NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey Relative Reflectivity

Project No. N/A

Registry No. N/A

LOCALITY

State Puerto Rico

General Locality Southwest Puerto Rico

Sublocality N/A

2007

PROJECT MANAGER
DARREN STEPHENSON

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DATE

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DESCRIPTIVE REPORT TO ACCOMPANY

RELATIVE REFLECTIVITY

FROM LIDAR DATA COLLECTED IN 2006

TENIX LADS AIRCRAFT, VH-LCL

TENIX LADS, INC. (TLI)

DARREN STEPHENSON, PROJECT MANAGER

PROJECT
Project Number: N/A
Date of Instructions: July 03, 2007

Original: DG 133C-06-CQ-0066
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Date of Supplemental Instructions:

PURPOSE

To provide the Center for Coastal Monitoring and Assessment of NOAA with relative reflectivity data from the seabed for the southwest of Puerto Rico. The relative reflectivity will be derived from lidar bathymetric data collected during April/May 2006 by TLI.

BACKGROUND

The processing of the bathymetric lidar data using a reflectance algorithm will provide the Center for Coastal Monitoring and Assessment of NOAA with seabed relative reflectivity. The relative reflectivity will be derived from lidar bathymetry data collected in southwest Puerto Rico. During April/May 2006 under contract to the National Ocean Service, TLI collected airborne lidar bathymetry under Contract Number DG133C-03-CQ-0011, Task Order T0008 and Project Number OPR-I305-KRL-06 and it is from this data that the relative reflectivity will be derived. The data was also processed to deliver bathymetry products and reports under Task Order 8.

A. AREA SURVEYED

Between April 7 and May 15, 2006, the LADS Mk II aircraft deployed to Puerto Rico for the project OPR-I305-KRL-06. During this period 21 survey sorties were flown under Task Order 8, Southwest Puerto Rico. Survey operations covered 11 survey registry numbers (See Figure 1). The coverage obtained by applying the relative reflectivity algorithm is illustrated in Figure 2.

The bathymetric data collected was with a 4 meter spot spacing and 200% seabed coverage that is compliant to the NOS Specification and Deliverables for bathymetry. The aircraft flew for a total of 134 hours from San Juan airport and flew a total of 102 hours for actual data acquisition. The total area acquired was 265 square nautical miles.

Environmental factors such as wind strength and direction, cloud cover, and water clarity influenced the area of data acquisition on a daily basis. See section B.2 Quality.

The coverage area is approximately bounded by the following polygon:

Vertex	**Latitude (NAD83)**	**Longitude (NAD83)**
1	18° 12’ 00” N	67° 27’ 00” W
2	18° 05’ 00” N	67° 27’ 00” W
3	18° 52’ 00” N	67° 18’ 00” W
4	18° 52’ 00” N	66° 57’ 00” W
5	17° 59’ 00” N	66° 57’ 00” W
6	17° 59’ 00” N	67° 09’ 00” W
7	18° 12’ 00” N	67° 09’ 00” W

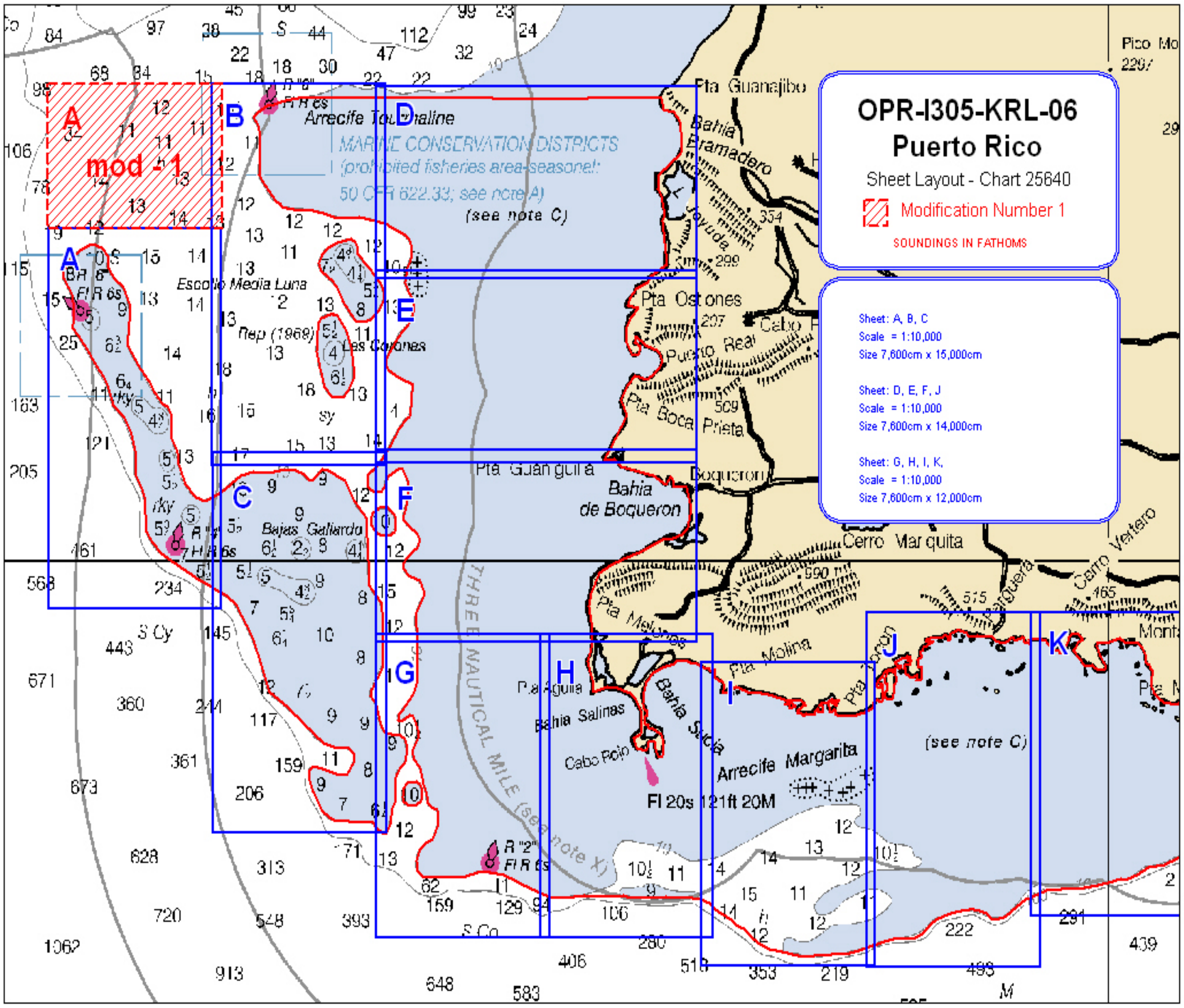

Figure 1 - Task Order 8 OPR-I305-KRL-06 Modification 1

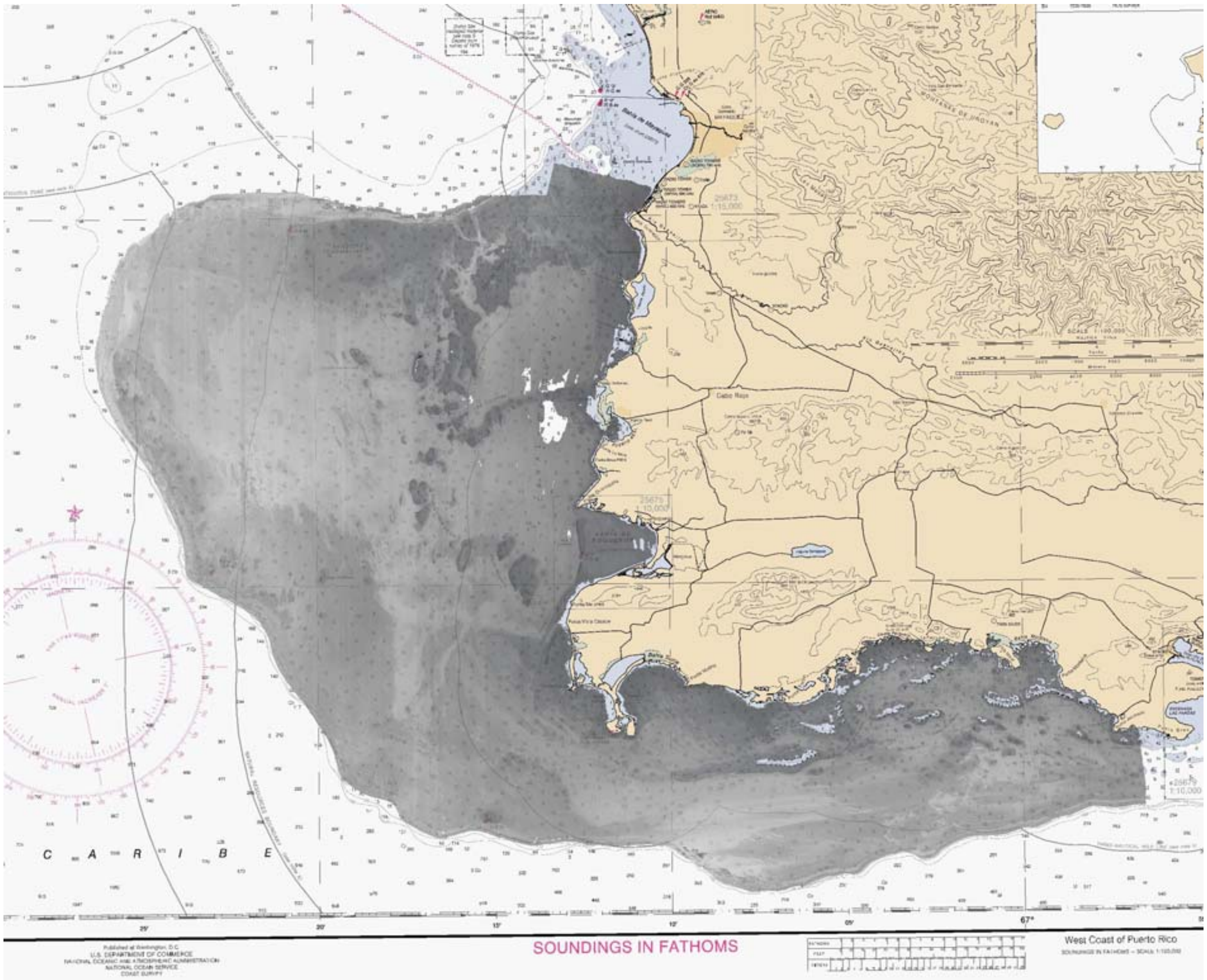

Figure 2 – Relative Reflectivity from the data collected during Task Order 8 OPR-I305-KRL-06 Modification 1

B. ACQUISITION AND PROCESSING

Refer to the Data Acquisition and Processing Report for a detailed description of the equipment, processing and quality control procedures that was delivered as part of project OPR-I305-KRL-06. A general description and items specific to this survey are discussed in the following sections.

B.1 EQUIPMENT

Data collection was conducted using the LADS Mk II Airborne System, data processing using the LADS Mk II Ground System and data visualization, quality control and final products using CARIS HIPS and SIPS 6.1 and CARIS BASE Editor 2.1.

B.1.1 Airborne System

The LADS Mk II Airborne System (AS) consists of a Dash 8-200 series aircraft, which has a transit speed of 250 knots at altitudes of up to 25,000ft and an endurance of up to eight hours. Survey operations are conducted from heights between 1,200 and 2,200ft at ground speeds between 140 and 175 knots. The aircraft is fitted with a Nd: YAG laser, which is eye safe in accordance with ANSI Z136.1-2000, American National Standard for Safe Use of Lasers. The laser operates at 900 Hertz from a stabilized platform to provide a number of different spot spacings.

Green laser pulses are scanned beneath the aircraft in a rectilinear pattern. The pulses are reflected from the land, sea surface, within the water column and from the seabed. The height of the aircraft is determined by the infrared laser return, which is supplemented by the inertial height from the Attitude and Heading Reference System and GPS height. Real-time positioning is obtained by an Ashtech GG24 GPS receiver combined with Wide Area DGPS provided by the Fugro Omnistar to provide a differentially corrected position. Ashtech Z12 GPS receivers are also provided as part of the Airborne System and Ground Systems to log KGPS data on the aircraft and at a locally established GPS base station. For more details on the airborne system, refer to the Data Acquisition and Processing Report.

B.1.2 Ground System

The LADS Mk II Ground System (GS) was used to conduct data processing in the field. It consists of a portable Compaq Alpha ES40 Series 3 processor server with 1 GB EEC RAM, 764 GB disk space, digital linear tape (DLT) drives and magazines, digital audio tape (DAT) drive, CD ROM drive and is networked to up to 12 Compaq 1.5 GHz PCs and a HP 800ps Design Jet Plotter, printers and QC workstations.

The GS supports survey planning, data processing, quality control and data export. The GS component also includes a KGPS base station, which provides independent post-processed position and height data. A comprehensive description of the GS is provided in the Data Acquisition and Processing Report delivered for project number OPR-I305-KRL-06.

The LADS ground system includes a reflectivity algorithm in which reflectivity is calculated for each sounding as the ratio of returned energy to transmitted energy, normalized for losses.

B.2 QUALITY CONTROL

B.2.1 Data Density

The survey area was sounded at 4x4m laser spot spacing with main lines of sounding spaced at 80m, which provided the required 200% coverage.

At the sea surface the footprint of the laser beam is approximately 2.5m in diameter. As the beam passes through the water column, it slowly diverges due to scattering. It should be noted that at 4x4m laser spot spacing, there is a gap of 1 to 1.5m between the illuminated areas of adjacent soundings at the sea surface. There is a possibility that small objects in shallow water along the coastline may fall between consecutive 4x4m soundings and not be detected. It should also be noted that a single reflectivity value is calculated per pulse, so some spatial filtering occurs.

This data was run through the reflectivity algorithm and the resulting data was imported into CARIS BASE Editor where the data was gridded at 5 meters.

B.2.2 Water Clarity

The water clarity in the survey area was ideal for laser bathymetry as the water was very clear. Coverage was obtained for the majority of the survey area. The only area where coverage was not achieved was due to turbidity or very shallow water. Water depths to 50m were achieved at the extent of the predominant reef structure in SW Puerto Rico. The majority of the survey area is less than 20m deep. There are a number of areas throughout the survey area where no depths were achieved due to turbidity or very shallow water and they are described in section D. The water clarity in some areas did vary on a daily basis, which required careful management. Additional survey lines were planned and flown to minimize the data gaps due to turbidity. Significant variations, temporally or spatially in turbidity may impact the reflectivity algorithm.

B.2.3 Data Management

The database is identified as follows:

Database Name	General Locality
06_3CaboRojo	Southwest Puerto Rico

A detailed table of survey line numbers is presented in the Data Acquisition and Processing Report.

B.2.4 Data Acquisition

Survey operations were conducted when suitable weather conditions prevailed. The first survey sortie was flown on April 9, 2006.

In general, the aircraft departed at 7 a.m. local time, prior to the build up of thunderstorms in the early afternoon.

B.2.5 Sea Conditions - Sea State, Waves, Swell, White Water

The sea state ranged from 1 to 3 throughout the survey and was generally between states 1 and 2 as determined from the Beaufort Wind Scale. This did not affect data quality.

Calm seas were experienced on occasions in the sheltered bays along the west and south coasts. Depending on the wind direction, calm seas occurred inshore of exposed reefs as well. Under such calm conditions, the sea may become glassy which degrades the sea surface model.

Long period swell was not significant during the survey, however an allowance has been made in the assessment of accuracy.

B.2.6 Nature of the Seabed

The seabed throughout the survey area is very complex with large reef structures and it is strewn with coral reefs, small coral outcrops protruding from the seabed and coral heads.

B.2.7 Wind

Survey operations were conducted in wind strengths of up to 20 knots during the survey. In general, the wind strength during the time of survey was around 10 knots from the southwest.

During the morning wind strengths would increase slightly.

B.2.8 Cloud

Low cloud coverage was not a significant factor for the survey. During the early afternoon the clouds would build up over land and move offshore. The occurrence of cloud buildup offshore increased towards the end of the survey. The effects of low cloud coverage were managed as follows upon completion of the data collection phase of the survey:

a. Limited weather forecasts were available for the actual survey area. Weather conditions were interpolated from generic weather Internet sites and local media weather forecasts.
b. For long-term trends the National Weather Service in San Juan provided information.
c. An Internet site showed the current San Juan radar. This proved invaluable during the later part of the survey to monitor the movement of thunderstorms. This Internet site is http://www.wunderground.com/radar/.

B.2.9 Effects of High Ground

For this survey the high ground was not an issue and the majority of the survey lines were flown at 1,600ft.

B.2.10 Receiver Gain

Changes in gain levels in the Airborne System automatically accommodate for changes in the sea surface, water column and seabed conditions. Changes in gain are normalized in the reflectance algorithm and do not effect the quality of relative reflectivity data.

B.2.11 Raw Laser Waveforms

The raw laser waveforms become dispersed in very complex areas, such as coral reefs, and in such areas the bottom object detection algorithm in the GS was used to define the extents and least depth of features.

The return energy for each laser sounding is calculated by integrating the waveform to produce a value of returned energy for each sounding. The amount of energy reflected from the seabed is a measure of its reflectivity. Each returned energy value is normalized for losses through the water column at the receiver and at the water / air interface. Losses through the water column are determined by water clarity and path length through the water. For angles of incidence in the LADS equipment at the air / water interface are considered constant.
A reflectance value for each pulse is calculated by determining the ratio between the transmitted laser pulse energy and the compensated return laser energy.

B.2.12 Relative Reflectivity

The reflectivity data has been treated as relative. By treating the data as relative, the model is less sensitive to absolute values of water clarity, sea surface conditions and sensor operating parameters.

Relative reflectivity data is a measure of the reflectance of the seabed in a single wavelength (green/blue 532nm). The numerical values for the relative reflectivity are scaled logarithmically to an 8-bit integer range 0 – 255.

The relative reflectivity data indicates variation in reflectivity across the survey area where bathymetry was acquired. Areas of differing reflectivity are clearly apparent with higher reflectivity values indicating more reflective surfaces.
The absolute reflectivity has not been calculated. If the same area was surveyed under different conditions with a different sensor the variations in reflectivity would match but the absolute values would not.

B.2.13 Data Processing

The bathymetric data was processed at the operating site in San Juan on the return from each sortie. Final validation, checking, approving, reporting and the generation of products were conducted in Biloxi, MS.

The relative reflectivity data processing was conducted in Adelaide, South Australia.

B.2.14 Progress Sketches

Progress sketches were provided to NOAA on a biweekly basis. The final progress sketch can be found in Appendix I.

B.3 DATA PROCESSING

The reflectance XYZ data was imported into CARIS HIPS and SIPS as Singlebeam data. The reflectance data was treated much the same as ordinary XYZ data (XY horizontal position and Z as reflectance value).

The procedure used is as follows:

- Modified XYZ file to add timestamp by using the CARIS XYZ File Manipulator utility
- Created an import script using the CARIS Generic Data Parser
- Imported modified XYZ file into CARIS HIPS and SIPS
- Computed Total Propagated Error (TPE) using zero values
- Applied tide corrections using a zero value file
- Merged TPE and tide correction with data
- Created fieldsheet to compute BASE surface of reflectance data

The XYZ had to be modified to add timestamp to each data point. The XYZ file was divided into smaller files containing a maximum of 1000000 points per file.

Each modified XYZ file was imported using the CARIS Generic Data Parser, creating an import script to recognize each field attribute. Two scripts were created to import timestamps 1000000 to 9999999 and the other 10000000 to 138000000.

Once each XYZ file was imported into CARIS a generic zero tide value was applied to each modified XYZ file followed by a zero TPE value computation.

The TPE and tide calculations were then merged with the reflectance data.

A single fieldsheet was then created to incorporate six ‘mean’ BASE surfaces, gridded at a 5m resolution, which covered the entire survey area. These six BASE surfaces were combined into one surface to produce a final ‘mean’ reflectance BASE surface.

The necessity to divide the area into six initially was purely due to processing limitations.

Also, the grid resolution does not change relative to depth, as the laser pulse footprint stays relatively constant regardless of depth and the laser spot spacing is consistent irrespective of aircraft altitude. The 5m grid provides the largest amount of detail that can be supported by the lidar data density.

B.4 DATA FORMATS

Data is provided in the following formats:

- HIPS\TIDE\: Contains zero value tide file
- HIPS\GDP\: Contains Generic Data Parser scripts
- HIPS\HDCS_Data\: Contains a project of the imported reflectance XYZ data
- HIPS\HDCS_Data\VesselConfig\: Contains a vessel configuration file for the reflectance data
- HIPS\Fieldsheets\: Contains a fieldsheet covering the six sheet limits as well as a final combined BASE Surface created from the reflectance data
- HIPS\Preprocess\: Contains the original XYZ reflectance file as well as the modified XYZ file(s)
- HIPS\Session\: Contains CARIS HIPS & SIPS session files for each sub-area (6) and the final reflectance surface
- ASCII_XYZ_Reflectance\: ASCII XYZ relative reflectance data, gridded at 5m mean.
- ACSII_XYZ_Bathymetry\: ASCII XYZ lidar bathymetric data, one gridded at 4m mean and the other gridded at 5m shoal bias.
- COVERAGE\: Coverage graphic supplied as a TIFF/TFW of entire survey area for both reflectance and bathymetric datasets.
- BAG\: Mean 5m gridded relative reflectance surface, shoal biased 5m gridded bathymetric surface (produced from 5m clashed radial dataset) and a mean 4m gridded bathymetric surface.
- REPORTS\: Data Acquisition and Processing Report for I305 (.doc) and a Descriptive Report (.doc)

B.5 POSITION CHECKS

Two independent positioning systems were used during the survey. Real-time positions were aided by WADGPS. A post-processed KGPS position was also determined relative to a local GPS base station that was established on the rooftop of the Courtyard Marriott Hotel in San Juan. The post-processed KGPS position solutions were applied to each sounding during post-processing and the height used in the datum filter.

Position checks were conducted prior to, during and following data collection as follows:

a. DGPS Site Confirmation. A 24-hour certification was conducted of the local GPS base station established on the roof of the Courtyard Marriott Hotel in San Juan. The results reveal that the local GPS base station is free from site specific problems such as multipath and obstructions.

b. Static Position Check. Prior to commencing data collection, the coordinates of the aircraft GPS antenna were determined relative to four NGS-CORS Base Stations in the southeast Puerto Rico area. Data was then logged by each LADS Mk II positioning system, enabling the positions to be checked against the NGS-CORS coordinated position of the aircraft GPS antenna. The accuracy of the post-processed KGPS solution during the static position check was 0.133m (95% confidence). The results and details of the static position check are enclosed in the Vertical and Horizontal Control Report for project OPR-I305-KRL-06.

c. Dynamic Position Check. During each sortie, GPS data was logged on the aircraft and at the local GPS base station. This provided a check between the real-time and post-processed GPS position solutions. The mean difference between the real-time and post-processed position was 0.873m, with an average standard deviation of 0.206. Details are provided in the Vertical and Horizontal Control Report for project OPR-I305-KRL-06.

d. Navigation Position Check. Navigation checks were also conducted over a coordinated point on the roof of the terminal at Mayaguez airport. This enabled the known position of the structure to be checked against the image on the downward looking video. This provided a gross error check of position. The mean error was 1.9m with a standard deviation of 3.62m. Details are provided in the Separates Report for project OPR-I305-KRL-06.

e. Position Confidence. The position quality was also monitored by checking a post-processed position confidence (C3), which is determined from the AS platform error, GPS error and residual errors between the actual GPS positions and aircraft position as determined from the line of best fit. No position anomalies were detected.

The position checks were within the expected tolerances and showed that the positioning systems were functioning correctly during the survey.

C. HORIZONTAL CONTROL

Refer to the Vertical and Horizontal Control Report for a detailed description of the vertical and horizontal control used during this survey. The Vertical and Horizontal Control Report was delivered as part of project OPR-I305-KRL-06. A summary of vertical and horizontal control for the survey follows.

C.1 HORIZONTAL CONTROL

Data collection and processing were conducted on the Airborne and Ground Systems in World Geodetic System (WGS84) on Universal Transverse Mercator (Northern Hemisphere) projection UTM (N) in Zone 19, Central Meridian 69° W. All units are in meters. This data was post-processed and all soundings are relative to the North American Datum 1983 (NAD83).

C.1.1 LADS Local GPS Base Station – Puerto Rico

Real-time positions were determined using an Ashtech GG24 GPS receiver aided by Wide Area Differential GPS (WADGPS). A local GPS base station was coordinated by John Oswald and Associates on the roof of the Courtyard Marriott Hotel, San Juan on March 7, 2006.

The derived NAD83 coordinates for the local GPS base station, are:

NAD83		**UTM (N) Zone 19**		
Latitude (N)	**Longitude (W)**	**Easting (m)**	**Northing (m)**	**Ellipsoidal Height (m)**
18° 27' 20.277"	66° 04' 56.271"	808 179.880	2 043 081.721	13.599

Post-processed KGPS positions were determined off-line using data logged at the local GPS base station and on the aircraft. This data was processed through Ashtech PNAV software to calculate both a DGPS and KGPS position solution. The post-processed KGPS positions were then imported into the GS and applied to all soundings. This provided increased sounding position accuracy and horizontal redundancy.

The local GPS base station site was checked for obstructions and multipath over a 24-hour period on April 20 and April 21, 2006. The results outlined in the Vertical and Horizontal Control Report reveal that the local GPS base station site is free from site specific problems such as multipath and obstructions.

On April 12, 2006 static position checks of the LADS Mk II positioning systems were undertaken. The results outlined in the Vertical and Horizontal Control Report revealed no gross errors and that all positioning systems functioned correctly.

During each sortie, GPS data was logged both on the aircraft and at the local GPS base station, which enabled a post-processed KGPS position solution to be determined. These positions were then compared to the position determined by the real-time positioning system. This dynamic positioning check provided quality control of the positioning systems, and the positional differences were within tolerance for the survey. These differences are tabulated in the Vertical and Horizontal Control Report.

Navigation position checks were attempted over the terminal at the Mayaguez airport during each sortie when suitable weather conditions prevailed. Following each sortie the logged aircraft position was processed against the downward looking video record to determine the difference in position at the time of overflight. This provided a gross error check on the aircraft positioning.

The tabulated results are presented in the Vertical and Horizontal Control Report and revealed that the positioning systems functioned to within expectations.

D. DATA GAPS AND ANOMALIES

There are some gaps in the data due to turbidity and very shallow water. Also there are some anomalies in the data due to an intermittent laser problem on the last survey sortie. This has resulted in some along track and cross track anomalies and at the time this satisfied the requirement of the survey. If it were known that these laser dropout areas would affect the quality of the reflectivity data then the lines would have been reflown.

D.1 GAPS AND IRREGULARITIES IN THE DATA

D.1.1 Turbidity

The following table describes gaps in the Relative Reflectance surface due to turbid data.

Area	Latitude (m)	Longitude (m)	Dimension (m)	Remarks
1	17° 57' 22"	67° 00' 31"	300x100	500m S of Isla Matel
2	17° 57' 29"	67° 00' 18"	200x50	300m S of Isla Matel
3	17° 56' 35"	67° 01' 05"	100x100	250m SW of Arrecife Enmedio
4	17° 57' 44"	67° 02' 41"	150x50	Offshore in a channel Approaching La Parguera
5	17° 57' 40"	67° 02' 45"	100x70	Offshore in a channel Approaching La Parguera
6	18° 06' 27"	67° 11' 20"	950x2200	950m S of Cayo Ratones
7	18° 05' 40"	67° 13' 59"	550x1150	3500m W of Punta Ostianes and 1000m N of Las Coronas
8	18° 05' 23"	67° 13' 19"	1650x50	1700m NW of Cayo Fanduca, directly N of Las Coronas, two small turbid patches located N
9	18° 05' 34"	67° 12' 34"	150x550	1200m N of Cayo Fanduca
10	18° 04' 22"	67° 13' 15"	1500x2300	1200m of Punta Carenero, many small turbid patches surrounding
11	18° 03' 19"	67° 14' 17"	800x200	3700m NW of Punta Guaniquilla, one turbid patch located S
12	18° 03' 20"	67° 15' 22"	450x450	3000m NE of Bajo Corona Larga, many small turbid patches in vicinity
13	18° 05' 10"	67° 16' 12"	60x130	Located within a channel 5700 of Las Coronas
14	18° 05' 55"	67° 15' 13"	150x250	1800m N of Las Coronas
15	18° 05' 51"	67° 14' 36"	100x110	2050m SW of Las Coronas

16	18° 05’ 04”	67° 15’ 34”	400x500	700m WNW of Las Coronas, turbid patch located W
17	18° 04’ 14”	67° 13’ 57”	500x100	2800m of Cayo Fanduca, two small turbid patches in vicinity
18	18° 05' 38”	67° 12' 00”	250x300	280m NW of Punta Ostiones
19	18° 04' 34”	67° 13' 57”	80x150	4100m WSW of Punta Ostiones
20	18° 03' 16”	67° 14' 17”	300x50	3700 NW of Punta Guaniquilla

Table 1: Gaps due to turbidity

D.1.2 Shallow Water

Gaps due to very shallow areas near the land/sea interface. Many of these areas exist around off-lying reefs, around mangroves areas and along the coast. Relative reflectivity data is not calculated for soundings less than 2 meters deep or for drying soundings.

Area	Latitude (m)	Longitude (m)	Dimension (m)	Remarks
1	18° 09' 06”	67° 14' 37”	450x270	6300m WSW of Punta Guanajibo
2	18° 07' 01”	67° 11' 18”	250x390	Surrounding Cayo Ratones
3	18° 06' 06”	67° 16' 11”	100x100	4500m E of Escollo Media Luna
4	18° 06' 22”	67° 16' 07”	160x200	4700m ENE of Escollo Media Luna
5	18° 06' 01”	67° 17' 06”	850x150	2800m E of Escollo Media Luna, two gap patches located E
6	17° 58' 24”	67° 12' 51”	440x160	1075m S of Punta Moja Cassabe
7	17° 56' 49”	67° 10' 53”	140x70	1380m NE of Cabo Rojo
8	17° 55' 06”	67° 06' 46”	3000x370	Shallow water gap located on Arrecife Margarita. Smaller gaps located north due to shallow water.
9	17° 56' 02”	67° 06' 58”	150x80	1400m SSW of Punta Tocon
10	17° 56' 01”	67° 05' 41”	1800x1000	Shallow water gap located on El Palo
11	17° 56' 29”	67° 05' 11”	560x500	2200m SSW of Isla Guayacan
12	17° 57' 15”	67° 04' 43”	400x250	900m SSW of Isla cueva
13	17° 56' 29”	67° 03' 42”	1580x500	1700m W of Arrecife Media Luna
14	17° 56' 20”	67° 02' 41”	1300x250	Shallow water gap located on Arrecife Media luna

15	17° 57' 18”	67° 02' 48”	1200x400	Shallow water gap located on Cayo Enrique, many smaller gaps located N in vicinity
16	17° 56' 13”	67° 01' 09”	480x250	Shallow water gap located 1300m NE of Arrecife Enmedio
17	17° 56' 43”	67° 00' 37”	1900x750	Shallow water gap located on Arrecife Enmedio
18	17° 57' 00”	67° 59' 15”	2400x630	Shallow water gap located on Arrecife Romero, smaller gaps located north in vicinity
19	17° 55' 48”	66° 58' 23”	230x216	Shallow water gap located 1800m WSW of Punta Jorobado
20	17° 55' 37”	66° 57' 07”	420x300	Shallow water gap located SE of Punta Jorobado
21	17° 55' 38”	66° 56' 40”	260x130	Shallow water gap located 1400m WSW of Punta Brea

Table 2: Gaps due to shallow water

D.1.3 Sparse Coverage

These are areas of marginal or sparse data caused primarily by low energy returns in deep water. Typically for the Southwest Puerto Rico area this effect occurs on the edge of the outer reef where coverage diminishes as the seabed slopes into deeper water.

The reflectivity data is also sensitive in these areas dependant on the turbidity model used when processing the reflectivity values, relative to the whole area. Potentially more coverage could be achieved in these deeper areas but may compromise bringing in areas of turbidity elsewhere.

Area	Latitude (E)	Longitude (W)	Dimension (m)	Remarks
1	18° 10’ 11”	67° 16’ 00”	3800x400	On northern edge of Escollo Negro reef, in steep dropoff beyond 10 fathom depth curve.
2	18° 10’ 17”	67° 18’ 34”	4800x400	On northern edge of Arrecife Tourmaline reef, in steep dropoff beyond 10 fathom depth curve.
3	18° 08’ 17”	67° 25’ 45”	2700x300	Sparse returns on north western most edge of coverage, in steep dropoff beyond 20-fathom depth curve.

4	17° 53' 41”	67° 16' 27”	150x30	Sparse returns on south western most area 2050m W of Buoy (R “2” FIR 6s)
5	17° 53' 30”	67° 17' 18”	3000x100	Sparse returns on southern most edge of coverage, in steep drop off canyons, beyond 10-fathom depth curve.
6	17° 53' 03”	67° 13' 31”	4500x216	Sparse returns on southern most edge of coverage, 6500m SW of Cabo Rojo in steep drop off canyons.
7	17° 52' 41”	67° 09' 20”	2000x450	Sparse returns on southern most edge, 6400m SW of Arrecife Margarita, beyond 10 fathom depth.
8	17° 52' 34”	67° 09' 31”	500x80	Sparse returns on southern most edge, 6800m SW of Arrecife Margarita, beyond 10 fathom depth
9	17° 51' 51”	67° 08' 12”	400x80	Sparse returns on southern most edge, 6500m SSW of Arrecife Margarita, beyond 10 fathom depth
10	17° 55' 26”	67° 01' 16”	500x50	Sparse returns, 3100m SE of Arrecife Media Luna

Table 3: Gaps due to sparse coverage

D.1.4 Surface Irregularity

Irregularities in the relative reflective surface are apparent particularly along the outer edge of the coverage, in deep water, where unconsolidated sediments full amongst the coral depressions. Many of these areas also have sparse coverage due to the low energy returns in deep water.

Area	Latitude (m)	Longitude (m)	Dimension (m)	Remarks
1	18° 10’ 32”	67° 21’ 36”	5500x800	On northern most edge of coverage, in steep drop off beyond 15 fathom depth curve. Unconsolidated sediments amongst coral depressions.

2	18° 09’ 49”	67° 24’ 23”	4500x800	On northwestern most edge of coverage, in steep drop off beyond 20 fathom depth curve. Unconsolidated sediments amongst coral depressions.
3	18° 03' 38”	67° 24' 56”	3000x200	Western most edge of coverage, in steep canyon, beyond 10 fathom depth
4	17° 59' 04”	67° 21' 33”	1500x80	Southwestern most edge of coverage, in steep canyon, beyond 10 fathom depth
5	17° 58' 15”	67° 21' 12”	480x70	Southwestern most edge of coverage, in steep canyon, beyond 10 fathom depth
6	17° 56' 04”	67° 19' 48”	3500x100	Southwestern most edge of coverage, in steep canyon, beyond 10 fathom depth
7	17° 54' 28”	67° 18' 46”	1500x80	Southwestern most edge of coverage, in steep canyon, within 10 fathom depth
8	17° 53' 32”	67° 17' 19”	3800x100	Southern edge of coverage, in steep canyon, beyond 10 fathom depth
9	17° 53' 09”	67° 14' 37”	3000x150	Southern most edge of coverage, in steep canyon, beyond 10 fathom depth
10	17° 53' 00”	67° 12' 24”	550x100	Southern most edge of coverage, in steep canyon, beyond 10 fathom depth
11	17° 52' 41”	67° 09' 23”	580x1900	Southern most edge of coverage, in steep canyon, beyond 10 fathom depth
12	17° 52' 08”	67° 08' 28”	780x400	6000m SW of Arrecife Margarita
13	17° 51' 48”	67° 08' 08”	2000x100	Southern most edge of coverage, in steep canyon, beyond 10 fathom depth
14	17° 51' 56”	67° 07' 34”	420x200	6100m SSW of Arrecife Margarita

Table 4: Irregularities in Surface

D.2 ANOMALIES

These anomalies show up in the data as along track and cross track anomalies due to the laser turning off intermittently on the last survey sortie. This has resulted in only 100% coverage in some areas which differs from adjacent areas which have 200% coverage. These areas satisfied the contract with the Office of Coast Survey and if at the time it was known that the data would be used to produce relative reflectivity then these areas would have been reflown. The variation of turbidity is also more pronounced on reflectivity data than the bathymetric data.

Area	Latitude (m)	Longitude (m)	Dimension (m)	Remarks
1	18° 07’ 39”	67° 22’ 07”	2500x6600	5400m W of Escollo Media Luna, Laser Pulse artefact
3	18° 02’ 42”	67° 21’ 31”	2000x1000	NW of Bajo Gallardo, Black spots
4	17° 55' 46”	67° 14' 30”	2000x180	Striping effect due to low laser amplitude on sortie (1300 survey lines)
5	17° 54' 58”	67° 12' 30”	2000x1600	Striping effect due to low laser amplitude on sortie (1300 survey lines)
6	17° 54' 06”	67° 07' 17”	1800x5000	Striping effect due to low laser amplitude on sortie (1300 survey lines)
7	17° 54' 50”	67° 16' 52”	12000x1500	Striping effect due to low laser amplitude on sortie (1300 survey lines)

Table 5: Data Anomalies

E. APPROVAL SHEET

LETTER OF APPROVAL

This report and the accompanying LADS deliverables are respectfully submitted.

Field operations contributing to the accomplishment of this survey were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and the accompanying digital data have been closely reviewed and are considered complete and adequate as per the Statement of Work.

Report	Submission Date
Descriptive Report	October 25, 2007

Darren Stephenson
Project Manager
Tenix LADS Incorporated

Date October 25, 2007

APPENDIX I – PROGRESS SKETCH

PROGRESS SKETCH

15 May 2006
OPR-I305-KRL-06
Puerto Rico
Tenix LADS Inc.
Darren Stephenson, Lead Hydrographer

Deployed to the field on April 07, 2006 and conducted the first survey sortie on April 09, 2006.

This status is of May 15, 2006 after 21 survey flights and the status includes an additional area to the west covered by the modification 1 to this task order T0008.

The area covered is 265SNM at 200% coverage.

	April	**May**	**Total**	**Total Planned**	**% Complete**
Days on project	22	15	37	36	
Line – nm - flown	7023.16	1264.44	8287.60	7581.26	109.3
Aircraft flown hours	111.1	23.0	134.1		
Aircraft on task hours	85.0	17.3	102.3		
Days with flight	17	4	21	23	91.3
No flight due to weather	0	0	0		
No flight due to system	0	0	0		
No flight due to aircraft	0	8	8		
Hours lost to weather	1.5		1.5		
Hours lost to system	2.5	1	3.5