files using Workbench.

3.2.9 CREATION OF SHORELINE CONTOURS

The shoreline contour was built using the final ASCII xyz products output from Workbench. The topo last return and bathy data were imported into QT Modeler version 6.0.2 (Figure 3-6). The module for generating contour lines was used with sampling rate set to 3, and a value of 0 for the minimum, spacing and maximum settings. The resultant contour was exported as an ESRI shape file. The coordinate system of the shapefile was defined using ArcGIS's Data Management Tools. The metadata for the shoreline products were created using Workbench.

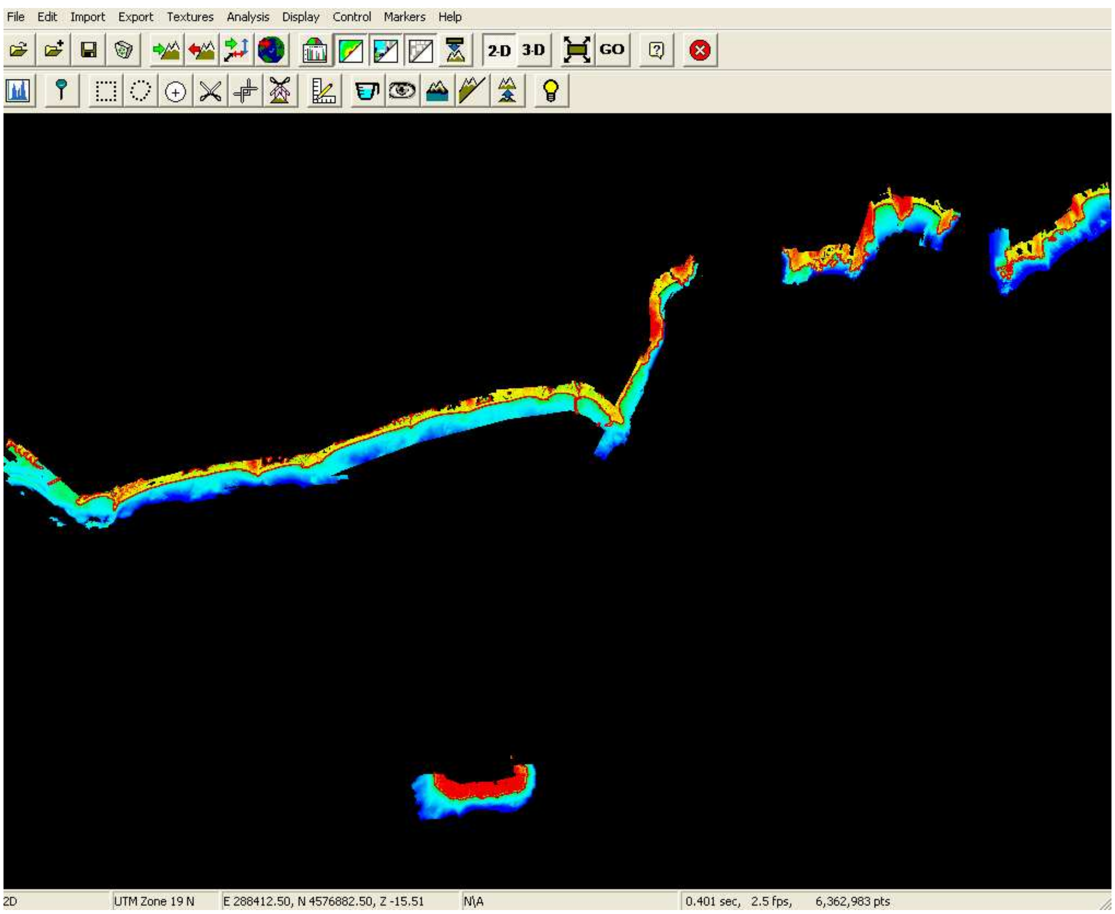


Figure 3-6 View of Rhode Island data in QT Modeler

3.2.10 IMAGERY

Land Info Worldwide Mapping delivered high-resolution satellite imagery for the topographic and hydrographic survey extents. The imagery was collected by DigitalGlobe QuickBird sensor. The satellite orbits at an altitude of 450 km with a 98° sun-synchronous inclination. QuickBird provides 60 cm (nadir) resolution pan-sharpened multi-spectral (PSM) 3-band natural color imagery (Figure 3-7).

Figure 3-7. Quickbird orthorectified imagery sample.

Land Info Worldwide Mapping supplied the satellite imagery as georeferenced TIFF and ECW wavelet compressed files in UTM NAD83 Zone 19 North projection. All imagery was rectified by Land Info and corrected for optical distortions and viewing geometry using both a satellite orbital model and a digital elevation model. The elevation data came from the bare-earth LiDAR data and from the 10m National Elevation Dataset. The US government National Agriculture Imagery Program (NAIP) ortho aerial photography was used for ground control.

The UTM projected imagery was converted to the NAD83 geographic coordinate system and cut into the USACE 5-km boxes using Leica Erdas Imagine 9.0. The Mosaic Wizard module was used which performed all these steps in one comprehensive process. Fugro Pelagos' Workbench then created metadata and converted the images to MrSID format for delivery.

3.2.11 CROSS CHECK LINES

Bathymetric cross lines were planned and acquired at every 20 km of coastline over the survey area. A difference analysis between the cross lines and the main survey lines was performed using the Crosscheck program within Fledermaus.

The crosscheck program creates an average grid of the main-scheme lines at a user selectable cell size (in units of the position of the data collected) and range weighting (in units of cells). In this case, a cell size of 0.00004 degrees (~4m) and no range weighting were used. The cross line depths were then compared to the grid. Data over steep slopes were removed from the analysis, since small acceptable differences in horizontal position within these areas can result in a large difference in vertical elevation.

The required survey vertical accuracy was +/-0.25m. The results of the cross check analysis are included in Table 3-1. The average absolute mean difference over the entire survey area was 0.077m and the average absolute difference in standard deviation was 0.12m. The total percentage of samples that were within +/- 0.5m of the mean for a particular line was always more than 97%, and often 100%. These statistics indicate that the crosscheck lines match the main scheme lines within the required survey accuracy.

Table 3-1 Cross Check Line Results for RCM-01 through RCM-04

CROSS CHECK LINE	SAMPLES (TOTAL)	DIFF MEAN	DIFF ST. DEV.	SAMPLES (± 0.5m)	PERCENTAGE (± 0.5m)
RCM-01					
169-1	2235	-0.1138	0.198970	2214	99.1%
001-1	4707	0.008	0.1237	4707	100.0%
002-1	8516	-0.0497	0.076687	8515	100.0%
003-1	8018	-0.0862	0.126240	7957	99.2%
001-1	11479	-0.0546	0.128980	11438	99.6%

CROSS CHECK LINE	SAMPLES (TOTAL)	DIFF MEAN	DIFF ST. DEV.	SAMPLES (± 0.5m)	PERCENTAGE (± 0.5m)
RCM-02					
211-1	16618	-0.1511	0.141500	16431	98.9%
212-1	12423	-0.0980	0.102650	12419	100.0%
209-1	4819	-0.0527	0.115600	4815	99.9%
155-1	3069	-0.1643	0.16546	3029	98.7%
156-1	5628	-0.2005	0.10397	5577	99.1%
157-1	1857	-0.0313	0.1522	1845	99.4%
001-1	2666	-0.1067	0.098314	2663	99.9%
002-1	6495	-0.1043	0.15359	6456	99.4%
233-1	12582	0.0364	0.11711	12564	99.9%
232-1	5385	0.0784	0.0818	5385	100.0%
154-1	9218	0.0820	0.100630	9214	100.0%
230-1	4828	-0.1131	0.098974	4822	99.9%
231-1	10843	0.0518	0.082594	10843	100.0%
286-1	19160	-0.0754	0.122920	19080	99.6%
287-1	5118	-0.0703	0.108110	5105	99.7%
288-1	7214	-0.0754	0.092583	7214	100.0%
310-1	23815	-0.0861	0.162230	23570	99.0%
424-1	14004	-0.0195	0.19	13789	98.5%

RCM-03					
289-1	9071	-0.0941	0.124960	9034	99.6%
290-1	11265	-0.0518	0.124440	11200	99.4%
291-1	22995	-0.0991	0.092066	22989	100.0%
290-1	15353	0.0038	0.093145	15347	100.0%
99-1	20463	-0.0520	0.068210	20462	100.0%
222-1	33483	0.0258	0.146880	33316	99.5%
224-1	19618	-0.0636	0.130880	19596	99.9%
226-1	34278	-0.0066	0.076159	34277	100.0%
227-1	9143	-0.0531	0.113520	9139	100.0%

CROSS CHECK LINE	SAMPLES (TOTAL)	DIFF MEAN	DIFF ST. DEV.	SAMPLES (± 0.5m)	PERCENTAGE (± 0.5m)
RCM-04					
18-1	8115	-0.0814	0.092030	8091	99.7%
18-1	7912	0.0745	0.081763	7907	99.9%
77-1	4620	0.1894	0.133800	4551	98.5%
19-1	23899	0.0612	0.197420	23538	98.5%
21-1	1017	0.1003	0.18752	990	97.3%
141-2	14221	-0.0994	0.095541	14203	99.9%
141-1	14196	-0.0747	0.096592	14186	99.9%
142-1	16851	-0.1210	0.118030	16700	99.1%
143-1	15634	-0.0283	0.098919	15591	99.7%
144-1	7542	-0.0384	0.148490	7486	99.3%

3.2.12 QUALITY CONTROL

Throughout the data acquisition and processing procedures there are numerous quality control checks. The Airborne Operator continually monitors the data collected in real-time to ensure all navigation and laser system quality parameters are within acceptable tolerances. The data processors continually inspect the data throughout the entire processing flow to ensure collected data is within project accuracy specifications. These checks include:

- System timing tests for each flight, which ensure that the system timing is not malfunctioning
- KGPS accuracy checks, such as RMS values of forward/reverse SBET solution separation and PDOP
- OPUS solutions for GPS control base stations
- Pre-deployment calibration of the system
- Visual inspection of adjacent line and dataset overlap regions to check for vertical offsets
- Cross check lines (see 3.2.11)
- Visual inspection of the data for anomalies

4 DATA PRODUCTS

After all processing and quality control audits were completed, the following deliverables for the survey were provided:

- XYZ data (ASCII space delimitated x y z i date)
- 1 meter raster grid (32-bit GeoTIFF Format)
- Ortho Mosaic Images (MrSID format)
- Zero Contour (ESRI Shape File format)
- All GPS Base Station information (Log Sheets, Data Sheets, etc)
- All ROS supporting documents created or obtained during the survey
- Report: FP-6284-002-RPT-01-00-NE

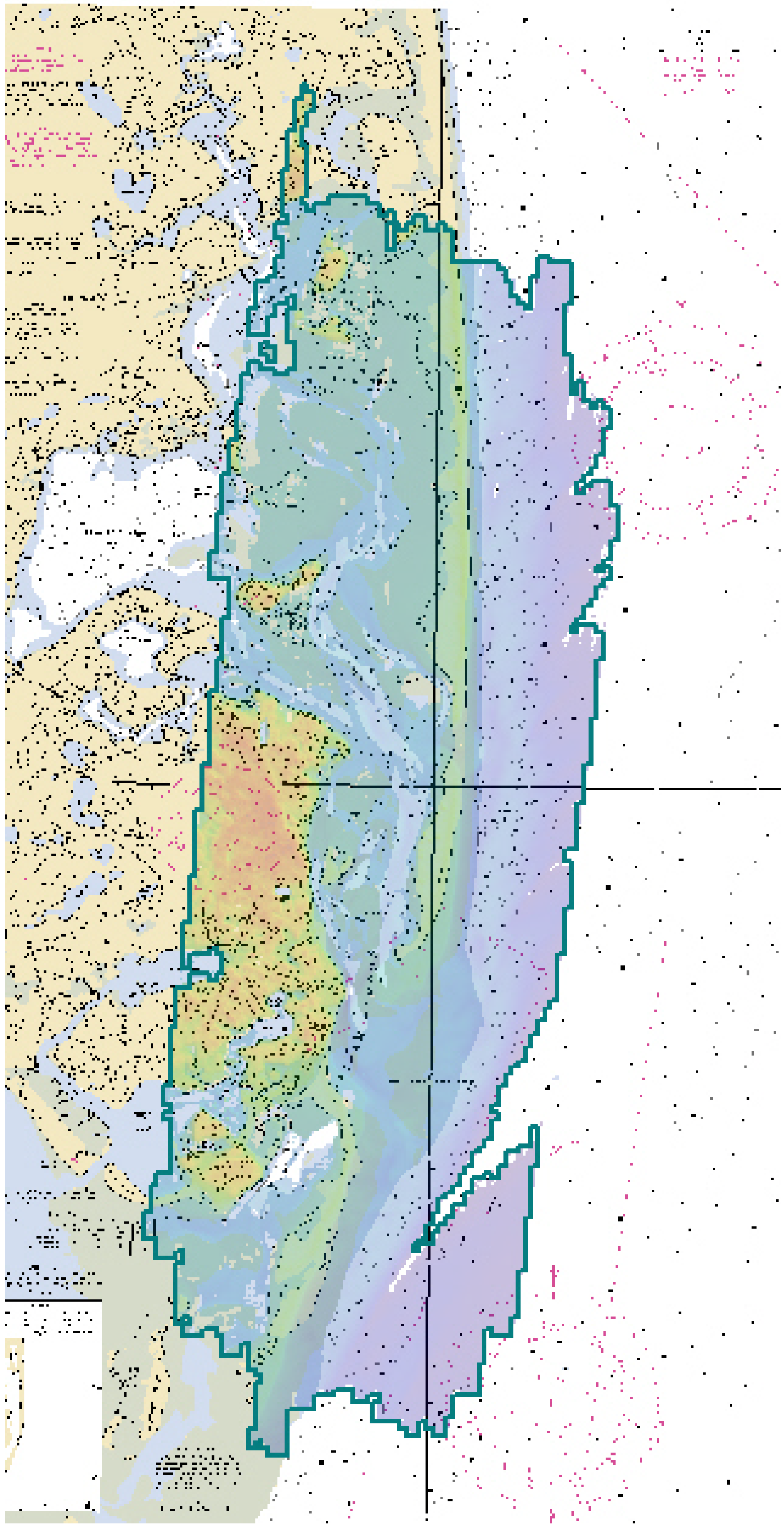
Appendix I: Danger to Navigation Report

No Dangers to Navigation were found in W00203

Appendix II: Survey Feature Report

Retain all features at charted, unless addressed by the H-Cell, W00203_CS.000

Appendix III: Survey Outline



Appendix IV: Tides and Water Levels

Discussed in H-Cell Report

Appendix V: Supplemental Survey Records and Correspondence

Subject: Re: Chatham, MA Shoreline Request
From: Tim Blackford <Tim.Blackford@noaa.gov>
Date: Wed, 04 Aug 2010 14:41:18 -0400
To: Katrina Wyllie <Katrina.Wyllie@noaa.gov>
CC: NGS.Shoreline.Request@noaa.gov

Hi Katrina,
RSD currently has the project area on our schedule for acquisition. We expect the flight mission to complete the collection over the area this field season. Orthoimagery will soon follow, according to our regular production process, once the collection is completed.

-Tim

Katrina Wyllie wrote:

> Hello,
>
> If it is possible, please provide AHB with RSD orthoimagery in the vicinity of Chatham Harbor, MA. This is a very changeable area and the most recent orthoimagery would be appreciated so the most up-to-date nautical chart product can be send to MCD. The minimum latitude is 41-37-34.0294N, maximum latitude 41-46-36.8976N, minimum longitude is 69-58-29.6287W, and maximum longitude is 69-54-23.3490W.
>
> Thank you,
>
> Katrina Wyllie

From: "Macon, Christopher L" <Christopher.L.Macon@usace.army.mil>
To: "katrina.wyllie" <Katrina.Wyllie@noaa.gov>
Sent: Wednesday, May 27, 2009 11:00 AM
Attach: Metadata_ASCII_Template.txt.xml
Subject: RE: Madaket/Tuckernuck and Chatham

Hello Katrina,

You've got it. H is for green laser returns, it will have both land and water shots. TF and TL are the first and last returns from the topographic laser. HTL is the hydro and topo last returns combined together. This was an attempt at getting data close to bare earth.

After a few folks pointed out that we did not explain this very well in the metadata, we adjusted our metadata templates to better explain. Would you read over the attached metadata and let me know if this would have clarified this?

Thanks, Chris

Chris Macon
JALBTCX
Work: 228-252-1121
Cell: 251-459-5920

-----Original Message-----
From: katrina.wyllie [mailto:Katrina.Wyllie@noaa.gov]
Sent: Wednesday, May 27, 2009 8:30 AM
To: Macon, Christopher L
Subject: Re: Madaket/Tuckernuck and Chatham

Good morning,

We received the DVD in the mail with both data sets (thank you) and I was just starting to get a feel for the data. I was able to get the surfaces converted for the Chatham data set but I had a quick question for you. The ASCII .xyz files are separated by _H, _TL, _T, _TF, and _TLH and I am not sure what the difference is between them. I used the _TLH files when I brought data into CARIS but the Madaket/Tuckernuck data do not have _TLH files. Would you mind clarifying for me what the difference is and which ones you think I /should/ be using?
Is H for Hydro? The TF and TL for the first and last return? TLH for last return and hydro?
I appreciate any clarification.

Thanks,
Katrina

Macon, Christopher L wrote:
> I was able to get the MA data back on the servers. The Madaket/Tuckernuck
> data will also be in the shipment (ASCII, 1m Grid, RGB). No need to try
and
> download the file from LDART.
>
>
> Chris Macon
> JALBTCX
> Work: 228-252-1121
> Cell: 251-459-5920
>
> -----Original Message-----
> From: michael gonsalves [mailto:Michael.Gonsalves@noaa.gov]
> Sent: Tuesday, May 19, 2009 5:33 PM
> To: Shep Smith
> Cc: Wozencraft, Jennifer M SAM; Macon, Christopher L;
> Katrina.Wyllie@noaa.gov; Eric W Berkowitz
> Subject: Re: Madaket/Tuckernuck and Chatham
>
> Good afternoon CDR Smith.
>
> My sincerest apologies for the delay in replying to your email.
> Tracking the datasets you requested off of the magnetic tape back-ups took
> longer than expected (actually, Chris might claim it took ~as~ long as
> expected). At any rate, Chris has burned you a DVD with the Chatham data
> that will be sent in tomorrow's mail.
>
> Included are XYZ++ files
>
(lat/long/utm_zone/easting/northing/elevation(navd88)/elevation(nad83)/date/t
> ime),
> 1-m grids and RGB mosaics. Included are metadata for the XYZ and grids.
> Neither approaches the level of Descriptive Report that is normally
submitted
> with a survey, but I might be able to stitch together some SOPs if it will
> make AHB comfortable with the processing pipeline.
>
> So far as the CSC site is concerned. I have come to discover there are
> actually two methods of retrieving data: the Digital Coast
> (http://www.csc.noaa.gov/digitalcoast/) and LDart
> (http://maps.csc.noaa.gov/TCM/). The Digital Coast provides you with a map
> up front to browse to your desired area. So far as I can tell, you can
only
> download a binary raster file (FLT) through this site. I suspect this is
the
> method Katrina tried. On the other hand, if you visit the LDart page and
> fill out the "Search Available Topo Data" form (I searched MA between 2006
> and present, with data type "bathymetry" and data class "any"). This will
> bring you to another screen that should reference the 2007 USACE New
England

> Topo/Bathy LiDAR dataset. Click the state abbreviation "MA", it is a
> hyperlink that will then pull up a map which you can use to zoom down to
> Nantucket. Once you've zoomed to your area of interest, clicking
"continue"
> will bring you to the LIDAR Data Retrieval Tool page. What makes this page
> better than the Digital Coast is you can select your output format. With
the
> "Bin Method" set to "none", you can download the XYZ points (or the binary
> raster file available through Digital Coast). You can also bin the data at
> whatever cell size and get DEMs.
>
> I requested the point file and got the following FTP site if you wish to
> proceed with the download:
>
ftp://ftp.csc.noaa.gov/pub/crs/beachmap/data/michael_gonsalves_LDART_8072.zip
>
> The file is ~238 MB and contains over 35 million points. The FTP site will
> be active for 10 days.
> Attached to this email is the full message I received from CSC that
explains
> the file nomenclature along with some other bits of housekeeping.
>
> This should hopefully provide you with most everything you need to march
> forward with Chatham and to data mine Nantucket. Please browse through and
> let me know what further information you feel would be helpful to AHB.
>
> Very respectfully,
>
> ~~ michael.gonsalves
>
> Shep Smith wrote:
>
>> Hi Mike,
>>
>> Katrina tried downloading the lidar data from the CSC site for
>> Madaket/Tuckernuck, but the point files do not seem to be available.
>> Do you understand that we can get those from there, or do we need to
>> go to you?
>>
>> In summary, what we are requesting is:
>>
>> -Full density point files in GSF, XYZ++, HDCS, PFM, or some other
>> exchangeable format.
>> -Any high-resolution gridded products you might have.
>> -Any reports of survey, project instructions, processing procedures
>> records, etc, that might be relevant to the data.
>>
>> For two areas:
>>
>> The western tip of Nantucket, Tuckernuck Island, and Madaket Island
>>

>>
>>
>> and Chatham (the beautiful dataset you showed us).
>>
>>
>>
>> I am hopeful we can use these two areas to open a line of
>> interoperability between JALBTX and OCS so we can reach out for
>> additional data in targeted areas in the future.
>>
>> Please advise on the best way to get these datasets, which pieces we
>> need to get from where.
>>
>> Thanks,
>>
>> Shep
>>

From: "shep.smith" <smith.shepard@gmail.com>
To: <Maureen.Kenny@noaa.gov>
Cc: "mary.erickson" <Mary.Erickson@noaa.gov>; "Rick Brennan" <Richard.T.Brennan@noaa.gov>; <Katrina.Wyllie@noaa.gov>
Sent: Tuesday, July 07, 2009 6:29 PM
Attach: vdatum_JALBLTX.doc
Subject: [Fwd: [Fwd: Re: Fw: [Fwd: JABLTEX boundaries]]]

Maureen,

A belated thanks for your help after a few weeks of leave. Much appreciated. I am getting really short and will now turn this over to Rick and Katrina to sort out to the best of their abilities.

Best,

Shep

-------- Original Message --------
Subject: [Fwd: Re: Fw: [Fwd: JABLTEX boundaries]]
Date: Wed, 17 Jun 2009 12:11:20 -0400
From: maureen.kenny <Maureen.Kenny@noaa.gov>
To: Shep Smith <Shep.Smith@noaa.gov>
CC: Mary Erickson <Mary.Erickson@noaa.gov>, Edward Myers <Edward.Myers@noaa.gov>

Hi Shep,

Below and attached are some information concerning your two areas of interest for using JABLTEX data. As we discussed, we had already built a hydrodynamic model for this region. The attachment shows the tidal differences in your areas of concern. The values represent the difference between MSL and MLLW. So for Nantucket, for instance, there is a difference of up to 0.3 meters from east to west or from the north side of the island to the south side. There is a lot going on tidal wise, unfortunately, in those two regions.

As for the tie to the ellipsoid, we didn't have time to get all the data on this. We did get the values for Nantucket and Chatham, but don't have the others yet. As Ed states below, there are differences between the two stations in the ellipsoid to "MSL." Nantucket is 28.777m and Chatham Lydia Cove is 28.086m. So as expected, the geoid is varying and it may not be correct to assume the Nantucket value would hold over to the west by the islands in the area of interest from where the station is. True, that may only vary by 0.1 meter, but add it to the uncertainty in the tidal part and it could be significant when combined.

The only place that would look OK for correcting is north of Lidia Cove (Chatham) along the coast and that's probably the area you least need to do I would guess.

For a clearer description, please read Ed Myers' comments below.

Our recommendation - wait until VDatum is available. My guess is that we may be able to get it out in Sept, 2010, but it's officially scheduled for Dec 2010.

Please let me or Ed Myers know if you have any questions, Mo

-------- Original Message --------
Subject: Re: Fw: [Fwd: JABLTEX boundaries]
Date: Tue, 16 Jun 2009 17:12:54 -0400
From: Edward Myers <Edward.Myers@noaa.gov>
To: 'maureen.kenny@noaa.gov' <Maureen.Kenny@noaa.gov>
CC: Zizang Yang <Zizang.Yang@noaa.gov>
References: <15F18EBD1E416843AF4B83FF39DE929E0EC66158DD@vmail5.noaa.nems>

Maureen,

It's going to take a little while to sort through the GPS database, so I am sending here what we have so far. The first two figures in the attached document show the tide model's representation of MLLW-to-(modeled)MSL. In the northern bounding box, MLLW-MSL can vary by as much as 40cm. In the box around Nantucket Island, MLLW-MSL can vary by as much as 35cm. The isolines in these first two figures show how MLLW-MSL varies in each of these two areas. The patterns of the isolines demonstrate that the changes in tides here are complex, both around Nantucket Island as well as around Cape Cod.

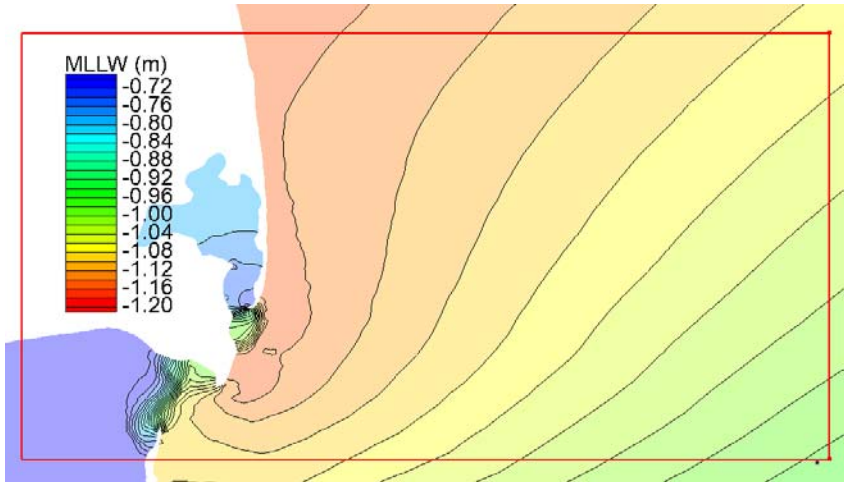
The third figure shows some of the station data available in the regions. In a conversation with Jerry Hovis of CO-OPS, it was noted that there is one benchmark for Nantucket Island and one for Chatham (Lydia Cove) that have a GPS measurement to NAD83. At the Nantucket Island benchmark location (9130 K 1981), NAD83 is 29.316/28.777 meters above MLLW/MSL, respectively. At the Chatham Lydia Cove benchmark location (7435 B), NAD83 is 29.033/28.086 meters above MLLW/MSL, respectively. Any official use of these values should be verified again with Jerry. This gives an indication of how much the relationship to NAD83 can change between these two regions, in addition to the tidal datum changes exemplified by the first two figures.

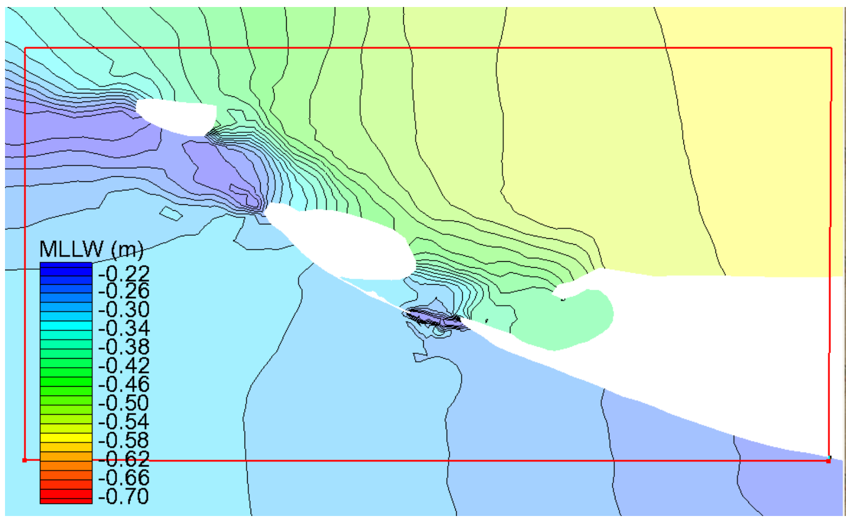
These patterns show that interpolations of the data and/or assumptions of constant offsets would most likely lead to significant errors. We would therefore recommend that the data be transformed when VDatum becomes available for this area.

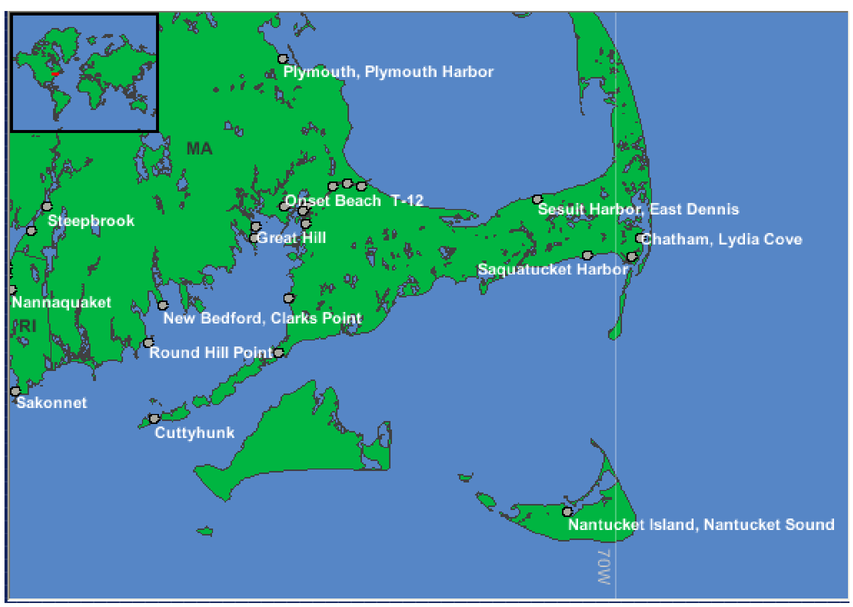
Ed

Mary Erickson wrote:
>
> Let's discuss
>
> --
> *From*: Shepard Smith
> *To*: Mary Erickson
> *Cc*: Jeffrey Ferguson
> *Sent*: Wed May 27 16:24:33 2009
> *Subject*: [Fwd: JABLTEX boundaries]
> Mary,
>
> We have two surveys from JALBLTX that are referenced vertically to
> NAVD88 and/or NAD83 ellipsoid. The bounding boxes are below, one near
> Chatham, MA, and the other off Nantucket. We need VDATUM support to
> transform the data to MLLW for update to the chart. Please advise the
> best way to proceed. I envision we would want 100m spaced points over
> the areas below with the datum difference and we can apply it from
> there.
>
> Thanks,
> Shep
>
> -------- Original Message --------
> Subject: JABLTEX boundaries
> Date: Wed, 27 May 2009 14:32:54 -0400
> From: katrina.wyllie <Katrina.Wyllie@noaa.gov>
> To: Shepard Smith <Shep.Smith@noaa.gov>
>
>
>
> Hi Shep,
>
> Still couldn't get Bathy Database to cooperate with me but here are the
> boundaries the metadata show for the two areas.
>
> W00203 (Chatham) Bounding Coordinates
> West: -70.0538
> East: -69.6355
> North: 41.8271
> South: 41.6024
>
> W00204 Bounding Coordinates
> West: -70.336772
> East: -70.135990
> North: 41.352718
> South: 41.247926
>
> Let me know what else you need.

>
> Thanks,
> Katrina
>


MLLW (m)
-0.72
-0.76
-0.80
-0.84
-0.88
-0.92
-0.96
-1.00
-1.04
-1.08
-1.12
-1.16
-1.20


MLLW (m)
-0.22
-0.26
-0.30
-0.34
-0.38
-0.42
-0.46
-0.50
-0.54
-0.58
-0.62
-0.66
-0.70


Plymouth, Plymouth Harbor
MA
Onset Beach
T-12
Sesuit Harbor, East Dennis
Steepbrook
Great Hill
Chatham, Lydia Cove
Saquatucket Harbor
Nannaquaket
RI
New Bedford, Clarks Point
Round Hill Point
Sakonnet
Cuttyhunk
Nantucket Island, Nantucket Sound
70W

From: "LCDR Rick Brennan, NOAA" <Richard.T.Brennan@noaa.gov>
To: "Katrina Wyllie" <Katrina.Wyllie@noaa.gov>
Sent: Thursday, December 10, 2009 10:29 AM
Attach: Chatham Update.eml
Subject: [Fwd: Chatham Update]

FYI - I knew I had documented this somewhere.
--

LCDR Rick Brennan, NOAA
Chief, Atlantic Hydrographic Branch
439 West York Street
Norfolk, VA 23510
Office: 757-441-6746
Cell: 443-994-3301

Learn about "America's Seventh Service":
www.noaacorps.noaa.gov
Learn about NOAA's Office of Coast Survey:
www.nauticalcharts.noaa.gov

LCDR Rick Brennan, NOAA wrote:

> Shep,
>
> Attached is a grid called LIDARminus29047mm.csar. It is a third generation version (done today) and I feel that it is as good as it will get doing a single point datum transformation. You can see where things get a little wonky in the datum field, but I feel much more confident than I did earlier. Here is what I did:
>
> NGS Datum Sheet listed the Ellipsoid height for station 8447435 as -24.214m. I added this to the MLLW elevation for this same benchmark taken from the CO-OPS web page of 4.833 to get an offset of 29.047m. The difference between the MLLW and MHW was 1.795m, so I created a color range file where 100m - 6m was dark blue, 6m - 0m was light blue, 0m - -1.795m was olive, -1.795m - -40.0m was green. Once this color range file was mapped onto the grid, things seemed to align nicely with the ortho photos.
>
> Folks here have already left so not sure where this SHPO FTP site is. The csar file is over 27Mb. Not that will make it through your tiny straw, so I will post it in the morning along with all the support files. I will try to send the csar file itself under a separate e-mail just in case you can pull it down.
>
> Rick
> --
>
> LCDR Rick Brennan, NOAA
> Chief, Atlantic Hydrographic Branch
> 439 West York Street
> Norfolk, VA 23510

Office: 757-441-6746
Cell: 443-994-3301

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From: "LCDR Rick Brennan, NOAA" <Richard.T.Brennan@noaa.gov>
To: "Katrina Wyllie" <Katrina.Wyllie@noaa.gov>; "Edward Owens" <Edward.Owens@noaa.gov>
Sent: Monday, August 09, 2010 2:57 PM
Attach: [Fwd_ [Fwd_ Chatham Harbor, MA Shoal Mess]].eml
Subject: [Fwd: [Fwd: [Fwd: Chatham Harbor, MA Shoal Mess]]]

Katrina,

Please ensure that you reference in survey W00203 (both by Bluenote and in the H-Cell Report) the need to chart the DTON from D00149. Also, please include this e-mail in Appendix 5.

Rick
--

LCDR Rick Brennan, NOAA
Chief, Atlantic Hydrographic Branch
439 West York Street
Norfolk, VA 23510
Office: 757-441-6746
Cell: 443-994-3301

Learn about "America's Seventh Service":
www.noaacorps.noaa.gov
Learn about NOAA's Office of Coast Survey:
www.nauticalcharts.noaa.gov

Jeffrey Ferguson wrote:

> Rick
>
> FYI and possible action. Should we just have AHB compile D00149 and W00203 into a single HCell and have MCD apply them all at once?
>
> Or just tell MCD not to worry, you'll have the DTON applied to the W00203 compilation/HCell which is in works now.
>
> Let me know what you think,
> Jeff
>
> -------- Original Message --------
> Subject: [Fwd: Chatham Harbor, MA Shoal Mess]
> Date: Mon, 09 Aug 2010 14:10:10 -0400
> From: Tara Wallace <Tara.Wallace@noaa.gov>
> To: Doug Baird <Doug.Baird@noaa.gov>, Brian Mohr <Brian.Mohr@noaa.gov>, Jeffrey Ferguson <Jeffrey.Ferguson@noaa.gov>
> CC: John Barber <John.Barber@noaa.gov>

Gentlemen ~

Below are the events related to the Chatham Harbor DTON that NDB received. Do we have a deliverable date for the survey?

Thanks,
Tara

-------- Original Message --------
Subject: Chatham Harbor, MA Shoal Mess
Date: Fri, 06 Aug 2010 15:37:08 -0400
From: ocs.ndb <OCS.NDB@noaa.gov>
To: Tara Wallace <Tara.Wallace@noaa.gov>
CC: Lance Roddy <Lance.Roddy@noaa.gov>

Tara,

The purpose of this message is to summarize again what's going on in Chatham Harbor, MA in order to explain the attached documents.

1. LIDAR survey W-00203 was performed in Chatham Harbor. In support of that survey, D-00149 was performed which located a shoal. The shoal was not located via W-00203.

2. W-00203 will deepen the charted soundings in the area, but it hasn't been received by MCD yet.
3. A DtoN for the shoal in D-00149 was submitted (L-5/10). Because W-00203 hasn't been applied, the DtoN is deeper than the soundings currently charted and the DtoN was no corrected. We don't know if AHB was made aware of the no correction of the DtoN and why it wasn't applied.

4. Now D-00149 has been received by NDB. Its sole purpose is to report again on the shoal that was already received via the DtoN. Because W-00203 hasn't been received by MCD or applied, if D-00149 is applied by MCD now, it will be no corrected, just like the DtoN.

Problem
If there is no mention of the shoal in W-00203 and we apply D-00149 now, the information about the shoal will be lost.

Resolution Possibility
Hold off on releasing D-00149 to PBC until W-00203 is received. Release both at the same time, cross-referenced to one another, and indicate in the records' Comments field that the surveys should be applied together. Provide feedback to AHB explaining this course of action.

Another Resolution Possibility
Register D-00149 as a History document with W-00203 FYI referenced to it and the appropriate Comments. Work with AHB/HSD Ops to ensure that the shoal is included in W-00203's deliverables. When W-00203 is registered, FYI reference D-00149 and L-5/10 to it with the appropriate comments.

**Along with hydro changes, major shoreline changes have occurred in the area. A recent GC is not available, so Lance has submitted a Shoreline Data Request to RSD.

-Diane

This Document is for Office Process use only and is intended to supplement, not supersede or replace, information/recommendations in the Descriptive or Evaluation Reports

AHB COMPILATION LOG

General Survey Information	
REGISTRY No.	**W00203**
PROJECT No.	**OSD-AHB-09**
FIELD UNIT	**FUGRO - BEECHCRAFT KING AIR 90** with **SHOALS-1000T**
DATE OF SURVEY	**20070630-20070717**
LARGEST SCALE CHART	***13248, edition10, March 2001, 1:20,000***
ADDITIONAL CHARTS	***13229_2, edition 30, April 2008, 1:20,000***
SOUNDING UNITS	**feet**
COMPILER	**Wyllie**

Source Grids	**File Name** H:\Compilation\W00203_JALBTX_08\AHB_W00203\SAR Final Products\GRIDS
	LidarMinus29047mm.csar
Surfaces	**File Name** H:\Compilation\W00203_JALBTX_08\AHB_W00203\COMPILE\Working
Interpolated TIN	\Interpolated TIN**W00203_10m_InterpTIN.csar**
Shifted Interpolated TIN	\Shifted Surface**W00203_10m_InterpTIN_Shifted.csar**
Final HOBs	**File Name** H:\Compilation\W00203_JALBTX_08\AHB_W00203\COMPILE\Final_Hobs
Survey Scale Soundings	**W00203_SS_Soundings.hob**
Chart Scale Soundings	**W00203_CS_Soundings.hob**
Contour Layer	**W00203_Contours.hob**
Feature Layer	**W00203_Features.hob**
Meta-Objects Layer	**W00203_MetaObjects.hob**
Blue Notes	**W00203_BlueNotes.hob**

Meta-Objects Attribution	
Acronym	**Value**
M_COVR	
CATCOV	Coverage available
SORDAT	20070717
SORIND	US,US,graph,W00203
M_QUAL	
CATZOC	Zone of confidence U (data not assessed)
INFORM	Fugro - Beechcraft King Air 90 with SHOALS-1000T
POSACC	10
SORDAT	20070717
SORIND	US,US,graph,W00203
SUREND	20070717
SURSTA	20070630
DEPARE	
DRVALV 1	-6.8898ft
DRVALV2	54.1339ft
SORDAT	20070717
SORIND	US,US,graph,W00203

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SPECIFICATIONS:

I. COMBINED SURFACE:

a. Number of SAR Final Grids: 1
b. Resolution of Source (m): 5

II. SURVEY SCALE SOUNDINGS (SS):

a. Radius
b. Shoal biased
c. Use Single-Defined Radius (mm at Map Scale): Sounding Space Range Table: W00203_SS_SSR.txt
d. Queried Depth of All Soundings
    i. Minimum: -6.8898ft
    ii. Maximum: 54.1339ft
e. Filter: Interpolated != 1

III. INTERPOLATED TIN SURFACE:

a. Resolution (m): 10
b. Linear
c. Shifted value: -0.75ft

IV. CONTOURS:

a. Use a Depth List: W00203_NOAA_depth_curves_list.txt
b. Line Object: DEPCNT
c. Value Attribute: VALDCO

V. CHART SURVEY SOUNDINGS (CS):

a. Number of ENC CS Soundings:900
b. Radius
c. Shoal biased
d. Use Single-Defined Radius: Sounding Space Range Table: W00203_CS_SSR.txt
e. Filter: Interpolated != 1
f. Number Survey CS Soundings:1108

ATLANTIC HYDROGRAPHIC BRANCH
H-CELL REPORT to ACCOMPANY
SURVEY W00203 (2007)

This H-Cell Report has been written to supplement and/or clarify the original Descriptive Report. Sections in this report refer to the corresponding sections of the Descriptive Report.

B. DATA ACQUISITION AND PROCESSING

B.2. QUALITY CONTROL

B.2.1. H-Cell

The AHB source depth grid for the survey's nautical chart update product entailed first obtaining the XYZ++ files from JALBTCX personnel. The XZY files were imported into CARIS BathyDataBASE 2.3 using the import wizard and a customized XYZ Format Information File. A TIN (Triangulated Irregular Network) was generated from the data points. This original surface was referenced to NAVD88, not the MLLW chart datum. The transformation from NAVD88 to MLLW of the LIDAR data could not be done with VDATUM because it is not available in this area until December 2010. Instead, benchmark station 8447435 was used as a single point transformation for the entire LIDAR survey area. The ellipsoid height at the benchmark is -24.214m and this value was added to the MLLW benchmark height (4.833m) for a total offset value of 29.047m. The LIDAR surface was shifted in CARIS BathyDataBASE 2.3 by the total offset value (29.047m) to correct to MLLW.

To compare and validate the transformation from NAVD88 to MLLW, the *Thomas Jefferson* was assigned reconnaissance survey D00149 and acquired MBES data in the same area as the LIDAR data. The track lines for this data were particularly planned to allow a source of comparison between traditional, tidally adjusted data with the single-point transformation employed with this survey. Small vertical differences can be associated with the two year time period between LIDAR acquisition and MBES acquisition as well as the sediment movement. Chart 13248 also indicates the area is highly changeable and local knowledge should be used.

A difference surface between the LIDAR and MBES data was performed. The absolute values of the differences have an average of 0.266m and a standard deviation of 0.34m. This statistical analysis also showed that

- 73.7% of the nodes in this difference surface are 0.3m or less
- 4.3% of the nodes are greater than 1m
- 95% of the differenced nodes are 0.92 meters or less

A comparison in CARIS BathyDataBASE 2.3 of preliminary survey scale (SS) soundings and chart scale (CS) soundings (a subset of survey scale soundings) was performed. The majority of the LIDAR CS soundings incorporated the TJ soundings seamlessly. There have been major charting discrepancies found during this survey, specifically a new breach in the barrier island off Chatham. In light of these changes, the transformation from NAVD99 to MLLW using a single point adjustment has been deemed a reasonable technical approach to support improving the navigational safety of the areas mariners.

The survey scale soundings were created from the source grid at using a Sounding Spacing Range file, W00203_SS_SSR.txt at 1:20,000 as well as a filter to exclude any interpolated nodes from the original grid. The chart scale selected soundings are a subset of the survey scale selected soundings. The surface model was referenced when selecting the chart scale soundings, to ensure that the selected soundings portrayed the bathymetry within the common area.

A TIN (Triangulated Irregular Network) surface was created from the survey scale soundings from which an interpolated surface was generated for the purpose of automatically generating depth contours. These contours were minimally edited and forwarded to MCD for reference only. The contours were utilized during chart scale sounding selection and quality assurance efforts at AHB. The depth contours are incorporated into the SS H-Cell product as per 2009 H-Cell Specifications.

The pre-compilation products or components (Stand Alone HOB files (SAHOB)) are detailed in the Compile Log attached directly before this H-Cell Report. The SAHOB files included depth areas (DEPARE), depth contours (DEPCNT), sounding selections (SOUNDG), features (COALNE, MORFAC, OBSTRN, SBDARE, SISTAW, SLCONS, UWTROC, WEDKLP, and WRECKS), Meta objects (M_COVR, M_QUAL), and cartographic Blue Notes ($CSYMB).

All of the components with the exception of the sounding selection and depth contours were inserted into one feature layer (including the Blue notes, as dictated by Hydrographic Technical Directive 2008-8 and HSD’s H-Cell Specifications 2009). The SAHOB H-Cell layers were exported to S-57 format for the H-Cell deliverable. W00203 H-Cell chart scale soundings were selected based upon the scale of the applicable chart. The H-Cell’s SS deliverable includes survey scale selected soundings and depth contours.

The SAHOB's were exported from CARIS Bathy DataBASE to a metric S-57 file (W00203_SS_metric.000 and W00203_CS_metric.000). These files were then opened in CARIS HOM and were converted from metric to chart units (feet) and exported for delivery to MCD. The final deliverables are two S-57 files; one that contains the chart scale soundings, all the features, meta objects, and blue notes (W00203_CS.000), and one that contains the survey scale sounding selections and depth contours (W00203_SS.000). Quality assurance checks were made utilizing CARIS S-57 Composer 2.0 validation checks and dKart Inspector 5.0 tests.

Chart compilation was performed by Atlantic Hydrographic Branch personnel in Norfolk, Virginia. Compilation data will be forwarded to Marine Chart Division, Silver Spring, Maryland.

W00203 CARIS H-Cell final deliverables include the following products:

W00203_CS.000	1:20,000 Scale	W00203 H-Cell with Chart Scale Selected Soundings
W00203_SS.000	1:20,000 Scale	W00203 Selected Soundings (Survey Scale)

B.4 DATA PROCESSING

The following software was used to process data at the Atlantic Hydrographic Branch:

CARIS Bathy DataBASE version 2.3 SP1 HF 1-16
CARIS Bathy DataBASE version 2.1 SP1 HF 1-10
CARIS S-57 Composer version 2.1 HF 1-4
DKART INSPECTOR, version 5.0 Build 732 SP1
CARIS HOM version 3.3 SP3 HF 8

C. VERTICAL AND HORIZONTAL CONTROL

Global Positioning System (GPS) data acquired simultaneously with the LiDAR were processed using Post Processed Kinematic methods and vertically referenced to the NAVD88 Ellipsoid by the field unit. The ellipsoidally referenced grid data resulting from this LiDAR survey was adjusted vertically to the MLLW chart datum using a single-point offset based on NGS values provided for water level station 8447435. While this transformation is not ideal, the criticality of the changes mapped during this survey were considered to outweigh any uncertainties that may arise from this datum conversion. To confirm this datum adjustment was valid, it was requested that NOAA Ship *Thomas Jefferson* run a comparison line through the main areas to be charted from this survey. These MBES lines were acquired referenced to the MLLW chart datum and served to inform AHB of the quality of their ellipsoid-MLLW adjustment. This comparison showed that the agreement was excellent across the survey area with 73.3% of the data agreeing within 0.3 meters – even with a two year difference in their acquisition times. The area of largest difference was in the approach to Chatham Harbor in deep water and an area known for its shifting sediment. See section B.2 above for further details of this analysis.

Horizontal control used for this survey during data acquisition is based upon the North American Datum of 1983 (NAD83), UTM projection zone 19N.

D. RESULTS AND RECOMMENDATIONS

D.1 CHART COMPARISON

13248 (10th Edition, Mar. /01)
Corrected through NM 08/14/2010
Corrected through LNM 08/03/2010
Scale 1:20,000

13229_2 (30th Edition, Apr./08)
Corrected through NM 08/14/2010
Corrected through LNM 08/03/2010
Scale 1:20,000

ENC Comparison

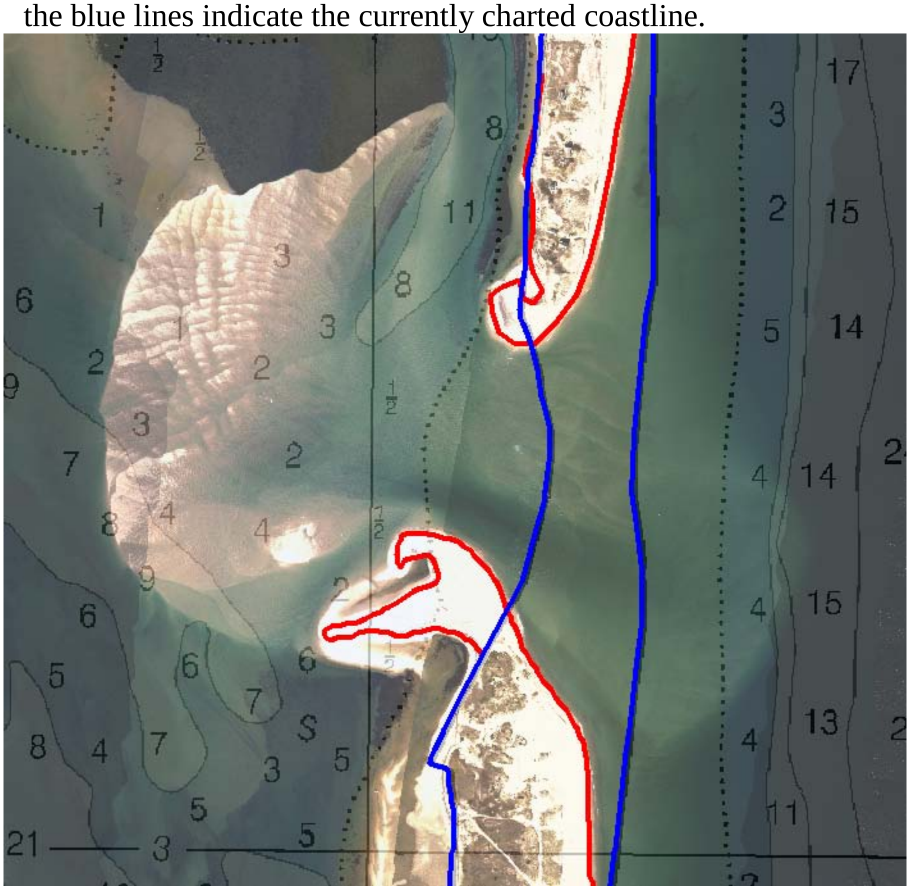
US5MA34M
Chatham Harbor and Pleasant Bay
Edition 1
Application Date 10/23/2009
Issue Date 10/23/2009
Chart 13248

D.1.1 Hydrography

The charted hydrography originates with prior surveys and requires no further consideration. The hydrographer makes adequate chart comparisons in section "D" and Appendix I and II of the Descriptive Report. Exceptions include:

a. Survey D00149 was completed in order to provide a baseline dataset for ellipsoid-referenced LIDAR survey W00203 and confirm the accuracy of the vertical datum transformation. The resolution of the sonar used for D00149 was able to identify an obstruction at 41-38-39.0509N, 69-56-11.5858W with a least depth of 30.2360ft which was not detected by the LIDAR used for survey W00203. The LIDAR data had a depth of 36ft at the location of the feature, thus not capturing the feature. It is recommended to include an 30ft obstruction at the D00149 surveyed location. See D00149 Chart Letter for more information. W00203_CS.000 includes a blue note ($CSYMB) at this location.
b. Eight new coastline features are included in W00203_CS.000 H-Cell. Only the most egregious shoreline updates are included. Orthoimagery from 2007, same year the LIDAR data was collected, was referenced while delineating new shore line as well as the MHW value of -6.8898ft. As per the conversation in Appendix V, this area will be surveyed by RSD this field season and the entire shoreline area will be updated.

   One of the most egregious shoreline examples is the breach in the barrier island off Chatham (41-42-17.2931N, 069-55-49.2076W), shown below. The red lines indicate the new coastline features included in W00203_CS.000 and the blue lines indicate the currently charted coastline.



Another example of the shoreline updates included in W00203_CS.000 is shown below, located at 41-40-01.6413N, 69-56-47.7574W.

c. All features, with the exception of the 8 COALNE features discussed previously, are to be retained as charted.

D.6. MISCELLANEOUS

Chart compilation was done by Atlantic Hydrographic Branch personnel, in Norfolk, Virginia. Compilation data will be forwarded to Marine Chart Division, Silver Spring, Maryland. See Section D.1. of this report for a list of the Raster Charts and Electronic Navigation Charts (ENC) used for compiling the present survey:

D.7. ADEQUACY OF SURVEY

The present survey is adequate to supersede the charted bathymetry within the common area. Any features not specifically addressed either in the H-Cell BASE Cell File or the Blue Notes should be retained as charted.

Considering the state of the chart compared to the W00203 data, the transformation from NAVD88 to MLLW by one value correction does not negatively affect this area for a preliminary chart update. W00203 was processed in an effort to bring cartographic relief to the area.

APPROVAL SHEET
W00203

Initial Approvals:

The completed survey has been inspected with regard to survey coverage, delineation of depth curves, representation of critical depths, cartographic symbolization, and verification or disproval of charted data. All revisions and additions made to the H-Cell files during survey processing have been entered in the digital data for this survey. The survey records and digital data comply with National Ocean Service and Office of Coast Survey requirements except where noted in the Descriptive Report and the Evaluation Report.

All final products have undergone a comprehensive reviews per the Hydrographic surveys Division Office Processing Manual and are verified to be accurate and complete except where noted.

Digitally signed by Katrina Wyllie
DN: cn=Katrina Wyllie, o=NOAA, ou=AHB, email=katrina.wyllie@noaa.gov, c=US
Date: 2010.08.27 12:10:56 -04'00'

Katrina Wyllie
Hydrographic Intern
Atlantic Hydrographic Branch

I have reviewed the H-Cell files, accompanying data, and reports. This survey and accompanying Marine Chart Division deliverables meet National Ocean Service requirements and standards for products in support of nautical charting except where noted.

Richard T. Brennan
I am approving this document
2010.08.31 18:28:52 -04'00'

Approved: ______________________________
Richard T. Brennan
Commander, NOAA
Chief, Atlantic Hydrographic Branch

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: 2010.09.03 08:33:12 -04'00'