STATE OF TEXAS §
§
COUNTY OF FORT BEND §

AGREEMENT FOR LIDAR SERVICES

THIS AGREEMENT is made and entered into by and between the Fort Bend County Drainage District, (hereinafter "District"), a body corporate and politic under the laws of the State of Texas, and Fugro EarthData, Inc., (hereinafter "Contractor"), a company authorized to conduct business in the State of Texas.

W I T N E S S E T H

WHEREAS, Contractor entered into an agreement with the State Council on Competitive Government (hereinafter "CCG") for the provision of High Priority Imagery and Data Sets and LiDAR services, Contract No. CCG-GIS-2008-001-4 as amended (hereinafter "CCG Agreement"); and

WHEREAS, District may participate in an agreement awarded by the CCG pursuant to Chapter 2162 of the Texas Government Code;

WHEREAS, District desires that Contractor provide services related to the collection of high resolution LiDAR (hereinafter "Services") pursuant to the terms and conditions of the CCG Agreement; and

WHEREAS, Contractor represents that it is qualified and desires to perform such services.

NOW, THEREFORE, in consideration of the mutual covenants and conditions set forth below, the parties agree as follows:

AGREEMENT

Section 1. Scope of Services

1.1 Contractor shall render Services to District as defined in the Scope of Services (attached hereto as Exhibit A).

1.2 The Services shall be provided in accordance with the terms and conditions of the CCG Agreement except as otherwise provided herein.

Section 2. Compensation and Payment

2.1 Contractor's fees shall be calculated at the rates set forth in the attached Exhibit A. The Maximum Compensation for the performance of Services within the Scope of Services

described in Exhibit A is one hundred and ninety-three thousand nine hundred and forty-five dollars and 50/100 ($193,945.50). In no case shall the amount paid by District under this Agreement exceed the Maximum Compensation without an approved change order.

2.2 All performance of the Scope of Services by Contractor including any changes in the Scope of Services and revision of work satisfactorily performed will be performed only when approved in advance and authorized by District.

2.3 District will pay Contractor based on the following procedures: Upon completion of Phase II of the Services, Contractor shall submit to District two (2) original copies of invoices showing the amounts due for services performed in Phases I and II of the Services in a form acceptable to District. Upon final completion of the Services, Contractor shall submit to District two (2) original copies of invoices showing the amounts due for services performed in Phases III and IV of the Services in a form acceptable to District. District shall review such invoices and approve them within 30 calendar days with such modifications as are consistent with this Agreement and forward same to the Auditor for processing. District shall pay each such approved invoice within thirty (30) calendar days. District reserves the right to withhold payment pending verification of satisfactory work performed.

Section 3. Limit of Appropriation

3.1 Contractor clearly understands and agrees, such understanding and agreement being of the absolute essence of this Agreement, that District shall have available the total maximum sum of one hundred and ninety-three thousand nine hundred and forty-five dollars and 50/100 ($193,945.50), specifically allocated to fully discharge any and all liabilities District may incur.

3.2 Contractor does further understand and agree, said understanding and agreement also being of the absolute essence of this Agreement, that the total maximum compensation that Contractor may become entitled to and the total maximum sum that District may become liable to pay to Contractor shall not under any conditions, circumstances, or interpretations thereof exceed one hundred and ninety three thousand nine hundred and forty-five dollars and 50/100 ($193,945.50).

Section 4. Time of Performance

The time for performance of the Scope of Services by Contractor shall begin with receipt of the Notice to Proceed from District and end no later than December 31, 2014. Contractor shall complete the tasks described in the Scope of Services within this time or within such additional time as may be extended by the District.

Section 5. Notices

5.1 Each party giving any notice or making any request, demand, or other communication (each, a "Notice") pursuant to this Agreement shall do so in writing and shall

use one of the following methods of delivery, each of which, for purposes of this Agreement, is a writing: personal delivery, registered or certified mail (in each case, return receipt requested and postage prepaid), or nationally recognized overnight courier (with all fees prepaid).

5.2 Each party giving a Notice shall address the Notice to the receiving party at the address listed below or to another address designated by a party in a Notice pursuant to this Section:

District:	Fort Bend County Drainage District P.O. Box 1028 Rosenberg, Texas 77471
With a copy to:	Fort Bend County Attn: County Judge 301 Jackson Street, Suite 719 Richmond, Texas 77469
Contractor:	Fugro EarthData, Inc. 7320 Executive Way Frederick, Maryland 21704

5.3 A Notice is effective only if the party giving or making the Notice has complied with subsections 5.1 and 5.2 and if the addressee has received the Notice. A Notice is deemed received as follows:

5.3.1 If the Notice is delivered in person, or sent by registered or certified mail or a nationally recognized overnight courier, upon receipt as indicated by the date on the signed receipt.

5.3.2 If the addressee rejects or otherwise refuses to accept the Notice, or if the Notice cannot be delivered because of a change in address for which no Notice was given, then upon the rejection, refusal, or inability to deliver.

Section 6. Applicable Law

The laws of the State of Texas govern all disputes arising out of or relating to this Agreement. The parties hereto acknowledge that venue is proper in Fort Bend County, Texas, for all legal actions or proceedings arising out of or relating to this Agreement and waive the right to sue or be sued elsewhere. Nothing in the Agreement shall be construed to waive the District's sovereign immunity.

Section 7. Captions

The section captions used in this Agreement are for convenience of reference only and do not affect the interpretation or construction of this Agreement.

Section 8. Conflict

In the event there is a conflict between this Agreement and the attached exhibit, this Agreement controls.

IN WITNESS WHEREOF, the parties hereto have signed or have caused their respective names to be signed to multiple counterparts to be effective on the 11 day of February, 2014.

FORT BEND COUNTY DRAINAGE DISTRICT

Robert E. Hebert, County Judge

2-11-2014

FUGRO EARTHDATA, INC.

Authorized Agent- Signature

Dave White

Authorized Agent- Printed Name

Vice President

Title

February 6, 2014

Date

ATTEST:

Dianne Wilson, County Clerk

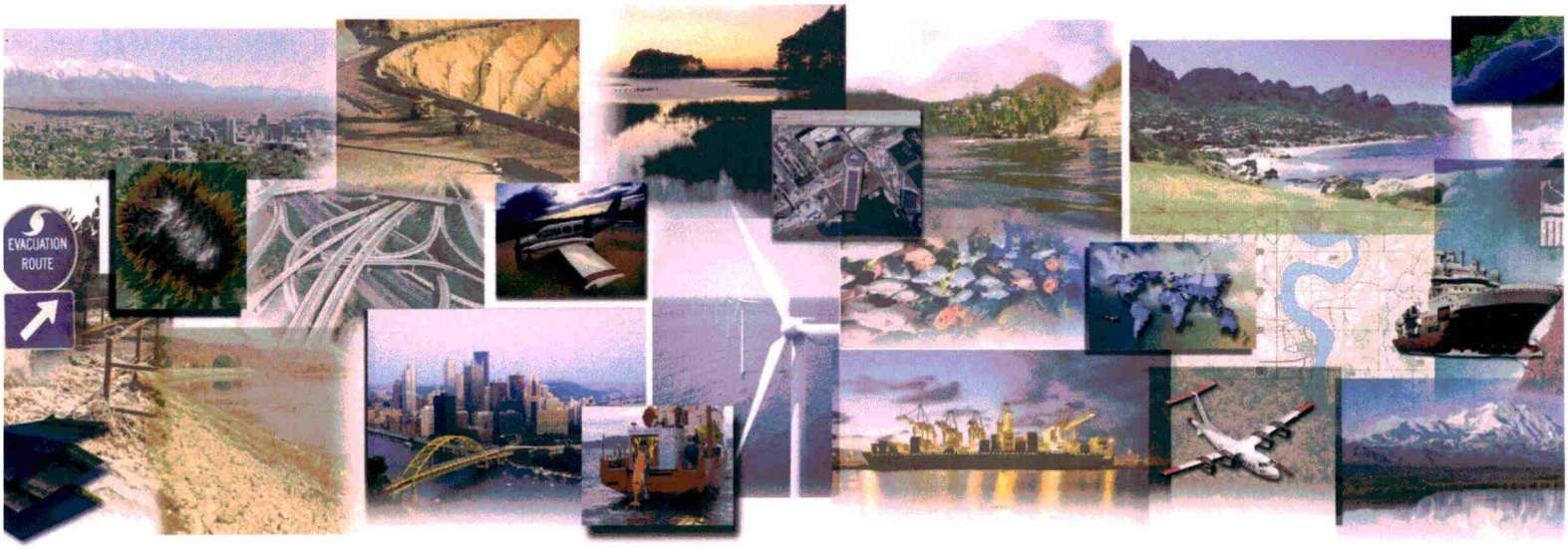
COMMISSIONERS COURT FORT BEND COUNTY, TEXAS

AUDITOR'S CERTIFICATE

I hereby certify that funds are available in the amount of $193,945.50 to accomplish and pay the obligation of the Fort Bend County Drainage District under this contract.

Robert Edward Sturdivant, County Auditor

EXHIBIT A



Proposal For:

Fort Bend County LiDAR

RFQ No. 580130627

January 31, 2014

Submitted to:

Texas Water Development Board
1700 North Congress Avenue, 6th Floor
Austin, TX 78701

TEL: 512 463 3154
FAX: 512 475 3009

Fort Bend County Drainage District
1004 Blume Road
Rosenberg, TX 77471

TEL: 281-342-2863

Submitted by:

Fugro EarthData, Inc
7320 Executive Way
Frederick, Maryland 21704

TEL: 301 948 8550
FAX: 301 963 2064

FUGRO EARTHDATA, INC.

7320 Executive Way
Frederick MD 21704

Tel: 301 948 8550
Fax: 301 963 2064

www.fugro.com

January 31, 2014

Texas Water Development Board
1700 North Congress Avenue, 6th Floor
Austin, TX 78701

Subject: TWDB RFQ No. 580130627 – Fort Bend County LiDAR

Dear Mr. Dillard and Ms. Bao:

Fugro EarthData (Fugro) is pleased to submit the attached response in support of the Texas Water Development Board's (TWDB) requirements for collection of high resolution LiDAR for Fort Bend County, TX.

Fugro's approach to this project is founded on over 10 years of experience in high density LiDAR acquisition and processing. In the course of performing acquisition and processing on hundreds of LiDAR projects we have encountered occasional unexpected challenges that have provided us with an opportunity to develop and apply creative solutions. These solutions have resulted in more efficient processes, higher quality products, and have kept us at the forefront of technical expertise and new technology adoption. In this proposal, we describe not only the methodology we will employ to deliver all products required, but also how this methodology evolved through our experiences and lessons learned analyses. Fugro's ISO9001:2008 quality management system (QMS) requires an assessment at the close out of every project. This important step of our standard QMS has led to a "first time right" delivery rating of over 99% for LiDAR product deliveries since 2009.

Large LiDAR acquisition and processing capacity: Fugro owns and operates 27 geospatial aircraft, 14 digital imagery sensors and 12 LiDAR sensors - backed by over 1400 geospatial technicians globally. This allows for multiple identical sensor systems to be used for collection, and provides additional back-up resources to be mobilized quickly should the need arise due to inclement weather or equipment malfunction. Having such large acquisition capabilities mean that we often have multiple projects that occur at the same time all over the US. However, because of our ISO management system in place, as well as our talented and dedicated staff, our approach will always be to put the customer first and to ensure that all their needs are met to the highest standards.

Key team personnel have a long history successfully completing similar projects: With this proposal we present a team of highly skilled team of geospatial professionals who have multiple years of experience working with each other. Our core management and supervisory personnel assigned to this project consist of:

- **Project Manager:** Richard McClellan, PLS, PMP (Project Management Professional
- **Quality Control Manager:** David White, CQM (Certified Quality Manager)
- **Acquisition/Flight Operations Manager:** Marshall Swenson
- **Raw Data Inspection/QC:** Douglas Johnson
- **LiDAR Production Manager:** Tian Wang
- **Ground Control Surveying Manager:** William Warrick R.P.L.S. (Texas Registration No. 4426)

The following personnel are available to respond to any additional information requests or questions regarding this proposal:

Mr. Richard McClellan, Project Manager
rmcclellan@fugro.com
301-948-8550 ext. 2227

Mr. Keith Owens, Client Liaison
kowens@fugro.com
301-948-8550 ext. 119

Our proposal demonstrates examples of past performance where this same team has successfully completed multi-resolution projects of similar complexity, size and scope as to the Fort Bend County project.

Thank you for considering our proposal. We look forward to your response and would be grateful to have the opportunity to work again with the TWDB on this important project.

Dave White, CQM
Vice President, Mapping Services

Table of Contents

1 EXECUTIVE SUMMARY

Fugro EarthData, Inc. (Fugro) is pleased to present our qualifications and proposal for providing Texas Water Development Board (TWDB) with acquisition and processing of the requested LiDAR services.

With over 58 years as an industry leader in the aerial mapping industry, Fugro offers TWDB a high-quality, low risk, and economical option to meet all of the specifications for the items requested in the RFP.

Fugro recognizes TWDB's interest in utilizing the latest aerial mapping technologies available that offer enhanced benefits in the form of faster turnaround times and higher accuracy products. As an industry leader in this regard, Fugro has a long history of investing in and developing advanced technologies that benefit our industry and our customer partners. Over the past few years we have:

- Expanded our Airborne LiDAR collection capabilities with a suite of sensors including:
  - Leica ALS
  - Riegl Q-680-i Waveform LiDAR
  - Riegl VQ-820-G Waveform Topographic/Bathymetric LiDAR
- Outfitted three (3) Aircraft with dual sensor collection capabilities.
  - Simultaneous collection of LiDAR and Imagery
  - Simultaneous collection of hyperspectral and multispectral imagery.
- Upgraded our ADS40-SH52 digital imagery sensors to the ADS80-SH82
- Invested in frame based digital camera technologies by purchasing the Z/I DMC, expanding our digital imagery solutions to both methods of data capture (Frame and Push-broom)
- Expanded our Aerial Oblique Solutions to include lower altitude high quality sensors
- Produced on-line capabilities for Oblique, LiDAR and Imagery Viewing, QA/QC, Measurement Capabilities and Project Tracking

1.1 Project Understanding

Fugro understands TWDB requires high resolution elevation data (4ppsm) and associated products over approximately 917 square miles over Fort Bend County Texas.

1.2 Approach / Methodology Summary- LiDAR

Fugro will acquire, process and deliver 4ppsm (points per square meter) LiDAR and contour data over the County using the Riegl Q-680-I waveform LiDAR sensor to acquire the LiDAR data.

1.3 Optional Products and Value Added Services

1.3.1 Informational/Training Workshops - Expanding User Groups adds value to dollars spent.

With the advancement in LiDAR technology over recent years, many customers are purchasing data with the intent of receiving specific deliverables (ie: cartographic contours –vs- engineering contours, or LiDAR classification schema choices, the use of all data, intensity image – stereo compilation, dissemination of LiDAR data to constituents).

Fugro can provide a 1-4 day workshops that will illustrate the benefits of high accuracy LiDAR data. The workshop demonstrates the fundamentals of LiDAR systems and performance. The objective of this workshop is to provide a dynamic forum that addresses current acquisition systems and acquisition parameters and to review industry best practices for collecting optional data products from various data sources. This program serves the purpose to expand data users understanding of geospatial applications and to expand the total number of users, in turn, adding value to the new data. The curriculum will include:

- What Is LiDAR?
- Operational Theory
- Data Processing Overview
- Calibration and Boresighting
- Topographic Mapping

2 PROJECT PLAN

This section outlines the process steps and techniques that Fugro will perform during each phase of this project.

2.1 Evaluation Criteria

2.1.1 Elaboration on Process Descriptions of Project Steps and Techniques

The process steps involved within the project plan follow proven techniques to ensure that all phases, tasks and methodologies are performed in the most efficient manner. Fugro will ensure the success of this project by following pre-defined and proven ISO9001:2008 quality processes, and we will provide ongoing status updates and reporting, as defined by TWDB, throughout the planning and production phases.

2.1.2 Flight Parameters for Daytime and Nighttime Collection

LiDAR technology allows for a wide operational window and can be operated at night to facilitate data acquisition in high traffic areas where daytime flight restrictions may be imposed. The flight parameters for both day and nighttime acquisition are the same for this project. Weather conditions are monitored several times daily to ensure that data is acquired during conditions that will produce high quality data. The following table details the operational parameters for this project. To maximize the flight window, Fugro plans to acquire data both during the day and night (2 lifts per day).

In order to meet the required LiDAR specification, survey point density and accuracy specifications for this project, the parameters for data capture will be:

Flight Parameters for LiDAR					
Point Density	Altitude (AMT)	# of lines	Total line miles	FOV (degrees)	Pulse Rate (Hz)
0.5 m	2400 ft	104	2868	60	330000

LiDAR Details		
Full Swath (m)	Horizontal Accuracy RMSEz (cm)	Vertical Accuracy RMSEz (cm)
812	50	9

2.1.3 Acquisition Plan with Assumptions for Weather Days

Fugro will mobilize to the project area from our base in Rapid City, South Dakota. Aircraft will be deployed to the project area in advance of favorable weather patterns to take full advantage of the first opportunity early in the season.

Fugro's flight operations are managed by Mr. Andy Weathers. Mr. Weathers is actively involved in all areas of flight operations including weather monitoring, flight planning, crew scheduling, and equipment systems tracking to ensure that flight crews are ready for rapid mobilization to maximize ideal remote sensing acquisition conditions.

2.1.4 Contingency Plan to Ensure Milestones are Met

Potential issues during acquisition and production are identified and addressed immediately so they do not impact the schedule or quality. This plan is made up of two separate components:

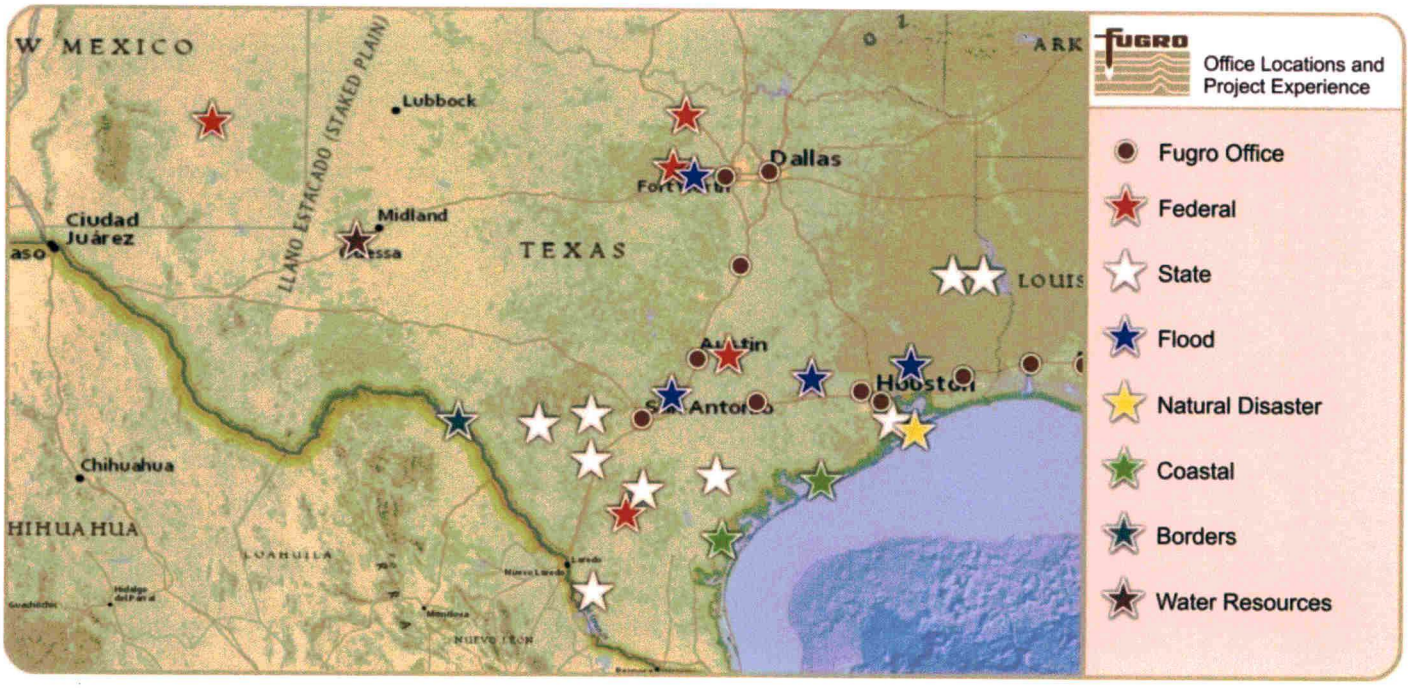
1) Data usability is verified throughout acquisition
2) Quality is checked throughout production according to our ISO quality procedures.

The following sections describe processes used by our team to ensure that quality data products are delivered to TWDB on time and first-time-right.

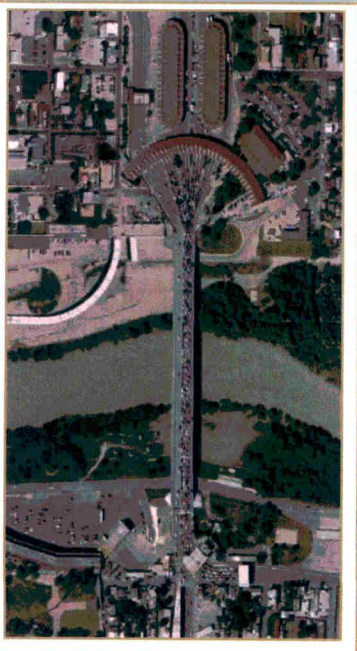
2.1.5 Consideration of Localized or Unique Issues for the Project

Fugro's experience acquiring geospatial data in Texas originates from the TOP Program in the mid 90's, every USDA NAIP collection since 2001, TX coastal benthic mapping for NOAA, acquisition of the TX Mexico Border for NGA, and corridor mapping work for the Lower Colorado River Authority (LCRA). As a result of this experience, our aviation crews are very familiar with Texas weather conditions, and are prepared for wind and unexpected storm fronts.

Fugro is a contractor with USGS, NOAA, DHS, NGA, FEMA and the USACE and will inform the TWDB of any known AOI's that are within the current projects region of acquisition. This will help facilitate any state/federal partnerships that can be leveraged for data acquisition.



2.1.6 Local Work Descriptions

Project	Description
US Borders Initiative and 133 Urban Area (UA) Mapping, Southern Border, Texas	In 2008 and 2009, Fugro participated in the NGA borders mapping project, a complex undertaking with multiple hurdles to overcome, from adverse weather conditions to securing cross-border flying authorizations. Part of the DHS Customs and Border Protection Secure Borders Initiative, this project was designed to produce digital orthorectified imagery over the entire extent of the U.S. border with Mexico, covering a 40 mile corridor - 10 miles into Mexico and 30 miles into the U.S. **Southern Border, Texas (2008)** – In fall 2008, Fugro captured 26,000 sq. mi. of 1 foot resolution imagery over a large portion of the Texas border and 6 inch resolution imagery over U.S. border crossing points of entry in just 6 weeks. Faced with extremely difficult weather patterns generated by Hurricanes Gustav and Ike, Fugro was able to mass aviation resources on the project (mobilizing up to four aircraft concurrently) to accelerate acquisition by taking advantage of every opportunity for favorable weather. We processed and delivered 118,236 orthophoto tiles achieving a 99.93% first-time-right acceptance rate. 

Project	Description
State of Texas, High Resolution Elevation Data, Ft. Worth, Tarrant County, TX	LiDAR, digital elevation models (DEMs) and breaklines for the Ft. Worth/Tarrant County area for both Urban and Flood/Soils areas comprising over 1200+ square miles. Through third party QA/QC, Fugro's accuracies were found to meet and exceed the required vertical accuracies throughout the entire project area. Independent QA/QC efforts found some areas having vertical accuracies of 2 centimeters RMSE vertically.
FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations	Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. Areas acquired in Texas include, Central TX (1,305 Sq mi), Liberty County, TX (1,055 sq mi) and Parker County (1,136 sq mi).

2.1.7 Sub-Contractors for Primary or Contingency Activities

To reduce contract and communication complexities, Fugro plans to use all Fugro resources to complete the requested deliverables. Fugro's worldwide resources in ground control, aerial acquisition, data processing and engineering are well positioned and equipped to respond to the requirements of the RFQ; as well as offer additional support should any unforeseen issues arise. Support includes additional aircraft, LiDAR and imagery sensors, computers, personnel and processing capacity.

2.1.8 Description of Production Centers and Associated Work

Fugro operates from two Texas based ground survey operations, two primary production facilities and two flight/acquisition operations:

Ground Survey Operations: Fugro's Texas based land survey offices are strategically placed throughout Texas to provide local, cost effective ground survey operations under the direct supervision of Texas Registered Land Surveyors.

Production Facilities: Our Frederick and Rapid City facilities house Fugro's mapping and GIS production staff as well as our research and development team. All production work for this project will be performed and managed at Fugro's main production facility in Frederick, Maryland; with additional support from production facilities placed around the globe. All aircraft will be mobilized from Rapid City, South Dakota.

Aircraft and Sensor Operations: Fugro's Aviation Division office and hangar, located in Rapid City, South Dakota, is home to flight and survey operation staff, 10 aircraft, and numerous cameras and sensors for the acquisition of airborne mapping data.

Fugro Hangar, Rapid City, SD

2.1.9 Fugro Office Locations

Fugro EarthData, Inc.
Aerial Imagery and LiDAR Production Facility
7320 Executive Way
Frederick, MD 21704
http://www.fugroearthdata.com

Fugro EarthData, Inc.
Aerial Imagery and LiDAR Production Facility
3600 Jet Drive
Rapid City, SD 57703
http://www.fugroearthdata.com

Fugro EarthData, Inc.
Aviation Hangar
18227 Airpark Dr.
Hagerstown, MD
http://www.fugroearthdata.com

Fugro EarthData, Inc.
Aviation Hangar
4350 Airport Road
Rapid City, SD 57703
http://www.fugroearthdata.com

Fugro John Chance Land Surveyors, Inc.
Land Survey
11009 Osgood St.
San Antonio, TX 78233
http://www.jchance.com/

Fugro John Chance Land Surveyors, Inc.
Land Survey
6100 Hillcroft
Houston, TX 77081
http://www.jchance.com/

Fugro Consultants, Inc.
Engineering
8613 Cross Park Drive
Austin, TX 78754
http://www.fugroconsultants.com/

Fugro Consultants, Inc.
Engineering
1850 Interstate 10 South
Beaumont, TX 77707
http://www.fugroconsultants.com/

Fugro Consultants, Inc.
Engineering
115 Topeka Drive
Waco, TX 76712
http://www.fugroconsultants.com/

Fugro Consultants, Inc.
Engineering
2880 Virgo Lane
Dallas, TX 75229
http://www.fugroconsultants.com/

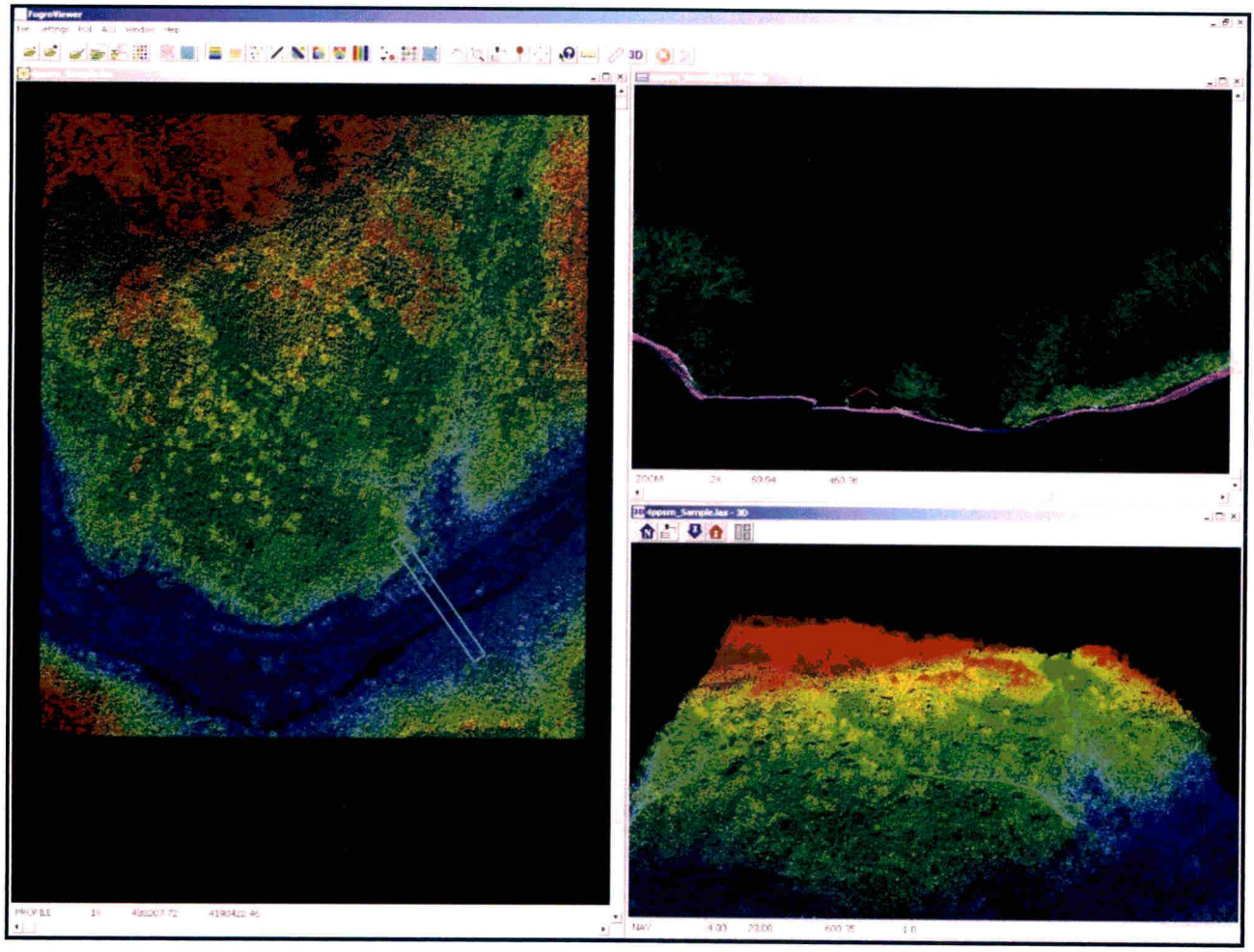
2.1.10 Options for Funding Partners to Review (Comment/Markup) Preliminary LiDAR

LiDAR data for on-line viewing and markup can exceed common bandwidth for today's internet capabilities. We recommend using Fugro Viewer as a method for reviewing data, marking areas of concern and communicating concern with Fugro. With delivery of the LiDAR project deliverables, Fugro will provide TWDB FugroViewer at no charge. FugroViewer is in-house developed software for visualizing and manipulating LiDAR data in an efficient and user-friendly interface. This proprietary software will also allow TWDB to access and overlay other geospatial datasets such as LiDAR, planimetric, and topographic data. FugroViewer comprises a Windows-based user interface with a dashboard of icons that call up the various functionalities of the software.

The functionalities and benefits of FugroViewer include:

- LiDAR and perspective viewing and navigation
- Cross section/profiling of DEM data
- Graphical display of data in custom tile schemes and attributes
- User-specified grid utilities
- Selectable gridding algorithms
- Graphical point cloud representation and navigation

Graphic color representation by elevation, flight line, multiple feature class and, grayscale, laser intensity



FugroViewer User Interface

2.2 Phase I: Pre-Flight Planning / Project Kick-Off Meeting LiDAR Process and Techniques

During the project Kick-Off Meeting, Fugro's project manager will present TWDB with our preliminary project design and recommendations to ensure successful data acquisition, processing and quality assurance. The project design includes the overall project schedule, flight plan, ground control layout, and sensor calibration documentation. This project design will be finalized based on comments from the TWDB. The final deliverables from this first task will be provided to the 3rd Party QA/QC Vendor for review and comment. Within this proposal we have included preliminary flight plans, ground control layout, and a project milestone schedule. At this point in the procurement of this project, the data included herein is Fugro's current recommendation for your project based on existing information. Fugro's project manager will outline our sensor calibration reports and processes for each aerial sensor during the kick-off meeting.

Our standard Fugro project management work plan is separated into four major components, as follows, with specific items to be analyzed and defined for each component: (discussed in further detail in Section 3: Communication Plan)

1. Project Planning
2. Executing the Project
3. Controlling the Project
4. Closing the Project

2.2.1 Develop Flight Operations Plan

After the project kick-off meeting Fugro's project manager will meet with Fugro's flight operations department to review and discuss the flight plan details. The finalized technical specifications and flight plan layouts for each AOI will be conveyed to the flight operations department for flight operations to commence. Additionally all technical aspects of final deliverables will be reviewed and finalized to ensure conformity with Fugro and TWDB regarding overall project expectations. Acquisition considerations such as airspace restrictions, airport accessibility, terrain, weather patterns, and other customer or special project needs will be addressed.

2.2.2 System Calibration and Geodetic Control Validation

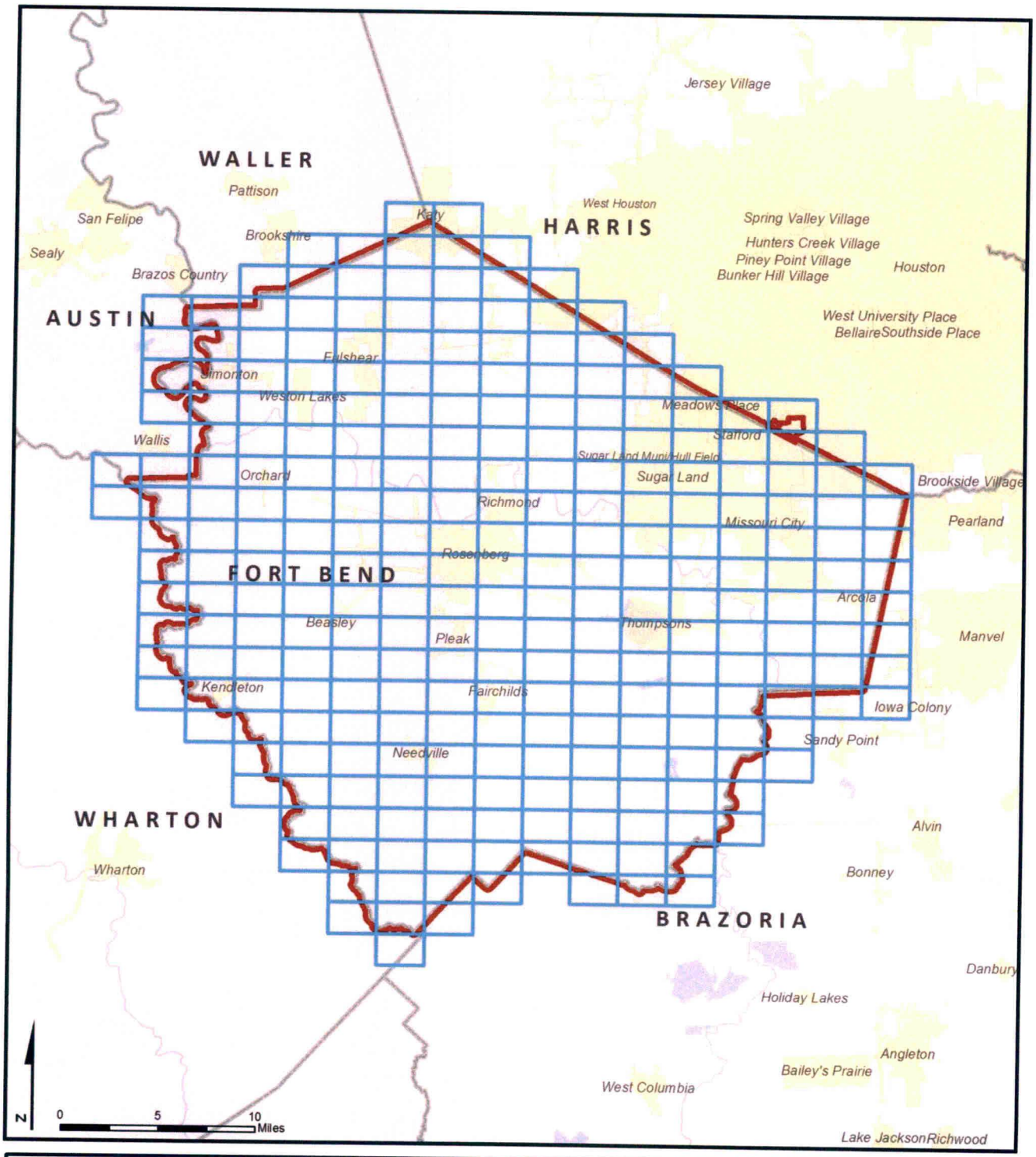
A complete review of Fugro's sensor calibration reports, geodetic control coverage and accuracy statements will be presented for review and comment.

2.2.3 Phase I Deliverables

Deliverable	Description	QA/QC Vendor Role
Schedule	Project schedule outlining milestones, deliveries and invoicing	Review and Comment
Flight Plan	Shapefiles showing flight line locations, flying heights, side-lap, airspace, and base line lengths	
Ground Control Plan	Ground control and check point locations and accuracy statements	
Sensor Calibration Reports	Most recent manufacture calibration reports for both sensor types	

2.2.4 Preliminary Flight Plans and Ground Control Layout

Preliminary flight maps for all areas and ground control layouts are included on the following pages for TWDB's review. Two (2) base stations will be operating within the required 40km base line length for each AOI. Additionally, Fugro will utilize NGS CORS stations at each project area for equipment redundancy and coverage.



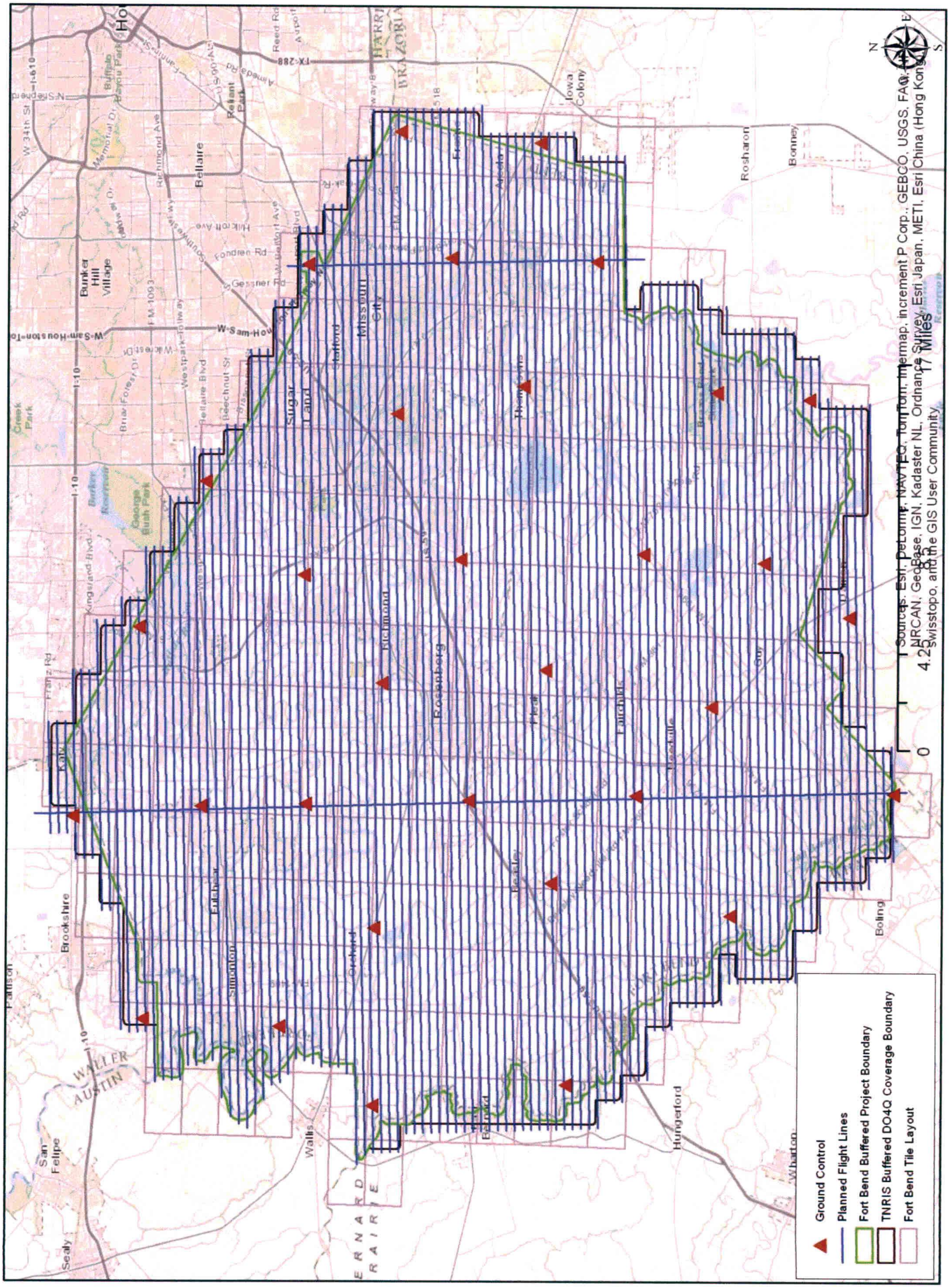
2014 Fort Bend Lidar Acquisition

Add-on to HPIDS 580130627

Fort Bend AOI - 917 Square Miles

Tile Grid

TNRIS


Ground Control
Planned Flight Lines
Fort Bend Buffered Project Boundary
TNRIS Buffered DO4Q Coverage Boundary
Fort Bend Tile Layout
0
4.25
8.5
17 Miles

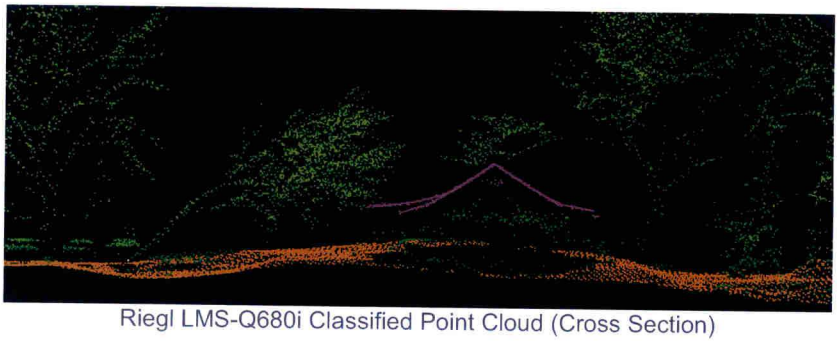
2.3 Phase II: LiDAR Data Acquisition Process and Techniques

As detailed in the previous section, preliminary flight plans and ground control layouts have been created to support 4pts / m^2 LiDAR data collection over the provided area of interest.

2.3.1 Acquisition Sensors

LiDAR - Riegl LMS-Q680i: The Riegl LMS-Q680i collects high density LiDAR with its powerful laser source, multiple time around (MTA) processing technology and full waveform digitization. With a variable scan rate of 10 to 200 scan lines per second and variable pulse rate from 80,000 to 400,000 ranges per second, the system incorporates a rotating polygon mirror with fixed 60 degree field of view, thus eliminating the torsion errors inherent with oscillating mirror LiDAR Systems. The rotating mirror technology results in improved positional accuracy to the edge of the field of view and greater coverage while achieving overall vertical accuracies of 9-15 cm RMSE with up to 15 discrete returns per LiDAR pulse (offering more foliage detail - exceeding project specifications).

The rotating mirror, variable scan rate and variable laser pulse rate results in a highly uniform point density and distribution in both the laser sensor cross track and along track. This allows for the use of the entire collection swath thus resulting in greater collection efficiency. The rotating mirror provides a continuous view at nadir creating a smooth evenly distributed LiDAR point cloud with reduced point to point variability and thus greater accuracy.



Riegl LMS-Q680i Classified Point Cloud (Cross Section)

2.3.2 Perform Flight Set-Up and Geodetic Control Process

Flight Set-Up: Prior to the Notice to Proceed by TWDB, Fugro will carefully review and finalize flight plans, ground control layouts and production blocks to verify the approach is the most efficient and accurate way to meet the specifications listed in the RFQ. Quality control checks (performed by our resident PhD and Photogrammetrist) will include:

- ✓ Nominal pulse spacing (NPS) - NPS ≤ 0.500 m, or point density ≥ 4 points per m2 for first-return data.
- ✓ Uniformity - Spatial distribution of points must be uniform and free from clustering. 90% of cells in a 1-meter grid will contain at least one first-return point. See Data voids for exclusions.
- ✓ Buffer - 300 meter buffer surrounding the AOI is required for flight planning and acquisition, with no buffer needed in between tiles. Buffer will not be included in final delivery.
- ✓ Multiple returns - Lidar sensor shall be capable of at least three (3) returns per pulse, including first and last returns. Multiple returns from a given pulse shall be stored in sequential order and point families must remain intact.
- ✓ Return attributes- Each return must include: easting, northing, elevation, intensity, order of return (i.e. first-return, second-return), classification, and Adjusted GPS Time. Easting, northing, and elevation must be recorded to the nearest 0.01 m and GPS second reported to the nearest microsecond (or better). May include additional attributes. No duplicate entries.
- ✓ Scan angle - For lidar systems with an oscillating mirror, scan angle should not exceed ±20 degrees from nadir. Total field of view or full scan angle ≤ 40°. Rotating mirror systems are exempt from this requirement.
- ✓ Swath overlap - Minimum 30% overlap on adjoining swaths.
- ✓ Data voids - Data voids are defined as areas ≥ 4 square meters [(4*NPS)2] with no first-return points. Data voids are unacceptable unless caused by water bodies or areas of low near-infrared (NIR) reflectivity (i.e. wet asphalt). No voids between swaths.
- ✓ Survey conditions - Leaf-off and no significant snow cover or flood conditions, unless approved by TWDB. Must be cloud, smoke, dust and fog-free between the aircraft and ground.

The final approved ground control point and base station locations will be sent to the Fugro survey department accompanied by the requested ground control accuracies to begin ground control collection.

The aircraft and required equipment will undergo a rigorous pre-flight/pre-project inspection to verify all equipment is ready to mobilize to the project area with the necessary support tools to complete the job.

Upon Notice to Proceed, Fugro will mobilize aircraft, equipment and crew to the project site and remain on site until the project is finished.

Geodetic Control: Carefully placed ground control points will be established in areas meeting the following criteria:

- Site will be flat or gently and uniformly sloping terrain for roughly 25-30 feet in all directions.
- Site will be free of structures and other ground obstructions for roughly 25 to 30 feet in all directions.
- Area will have an open view of the sky (no overhanging branches or power lines).
- Ideal sites for LiDAR ground control are in short grass flat terrain areas such as golf courses and residential lawns (10cm or less in height).
- Areas that typically cause problems for control purposes include: newly paved road surfaces, ditches, vegetated areas, and sites located near structures or trees.
- Avoid areas of high or low reflective surfaces.

High Reflectivity Examples	Low Reflectivity Examples
Reflective paint or tape	Asphalt parking lots
White colored surfaces	Fresh tilled soil
Sandy light color surfaces	Dark colored surfaces

The approved ground control layout and accuracy statement is provided to Fugro's Texas survey operations for collection. Internal QC checks will be conducted by Fugro's Texas registered Land Surveyor to ensure all survey points collected will meet the following requirements:

- ✓ Accuracy will be at least three (3) times more accurate than the dataset.
- ✓ The most recent NGS-approved geoid shall be used to convert GPS ellipsoid heights (NAVD88) into orthometric heights.
- ✓ The survey crew will mark each control point with a 60d nail or larger. The station ID number will be written on an adjacent above-ground flag or stake within one (1) foot of the referenced point.

2.3.3 Fly Project to Collect Data

Daily monitoring of weather will be performed by both the aviation field crew and the flight operations manager. Decisions on priority areas, cloud cover and likelihood of successful acquisitions will be determined at this time. Subsequently the aircraft will station at one of the three project locations where base stations will be setup and acquisition will commence. Flight operations steps will include:

- ✓ The lead pilot will contact Air Traffic Control (ATC) to schedule and coordinate flight.
- ✓ Base station locations provide complete project coverage (within the 40km base line length requirement)
  - Verify redundant NGS CORS stations used are recording at a 1second interval
- ✓ Prior to full flight, the following steps will be performed:
  - Inspect storage and system components to ensure all units are operational and there is sufficient storage space
  - Select and confirm the lever arm coordinates
  - Load navigation system and perform system check
  - Perform 5 minute static alignment and record PDOP, GPS, and UTC start time
  - Ensure all channels are operational, as applicable and at working altitude fire laser and ensure laser returns, ranges, and settings are correct
- ✓ The crew will begin flight line data recording: observe video display, POS status and mass memory screens; record UTC start/stop times, GPS data, ground speed, altitude, comments/concerns, lines, waypoints and times on flight log.

- ✓ After the flight mission is complete, a 5 minute static alignment will be performed followed by a systematic shutdown of the system.
- ✓ Collected data will be downloaded for QC.
- ✓ Arrange delivery of data and email flight log to team; perform data backup.

2.3.4 Verify Data

After each lift, the field crew will back up and inspect the data for completeness and quality prior to shipping data to the production facility. Emailed status reports and flight logs are sent to the Project Manager after each flight for up-to-date project status. Data is shipped to the production facility (priority overnight) for immediate detailed review of the acquired data. Field and office data evaluation steps include:

- ✓ Ensure that there are no gaps between flight lines before the flight crew leaves the project site.
- ✓ Turbulence will be inspected and if it affects the quality of the data, the flight line will be rejected.
- ✓ Full office visual review to ensure that it is complete, uncorrupted, and that the entire project area has been covered without gaps between flight lines.
- ✓ Confirm flight line trajectory files to ensure completeness of acquisition for project flight lines, calibration lines, and cross flight lines.
- ✓ Review and analyze intensity histogram to ensure the quality of the intensity values.
- ✓ Generate a sample TIN surface to ensure no anomalies are present in the data.
- ✓ Verification of post spacing against project specifications.
- ✓ Boresight for the refinement of the initial calibration parameters.
    - Check and correct the vertical misalignment of all flight lines and also the matching between data and ground truth. This process includes calculating the zbias value for each flight line so that all flight lines are aligned vertically.
    - The entire dataset is then matched to ground control points within the project specified accuracy range.
    - The technician will then run a final vertical accuracy check after the z correction. The result will be analyzed against the project specified accuracy to make sure it meets the requirement. The final boresight parameters and accuracy check result will be archived in the project database for future reference.
    - Once boresighting is complete and all lifts are tied to ground control. The LiDAR data will be cut to production tiles and clipped to the project boundary.
- ✓ The project or block of strips is further examined for the following:
    - Preprocessing errors (gaps, slivers, missing data, and steps)
    - Automated vegetation removal errors, including misclassified banks and any other anomalies that are unique to the dataset.
- ✓ The general terrain (flat, hilly, steep, swamp) and land cover (forested, agricultural, urban) are assessed. This allows the technicians to set up classification parameters during the manual filtering that closely match the terrain type.
- ✓ Creating a color shaded TIN from points that have been classified as bare earth provides a view of the data that is useful in detecting errors in the bare earth product. Color shaded TIN are used both during the manual filtering process and during the peer review after manual editing.
- ✓ Another step of the QC process is for the final product to be consistent in quality across the project.
    - Each group or number of strips in a project is assigned to a lead technician who is responsible for the quality of the block.
    - Once strips in the block have been edited, they are checked over by the lead technician and are either approved or sent back to the editors for further edits.
    - Once all strips in a given block have been reviewed, the lead technician then edge matches all the strips to ensure that there is conformity across the block, between strips, and between completed, adjoining blocks of strips.

- ✓ The project manager is responsible for conducting a final overview QC of all deliverables leaving the department. A review of the lead technician's QC, file management procedures, and delivery format and coverage are all checked a final time before a deliverable is sent out. Reporting of deliveries and submitting any QC reports is the direct responsibility of the project manager.

2.3.5 Phase II Deliverables

Deliverable	Description	QA/QC Vendor Role
Flight Trajectories and Airborne GPS Report	LiDAR – SBET files with recorded aircraft position and altitude with adjusted GPS time recorded at 1 second intervals in a shapefile format.	Deliver Selected Checkpoints to Acquisition Vendor
Ground Control Table	Acquired ground control point numbers and coordinates (to 3 decimal places) with network parameters and base station ID's and location.	
Ground Control Survey Report	Report outlining ground control process, network, achieved accuracies with ground photos of each photo identifiable and LiDAR vertical control points.	
Data Acquisition Status Updates	Weekly project reports (via email) updating TWDB on status of acquisition and production.	

2.4 Phase III: Data Processing (LiDAR) Process and Techniques

2.4.1 Boresight/Calibration

Fugro understands the importance of a LiDAR sensor boresight calibration as a cornerstone to achieve the final LiDAR data accuracy and overall project success. Careful project flight planning and coordination with proper flight line sidelap or additional flight lines ensuring a concrete boresight procedure is imperative to create a quality data product. The technician will use selected flight lines to create settings to adjust the boresight. The adjustment settings will be applied to all of the flight lines for each lift and checked for consistency to ensure the results meet the project specifications. Once the boresight adjustment is completed for each individual lift, the technician will run a routine to check the vertical misalignment of all flight lines in the project and also compare data to ground truth. Then the entire dataset will be adjusted to the ground control points. Finally, the technician will run a vertical accuracy check between the adjusted data and surveyed ground control points after the z correction.

The result will be analyzed against the project specified accuracy to make sure it meets the project requirements of <50cm Horizontal RMSE and <12cm Vertical RMSE, as well as the relative accuracy at <=7cm within individual swaths and <=10cm between adjacent swaths.

2.4.2 Point Classification

Fugro has developed a unique, time efficient, and cost effective method for processing LIDAR data. Once boresighting is complete, the project will be set up for automatic classification. The LIDAR data will be cut to production tiles. The flight line overlap points, noise points and ground points will be classified automatically in this process. We utilize commercial software, as well as proprietary, in-house developed software for automatic filtering. The parameters used in the process are customized for each terrain type to obtain optimum results. These parameters can also be customized to capture multiple categories of vegetation based on low vegetation, medium vegetation and high vegetation. After all building and bridges and "low" points are classified, points remaining are reclassified automatically based on height from the ground. Below are the customized parameters for each vegetation class:

- Low Vegetation: 0.01m to 1.10m above ground
- Medium Vegetation: 1.11m to 2.40m above ground
- High Vegetation: 2.41m or more

The algorithm has the ability to process large amounts of elevation point data in batch mode. The goal of this initial automated processing is to classify the points to their proper classification as accurate as possible automatically, thereby reducing the amount of manual editing that is required. The water points will be classified once hydro breakline vector data is collected and checked for quality.

Once the automated filtering has been completed, the files are run through a visual inspection to ensure that the filtering was not too aggressive or not aggressive enough. In cases where the filtering is too aggressive and important terrain have been filtered out, the data is either run through a different filter within local area or is corrected during the manual filtering process. Interactive editing is completed in visualization software that provides manual and automatic point classification tools. Fugro utilizes commercial and proprietary software for this process. All manually inspected tiles will then go through a peer review to ensure proper editing and consistency. After the manual editing and peer review, all tiles will go through another final automated classification routine. This process ensures only the required classifications are used in the final product (all points classified into any temporary class during manual editing will be re-classified into proper customer specified classifications). During this process, buildings, bridges, and vegetation points are classified, and the flight line overlap points are tagged as withheld points.

The following classifications will be included in the LiDAR point cloud deliverable:

Class 1. Unclassified
Class 2. Bare-Earth Ground
Class 3. Low Vegetation
Class 4. Medium Vegetation
Class 5. High Vegetation
Class 6. Building
Class 7. Low Point (noise)
Class 9. Water
Class 13. Bridges/Culverts

The LAS point cloud data will then be packaged to the project specified tiling scheme, clipped to project boundary and LAS delivery format. It will also be re-projected to project specified projection, datum, and unit.

The file header will be formatted to meet project specifications. This ASPRS standard Classified Point Cloud product will be used for the generation of derived products and will be delivered in fully compliant LAS v1.2, Point Record Format 1 with Adjusted Standard GPS Time. Georeferencing information included in all LAS file headers. Intensity values will be included for each point. The Point Source ID will match to the flight line ID in flight trajectory files.

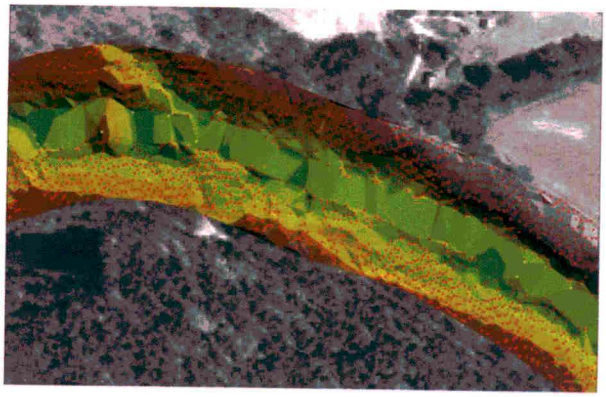
2.4.3 Intensity Image Production

Intensity images of the 1st returns will be created at 1 meter pixel per ¼ USGS 7.5 minute quadrangle (3.75 minute by 3.75 minute tiles). Similar in appearance to low-resolution photographs, georeferenced LiDAR intensity images will be created and delivered and can be used to extract planimetric features and serve as ancillary input for LiDAR data processing. Intensity images also are used to check the horizontal accuracy of the LiDAR data and other criteria.

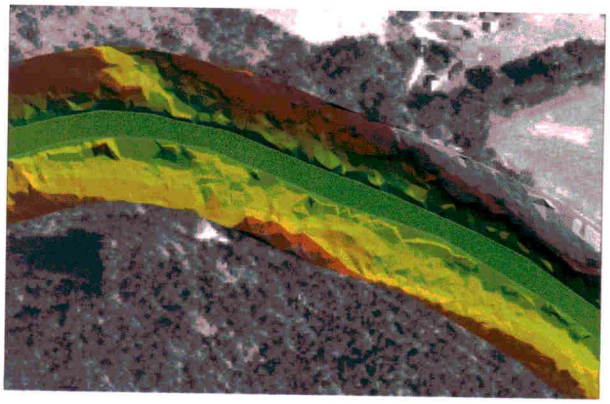
2.4.4 Generate Hydro-Flattening Breaklines

Breaklines representing the banks of streams, rivers, ponds, lakes, oceans, and islands are extracted and converted into polygon shapefiles. These are used in the classification process of the LiDAR point cloud data where points that exist within water bodies are re-classified to Class 9. The 3D hydro breakline vectors are also used in Hydro Flattened Bare Earth DEM creation where the water bodies defined by these vectors are flattened in the DEM surface. This process ensures that the bare-earth LiDAR product matches seamlessly with the hydro breakline data.

LiDAR data consists only of points, which are not suited to defining water flow through the terrain. Hydro breaklines are required to flow in a downhill direction and may deviate from the underlying LiDAR terrain surface. Please refer below to an illustrated example of why hydro breaklines are important:



TIN unsuitable for H&H modeling prior to hydro enforcement.



Resulting TIN after hydro flattening

2.4.5 Phase III LiDAR Deliverables

Deliverable	Description	QA/QC Vendor Role
PILOT	Four (4) contiguous tiles within the project AOI including the all return point cloud, DEM and intensity products	Review Pilot and Comment
All-Return Point Cloud Intensity Imagery Hydro-Flattened Breaklines	Delivered to the QA/QC review consultant on or before Phase III deliverables due date	Review Data Deliverables and Comment

2.5 Phase IV: Final Product Development (LiDAR) Process and Techniques

2.5.1 Create DEM

The product development phase includes the steps and techniques used to create the digital elevation models used by the majority of geospatial analysts. The techniques that are employed by Fugro all follow strict QC procedures in order to maintain the integrity of the elevation data. The bare earth (DEM) areas are generated using the bare earth points, as well as the 3D hydro breaklines. Once the deliverable LAS files are generated for the entire project area and have been checked for quality, and 3D breaklines have been collected and checked for quality, they will be used to produce the bare earth DEM. First the bare earth points that fall within 1*NPS along the hydro breaklines will be re-classified temporarily as class 10 so that these points are excluded from the DEM generation process. This is analogous to the removal of mass points for the same reason in a traditional photogrammetrically compiled DTM. This process will be done in batch using Fugro proprietary software. The technician will then use Fugro proprietary software for the production of LiDAR-derived hydro flattened bare earth DEM surface in initial grid format at 1m GSD and 5m GSD. The DEM tiles will follow the customer provided tiling scheme. The transition of the surface from tile to tile will be seamless. Water bodies (inland ponds and lakes), inland streams and rivers, and other non-tidal water bodies will be hydro-flattened within the DEM.

Hydro-flattening will be applied to all water impoundments, natural or man-made, that are larger than ~2 acres in area, to all streams that are nominally wider than 50', and to all non-tidal boundary waters bordering the project area, regardless of size. This process will be done in batch. Once the initial, hydro-flattened bare earth DEM is generated, the technician checks the tiles to ensure that the grid spacing meets specifications. The technician will also check the surface to ensure proper hydro-flattening. The entire data set will be checked for completed project coverage. Once the data has been checked, the tiles are then converted to the format specified by the customer. Georeferencing information will be included in raster files. Void areas (i.e., areas outside the project boundary but within the tiling scheme) will be coded using "NODATA" value -9999. The 1m DEM will be delivered in DO**4Q** tiles. The 5m DEM tiles will be merged and delivered in project wide mosaic.

2.5.2 Generate Metadata

Metadata records will be developed to document each data deliverable in accordance with the FGDC Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998) as requested by the TWDB. Compliance with these guidelines will be verified using the MP metadata parser available on the FGDC web portal. Metadata records will be peer reviewed to identify and correct any typographic or other errors that would not be flagged by automated tools.

Fugro has developed proprietary automated metadata tools that greatly increase the speed and efficiency of metadata production. During the imagery production a metadata master file is developed that has input and review from leads at all key phases of production. Once the master file has been submitted and approved by the customer it is used to propagate tile level metadata.

2.5.3 Phase IV LiDAR Deliverables

Deliverable	Description	QA/QC Vendor Role
DEM Raster Metadata	Delivered to QA/QC review consultant on or before Phase IV deliverables due date	Review and Comment
		Deliver whole (Ortho & LiDAR) QA/QC checkpoint table

3 COMMUNICATION PLAN AND PROJECT SCHEDULE

Because project events are often unpredictable, effective communication is an integral part of Fugro's project management plan. Ongoing communication throughout the duration of the project ensures that unanticipated issues are immediately and effectively addressed and resolved and potential issues are often prevented as a result.

We will work with TWDB up front to develop a structured plan with scheduled meetings, status updates, and points of communication so that both parties are able to commit in advance and allocate the resources needed to ensure project success.

Our performance-focused communication plan is based on four premises:

1. The client is best served by a **full-time project manager**. Our proposed project manager, Mr. Richard McClellan, has more than 23 years of experience in all aspects of photogrammetric and LiDAR mapping and GIS, including the management of large state and county mapping programs throughout the US. It is Mr. McClellan's responsibility to ensure that the project is completed on schedule, on budget, and to the required specifications.

   Project Manager oversight responsibilities include:

   - Project initiation
   - Project plan compilation and review (with TWDB staff and Project Manager)
   - Flight plan review
   - Control plan review
   - Pilot project plan review
   - Quality control plan review
   - Final project report

   Project Manager quality control responsibilities include:

   - Acquisition QC
   - Control Report(s) review
   - LiDAR Processing / Deliverables
   - Production QC
   - Final Deliverable Formatting and Production QC

2. **An up-front investment of time and resources in project planning ensures success.** Experience has proven that an investment in planning, establishing and maintaining lines of communication, and customizing our reporting system to fit the project and our clients' needs serves everyone well throughout the life of the contract.

3. **First-time-right, on-time means staying on schedule and within budget**. Because project events are not always predictable, effective communication ensures that unanticipated issues are immediately and effectively addressed and resolved. In many cases, our project tracking system enables project personnel to avert potential problems.

4. **Client involvement is requisite to project success.** Fugro project management requires the combined efforts of Fugro and TWDB in planning, careful examination and discussion of project scopes of work and specifications, ongoing monitoring of production schedules, and regular communication.

3.1 Reporting and Expectations

As requested, weekly status reports will be delivered by the Project Manager to TWDB. During the Kickoff Meeting, TWDB will have the opportunity to define the detail to which the weekly reports will be presented. These requirements will be built into TWDB's project work plan. This includes the type of information required, the frequency of reporting, and the format of the reports. This enables us to document TWDB's expectations up front, and also provides a quality checklist that will be used to verify that all requirements are met.

Status of project phases are generally provided through written reports, email notifications, and daily interactions with the TWDB and Fugro staff. Mr. McClellan will be dedicated to this project on a daily basis, and will be available to respond to the TWDB's questions regarding the project status and deliverables.

To further ensure that Fugro meets TWDB's requirements and expectations Mr. McClellan will provide oversight and supervision on all aspects of the project and will provide final review and signoff on all deliverables before they leave our facility.

Mr. McClellan will document detailed information for each of these items based on careful analysis of the project scope of work and based on discussion with all team participants, including TWDB's technical staff and partnering stakeholder agencies. This information will be compiled into the project work plan, and TWDB will have opportunity to review and provide input, as well. Once complete, the project work plan will serve as the basis for managing and executing the project from start to finish.

Our standard Fugro project management work plan is separated into four major components, as follows, with specific items to be analyzed and defined for each component:

1. Project Planning
- a. Scope Statement
- b. Key Personnel Organization Chart
- c. Review of Flight/Ground Control Plan
- d. Project Schedule w/ Milestones
- e. Schedule Management Plan
- f. Communications Plan
- g. Risk Management Plan
- h. Risk Analysis and Response Actions (by project phase)

2. Executing the Project
- a. Project Status Review Meetings and Reports
- b. Project Status Report
- c. Quality Audit Report

3. Controlling the Project
- a. Lessons Learned
- b. Formal Acceptance of Product or Phase
- c. Schedule Change Request

4. Closing the Project
- a. Project Closure Checklist
- b. Project Wrap Up Meeting
- c. Formal Acceptance and Closure

3.1.1 Availability for Kick-Off and Subsequent Meetings

At the onset of the project, Fugro will work with TWDB to establish a custom project work plan and schedule that includes planned meetings and milestones from project kickoff through final delivery and acceptance. Our staff is committed to adhering to this work plan throughout the duration of the project.

Fugro will attend a project kickoff meeting held onsite at the Texas Natural Resources Information System (TNRIS) office in Austin – Date TBD.

3.1.2 Report on Mobilization

TWDB will receive ongoing status notifications and updates throughout the acquisition phase, from mobilization through the end of acquisition. The frequency and format of these updates vary from client to client, and will be defined between TWDB and Fugro during the project kickoff meeting.

At a minimum, reports will be submitted on a weekly basis or more often as required, especially during the mobilization and aerial data acquisition phase. The formats generally used include:

- Written status reports
- Scheduled conference calls
- Email notifications
- Phone notifications

TWDB will be immediately notified by the Project Manager, Richard McClellan, of any issues that will affect the production schedule.

3.1.3 Report Frequency During Acquisition Until Completion

It is anticipated that communication between TWDB and Fugro will increase during the acquisition phase of this project. Mr. McClellan will monitor acquisition progress against schedule through daily communications with the flight/acquisition crew. He will prepare daily written reports (to be sent electronically to the TWDB) to track the status of the acquisition and note milestones and/or issues that require resolution. Report format will be confirmed during the project kick-off meeting.

3.1.4 Report Frequency During Post Processing Until Completion

Status updates during the production phase are defined and scheduled based on discussions between TWDB and Fugro during the project kickoff meeting.

Through our ISO 9001:2008 certified Quality Management System, we have established and documented procedures to maintain product quality standards through the provision of **evaluation, inspection, and verification at all stages of production.** This approach has made quality control an integral part of our project management and production systems.

All departments within Fugro's organization, as well as the operations of team members, are involved in quality management. Our manager of production operations, Mr. Dave White, will oversee all department and division supervisors to ensure that quality control documentation and procedures are followed in compliance with ISO9001:2008 standards. Within each department, and in conjunction with client personnel, specific quality control checks are built into all production processes, thus quality control occurs throughout the life of a project and not simply as a final review.

3.1.5 Report on Delivery of Products and % of Completion of Project Phase According to Schedule

TWDB will have the opportunity to define the level of reporting they require during the Kickoff Meeting. These requirements will be built into the final project plan. This includes the type of information required, the frequency of reporting, and the format of the reports to provide percentage of completion for each task in the project plan.

Status of project phases is generally provided through written reports, email notifications, and daily interactions with the TWDB and Fugro staff. Rich McClellan will be dedicated to this project on a daily basis, and will be available to respond to questions from TWDB regarding the status of the project and the deliverables.

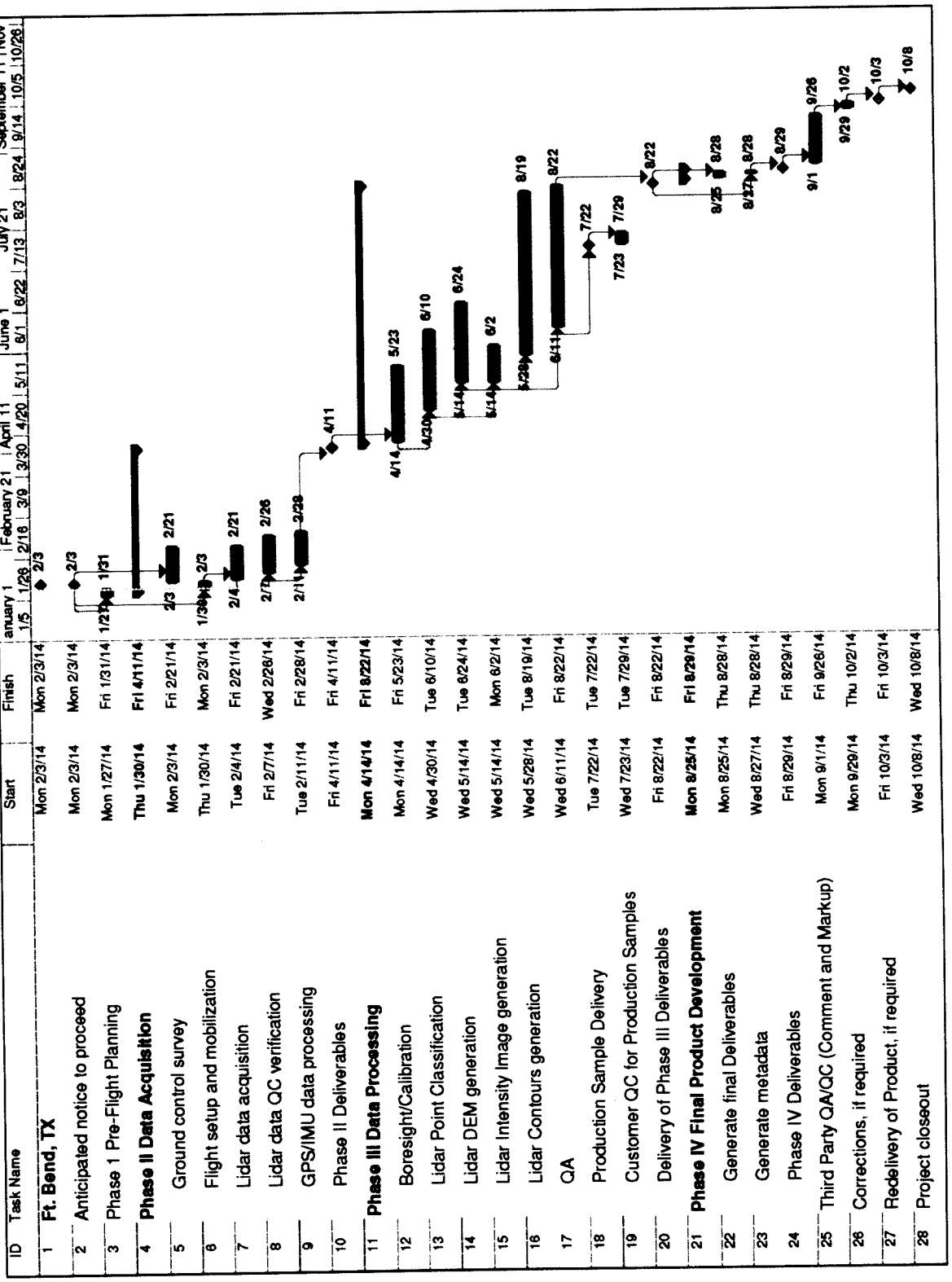
To ensure that all of Fugro's personnel and resources are meeting the needs and expectations of the TWDB, Fugro's Project Manager, Mr. Richard McClellan, will provide oversight and supervision on all aspects of the project.

3.2 Presentation of Timelines and Production Schedule including Internal QA/QC

Fugro's quality policy is to continually improve our processes to ensure customer satisfaction. Our policy has been implemented through an ISO9001:2008-certified quality management system. This internationally recognized certification encompasses all operations and provides customers with an added level of assurance in our design, development, production, and delivery processes. The system establishes and documents procedures to maintain product quality standards through the provision of evaluation, inspection, and verification at all stages of production. This approach has made quality control an integral part of our project management and production systems.

All departments within Fugro's organization, as well as the operations of team members, are involved in quality management. Mr. Dave White, CQM, will oversee all department and division supervisors to ensure that quality control documentation and procedures are followed in compliance with ISO9001:2008 standards. Within each department, and in conjunction with client personnel, specific quality control checks are built into all production processes, meaning that quality control occur throughout the life of a project and not simply as a final review. Fugro also has realized dramatic and measured improvements for cycle time reduction, reduced training and rework, improved subcontractor management and performance, and decreased client complaints.

3.2.1 Preliminary Project Schedule



ID	Task Name	Start	Finish
1	**Ft. Bend, TX**	Mon 2/3/14	Mon 2/3/14
2	Anticipated notice to proceed	Mon 2/3/14	Mon 2/3/14
3	Phase 1 Pre-Flight Planning	Mon 1/27/14	Fri 1/31/14
4	**Phase II Data Acquisition**	Thu 1/30/14	Fri 4/11/14
5	Ground control survey	Mon 2/3/14	Fri 2/21/14
8	Flight setup and mobilization	Thu 1/30/14	Mon 2/3/14
7	Lidar data acquisition	Tue 2/4/14	Fri 2/21/14
8	Lidar data QC verification	Fri 2/7/14	Wed 2/26/14
9	GPS/IMU data processing	Tue 2/11/14	Fri 2/28/14
10	Phase II Deliverables	Fri 4/11/14	Fri 4/11/14
11	**Phase III Data Processing**	Mon 4/14/14	Fri 8/22/14
12	Boresight/Calibration	Mon 4/14/14	Fri 5/23/14
13	Lidar Point Classification	Wed 4/30/14	Tue 6/10/14
14	Lidar DEM generation	Wed 5/14/14	Tue 6/24/14
15	Lidar Intensity Image generation	Wed 5/14/14	Mon 6/2/14
16	Lidar Contours generation	Wed 5/28/14	Tue 8/19/14
17	QA	Wed 6/11/14	Fri 8/22/14
18	Production Sample Delivery	Tue 7/22/14	Tue 7/22/14
19	Customer QC for Production Samples	Wed 7/23/14	Tue 7/29/14
20	Delivery of Phase III Deliverables	Fri 8/22/14	Fri 8/22/14
21	**Phase IV Final Product Development**	Mon 8/25/14	Fri 8/29/14
22	Generate final Deliverables	Mon 8/25/14	Thu 8/28/14
23	Generate metadata	Wed 8/27/14	Thu 8/28/14
24	Phase IV Deliverables	Fri 8/29/14	Fri 8/29/14
25	Third Party QA/QC (Comment and Markup)	Mon 9/1/14	Fri 9/26/14
26	Corrections, if required	Mon 9/29/14	Thu 10/2/14
27	Redelivery of Product, if required	Fri 10/3/14	Fri 10/3/14
28	Project closeout	Wed 10/8/14	Wed 10/8/14

3.3 Representations of Commitment of Resources to Ensure Timely, Successful Performance

Fugro's team has large acquisition and production equipment and personnel capacity available to support successful acquisition, processing and delivery of LiDAR data for each AOI locations in Texas.

Fugro employs a full-time production coordinator who is responsible for maintaining a detailed production schedule that shows, among other things:

1) Available and committed production hours per department,
2) Estimated and actual (accrued daily) hours per production phase,
3) Anticipated projects expected to enter production in the next 30, 60, and 90 days, and
4) Their potential impacts on the production schedule.

Fugro uses this master schedule to:

1) Determine whether or not we can take on a new project, and
2) Evaluate the length of time required for production so we can work with TWDB to develop a delivery schedule that meets both parties' expectations.

The production scheduling system comprises the number of hours available in each major production department against jobs sold (in hours) and those leads that are rated as highly likely to become jobs. Team members are polled weekly to determine production capacity and ability to perform within the desired timeframe.

Fugro also creates a project-specific production schedule that outlines all major production phases, milestones, interim deliverables and due dates, and final deliverables and due dates. This schedule is developed during the project initiation phase and guides production throughout the life of the project.

3.4 Past Project Performance to Meet Delivery Deadline

Fugro is committed to meeting delivery deadlines that are agreed upon at the project kickoff meeting. Additional resources can be added to any phase of the project to ensure that internal milestone deadlines outlined within the project management plan are met. In 2009, Fugro delivered over 1,000 square miles of LiDAR data flown for the TWDB on schedule. There were times additional personnel were added to the project to meet the schedule. This is in the best interest of TWDB and Fugro to ensure that production deadlines are met.

The importance of keeping delivery on schedule cannot be overstated. Fugro has demonstrated the ability to manage the schedule of numerous projects many times over. Adherence and adaptation to a schedule with little time to prepare takes an experienced and organized project manager with access to the resources required to complete the scope of work.

The **Project Workbook** is a document we use on nearly every project that records successes and failures in terms of schedule, budget, communications, team member performance, and many other metrics that can be used to determine the success of a project.

Fugro's project management approach is based on previous experience serving many State agencies and is designed to meet the following objectives:

- Serve as an advocate for TWDB
- Provide a central source for all communications between TWDB
- Track progress against schedule, budget with regular reporting to TWDB and authorized participants.
- Risk mitigation as an integral part of project planning and execution; this is a critical component, and even more so during rapid response events.
- Identify technical issues early and resolve them in a timely manner.
- Produce quality products and services.
- Ensure the successful completion of each task order, on time, first time right.
- Incorporate lessons learned and best practices into subsequent tasks.
- Adherence to our ISO9001 standards.

3.4.1 Past Performance Documentation / Client Statements

Our customer satisfaction measurement system has been created in accordance with the ISO9001-2008 standard. We employ a project-based, qualitative customer satisfaction survey which queries customers directly against our satisfaction criteria. In addition, we utilize a customer feedback database to capture quantitative feedback, positive or negative, that enables us to take immediate corrective action when necessary.

Fugro actively solicits feedback after project completion in pursuit of achieving better performance on projects and better service for our clients. This feedback comes in the form of our own customer survey which we request at the close of each project/task order. These feedback forms consistently comeback to us with a 4.5 to 5.0 out of a possible 5.0, defined as very satisfied.

Many government agencies have project/vendor evaluation procedures that they follow which include questions relating to progress reports, communication, and quality of deliverables, schedule, an overall rating, and a comments area. Following are summarized ratings Fugro has received on some large contracts, including the and NOAA CSC Geospatial Services, and USGS GPSC; Both contracts were managed by Richard McClellan, the PM we are proposaing for this TWDB project.

A/E Contract Number	Task Order # (If applicable)	Official Report Date	Overall Rating	Summary of Comments, If provided.
NOAA CSC Coastal Geospatial Services EA133C-05-CQ-1051	T005	4/17/2009	Excellent	"Everyone on the team did a fantastic job and the result is an excellent set of data for Texas and NOAA. I would definitely use this team again for future work and I believe the lessons learned from this effort will benefit others doing similar projects in the future."
	T006	04/17/2007	Excellent	No comments provided
	T008	10/02/2008	Good	"The quality of the work was very good."
	T009	01/29/2009	Excellent	No comments provided
	T010	08/30/2007	Excellent	"The final deliverable reflected all comments and concerns that CSC had with the draft product."
	T011	9/4/2008	Very Good	"The data was of very high quality and I felt comfortable with the team."
	T012	10/10/2008	Good	No comments provided
	T013	10/08/2010	Excellent	No comments provided
	T014	02/24/2010	Very Good	"The final deliverable... was a particularly strong and important contribution to the overall project."
NOAA CSC Coastal Geospatial Services EA133C-11-CQ-0008	T001	10/14/2011	Excellent	This project went very well.
USGS Contract GPSC II	Fresno CA 133 UA 1' Ortho	01/12/2012	Excellent	"Excellent Project with good communication and coordination by FEDI. Delivered 1 1/2 months early and accepted 2 1/2 months ahead of schedule."
	District of Columbia 133 UA 1' Ortho	09/19/2012	Excellent	"Difficult task because of coordination with US Secret Service schedules to obtain imagery and review imagery. Contractor kept us up to date with status of the SS availability."
	Spokane WA 133 UA 1' Ortho	09/13/2012	Excellent	"Only 1 minor error to correct. All deliveries were either early or on time."
	Pierre SD 133 UA 1' Ortho	08/15/2012	Excellent	"Fugro-EarthData handled this task very professionally, communicated extremely well, and submitted deliverables significantly ahead of time. Only one minor error was found amongst all deliverables."

3.5 Contingency Plans/Resolution to Resolve Post Acquisition Performance

3.5.1 Production Phases

For the production phases of the project, Fugro has access to a large number of production resources that can be assigned to perform LiDAR production processes. These resources are located in our main facility in Frederick, Maryland, and other global Fugro offices. Production resources can be ramped up to 3 shifts in order to meet milestone delivery dates if needed. Additionally, our team offers TWDB rapid mobilization of assets and crews in response to emergency or crisis situations.

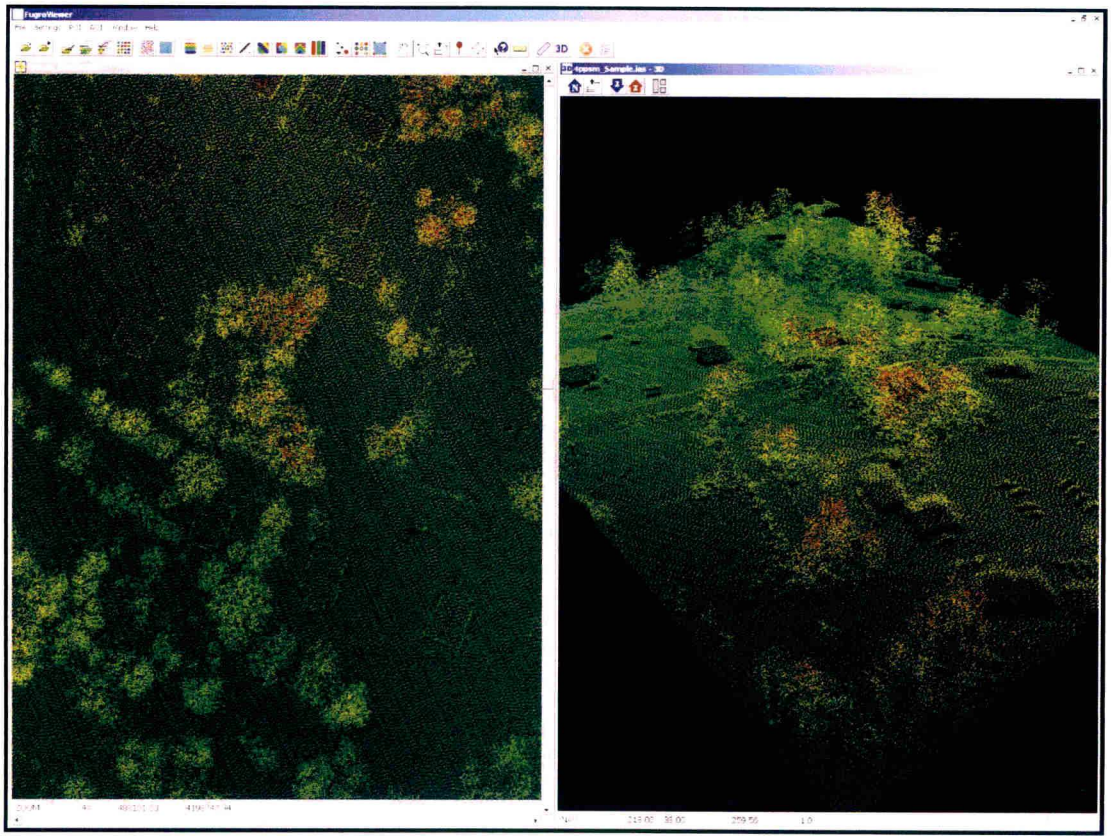
As stated earlier in this proposal, Fugro owns and operates 27 geospatial aircraft, 14 digital imagery sensors and 12 LiDAR sensors - backed by over 1400 geospatial technicians globally. This allows for multiple identical sensor systems to be used for collection, and provides additional back-up resources to be mobilized quickly should the need arise due to inclement weather or equipment malfunction.

4 PRODUCT SAMPLE (SUBMITTED ON ENCLOSED DVD)

The following sample is provided on a separate DVD with this submittal. This sample is representative of the deliverables and methods used to acquire high resolution elevation data requested in the TWDB's scope of work. Samples were acquired with the sensors we are proposing (Riegl LMS-Q680i) and were created using similar equipment and processing techniques that we have described in this proposal.

Sample LiDAR: 2013 Boy Scouts of America Jamboree Camp, Mount Hope, WV

This sample is of a 4ppsm LiDAR project of the Boy Scouts of America's National Jamboree Camp and surrounding area near Mount Hope, WV. Fugro was tasked to acquire aerial data, compile 1"=100' scale planimetric features and create 2' contours within a rapid response type scenario utilizing the Frederick, MD, Rapid City, SD and Qinhuangdao, China production facilities. 1"=100' scale planimetric features were stereo-compiled using softcopy Intergraph SSK workstations. The project resulted in data maps used in data applications to support the National Jamboree. This sample data has been formatted to match the LiDAR deliverables requested by the TWDB.



5 KEY PERSONNEL / PROJECT TEAM

5.1 Teaming Approach

The project team we are proposing, comprised of highly qualified and experienced personnel, will complete this project without the use of subconsultants. This "seamless team" approach will increase efficiencies and reduce the overall risk of the project by maintaining all management and control under the Fugro umbrella. Fugro's data acquisition and production processes for LiDAR products have been developed by the personnel presented here based on lessons learned over the course of hundreds of projects.

This project team was developed by and will be led by Fugro's project manager, Mr. Richard McClellan, a certified Professional Land Surveyor (PLS) and Project Management Professional (PMP). Mr. McClellan will be the primary point of contact for the TWDB, and will design a project plan to ensure all deliverables are successfully developed throughout the contract in adherence to TWDB standards. He will coordinate technical requirements with the TWDB, and commit needed resources, provide contract supervision and oversight, and ensure product conformance to the required specifications. Most importantly, Mr. McClellan will continuously monitor progress and quality on all production, resolve issues, prepare progress reports and other communications with the TWDB.

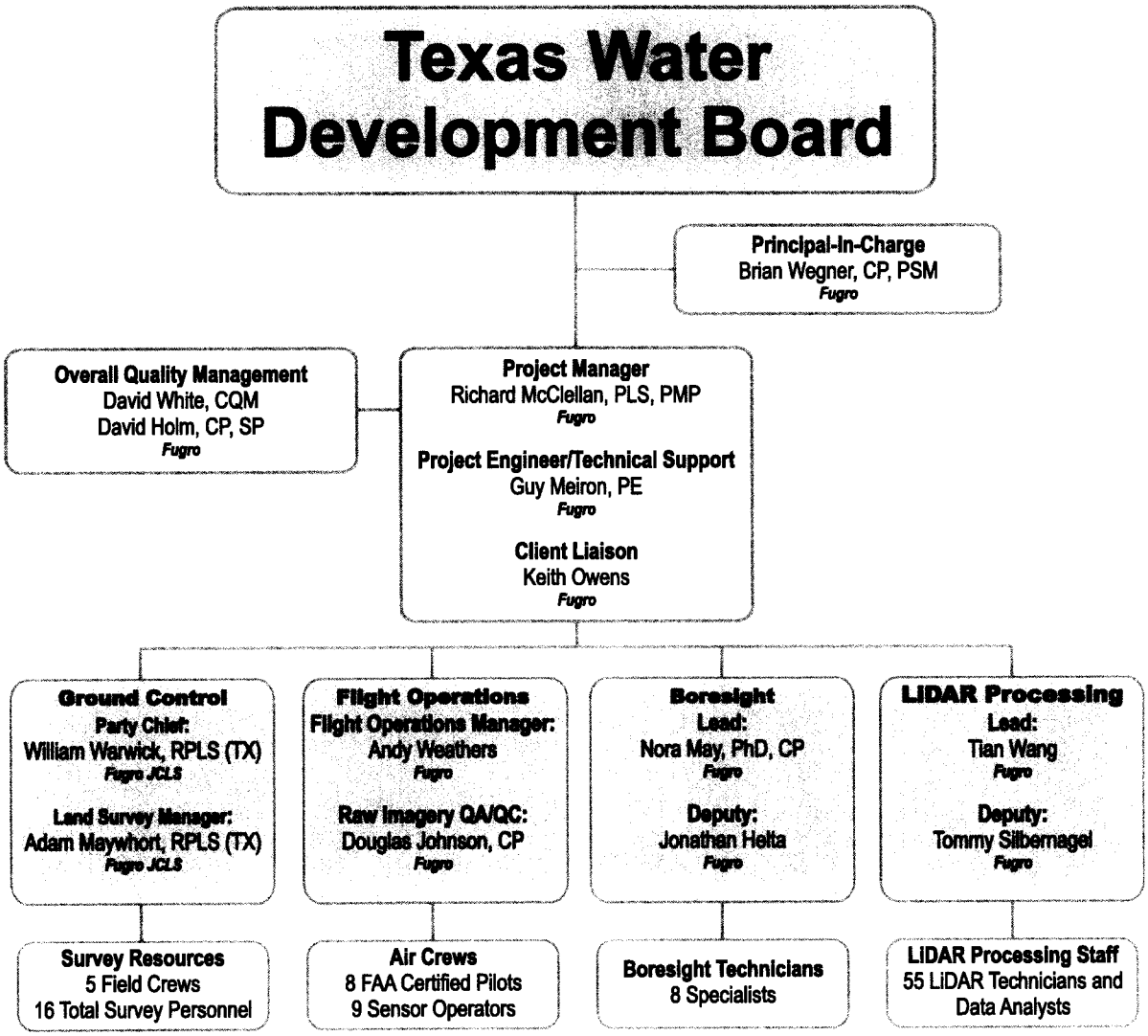
Mr. McClellan designed this team not only based on the skills, qualifications and experience each member individually brings to the project, but also for the experience they have working on projects together, developing complex solutions to overcome difficult issues.

The table below illustrates the experience that the core supervisory technical personnel on this team have working together on complex mapping projects.

		Project Examples (See List Below)							
Name	**Role**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Richard McClellan, PLS, PMP	Project Manager	X	X	X	X	X	X	X	X
Andy Weathers	Flight Operations Manager	X	X	X	X	X	X	X	X
Douglas Johnson, CP	Raw Data Quality Control	X	X	X	X	X	X	X	X
Tian Wang	LiDAR Production Supervisor	X	X	X	X	X	X	X	X
Tommy Silbernagel	LiDAR Production Deputy	X	X	X					

1. **2013 Boy Scouts of America Jamboree Camp, Mount Hope, WV (17.5 sq. mi. AOI)**
   Orthoimagery (4-band, 6-inch pixel GSD), LiDAR (4 pts/m2), and Planimetric Mapping (100 scale and 50 scale)
2. **2011 FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations**
   Multiple task orders for LiDAR acquisition and processing covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM. AOI's include Central TX, Liberty County, TX, and Parker County, TX.
3. **2009 to 2012 Thurston County, WA – Multiple contracts for Orthoimagery & LiDAR (819 sq. mi. AOI)**
   2009/2012 Countywide Orthoimagery (4-band, 6-inch), 2011 LiDAR / Lessons learned on the 2009 project included an understanding of the mountainous / varied terrain.
4. **Ongoing since 2004 - Rutherford County, TN – Orthoimagery and LiDAR**
   Orthoimagery, Oblique Imagery, LiDAR, and planimetric/structures mapping
5. **2012 Hurricane Sandy LiDAR Rapid Response, CT Coastline**
   Rapid response scenario to collect LiDAR data post Hurricane Sandy along the CT coastline
6. **2010 California Coastal Mapping Orthoimagery and LiDAR**
   First of its kind, Bathymetric, Topographic, and Multispectral imagery collection of the entire California Coastline with follow-on data merge between topographic and bathymetric LiDAR to create a seamless LiDAR representation from off-shore to on-shore elevation data.
7. **USGS Geospatial Products/Services Contract (GPSC), Various Locations Nationwide**
   LiDAR and Orthoimagery task orders since 2008
8. **San Francisco Bay, CA - LiDAR/Imagery Data Merge (2010)**
   A combined digital imagery and LiDAR collection over San Francisco and San Francisco Bay.

5.2 Team Organization Chart



5.3 Key Personnel Resumes

Resumes for Key Supervisory Personnel are presented on the following pages in the order listed below:

Richard McClellan, PLS, PMP **Role:** Project Manager
Fugro EarthData, Inc

Mr. McClellan is certified as a Project Management Professional and is currently the program manager for some of Fugro's largest and most complex contracts including our current, NOAA and U.S. Army Corps of Engineers multi-year indefinite delivery contracts. He is experienced managing multiple projects requiring planning for multiple users and delivery of products and services that range from aerial data acquisition to multi-sensor product deliveries.

Mr. McClellan is a licensed as a Professional Land Surveyor in multiple states with over 27 years of experience in project management, supervision, and professional oversight in all phases of mapping projects, including client liaison, supervision of staff and subcontractor, training and development, job estimating, proposal preparation, and client billing.

Experience
- Years with Fugro: 4
- Years with Other Firms: 25

Education
- MS, Natural Resources Management, Slippery Rock University
- BS, Business Management, Mount St. Mary's University
- AAS, Forestry and Surveying, Paul Smiths College

Affiliations / Certifications
- Project Management Professional, #1320560
- Professional Land Surveyor, PA, VA, NC, NY, MD
- ASPRS Member

PROJECT EXPERIENCE

- Thurston County 2009/2012 Orthoimagery and 2011 LiDAR Program

  Project Manager: Mr. McClellan manages this multi-year program (under separate contracts) which included the capture of 6-inch natural color orthoimagery and color infrared (CIR) imagery, with a follow-on LiDAR product in 2011. The 819 sq. mi. area of interest is located in the south Puget Sound region of Washington State, with an additional 20 sq. mi. in Grays Harbor County encompassing land within the jurisdiction of the Confederated Chehalis Tribe.

- FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

  Project/Task Manager: Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. To date Fugro has acquired LiDAR data covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM.

- Boy Scouts of America 2013 Orthoimagery, LiDAR, Planimetrics and Contours Program, Mount hope, WV

  Project Manager: Mr. McClellan managed the 2013 2" and 3" Aerial Photography and 4ppsm LiDAR program for the Boy Scouts of America's National Jamboree. Fugro was tasked to acquire aerial data, compile 1"=100' scale planimetric features and create 2' contours within a rapid response type scenario utilizing the Frederick, MD, Rapid City, SD and Qinhuangdao, China production facilities. 1"=100' scale planimetric features were stereo-compiled using softcopy Intergraph SSK workstations. The project resulted in data maps used in data applications to support the National Jamboree.

- St. Louis District Photogrammetric Mapping and Aerial Photography, ID/IQ Contracts

  Program Manager: Since 2008, Mr. McClellan has managed more than 30 task orders through U.S. Army Corps of Engineers, St. Louis District ID/IQ Contracts. Through this contract, geospatial data is being supplied to the National Guard Bureau (NGB) for use in the development of a GIS used to promote effective environmental management of the facility, as well as inventory and management of the facility assets and resources. Mr. McClellan has had direct oversight for multiple task orders for National Guard training sites nationwide, including 100 orthophotography sites, 12 planimetric sites, 5 thermal sites, 4 LiDAR sites, and 3 contour sites.

Brian Wegner, CP, PSM **Role: Principal in Charge**
Fugro EarthData, Inc

Brian Wegner began his career with Fugro in 1987. Having advanced through both production and management positions, Mr. Wegner became vice president of group subcontracting services, and has since progressed to become senior vice president of mapping services. Mr. Wegner oversees all business development and operations occurring within the mapping division at Fugro. He works closely with sales and project management staff to ensure that all projects are performed to specifications and according to customer expectations. He ensures quality control and facilitates workflow among Fugro divisions and all subconsultants. In addition, Mr. Wegner reviews and oversees all project specifications, development of work schedules and delegation of work programs, and liaises with clients and subconsultants to ensure that client needs are met on time and to specification.

Mr. Wegner's technical understanding of photogrammetric mapping, combined with his expertise in project administration and management, promotes high levels of accuracy and efficiency in production and expands Fugro's capacity to undertake complex acquisition and mapping projects for federal, state, and local government agencies, utility companies, and private engineering firms.

Experience

- Years with Fugro: 27
- Years with Other Firms: 0

Education

- MBA, 1996, Johns Hopkins Univ
- BS, 1987, Cartography, Univ of WI

Affiliations / Certifications

- Professional Surveyor and Mapper, FL License #LS0005422
- American Society for Photogrammetry and Remote Sensing, Member

PROJECT EXPERIENCE

- US Army Corps of Engineers, St. Louis District - Ongoing

  Principal in Charge: Mr. Wegner oversees all technical and contractual aspects for task orders under this 5-year ID/IQ contract for the St. Louis District Army Corp of Engineers. The contract requires aerial photography and airborne GPS data acquisition, remote sensing with hyperspectral and multispectral sensors and passive microwave radiometer, aerotriangulation, large and small-scale topographic mapping, LiDAR, land-use/land-cover mapping, digital orthophotography, and a variety of advanced mapping and surveying services. Fugro has held indefinite delivery contracts with the St. Louis District for more than 20 years and through this ID/IQ, supports a wide array of clients, including other federal agencies such as the National Guard, the US Army and Navy, the Departments of the Interior and Agriculture well as state agencies.

- Thurston County 2009 & 2012 Aerial Photography and LiDAR Program

  Principal-in-Charge Mr. Wegner provided contractual and technical oversight for all components of EarthData's Thurston County project. This county-wide project, encompassing an 819 sq mile area of interest located in the south Puget Sound region of Washington State, called for 6-inch RGB and CIR orthoimagery, and LiDAR mapping.

- Tennessee Statewide Base Mapping Program

  Principal-in-Charge Mr. Wegner provided contractual and technical oversight on this 5-year statewide mapping program requiring digital orthoimagery at 1"=100' (1' pixel resolution for urban/suburban areas), 1"=400' digital orthoimagery (2' resolution for rural areas), and planimetrics including hydrography, roads, and tree lines.

- Photo Interpretation and Damage Assessment Response to Hurricane Ike, Texas, Gulf Coast Area

  Principal-in-Charge. As principal in charge, Mr. Wegner provided contractual and technical oversight and guidance during this DHS/FEMA task order which included photo interpretation and geospatial data development services to aid in the emergency response to Hurricane Ike in 2008. Fugro provided assessment and photo interpretation of approximately 11,000 sq. miles.

- National Coastal Mapping Program (NCMP) CA, OR, WA Coastal Mapping, USACE, Mobile District

  Principal in Charge: Mr. Wegner oversees all Fugro EarthData contractual and technical elements of this project. Fugro EarthData is a subcontractor on this program through Fugro Pelagos' USACE Mobile District IDC contract. The NCMP's mission is to collect and merge shoreline topographic, bathymetric, and imagery data to create a seamless dataset that accurately represents the coastal condition.

Dave White, CQM — **Role: Quality Control / Assurance Manager**
Fugro EarthData, Inc

Dave White, vice president of Fugro's mapping services, leads program-based operations, from program initiation, to contract negotiations and quality management, to production. He is uniquely qualified to serve in this capacity, having advanced through technical and management positions in every Fugro production group since joining the company in 1990. Mr. White began his career with Fugro as a geospatial analyst and quickly advanced to planning, developing, and managing the specialized production processes required for federal, state, and local government agency programs and providing project oversight and coordination, work scope definition and guidance, resource allocation, scheduling of tasks, and quality assurance management for numerous programs and clients.

His hands-on experience handling diverse projects for essential clients contributes to overall program efficiencies, and, in compliance with Fugro's ISO9001:2008 quality system, continuous improvement of management and production processes.

Experience

- Years with Fugro: 22
- Years with Other Firms: 0

Education

- Information Science, Business / 2 Years
- Photogrammetry / 1 Year

Affiliations / Certifications

- American Society for Quality/1997/Certified Quality Manager
- American Society for Photogrammetry and Remote Sensing (ASPRS)
- Society for American Military Engineers

PROJECT EXPERIENCE

- USACE St. Louis District Photogrammetric Mapping & Aerial Photography ID/IQ Contracts, Nationwide Coverage

  Operations and Quality Manager: Mr. White oversees all technical and contractual aspects for task orders under this 5-year ID/IQ contract for the St. Louis District Army Corp of Engineers. The contract requires aerial photography and airborne GPS data acquisition, remote sensing with hyperspectral and multispectral sensors and passive microwave radiometer, aerotriangulation, large and small-scale topographic mapping, LiDAR, land-use/land-cover mapping, digital orthophotography, and a variety of advanced mapping and surveying services.

- NOAA Coastal Services Center Geospatial Services, Nationwide Coverage

  Operations and Quality Manager: Mr. White oversees project management and production operations for task orders under this multi-year ID/IQ contract for the NOAA CSC. The contract covers a wide range of services, including: acquisition and processing of airborne imagery, LiDAR, multi-spectral, GRAV-D, and IFSAR data; production of digital orthophotos, DEMs, planimetric and topographic mapping; land-use/land-cover and SAV classification, surveying, bathymetric mapping and hydrographic surveying.

- Orthoimagery and Other Mapping Services, Rutherford County, TN

  Operations and Quality Manager: Since 2004, Mr. White has provided quality management for multiple, highly successful imagery and mapping projects beginning with a county-wide (620 sq. mi.) update to the digital orthophoto and topographic base map. LiDAR data, acquired with the Leica ALS40 LiDAR sensor, was also acquired to develop county-wide, 2-foot interval contours. In 2007, Fugro was again selected to provide county-wide 6-inch pixel GSD color orthoimagery. Additional products from this work included contours, planimetric feature extraction. In 2009, Rutherford County awarded Fugro a 5 year base mapping contract with a one year extension (2009-2014) to provide a wide range of product services, including digital orthophotography, LiDAR, planimetric mapping, contour generation, and oblique imagery.

- FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

  Operations and Quality Manager: Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. To date Fugro has acquired LiDAR data covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM.

Guy Meiron, PE **Role: Technical Lead / Project Engineer**
Fugro EarthData, Inc

Guy Meiron is a registered Professional Engineer with 24 years of project experience. He is responsible for the overall execution of projects - overseeing task and work order specifications in every department. He provides day-to-day engineering support and direction to staff throughout the entire photogrammetric and mapping process, along with technical QA/QC review. Mr. Meiron ensures that each project conforms to technical requirements, client specifications as well as budget and schedule conformity.

Experience

- Years with Fugro: 23
- Years with Other Firms: 1

Education

- BS, Aerospace Engineering, Parks College of St. Louis University

Affiliations / Certifications

- Professional Engineer, SD, #6594 (1998)

PROJECT EXPERIENCE

- St. Louis District Photogrammetric Mapping and Aerial Photography ID/IQ Contracts, Nationwide Coverage

  Lead Engineer: Mr. Meiron serves as the Project coordinator and lead engineer of multiple 3-year and 5-year ID/IQ contracts encompassing photogrammetric mapping, aerial photography (conventional, digital, LiDAR), remote sensing, aerotriangulation, large and small-scale topographic maps, and land use / land cover analysis and mapping services.

- Bureau of Reclamation – Multi-region ID/IQ Contract(s) for Photogrammetry and Remote Sensing, Nationwide Coverage.

  Lead Engineer: Mr. Meiron serves as the lead engineer and project coordinator of multiple 5-year ID/IQ contracts encompassing aerial photography acquisition, LiDAR data acquisition and processing, orthophotography, topographic and planimetric mapping services throughout 17 western states.

- Red River of the North Basin (US) Mapping Initiative Digital Elevation Data Acquisition, MN, ND, SD

  Lead Engineer: Mr. Meiron served as the lead engineer and project coordinator for the acquisition and processing of 41,700 sq. mi. of color aerial photography and LiDAR data to develop a high-resolution digital elevation map of the entire U.S. portion of the Red River North Basin.

- Fire Prevention Database Creation for Coeur d'Alene Tribe, Plummer, ID

  Lead Engineer: As lead engineer and project coordinator, Mr. Meiron oversaw the acquisition and processing of 343,561 acres of LiDAR data. The project encompassed the entire Reservation including large tracks of forested area to assist in the development of a fire prevention database.

Keith Owens **Role: Client Liaison**
Fugro EarthData, Inc

Keith Owens, Regional Sales Manager of Fugro's mapping services, leads program-based communication, from program initiation, to contract negotiations, to production. Keith's hands on experience with Land Surveying, Aerial Data Acquisition, Project Planning, Project Estimating, Data Processing, Map Compilation, Project Management and Business Development uniquely qualifies him to manage and implement project goals, accuracies, expectations and execution.

Keith's detailed understanding of every aspect of the mapping industry ensures all communication for Fugro's geospatial efforts are clear and accurate.

Experience

- Years with Fugro: 09
- Years with Other Firms: 08

Education

- Business / 2 Years
- Photogrammetry / 1 Year

Affiliations / Certifications

- N/A

PROJECT EXPERIENCE

- NOAA Coastal Services Center Geospatial Services, Nationwide Coverage

  Project Staging and Controls: Mr. Owens designed and estimated most NOAA CSC projects from Flight Planning, Ground Control Layout, to Project Estimating. His clear understanding of client expectations, accuracy requirements and geographic or atmospheric restrictions provides a clear project understanding at the development stage. Having this clear understanding at each phase of the project during the design stage allows Fugro to properly anticipate and communicate project financial expectations and geographic or atmospheric constraints which prepares the team for proper project execution.

- USACE National Coastal Mapping Program (JALBTCX), Nationwide Coverage

  Project Staging and Controls: Mr. Owens designed and estimated USACE National Coastal Mapping Program Task Orders from Flight Planning, Ground Control Layout, to Project Estimating. His experience working in challenging environments paved the way for proper project expectations. Project planning and estimating was clearly laid out anticipating difficult atmospheric conditions, tidal requirements and short flight windows for data acquisition.

- Thurston County 2009 & 2012 Aerial Photography and LiDAR Program

  Project Staging and Controls: Client satisfaction starts with understanding the client's region. Mr. Owens' experience acquiring data in difficult terrain and challenging atmospheric conditions put forth a proper project design which would help the team tackle the upcoming acquisition and processing efforts. His proper flight plan and control layout kept Fugro within accuracy specifications, point densities and imagery ground sample distances (GSD's) while tackling a diverse terrain environment, which included high relief, urban areas and heavily forested areas.

- Vermont Statewide Orthoimagery Multi-Year Program

  Project Staging and Controls: Mr. Owens designed and estimated the five (5) year statewide project. Vermont's short acquisition window, challenging atmospheric conditions, flood characteristics (from winter snow melt) and heavy terrain required a proper project design and financial understanding from year one. Vermont's statewide project includes the base map Ortho deliverable with options for buy-ups. Mr. Owens' planning of each year's acquisition easily adjusts to state agency buy-ups providing a seamless data collection and processing effort holding to strict deliverable times.

Andy Weathers **Role: Flight Operations Manager**
Fugro EarthData, Inc

Mr. Weathers has served as a pilot for all types of acquisition including imagery, LiDAR, GeoSAR (IFSAR) and GRAV-D acquisition. With over 28 years of flying experience 13 of which is in the field of aerial mapping and surveying, Mr. Weathers has recently transitioned to the role of Flight Operations Manager for Fugro. Mr. Weathers knowledge and experience on the aviation side of Fugro's mapping business is an invaluable asset and maintains quality, efficiency and resource management on all mapping projects.

Mr. Weathers provides direction and oversight of the aviation crews, and ensures that Fugro has highly trained and qualified flight crews available to perform varied types of imagery acquisition.

Experience

- Years with Fugro: 5
- Years with Other Firms: 25

Education

- BS, Professional Aviation, Middle College of Georgia

Affiliations / Certifications

- Airline Transport Pilot – AMEL

PROJECT EXPERIENCE

- USACE National Coastal Mapping Program (JALBTCX), Nationwide Coverage

  Pilot in Command: Mr. Weathers managed the acquisition flights for topographic LiDAR, RGB imagery, and hyperspectral data collection, and topographic and RBG imagery for the US Army Corps of Engineers (USACE) Mobile District Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX) National Coastal Mapping Program (NCMP) for the entire US west coast. Fugro EarthData was a subcontractor on this program through Fugro Pelagos' USACE Mobile District ID/IQ contract. The NCMP's mission is to collect and merge shoreline topographic, bathymetric, and imagery data to create a seamless dataset that accurately represents the coastal condition and engineering and research.

- 2011 – 2012 NOAA GRAV-D (Gravity for the Redefinition of the American Vertical Datum), Great Lakes Region, Lake Superior

  Pilot, Participated in the successful completion of the Great Lakes Region Airborne Gravity data collection. The data collection occurred during August and September, 2011 as well as the successful completion of the Great Lakes Region, Lake Superior Airborne Gravity data collection, April – July, 2012.

- Thurston County Orthophotography and LiDAR Mapping Program, Washington

  Chief Pilot. Mr. Weathers served as chief pilot for the Thurston County acquisition. He managed all flight operations conducted by Fugro for countywide imagery acquisition. Mr. Weathers devised a flight strategy, using the ADS40-SH54 digital sensor at varying altitudes, to complete acquisition of this challenging mountainous area.

- USACE, St. Louis District IDC, Multiple task Orders

  Chief Pilot. As chief pilot Mr. Weathers is responsible for the development and management of various flight operation programs on a daily basis. He coordinates all project planning, managing, and executing with appropriate agencies. Fugro EarthData has held an indefinite delivery contract with the St. Louis District for more than 20 years. This IDC supports a wide array of clients, including both federal and state agencies.

- USACE, Mobile District (subcontractor for Fugro Pelagos), West Coast LiDAR

  Pilot In Command. As pilot in command, Mr. Weathers serves oversees aircraft and crew performing photography and remote sensing for this project. Mr. Weathers flew over 50% of the entire California coastline using ADS40 in fall of 2009, and more than 40% of the entire coastline using LiDAR. He is also responsible for planning, managing, and executing Fugro EarthData's portion of this one of a kind mapping project which includes topographic LiDAR, RBG imagery, and hyperspectral data collection. Fugro EarthData is a subcontractor on this program through Fugro Pelagos, Inc.'s USACE Mobile District IDC contract. The NCMP's mission is to collect and merge shoreline topographic, bathymetric, and imagery data to create a seamless dataset that accurately represents the coastal condition.

- NOAA Coastal Geospatial Services IDC, Coastal Georgia

  Chief Pilot. Mr. Weathers serves as chief pilot responsible for planning, managing, and executing flight operations for the Coastal Georgia project, calling for 1m post spacing LIDAR data along or near the coast of 4 northern counties - Bryan, Effingham, Bullock, and Screven. Mr. Weathers is also responsible for overseeing all ground based GPS stations, shipping of data, and generation and review of all flight plans for aerial missions under this IDC.

Douglas Johnson, CP
Fugro EarthData, Inc

Role: Raw Data Inspection and Quality Control

Mr. Johnson has 31 years of expertise in the mapping industry. He is primarily responsible for the quality control of Fugro's digital imagery and LiDAR data. He inputs coordinates into the flight management system along with flight maps to be distributed to the flight crews. Mr. Johnson also checks raw imagery/data for contract limits and quality.

He performs in-house flight line programming, project coordination and crew dispatching. Mr. Johnson's other duties include film editing of locally collected raw imagery both film and digital. He also responsible for the QA/QC review of imagery for the United States Department of Agriculture (USDA) and National Agriculture Imagery Program (NAIP).

Experience

- Years with Fugro: 22
- Years with Other Firms: 09

Education

- BS Geography

Affiliations / Certifications

- ASPRS Certified Photogrammetrist (CP)

PROJECT EXPERIENCE

- FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

  Raw imagery Inspection: Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. To date Fugro has acquired LiDAR data covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM.

- NAIP Digital Imagery Acquisition and DOQQ Production of the Entire State of Texas for North West Group, Calgary, Canada and USDA-FSA, Salt Lake City, Utah

  Raw Imagery inspection for 8,900 flight line miles digital imagery acquisition with ADS40 digital imagery sensor fully integrated with airborne GPS, IMU and CCNS-4 flight management system and installed on our Cessna 441 Conquest, 1-meter DOQQs production.

- NAIP Digital Imagery Acquisition & Orthophoto Production of the Entire State of Nebraska for North West Group, Calgary, Canada and USDA-FSA, Salt Lake City, Utah (8,583 flight line miles)

  Raw Imagery inspection for 1-meter DOQQs production.

- Utah Statewide Digital Orthophoto (84,000 square miles)

  Raw Imagery inspection for 16,963 flight line miles of imagery with ADS40 digital imagery sensor fully integrated with airborne GPS, IMU and CCNS-4 flight management system at altitudes of 4,800' and 9,600' AMT. The digital Imagery data was processed to produce 12.5cm and 25cm pixel resolution color orthophoto in standard TIFF format.

- National Park Service/ Bureau of Reclamation Craters of the Moon National Monument Vegetation Study Project Twin Falls, Idaho for the USDI/Bureau of Reclamation, Denver, Colorado

  Raw Imagery inspection of 643 square miles of digital color imagery for photo interpretation and detailed vegetation mapping. Very dark, almost black, Lava beds adjoin highly reflective open range land. 82 images acquired with our Leica ADS40-SH52 at 24,000' AMT fully integrated with airborne GPS, IMU and CCNS-4 flight management system and installed on our Cessna 441 Conquest.

- Missouri River LiDAR and Orthophotography Project for South Dakota Game Fish & Parks, Pierre, South Dakota (658 square miles)

  Raw Imagery inspection of 1,957 exposures of color aerial photography. Imagery was acquired using airborne GPS control with six-inch focal length Zeiss RMK TOP 15 camera fitted in a Cessna 310R aircraft. Softcopy AT was performed on 1728 models to extend control to produce Digital Terrain Models (DTM). Aerotriangulation of the photography was performed utilizing ORIMA software.

Tian Wang
Fugro EarthData, Inc

Role: LiDAR Processing Department Manager

Ms. Wang currently manages LiDAR production operations for Fugro. Ms. Wang has developed significant knowledge, insight, and proficiencies during her 11 years in the mapping and GIS industry. She has completed and managed a variety of mapping projects that have involved multiple applications and map scales for clients who include federal, state, and city government agencies and private engineering and development firms.

Experience

- Years with Fugro: 11
- Years with Other Firms: 0

Education

- BS, Engineering, Tsinghua University, Beijing, China

PROJECT EXPERIENCE

- NOAA Coastal Services Center Geospatial Services, Nationwide Coverage

  LiDAR Team Lead: Ms. Wang manages the LiDAR /Terrain production team for task orders under this multi-year ID/IQ contract for the NOAA CSC. The contract covers a wide range of services, including: acquisition and processing of airborne imagery, LiDAR, multi-spectral, and IFSAR data; production of digital orthophotos, DEMs, planimetric and topographic mapping; land-use/land-cover and SAV classification, surveying, bathymetric mapping, hydrographic surveying, and tsunami inundation modeling.

- FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

  Flight Operations Manager: Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. To date Fugro has acquired LiDAR data covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM.

- Tennessee Valley Authority – Rapid Response Projects Kingston Fossil Plant's Fly Ash Pond Spill

  LiDAR Processing Lead: As LiDAR processing lead, Ms. Wang oversaw Fugro's LiDAR production operations for the Kingston Fossil Plant's fly ash pond spill rapid response project. After the coal ash spill that affected more than 300 acres of land adjacent to the plant, Fugro acquired and delivered airborne digital imagery and generated 25 cm orthos over 140 sq. mi. spill radius for damage assessment use, within 48 hours of notice to proceed. Ms. Wang ensured that her team produced high-quality seamless topographic mapping for TVA for use in assessing damage and controlling toxic spillage. Fugro's successful performance has led to a recent contract renewal ($2.5M over 5 years contract 2011 –2016)

- St. Louis District Photogrammetric Mapping and Aerial Photography, ID/IQ Contracts, Nationwide Coverage

  LiDAR Processing Lead: Ms. Wang served as LiDAR specialist for consulting, quality control, and processing for task orders under this 5-year ID/IQ contract for the St. Louis District Army Corps of Engineers. The contract requires aerial photography and airborne GPS data acquisition, remote sensing with hyperspectral and multispectral sensors and passive microwave radiometer, aerotriangulation, large- and small-scale topographic mapping, LiDAR, land-use/land-cover mapping, digital orthophotography, thermal imagery and a variety of advanced mapping and surveying services. Fugro has held an indefinite delivery contract with the St. Louis District for more than 20 years and through this ID/IQ, supports a wide array of clients, including other federal agencies such as the National Guard, the US Army and Navy, the Departments of the Interior and Agriculture well as state agencies.

- USACE National Coastal Mapping Program (JALBTCX), Nationwide Coverage

  LiDAR Team Lead: Ms. Wang manages the topographic Terrain / LiDAR processing for USACE Mobile District's National Coastal Mapping Program (NCMP). Fugro EarthData is a subcontractor on this program through Fugro Pelagos' USACE Mobile District ID/IQ contract. The NCMP's mission is to collect and merge shoreline topographic, bathymetric, and imagery data to create a seamless dataset that accurately represents the coastal condition. Final deliverables, delivered in 2011, are used by the NCMP for coastal monitoring.

Tommy Silbernagel
Fugro EarthData, Inc

Role: LiDAR Production Deputy

Since joining Fugro in 2001, Mr. Silbernagel has trained in all facets of photogrammetric mapping, digital photogrammetry, and flight planning and ground control survey coordination. As production manager, he is directly responsible for project layout, management, client liaison and coordination, engineering, ground control planning, and the supervision of all phases of both large and small scale digital mapping projects. Mr. Silbernagel's project experience includes municipal GIS, transportation, hydrology, mining, local, state and federal governments and the private industry.

Skilled in staff supervision and scheduling, as proven on the Missouri River project and previous employment. Background includes qualified training in several AutoCAD releases. Other computer qualifications include MicroStation, Terrascan, Terramodel, ESRI software, DOS, batch processing, and script writing.

Experience

- Years with Fugro: 11
- Years with Other Firms: 0

Education

- Western Dakota Technical Institute (Associates Degree in Computer-Aided Drafting) (1999-2001)

Affiliations / Certifications

- N/A

PROJECT EXPERIENCE

- High-Resolution LiDAR Acquisition for Upper James River Watershed in North Dakota and South Dakota (2010 – 2013)

  LiDAR dataset production. This task order on Fugro's ID/IQ Contract with the St. Louis District COE to provide high resolution LiDAR and intensity imagery for a detailed surface elevation data of the James River Watershed along with surrounding watersheds in North and South Dakota for use in conservation planning, design, research, delivery, floodplain mapping, and hydrologic modeling. The LiDAR resolution is 1.4 points/m^2; the RMSE is a minimum of 15 cm vertical and a minimum of .6 m horizontal accuracy. The project includes three (3) phases of collection and processing totals 18,982 sq. mi. For all areas FEMA Guidelines and Specifications for Flood Hazard Mapping and National Digital Elevation Program (NDEP) specifications are met.

- Red River High Resolution LiDAR Digital Elevation Data Acquisition, Red River of the North Basin, ND, SD, &, MN

  LiDAR dataset production. Raw LiDAR data and the IMU files preprocessed to bring the data to a 15 cm vertical accuracy (RMSE), bare-earth LiDAR data and stereo imagery were edited. (41,700 square miles)

- FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

  Flight Operations Manager: Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI. To date Fugro has acquired LiDAR data covering approximately 10,127 sq. mi. of data at 1 meter point density. Deliverables include over 8,000 sq mi of bare earth DEM; over 3,200 sq mi. of hydro breaklines including a hydro enforced DEM.

- Four County Aerial Mapping Services Project for The Omaha-Council Bluffs Metropolitan Area Planning Agency (MAPA), Omaha, NE

  LiDAR dataset production. LiDAR elevation data obtained utilizing ALS40 LiDAR system at 8,000' AMT with a field view of 35 degrees and post spacing of 3.0 meters for a 2,249 square mile area. The LiDAR data provided an elevation models for the project 2' and 4' contour mapping area. A detailed floodplain study area was also mapped with additional procedures to meet FEMA specifications.

- Digital Orthophoto And LiDAR Elevation Model Project, Statewide, UT

  Dataset Production. Raw LiDAR data at altitudes of 3,500', 4,000', and 7,000' AMT and IMU files preprocessed and brought to a 15 cm vertical accuracy RMSE to derive the 'bare-earth' elevation model in ARC-GRID format by tile. (84,000 square miles)

William Warwick, RPLS **Role:** Change Detection Lead
Fugro EarthData, Inc

Mr. Warrick is a decisive, action oriented and results-focused professional offering over 36 years experience in the field of surveying. He has worked extensively with Federal, State and Local Governments, LCRA, various Engineering firms, Oil and Gas Companies, and many Construction Firms and Private Individuals on a large variety of survey projects. These projects were as varied as the clients he served, ranging from; lot survey, to large horizontal and vertical control projects, aerial mapping projects, oil well locations surveys, subdivision surveys, acreage surveys, route surveys, Right-Of-Way surveys, large and small design/topographic surveys, cellular towers site surveys, construction projects and GPS Static control projects and GPS RTK surveying and mapping.

Mr. Warrick has performed in many positions in the survey profession, beginning as an instrument man, fresh out of college, being promoted to a party chief and then office survey technician, acquiring his Registered Professional Land Surveyor license in 1986, becoming a Task Manager, Assistant Project Manager, Project Manager and Vice President and Owner of a 30+ employee survey firm over the years. Through his many duties he has monitored the performance of as many as six office technicians and eight field crews, at one time, managed various types of survey projects, handled client relations and managed office budgets and billings for clients.

Experience

- Years with Fugro: 02
- Years with Other Firms: 34

Education

- Stephen F. Austin State University, August 1978 - Bachelor of Science from School of Forestry

Affiliations and Certifications

- Texas RPLS No. 4426
- Colorado PLS No. 38335,
- Texas Society of Professional Land Surveyor Member since 1986

PROJECT EXPERIENCE

- Hillebrandt Bayou Widening Project, Jefferson County, Texas

  Project Manager for a 21 mile route and Boundary Survey from the Gulf of Mexico upstream to Beaumont, Texas. Included Parcel Maps, ROW maps and Metes and Bounds descriptions for property takes.

- US 69 Corridor Study, Hardin And Tyler Counties, Texas

  Project Manager for a 71 mile Aerial Mapping Project, from Beaumont, Texas to Woodville, Texas - Included establishing Horizontal and Vertical control for Aerial Mapping.

- Colonial 16" Pipeline Survey, Jefferson County, Texas

  Project Manager for a 7 mile Route and Boundary Survey through several patents in East Texas. Included Parcel maps, ROW maps and Metes and bounds descriptions for Pipeline easements.

- FM 1187 Row – Fort Worth, Texas

  Project Manager for approximately 6 miles of Route and Boundary Survey along FM 1187 in Tarrant County, Texas for widening of ROW. Included establishing original GPS Control for project, researched all affected parcels along route, located sufficient monumentation to establish all boundary lines, created all ROW Maps, Parcel Sketches and Metes and Bounds Descriptions.

- Chesapeake Energy & BHP Billiton – Dimmit And Webb Counties, Texas

  On call surveying services for Oil and Gas explorations in the Eagle Ford Shale. These projects required research of General Land Office records for Patent Survey information, field surveying Abstract Boundaries and mineral land owner boundaries for permitting through the Rail Road Commission and creation of Unit Boundaries for recording Lease areas.

6 PROJECT EXPERIENCE AND REFERENCES

6.1 References

6-Inch RGB/CIR Digital Orthophotography, LiDAR, Thurston County, WA

Date Completed: 2012
Project Owner: Thurston County, Washington
Point of Contact: Owen Reynolds, GIS Analyst **Tel:** (360) 754-3355 **Email:** ofr@co.thurston.wa.us

In Spring 2012, Fugro was awarded a contract for 4-band, 6-inch orthoimagery acquisition and processing for Thurston County, Washington. This was a subsequent project to a similar 2009 Orthoimagery collection, and 2011 LiDAR collection for the same project area.

This county-wide project encompassed an 819 sq. mi. area located in the south Puget Sound region of Washington State, with an additional 20 sq. mi. area in Grays Harbor County within the jurisdiction of the Confederated Chehalis Tribe. The region's mountainous terrain and varying altitudes provided an added challenge for this project.

The 2012 imagery was acquired using a Leica ADS80-SH82 digital imaging sensor, and Fugro's unique Pixel Factory was used to complete the data processing for the project.

PROJECT HIGHLIGHTS:

- 819 sq mile area located in the south Puget Sound region, plus 20 sq. mi. encompassing Confederated Chehalis Tribe territory
- Challenging acquisition used the ADS40-SH54 digital sensor, and involved mountainous terrain and varying altitudes
- Services included 6-inch natural color (RGB) and color infra-red (CIR) orthoimagery, and LiDAR mapping

National Coastal Mapping Program, California, Washington and Oregon

Date Completed: December 2010
Project Owner: USACE, Mobile District
Point of Contact: Mike McBurney, **Email:** Michael.D.McBurney@usace.army.mil **Tel:** (251) 694-4188

This important project involves mapping the entire West Coast (California, Oregon, and Washington) and features a unique, first-of-its-kind scope that combines both on-shore and off-shore mapping. The project was executed under a contract with the USACE Mobile District.

The project included the collection of bathymetric LiDAR the shoreline to 1 kilometer offshore and topographic LiDAR from the shoreline to 500 meters inland. Fugro EarthData was responsible for tide-coordinated simultaneous collection of topographic LiDAR and hyperspectral imagery using the Leica ALS60 and CASI 1500 respectively. Additionally both on-shore and off-shore components of project included collection of Orthoimagery. Fugro EarthData used the Leica ADS40-SH52 digital sensor to collect 35 cm pixel resolution orthoimagery in color and color-infrared for the on-shore imagery.

Data acquisition for this project is part of an effort to develop a climate change strategy to address and mitigate the impacts of sea-level rise on coastal communities. The data will be used to assist in the management of coastal resources, including base-lining for sea-level rise and beach erosion/replenishment. This project supports the Digital Coast program, as well as the goals set forth in the West Coast Governors' Agreement on Ocean Health.

PROJECT HIGHLIGHTS:

- Large mapping project includes LiDAR, Multispectral (RGB+CIR) Imagery and Hyperspectral imagery

FEMA Region 6 (TX, NM, LA, OK, AR) Risk Map LiDAR, Various Locations

Date Completed: 2010-2011
Project Owner: RAMAPP JV c/o URS Corporation
Point of Contact: Bob Ryan, URS Corporation, MD, (301) 258-9780

Fugro is the primary LiDAR data acquisition and digital elevation data provider under the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program. Through the Production and Technical Services (P&TS) contract, the RAMPP JV provides comprehensive floodplain mapping, GIS, and hazard risk mitigation services for FEMA to include specifically serving FEMA Regions II, III, and VI.

Through this contract, Fugro provides LiDAR data acquisition to gathering the elevation data necessary to support the creation of digital elevation models (DEMs) for hydraulic modeling of floodplains, digital terrain maps, and other National Flood Insurance Program (NFIP) products.

For the RAMPP JV Fugro was tasked to capture 1 meter LiDAR data covering 10,127 sq miles. LiDAR boresight calibration for data captured. LiDAR processing of more than 8,000 sq miles with a bare earth deliverable. For over 3,200 sq miles hydro breaklines were captured and a hydro enforced DEM. All production work was done to the USGS-NGP Base LiDAR Specification v12 & v13, FEMA Guidelines and Specifications for Flood Hazard Mapping Partners: Appendix A, and FEMA Procedure Memorandum No. 61—Standards for LiDAR and Other High Quality Digital Topography. The table below just a few of the Region 6 LiDAR projects that Fugro has completed for the RAMPP JV under the Risk Map program:

Task Name & Location	Services Provided	Size (area)	Dates
RiskMap Central, Texas	LiDAR Acquisition 1.0m nominal post spacing	1,305 sq. mi.	2010
RiskMap Liberty County, Texas	LiDAR Acquisition and processing 1.0m nominal post spacing	1,055 sq. mi	2011
RiskMap Parker County, Texas	LiDAR Acquisition and processing 1.0m nominal post spacing	1,136 sq. mi.	2011
RiskMap Pulaski, AR	LiDAR Acquisition and processing 1.0m nominal post spacing	563 sq. mi.	2011

Orthoimagery and Other Mapping Services, Rutherford County, TN

Date Completed: 2004 - Ongoing
Project Owner: Rutherford County, Tennessee
Point of Contact: Barbara Seivers **Tel:** 615-898-7762 **Email:** bseivers@rutherfordcounty.org

Since 2004, Fugro and Rutherford County have engaged in multiple, highly successful imagery and mapping projects beginning with a county-wide (620 sq. mi.) update to the digital orthophoto and topographic base map. Fugro acquired natural color digital imagery in the spring of 2004 using the Leica ADS40 system. LiDAR data, acquired with the Leica ALS40 LiDAR sensor, was also acquired to develop county-wide, 2-foot interval contours.

In 2007, Fugro was again selected to provide county-wide 6-inch pixel GSD color orthoimagery. Additional products from this work included contours, planimetric updates, and color infrared (CIR) orthoimagery with a 3-inch pixel GSD.

In 2009, Rutherford County awarded Fugro a 5 year base mapping contract with a one year extension (2009-2014) to provide a wide range of product services, including digital orthophotography, LiDAR, planimetric updates, contours, and oblique imagery. Under the 5-year base mapping contract, Fugro was awarded a task order in 2012 to provide county-wide, 6-inch GSD orthoimagery and LiDAR data. Acquisition of this project was completed in early 2012, and processing and delivery was completed within the County's time frame.

PROJECT HIGHLIGHTS:

- Successfully delivered base map of the 620 sq mile county, including orthoimagery, topography, and planimetrics.
- Bare-ground LiDAR data was combined with breaklines that were produced from the ADS40 imagery to create a countywide digital terrain model (DTM) used to produce 2' contour data for the entire county
- Additional deliverables included updated color orthoimagery

6.2 Additional LiDAR Experience

The table below provides a snapshot of the Fugro's extensive history and experience providing topographic LiDAR data and derived data products for a host of clients over the past several years.

PROJECT NAME	CLIENT/END USER	DATE	PROJECT SIZE (SQ MI)	POST SPACING	TOPO PRODUCTS /METHODS USED
Nuclear Power Plant Post-Earthquake, Mineral, VA	Burgess & Niple, Inc.	2012	108	6 pts / sq meter	LiDAR DEM, 6-inch Contours
FEMA VI – Lower NC McIntosh / Pottawatomie, OK	USGS/FEMA	2012	1,100	2.0	Two task orders for high resolution LiDAR to assist in floodplain mapping of portions the Lower North Canadian region in central Oklahoma.
California Coastal Mapping Program (CCMP)	NOAA/OPC	2011	Entire CA Coast	1m	Tidal controlled for sea-level rise for flood modeling
California Coastal Mapping Program (CCMP)	NOAA/OPC	2012	Entire CA Coast	Variable	Multi sensor data merge including acoustic/optical topographic/bathymetric for sea-level rise for flood modeling
Louisiana Coastal LiDAR	State of Louisiana	2011	40 linear miles	15 pt. per sq. m	Very high res. LiDAR supporting coastal environmental programs
James River Flood Mapping	USACE/St. Louis	2011	8,060	1.4 m	bare earth DEM, hydro breaklines, contours supporting for floodplain mapping
Red River Basin Mapping Initiative	USACE/St. Louis	2010	11,239	1.37m	bare earth DEM, hydro breaklines, contours supporting for floodplain mapping
National Coastal Mapping Program –CA, WA, OR	USACE, Mobile	2010	3,427 linier miles	4m/1 m	Comprehensive bathy/topo LiDAR project of the entire CA coast from 1000m off shore to 500 miles inland
San Francisco Bay	NOAA	2009	>430	1 m/2 m	Two adjacent projects collecting LiDAR in support floodplain mapping
Fort Worth Area LiDAR	TWDB	2009	1,200	2 pts / sq meter	DEM and breaklines for the Ft. Worth / Tarrant County area for both Urban and Flood/Soils areas
NJ LiDAR - RiskMap	FEMA	2009	1,665	1m	Flood study of NJ Coastal Counties
South Carolina 16 Co. LiDAR	USGS / SC	2009	10,194	1.4m	1.4m LiDAR bare earth, hydro breaklines, and intensity images
Sacramento/San Joaquin Delta	CA DWR	2009	1,600	1m	1 m LiDAR bare earth, first returns, intensity images, hydro-breaklines, and contours.
West Virginia LiDAR	FEMA	2008	26	1m	Post flooding study for Harrison, Marion, and Taylor co. in WV
Louisiana LiDAR	FEMA	2008	43,000	5m	FEMA Attachment A in support of floodplain mapping
Kent, Queen Anne, and Caroline Co.	USACE St. Louis	2008	791	2m	2 m LiDAR bare earth, intensity images
Okaloosa County LiDAR	NOAA	2008	874	1.5m	1.5 m LiDAR bare earth
PA Map LiDAR	State of PA	2008	2,114	1.4m	1.4 m LiDAR processed to LAS format
New England LiDAR	USACE-Mobile	2007	131	0.72m	processed to LAS format
Coastal Mississippi	NOAA	2006	1,204	2m	5 m LiDAR bare-earth, hydro-breaklines
NC Floodplain Mapping Program	NCFMP	2003	40,000	3m	LiDAR; DEMs, Point Cloud, hydro-enforced DEMs

7 PRICING

Fort Bend County TX Lidar Pricing Table		
TWDB 580130627		
Company Name: Fugro EarthData, Inc.		
Square Miles (DO4Q)	~917	
Point Density	4 points/square meter (0.5 m NPS)	
RMSEz	12 cm	
Deliverables		
Classified LAS Point Cloud *Bare Earth DEM* *Intensity Image* *Hydro-Flattening Breaklines* *Metadata* *1 Foot Contours*		
Unit Cost per DO4Q (Sq.Mi.)	$188.00	$172,396.00
1 Ft Contours	$23.50	$21,549.50
	Total:	$193,945.50

CERTIFICATE OF LIABILITY INSURANCE 7/1/2014

DATE (MM/DD/YYYY) 2/10/2014

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER LOCKTON COMPANIES, LLC 5847 SAN FELIPE, SUITE 320 HOUSTON TX 77057 866-260-3538	CONTACT NAME: PHONE (A/C, No, Ext): FAX (A/C, No): E-MAIL ADDRESS:
INSURED 1365452 Fugro EarthData, Inc. 7320 Executive Way Frederick MD 21704	INSURER(S) AFFORDING COVERAGE / NAIC # INSURER A : Liberty Mutual Fire Insurance Company 23035 INSURER B : Lloyd's/Liberty Int'l Underwriters INSURER C : Liberty Insurance Corporation 42404 INSURER D : INSURER E : INSURER F :

COVERAGES **CERTIFICATE NUMBER:** 12777791 **REVISION NUMBER:** XXXXXXX

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	**GENERAL LIABILITY** [X] COMMERCIAL GENERAL LIABILITY [ ] CLAIMS-MADE [X] OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: [ ] POLICY [X] PRO-JECT [X] LOC	Y	Y	TB2-641-005066-033	7/1/2013	7/1/2014	EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG $	$ 1,000,000 $ 100,000 $ 5,000 $ 1,000,000 $ 2,000,000 $ 2,000,000 $
A	**AUTOMOBILE LIABILITY** [X] ANY AUTO [ ] ALL OWNED AUTOS [ ] SCHEDULED AUTOS [ ] HIRED AUTOS [ ] NON-OWNED AUTOS	Y	Y	AS2-641-005066-023	7/1/2013	7/1/2014	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident) $	$ 2,000,000 $ XXXXXXX $ XXXXXXX $ XXXXXXX $ XXXXXXX
B	[ ] **UMBRELLA LIAB** [X] OCCUR [X] **EXCESS LIAB** [X] CLAIMS-MADE [ ] DED [ ] RETENTION $	Y	Y	LME-5710	7/1/2013	7/1/2014	EACH OCCURRENCE AGGREGATE $	$ 5,000,000 $ 5,000,000 $ XXXXXXX
C	**WORKERS COMPENSATION AND EMPLOYERS' LIABILITY** Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? [N] N/A (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below		Y	WA7-64D-005066-083	7/1/2013	7/1/2014	[X] WC STATU-TORY LIMITS [ ] OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 $ 1,000,000 $ 1,000,000 $ 1,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES /(Attach ACORD 101, Additional Remarks Schedule, if more space is required)

All policies include a blanket notice of cancellation to certificate holders endorsement, providing for (30) days' advance notice if the policy is cancelled by the company other than for nonpayment of premium, (10) days' notice if the policy is cancelled for nonpayment of premium. Notice is sent to certificate holders with mailing addresses on file with the agent or the company. The endorsement does not provide for notice of cancellation if the named insured requests cancellation. The Workers' Compensation/EL policy includes Longshore & Harbor Workers' Compensation Act Coverage Endorsement per form # WC000106A and Outer Continental Shelf Lands Act Coverage Endorsement per form # WC000109B

CERTIFICATE HOLDER

12777791

Fort Bend County
and the members of Commissioners Court
301 Jackson Street, Suite 201
Richmond TX 77469

CANCELLATION See Attachment

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

All Policies (Except Workers' Compensation/EL) include a blanket automatic additional insured endorsement [provision] that confers additional insured status to the certificate holder only if there is a written contract between the named insured and the certificate holder that requires the named insured to name the certificate holder as an additional insured. In the absence of such a contractual obligation on the part of the named insured, the certificate holder is not an additional insured under the policy.

All Policies include a blanket automatic waiver of subrogation endorsement [provision] that provides this feature only when there is a written contract between the named insured and the certificate holder that requires it. In the absence of such a contractual obligation on the part of the named insured, the waiver of subrogation feature does not apply.

CERTIFICATE OF LIABILITY INSURANCE 6/30/2014

DATE (MM/DD/YYYY): 2/10/2014

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER: LOCKTON COMPANIES, LLC 5847 SAN FELIPE, SUITE 320 HOUSTON TX 77057 866-260-3538	CONTACT NAME: PHONE (A/C, No, Ext): FAX (A/C, No): E-MAIL ADDRESS:
INSURED: Fugro EarthData, Inc. 1365454 7320 Executive Way Frederick MD 21704	INSURER(S) AFFORDING COVERAGE / NAIC # INSURER A : Lexington Insurance Company 19437 INSURER B : A.F. Beazley 2623/623 INSURER C : INSURER D : INSURER E : INSURER F :

COVERAGES **CERTIFICATE NUMBER:** 12777792 **REVISION NUMBER:** XXXXXXX

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	GENERAL LIABILITY COMMERCIAL GENERAL LIABILITY CLAIMS-MADE OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: POLICY PRO-JECT LOC			NOT APPLICABLE			EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG $	$ XXXXXXX $ XXXXXXX $ XXXXXXX $ XXXXXXX $ XXXXXXX $ XXXXXXX $
	AUTOMOBILE LIABILITY ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS HIRED AUTOS NON-OWNED AUTOS			NOT APPLICABLE			COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident) $	$ XXXXXXX $ XXXXXXX $ XXXXXXX $ XXXXXXX $
	UMBRELLA LIAB OCCUR EXCESS LIAB CLAIMS-MADE DED RETENTION $			NOT APPLICABLE			EACH OCCURRENCE AGGREGATE $	$ XXXXXXX $ XXXXXXX $
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) Y / N If yes, describe under DESCRIPTION OF OPERATIONS below	N / A		NOT APPLICABLE			WC STATU-TORY LIMITS OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 $ XXXXXXX $ XXXXXXX $ XXXXXXX
A B	Professional Liab - Incl. Contractor's Pollution	N	N	015438063 GLOPR1301253	6/30/2013 6/30/2013	6/30/2014 6/30/2014	Each Claim $1,000,000 Aggregate $5,000,000 SIR Per Claim $2,500,000	

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES /(Attach ACORD 101, Additional Remarks Schedule, if more space is required)

The Professional Liability includes a blanket notice of cancellation to certificate holders endorsement, providing for (30) days' advance notice if the policy is cancelled by the company other than for nonpayment of premium, (10) days' notice if the policy is cancelled for nonpayment of premium. Notice is sent to certificate holders with mailing addresses on file with the agent or the company. The endorsement does not provide for notice of cancellation if the named insured requests cancellation.

CERTIFICATE HOLDER

12777792

Fort Bend County
301 Jackson Street, Suite 201
Richmond TX 77469

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE