

Mississippi Canyon 252 Spill Light Detection and Ranging (LIDAR) Data Acquisition

Deepwater Horizon/Mississippi Canyon 252 Spill

Deepwater Horizon, Mississippi Canyon 252 Spill – Light Detection and Ranging (LIDAR) Data Acquisition

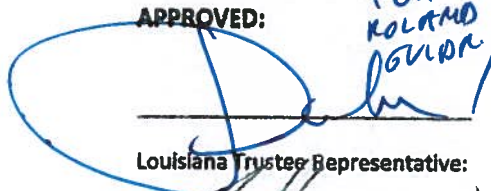
All materials associated with the collection or analysis of data or samples under these protocols or pursuant to any approved work plan, except those consumed as a consequence of the applicable sampling or analytical process, must be retained unless and until approval is given for their disposal in accordance with the retention requirements set forth in paragraph 14 of Pretrial Order # 1 (issued August 10, 2010) and any other applicable Court Orders governing tangible items that are or may be issued in MDL No. 2179 IN RE: Oil Spill by the Oil Rig "DEEPWATER HORIZON" (E.D. LA 2010). Such approval to dispose must be given in writing and by a person authorized to direct such action on behalf of the state or federal agency whose employees or contractors are in possession or control of such materials.

By signing this work plan and agreeing to fund the work outlined, BP is not endorsing the methodology articulated in the work plan. Further, although BP is agreeing to fund this work and will participate in the data collection herein, it does not necessarily endorsing the application of the LIDAR technology in this plan, the concept behind collecting LIDAR data expressed in this plan, nor the potential results. This plan will be implemented consistent with existing trustee regulations and policies. All applicable state and federal permits must be obtained prior to conducting work.

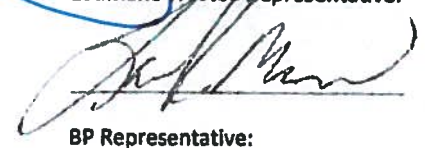
Approval of this work plan is for the purposes of obtaining data for the Natural Resource Damage Assessment (NRDA). Parties each reserve its right to produce its own independent interpretation and analysis of any data collected pursuant to this work plan.

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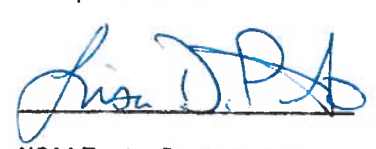
**Deepwater Horizon, Mississippi Canyon 252 Spill –
Light Detection and Ranging (LIDAR) Data Acquisition**

APPROVED: *FOR KOLAND LIDAR*


Louisiana Trustee Representative: Date 11/29/11



BP Representative: Date Nov. 20, 2011



NOAA Trustee Representative Date 11/21/2011
(on behalf of all other trustees)

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1.0 Overview

As part of the Natural Resource Damage Assessment (NRDA) effort for the Deepwater Horizon, Mississippi Canyon 252 (MC252) oil spill, this work plan has been developed under the Shoreline Technical Working Group (TWG) by the Trustees. The purpose of this plan is to acquire Light Detection and Ranging (LIDAR) data along affected and unaffected (reference) areas of the Louisiana coast. The LIDAR data will provide information for deriving and mapping elevation and shoreline position along impacted and reference shorelines. Data acquisition is intended to occur during the same season as that of the ground sampling data collection (as described in the "Sampling and Monitoring Plan for the Assessment of MC252 Oil Impacts to Coastal Wetland Vegetation in the Gulf of Mexico") and will be collected in the same general vicinity. Eighty-three (83) of the 150 established assessment sites are included in the LIDAR acquisition regions. The LIDAR data set, used in combination with high-resolution, multi-spectral, aerial ortho-imagery (currently being collected as described in the Technical Specifications and Scope of Work for Aerial Imagery Acquisition - Fall 2010 – Spring 2012) and the ground sampling data, will provide multiple layers of discrete and continuous data across both affected and reference areas. Since many of the discrete ground sampling locations may represent shoreline segment endpoints, and stretches of shoreline between these endpoints will not be directly measured on the ground, the LIDAR and aerial imagery data sets may be useful in further delineating these areas. Other work plans have not directly addressed the documenting of elevation and shoreline position along the coast, which will ultimately provide the means for deriving shoreline change over time. This document sets forth the methodology and specifications of the optical remote sensing technology to be used for data acquisition and pre-processing data analysis, including the precision and accuracy of the system, and identifies the frequency and spatial extent of data collection.

2.0 Scope of Work

A review of the Shoreline Clean-up Assessment Technique (SCAT) data and rapid assessment data collected by the Shoreline TWG was conducted for areas throughout the Louisiana coast to identify areas of LIDAR data acquisition. The most important criterion used for delineating these areas was identifying where oil had impacted marsh shorelines and sandy shorelines (i.e. shorelines along the barrier islands). In addition, areas potentially suitable for reference areas were examined and identified. From this assessment, polygons delineating areas for LIDAR data acquisition were generated and cost estimates developed (Appendix A, Figure 1).

2.1 Methodology of Data Collection

The data acquisition will utilize the FLI-MAP 400® technology or Fast Laser Imaging-Mapping and Profiling system mounted to a fixed-wing aircraft. This system integrates an accurate Global

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Positioning System (GPS) with digital still imaging, and a scanning reflector less laser rangefinder to provide fast and accurate aerial surveys. The system, aboard a specially equipped aircraft, is flown over the area of interest collecting raw GPS and platform attitude observables, laser ranges, and imagery data.

Regular bore-site calibration maintains consistently accurate data acquisition on each project. Prior to mobilizing to the project area, planning software is run concurrently with United States Geological Survey (USGS) Digital Elevation Model (DEM) underlay to pre-determine the flight line length, altitude, and terrain to set the exact terrain following rates of decent and/or climb for the pilot to implement during each days flight mission.

Local GPS survey monuments will be used to control the surveys and reference the FLI-MAP data to the desired horizontal coordinate system and vertical datum (see section 2.8). The control will be utilized for kinematic post processing of the FLI-MAP data.

The GPS data from the base stations and the primary and secondary navigation receiver on the airplane (Cessna 210) are reduced to produce 3D vectors from all the base stations to the airplane. The processed GPS data from the two on-board GPS receivers are blended with the inertial data to produce accurate XYZ and attitude information of the airplane. This position and attitude information is time-mated with laser data to produce accurate XYZ's of the laser returns. The FLIP7 software allows the laser data to be viewed, processed, filtered, and merged with the laser data with imagery.

2.2 FLI-MAP 400 Specifications

Below are the specifications of the FLI-MAP 400:

- **Laser Pulse Rate** 150,000; 200,000; or 250,000 pulses per second (selectable)
- **Multiple Return Capability** Yes – Maximum of 4 returns per pulse
Typically 150,000 transmitted will generate approx. 180,000 returns (including multiple returns)
- **Laser Eye Safety** FDA Certified Class 1 laser
Eye safe at the aperture
- **Laser Point Density (single pass)** Approx 15 points per square meter @ 1,100 ft altitude and 120 kts speed with 505 ft line spacing
- **Laser Ranging Accuracy** 1 cm
- **Laser Swath Angle** 60 degrees – Swath width approximates to flying height

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- Laser Look Angles Nadir (50% of pulses)
Forward looking -- 7 degrees (25% of pulses)
Rear looking -- 7 degrees (25% of pulses)
- Laser Beam Divergence Approx 0.45 mR
- Laser Spot Size Approx 15 cm @ 1,100 ft altitude
- Maximum Operating Height 900 meter
- Total System Accuracy (absolute) 15 cm horizontal RMSE (Root Mean Square Error)
10 cm vertical RMSE
- Total System Accuracy (relative) 5 cm horizontal and vertical @ 2 sigma (95% confidence level)
- Digital Still Imagery Twin 16.0 Megapixel; Down looking perspective; Approx 60% image overlap for subsequent frames
- Line Scan Imagery Yes – Integrated line scan camera fitted to laser scanner
Used to generate RGB values for each laser return
- GPS Positioning Rate 10 Hz

2.3 Accuracy of Raw LIDAR Data

The stated absolute accuracy of the discrete laser points (representing ground and feature data points) with the fixed-wing FLI-MAP using On-The-Fly (OTF) kinematic positioning is 15 cm (6 inches) horizontally and 10 cm (4 inches) vertically. The relative accuracy of the data points collected with the subsequent scans and to the kinematic control network is 10 cm horizontally and 7 cm vertically. The relative accuracy of points common to a single scan is 5 cm. The stated accuracies are RMSE.

2.4 Survey Control

The data will be referenced to the Continuously Operating Reference Station (CORS) network or monuments tied to the CORS network both horizontally and vertically. Base stations will be set up at selected control points to check the accuracy and consistency of the control network. At least 1 base station will be within 18 miles of the data collection aircraft at all times during data collection.

2.5 Aerial Imagery

The fixed-wing FLI-MAP 400 system is fitted with 2 digital mapping cameras. Both capture imagery in the down looking (vertical) perspective.

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Imagery from the mapping cameras may be orthorectified using the LIDAR data, and then tiled, color balanced and edge mated, to provide orthophotography.

2.6 Data Acquisition Criteria and Frequency

In order to maximize the utility of the data, data collection efforts need to be conducted while water levels are lower than the marsh surface. Water levels in coastal Louisiana are usually lowest during the winter months (December – March), particularly during low-tide and after a cold front passage; therefore all attempts will be made to acquire the data at or near low tide and after a cold front has passed through the area (i.e. winds are northerly), thereby increasing the likelihood that water levels will be below the marsh surface. Due to the timing of the development of this work plan, the first data collection will occur in February to early March 2011. Data acquisition in subsequent years will occur during the same seasonal time period (i.e. winter), but will be timed for late December through early February.

Data collection under this plan is intended to coincide with and supplement the data collection efforts associated with the “Sampling and Monitoring Plan for the Assessment of MC252 Oil Impacts to Coastal Wetland Vegetation in the Gulf of Mexico”. Although it is unlikely that the LIDAR data will be collected at the exact same time as the ground sampling data, the seasonal frequency will be the same. Hence, the LIDAR data will be collected in February/March 2011, and the winters of 2012, 2013, 2014, 2016, and 2021 (December through February time period).

2.7 LIDAR Data Processing

2.7.1 Pre-Processing

Data pre-processing will be as follows:

- LIDAR, GPS and Inertial Measurement Unit (IMU) data are processed together using LIDAR processing software;
- The LIDAR data set for each flight line is checked for project area coverage and LIDAR post spacing is checked to ensure it meets project specifications;
- The LIDAR collected at the calibration area is used to correct the rotational, atmospheric, and vertical elevation differences that are inherent to the LIDAR data;
- Intensity raster is generated to verify that intensity was recorded for each LIDAR point;
- LIDAR data is transformed to the specified project coordinate system by utilizing the ground survey data collected at the calibration site and project area. The LIDAR data is vertically biased to the ground;
- Comparisons between the biased LIDAR data and ground survey data with the project area are evaluated and final RMSE value is generated to ensure the data meets the project specifications;

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- The data set is trimmed to the digital project boundary including an additional buffer zone, which is typically about 50 feet (buffer zone assures adequate contour generation from the DEM);
- The resulting data set is referred to as the raw LIDAR data.

2.7.2 Final Processing/Analysis

Final processing/analysis is not included in this work plan. Upon completion of the pre-processing, Trustee and BP representatives will meet to formulate a protocol for analyzing the data. A separate work plan will be developed and a cost estimate provided. Deliverables could include marsh shoreline determination, digital terrain model (DTM), contour mapping, and/or orthophotography.

2.8 Deliverables

Federal Geographic Data Committee (FGDC) metadata will be produced for the data deliverable. Data will be referenced to the North American Datum of 1983 (NAD83 [NSR2007]) UTM Zone 15. Geoid09 shall be used to reduce NAD83 (NSRS2007) ellipsoidal heights to North American Vertical Datum of 1988 (NAVD88) orthometric heights. All data will be reported in meters.

All raw and pre-processed data will be delivered under Chain of Custody to the Louisiana Oil Spill Coordinators Office (LOSCO) for dissemination to the NRDA Shoreline TWG representatives for NOAA and BP. All raw and pre-processed data will be delivered on external hard drives (Firewire/USB) and will contain:

- FLIP7 ready flight files (raw FLI-MAP data)
- LIDAR data in LAS1.2 format
- High Resolution Mapping Camera Imagery in Serial Digital Interface (SDI) format
- Survey Control report

2.9 Data Sharing

Each laboratory shall simultaneously deliver raw data, including all necessary metadata, generated as part of this work plan as a Laboratory Analytical Data Package (LADP) to the trustee Data Management Team (DMT), the Louisiana Oil Spill Coordinator's Office (LOSCO) on behalf of the State of Louisiana, and to BP (or CardnoENTRIX on behalf of BP). The electronic data deliverable (EDD) spreadsheet with pre-validated analytical results, which is a component of the complete LADP, will also be delivered to the secure FTP drop box maintained by the trustees' Data Management Team (DMT). Any preliminary data distributed to the DMT shall also be distributed to LOSCO and to BP (or CardnoENTRIX on behalf of BP). Thereafter, the DMT will validate and perform quality assurance/quality control (QA/QC) procedures on the LADP consistent with the authorized Analytical Quality Assurance Plan, after which time the validated/QA/QC'd data shall be made available simultaneously to all trustees and BP (or CardnoENTRIX on behalf of BP). Any questions raised on the validated/QA/QC results shall be

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handled per the procedures in the Analytical Quality Assurance Plan and the issue and results shall be distributed to all parties. In the interest of maintaining one consistent data set for use by all parties, only the validated/QA/QC'd data set released by the DMT shall be considered the consensus data set. In order to ensure reliability of the consensus data and full review by the parties, no party shall publish consensus data until 7 days after such data has been made available to the parties. Also, the LADP shall not be released by the DMT, LOSCO, BP or CardnoENTRIX prior to validation/QA/QC absent a showing of critical operational need. Should any party show a critical operational need for data prior to validation/QA/QC, any released data will be clearly marked "preliminary/unvalidated" and will be made available equally to all trustees and to BP (or CardnoENTRIX on behalf of BP).

3.0 Cost Estimate

The cost for this work plan is estimated at \$735,000 for February/March 2011. The Parties acknowledge that this budget is an estimate, and that actual costs may prove to be higher due to a number of potential factors. BP's commitment to fund the costs of this work includes any additional reasonable costs within the scope of this work plan that may arise because of any contingencies. The trustees will make a good faith effort to notify BP in advance of any such contingencies.

The cost estimate breakdown is as follows:

<u>Item</u>	<u>Cost Estimate</u>
Mobilization ¹	\$ 30,000
Base Station Support ²	\$160,000
Flight Operations	\$445,000
Pre-Processing	\$ 75,000
<u>Project Management</u>	<u>\$ 25,000</u>
TOTAL	\$735,000

¹Mobilization: Cost to bring the plane from headquarters to data collection area.

²Base Station Support: Cost for survey crew(s) to establish total stations on benchmarks and set-up items in on the ground for quality assurance.

Appendix A

LIDAR Data Acquisition Areas

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