PROFESSIONAL SERVICES
Rapid City Area Metropolitan Planning Organization
LiDAR, Orthophotography, and Elevation Contours

THIS AGREEMENT made on this _____ day of February, 2015 between the City of Rapid City, 300 Sixth Street, Rapid City, South Dakota 57701, hereinafter referred to as OWNER, and Fugro Geospatial, Inc., 4350 Airport Road, Rapid City, SD 57701, hereinafter referred to as CONSULTANT. This project will encompass the LiDAR, Orthophotography and Elevation Contours for the Rapid City Metropolitan Planning Organization Area.

OWNER and CONSULTANT in consideration of their mutual covenants herein agree in respect of the performance of LiDAR, Orthophotography and Elevation Contour services by CONSULTANT and the payment for those services by OWNER as set forth below.

SECTION 1 - BASIC SERVICES TO CONSULTANT

1.1 General

CONSULTANT shall provide to OWNER services in all phases of the Project to which this Agreement applies as hereinafter provided. These services will include new acquisition and processing of LiDAR elevation data, digital orthophotography, oblique photography and planimetric mapping of building footprints.

1.2 Scope of Work

The Basic Services Scope of Work is described in detail in Exhibit A and shall include Components 1 through 5 to include Light Detection and Ranging (LiDAR) data acquisition, aerial photography acquisition, digital orthophoto production, digital color oblique aerial imagery and digital planimetric feature compilation (building footprints).

SECTION 2 - OWNER'S RESPONSIBILITIES

OWNER shall do the following in a timely manner so as not to delay the services of CONSULTANT:

2.1 The Community Planning and Development Services Director or their designee shall act as OWNER'S representative with respect to the services to be rendered under this Agreement. The Community Planning and Development Services Director shall have complete authority to transmit instructions, receive information, interpret and define OWNER'S policies and decisions with respect to CONSULTANT'S services for the Project.

2.2 Assist CONSULTANT by placing at CONSULTANT'S disposal all available information pertinent to the Project including previous reports and any other data relative to the Project.

2.3 Examine all studies, reports, sketches, drawings, proposals and other documents presented by CONSULTANT, obtain advice of an attorney, insurance

counselor and other consultants as OWNER deems appropriate for such examination and render in writing decisions pertaining thereto within a reasonable time so as not to delay the services of CONSULTANT.

2.4 Give prompt written notice to CONSULTANT whenever OWNER observes or otherwise becomes aware of any development that affects the scope or timing of CONSULTANT'S services.

2.5 Furnish or direct CONSULTANT to provide Additional Services as stipulated in paragraph 2.1 of this Agreement or other services as required.

SECTION 3 - PERIOD OF SERVICE

The CONSULTANT'S period of service shall complete the scope of work stated in Exhibit A by December 31, 2015. No payment will be made for work undertaken before the OWNER issues a written "Notice to Proceed". The CONSULTANT'S services shall be provided in general accordance with the schedule as defined in Exhibit B.

SECTION 4 - PAYMENTS TO CONSULTANT

4.1 Methods of Payment for Services and Expenses of CONSULTANT

4.1.1 *For Basic Services*. The OWNER will pay the CONSULTANT in a lump sum amount of $199,925.32 as detailed in the attached Exhibit C "Cost Estimate" for services rendered under Section 1 as detailed in Exhibit A.

Payment will be made pursuant to invoices submitted by the CONSULTANT with a signed voucher. Progress payments may be made upon completion of each component as detailed in Exhibit A or at the OWNER's discretion based on work completed and documented on progress reports.

4.2 Times of Payments

CONSULTANT may submit vouchers for Basic Services by each component as that component is completed or for all completed components. OWNER shall make prompt payments in response to CONSULTANT'S signed vouchers.

For these services the OWNER shall make prompt payments to the CONSULTANT based on component billings submitted by the CONSULTANT up to 90% of the maximum fee for each Component as shown on Exhibit C, "Cost Estimate". The remaining 10% shall be due upon approval of the deliverables for the Project as accepted by OWNER.

4.3 Other Provisions Concerning Payments

4.3.1 If OWNER fails to make any payment due CONSULTANT for services and expenses within forty-five (45) days after receipt of CONSULTANT'S statement, the CONSULTANT may, after giving seven (7) days written

notice to OWNER, suspend services under this Agreement until CONSULTANT has been paid in full all amounts due for services, expenses and charges.

4.3.2 In the event of termination by OWNER upon completion of any phase of Basic Services, progress payments due CONSULTANT for services rendered through such phase shall constitute total payment for such services. In the event of such termination by OWNER during any phase of the Basic Services, CONSULTANT also will be reimbursed for the charges of independent professional associates and consultants employed by CONSULTANT to render Basic Services incurred through such phase. In the event of any such termination, CONSULTANT will be paid for unpaid Reimbursable Expenses previously incurred.

4.3.3 The employees of CONSULTANT, professional associates and consultants, whose time is directly assignable to the program shall keep and sign a time record showing the element of the Project, date and hours worked, title of position and compensation rate.

4.3.4 *Records*. The CONSULTANT shall maintain an accurate cost keeping system as to all costs incurred in connection with the subject to this Agreement and shall produce for examination books of accounts, bills, invoices and other vouchers or certified copies there under if originals be lost at such reasonable time and place as may be designated by the OWNER and shall permit extracts and copies thereof to be made during the contract period and for three years after the date of final payment to CONSULTANT.

All personnel employed by CONSULTANT shall maintain time records for time spent performing work on study described in this Agreement for a period of three years from the conclusion of the requested services. Time records and payroll records for said personnel shall be similarly retained by CONSULTANT for a period of three years from the conclusion of the requested services.

Upon reasonable notice, the CONSULTANT will allow OWNER auditors to audit all records of the CONSULTANT related to this Agreement. These records shall be clearly identified and readily accessible. All records shall be kept for a period of three (3) years after final payment under Agreement is made and all other pending matters are closed.

4.3.5 *Inspection of Work*. The CONSULTANT shall, with reasonable notice, afford OWNER or representative of OWNER reasonable facilities for review and inspection of the work in this Agreement. OWNER shall have access to CONSULTANT'S premises and to all books, records, correspondence, instructions, receipts, vouchers and memoranda of every description pertaining to this Agreement.

4.3.6 *Audits.* The CONSULTANT shall, with reasonable notice, afford

representatives of the OWNER reasonable facilities for examination and audits of the cost account records; shall make such returns and reports to a representative as he may require; shall produce and exhibit such books, accounts, documents and property as he may determine necessary to inspect and shall, in all things, aid him in the performance of his duties.

4.3.7 Payment shall be made subject to audit by duly authorized representatives of the OWNER. Payment as required in Super Circular 200.

The CONSULTANT shall pay subcontractors or suppliers within 15 days of receiving payment for work that is submitted for progress payment by the OWNER. If the CONSULTANT withholds payment beyond this time period, written justification by the CONSULTANT shall be submitted to the OWNER upon request. If it is determined that a subcontractor or supplier has not received payment due without just cause, the OWNER may withhold future estimated payments and/or may direct the CONSULTANT to make such payment to the subcontractor or supplier. Prompt payment deviations will be subject to price adjustments.

4.3.8 In the event the service to the contract is terminated by the OWNER for fault on the part of the CONSULTANT, the agreement shall be null and void, and, the OWNER shall be entitled to recover payments made to the CONSULTANT on the work which is the cause of the at-fault termination. The CONSULTANT shall be paid only for work satisfactorily performed and delivered to the OWNER up to the date of termination. After audit of the CONSULTANT'S actual costs to the date of termination and after determination by the OWNER of the amount of work satisfactorily performed, the OWNER shall determine the amount to be paid the CONSULTANT.

4.4 Definitions

Reimbursable Expenses means the actual expenses incurred by CONSULTANT or CONSULTANT'S independent professional associates or consultants directly in connection with the Project, including expenses for: transportation and subsistence incidental thereto; reproduction of reports, graphics, and similar Project related items; and if authorized in advance by OWNER, overtime work requiring higher than regular rates. In addition, if authorized in advance by OWNER, Reimbursable Expenses will also include expenses incurred for computer time and other highly specialized equipment, including an appropriate charge for previously established programs and expenses of photographic production techniques times a factor of 1.0 as determined in accordance with CONSULTANT'S normal accounting practices. All costs must be accumulated and segregated in accordance with Consultant's normal business practice and FAR Part 31.

4.5 Ownership of Data

Documents and all products of this Agreement are to be the property of the OWNER. Any reuse of documents for extensions of the Project or other projects shall be at the OWNER's sole risk and liability.

4.6 Publication and Release of Information

The CONSULTANT shall not copyright material developed under this Agreement without written authorization from the OWNER. The OWNER reserves a royalty-free non-exclusive, and irrevocable license to reproduce, publish or otherwise use, and to authorize others to use, the work for government purposes.

4.7 Acquisition of Property or Equipment

The acquisition of property or equipment will be in accordance with Super Circular 200.

4.8 Independent Consulting and Subcontracting

While performing services hereunder, CONSULTANT is an independent contractor and not an officer, agent, or employee of the City of Rapid City.

Any employee of the CONSULTANT engaged in the performance of services required under the agreement shall not be considered an employee of the OWNER, and any and all claims that may or might arise under the Worker's Compensation Act of the State of South Dakota on behalf of said employees or other persons while so engaged and any and all claims made by any third party as a consequence of any act or omission of the part of the work or service provided or to be rendered herein by the CONSULTANT shall in no way be the obligation or responsibility of the OWNER.

CONSULTANT shall perform all work except specialized services. Specialized services are considered to be those items not ordinarily furnished by CONSULTANT which must be obtained for proper execution of this Agreement. Specialized services required by the study, if any, will be provided pursuant to Section 2 of this Agreement.

Neither this Agreement nor any interest therein shall be assigned, sublet or transferred unless written permission to do so is granted by the OWNER. Subcontracts are to contain all the required provisions of the prime contract as required by Super Circular 200, definitions.

4.9 Personnel Employment

The CONSULTANT warrants that it has not employed or retained any company or person, other than a bona fide employee working solely for the CONSULTANT, to solicit or secure this agreement, and that he has not paid or agreed to pay any company or person, other than a bona fide employee working

solely for the CONSULTANT, any fee, commission, percentage, brokerage fee, gifts, or any other considerations, contingent upon or resulting from the award of making of this Agreement. For breach or violation of this warranty, the OWNER shall have the right to annul this Agreement without liability or, in its discretion to deduct from the agreement price or consideration, or otherwise recover, the full amount of such fees, commission, percentage, brokerage fee, gift or contingent fee.

4.10 Nondiscrimination/ADA

The CONSULTANT agrees to comply with the requirements of Title 49, CFR Part 21 and Title VI of the Civil Rights Act of 1964, identified as Appendix A attached hereto and hereby, by this reference, made a part of this Agreement. The CONSULTANT agrees to provide services in compliance with the Americans With Disabilities Act of 1990.

4.11 Claims

To the extent authorized by law, the CONSULTANT shall indemnify and hold harmless the OWNER, its employees and agents, against any and all claims, damages, liability and court awards including costs, expenses and reasonable attorney fees to the extent such claims are caused by any negligent performance of professional services by, the CONSULTANT, its employees, agents, subcontractors or assignees.

It is further agreed that any and all employees of either party, while engaged in the performance of any work or services, shall not be considered employees of the other party, and that any and all claims that may or might arise under the Worker's Compensation Act of the State of South Dakota on behalf of said employees, while so engaged on any of the work or services provided to be rendered herein, shall in no way be the obligation or responsibility of the other party.

4.12 Acceptance and Modification

This Agreement together with the Exhibits, Appendices and schedules identified above constitute the entire agreement between OWNER and CONSULTANT and supersede all prior written or oral understandings. This Agreement and said Exhibits and schedules may only be amended, supplemented, modified or canceled after consultation with, and approval in writing by, the parties to this Agreement.

4.13 Termination or Abandonment

The CONSULTANT and the OWNER share the right to terminate this Agreement upon giving thirty (30) days written notice of such cancellation to the other party. If this Agreement is terminated under this paragraph, CONSULTANT shall deliver to OWNER all work product produced up to the time of termination. OWNER shall reimburse CONSULTANT for all work completed to the date of

termination.

In the event the CONSULTANT breaches any of the terms or conditions hereof, this Agreement may be terminated by the OWNER at any time with ten (10) days written notice and an opportunity to cure. If termination for such a default is effected by the OWNER, any payments due to CONSULTANT at the time of termination may be adjusted to cover any additional costs to the OWNER because of CONSULTANT'S default. Upon termination the OWNER may take over the work and may award another party an agreement to complete the work under this Agreement. If after the OWNER terminates for a default by CONSULTANT it is determined that CONSULTANT was not at fault, then the CONSULTANT shall be paid for eligible services rendered and expenses incurred up to the date of termination.

SECTION 5 – GOVERNING LAW

This agreement and any dispute arising out of this agreement shall be governed by the laws of the State of South Dakota.

5.1 Forum Selection

Any dispute arising out of this contract shall be litigated in the Circuit Court for the 7th Judicial Circuit, Rapid City, South Dakota.

5.2 Compliance Provision

The CONSULTANT shall comply with all federal, state and local laws, together with all ordinances and regulations applicable to the work and will be solely responsible for obtaining current information on such requirements. The CONSULTANT shall procure all licenses, permits or other rights necessary for the fulfillment of its obligation under the Agreement.

SECTION 6 – MERGER CLAUSE

This written agreement which includes the Request for Proposals and associated exhibits, to include Exhibit A – Scope of Work, Exhibit B – Project Schedule, Exhibit C – Cost Estimate, Appendix A – Assurances, Appendix B – Debarment, and the Request for Proposals, constitute the entire agreement of the parties. No other promises or consideration are a part of this agreement.

SECTION 7 – COMPLIANCE WITH CLEAN AIR ACT

CONSULTANT stipulates that any facility to be utilized in the performance of this contract, under the Clean Air Act, as amended, Executive Order 11738, and regulations in implementation thereof is not listed on the U.S. Environmental Protection Agency List of Violating Facilities pursuant to 40 CFR 15.20 and that the OWNER and the State Department of Transportation shall be promptly notified of the receipt by the CONSULTANT of any communication from the Director, Office of Federal Activities, EPA, indication that a facility to be utilized for the contract is under consideration to

be listed on the EPA List of Violating Facilities.

SECTION 8 – CERTIFICATION REGARDING DEBARMENT, SUSPENSION, INELIGIBILITY AND VOLUNTARY EXCLUSION

CONSULTANT certifies, by signing this agreement that neither it nor its Principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency, attached as Appendix B.

SECTION 9 – INSURANCE AND REPORTING

Before the CONSULTANT begins providing service, the CONSULTANT will be required to furnish the OWNER the following certificates of insurance and assure that the insurance is in effect for the life of the contract:

A. Commercial General Liability Insurance: CONSULTANT shall maintain occurrence based commercial general liability insurance or equivalent form with a limit of not less than $1,000,000.00 for each occurrence. If such insurance contains a general aggregate limit it shall apply separately to this Agreement or be no less than two times the occurrence limit.

B. Professional Liability Insurance or Miscellaneous Professional Liability Insurance: CONSULTANT agrees to procure and maintain professional liability insurance or miscellaneous professional liability Insurance with a limit not less than $1,000,000.00.

The insurance provided for general liability and errors and omissions shall be adequate for the liability presented, and shall be written by an admitted carrier in the State of South Dakota.

C. Business Automobile Liability Insurance: CONSULTANT shall maintain business automobile liability insurance or equivalent form with a limit of not less than $500,000.00 for each accident. Such insurance shall include coverage for owned, hired and non-owned vehicles.

D. Worker's Compensation Insurance: CONSULTANT shall procure and maintain workers' compensation and employers' liability insurance as required by South Dakota law.

Before beginning work under this Agreement, the CONSULTANT shall furnish the OWNER with properly executed Certificates of Insurance which shall clearly evidence all insurance required in this Agreement and which provide that such insurance may not be canceled, except on 30 days' prior written notice to the OWNER. The CONSULTANT shall furnish copies of insurance policies if requested by the OWNER.

SECTION 10- REPORTING

CONSULTANT agrees to report to the OWNER any event encountered in the course of performance of this Agreement which results in injury to any person or property, or which may otherwise subject CONSULTANT, or the OWNER or its officers, agents or employees to liability. CONSULTANT shall report any such event to the OWNER immediately upon discovery.

CONSULTANT'S obligation under this section shall only be to report the occurrence of any event to the OWNER and to make any other report provided for by their duties or applicable law. CONSULTANT'S obligation to report shall not require disclosure of any information subject to privilege or confidentiality under law (e.g., attorney-client communications). Reporting to the OWNER under this section shall not excuse or satisfy any obligation of CONSULTANT to report any event to law enforcement or other entities under the requirements of any applicable law.

SECTION 11 – DISCLOSURE TO REPORT LOBBYING

CONSULTANT certifies, to the best of CONSULTANT'S knowledge and belief, that: No Federal appropriated funds have been paid or will be paid, by or on CONSULTANT'S behalf, to any person for influencing or attempting to influence an officer or employee of any agency, a member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of a Federal contract, grant, loan, or cooperative agreement. If any funds other than Federal appropriated funds have been paid or will be paid to any of the above mentioned parties, the undersigned shall complete and submit Standard Form LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

CONTRACTOR shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty or not less than $10,000 and not more than $100,000 for each such failure.

SECTION 12 - SEVERABILITY PROVISION

In the event that any court of competent jurisdiction shall hold any provision of this Agreement unenforceable or invalid, such holding shall not invalidate or render unenforceable any other provision hereof.

IN WITNESS WHEREOF, the parties hereto have made and executed this Agreement by their duly authorized officers on the day, month and year first written above.

OWNER:

Attest:

_____
Mayor Date

_____
Finance Officer Date

APPROVED AS TO FORM

Carla R. Cushman 2-2-15
Carla Cushman Date
Assistant City Attorney

STATE OF SOUTH DAKOTA

COUNTY OF PENNINGTON

On this _____ day of _____, 2015, before me, a Notary Public, personally appeared Sam Kooiker, Mayor of the City of Rapid City, and acknowledged to me that he did sign the foregoing document as such officer and for the purposes therein stated.

_____
Notary Public

My Commission Expires:

_____

(SEAL)

CONSULTANT:

By:_____
Title

STATE OF _____

COUNTY OF _____

On this _____ day of _____, 2015, before me, a Notary Public, personally appeared _____, a Principal of Fugro Geospatial, Inc., and acknowledged to me that s/he did sign the foregoing document as such officer and for the purposes therein stated.

_____
Notary Public

My Commission Expires:

_____

(SEAL)

Address for Giving Notices:

City of Rapid City
Community Planning and Development Services
300 Sixth Street
Rapid City, South Dakota 57701

3 PRODUCT PROCEDURES

3.1 Component 1 – Light Detection and Ranging (LiDAR) Data Acquisition

Upon confirmation of ground control and airborne GPS base station installation, we propose to conduct LiDAR elevation data acquisition during the spring of 2015 controlled by airborne GPS with one of our Riegl LMS-Q680i LiDAR Sensor aboard the Cessna 310-R FAA Certified aircraft from an altitude required for the nominal successful point vertical of 9.25cm and to meet topographical relief considerations. A matching aircraft and sensor will be allocated at our Rapid City aviation center to a support position to mitigate possible delays in data acquisition and to provide a significant reduction in risk assessment for primary elevation data collection or re-flight. Acquisition of LiDAR data is scheduled to be completed in 2-4 days for the project area(s).

Fugro's recent investment in the **Riegl LMS-Q680i LiDAR** sensor provides the ability to acquire waveform LiDAR data. The "more data / more value" aspects of waveform LiDAR include multiple environmental and forestry applications such as vegetation species identification, invasive species identification, and canopy structure inspection.

LiDAR Acquisition Specifications	Riegl LMS-Q680i System
Laser Class	Class 3R
Flight Altitude (Above Ground Level)	3,381-ft.
Side lap	30% minimum
Flight Acquisition Speed (knots)	140kts
MPiA (Multi pulse in Air)	Yes, 4 pulses
Scan Angle (FOV) Field of View	60° (30° from Nadir) Fixed
Scan Pattern	Parallel Scan Lines
Laser Wavelength	1550 nm
Nominal Point Spacing	No greater than 0.7 meters
Returns per Pulse	Virtually unlimited with full waveform
Flight Lines with cross flights	46
Flight line miles with cross flights	930

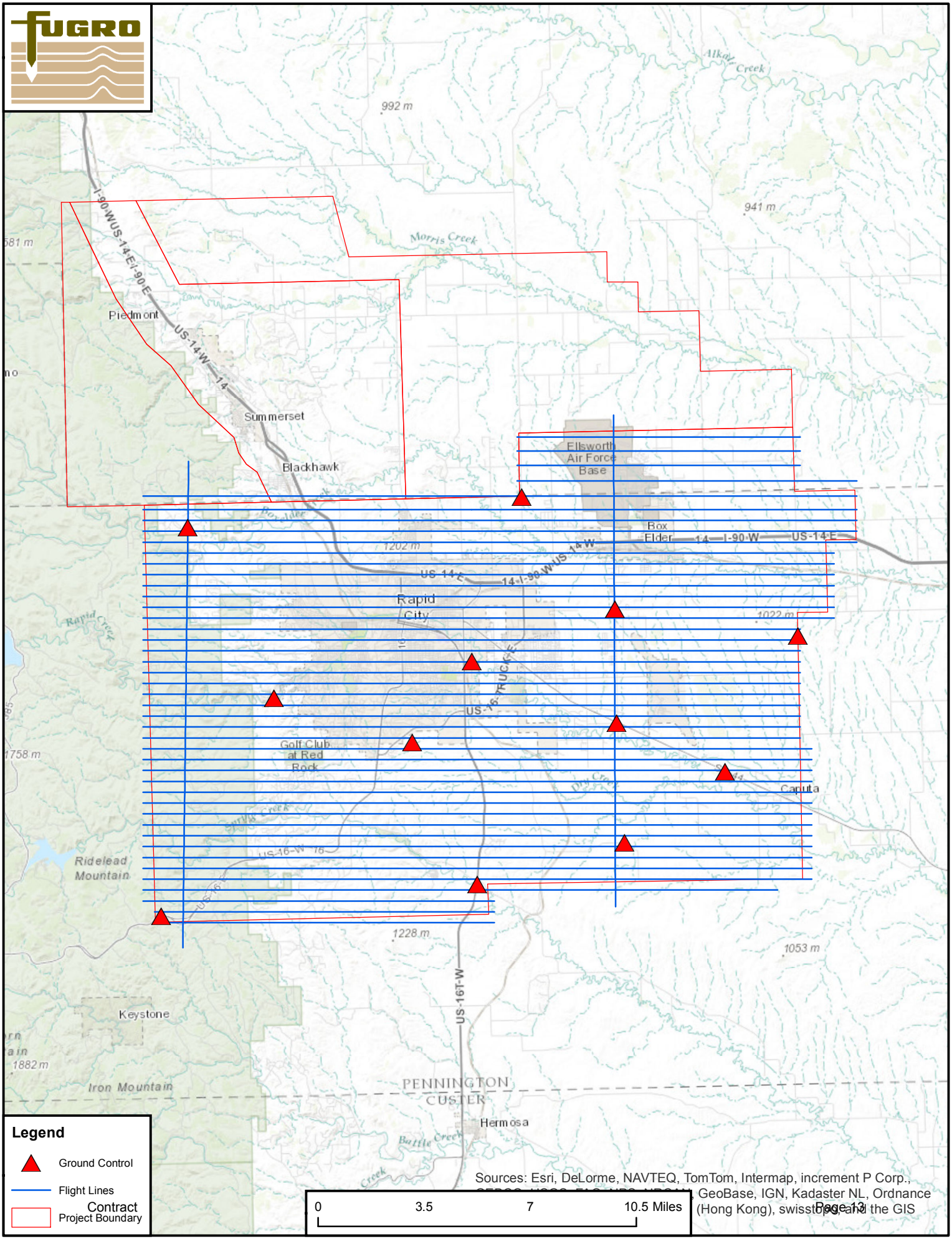
3.1.1 Boresight Calibration

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 project success. 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 ground control points. Finally, the technician will run a final 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 vertical accuracy to make sure it meets the project RMSEz requirements.

3.1.2 LiDAR Flight Plan

The preliminary flight plan for LiDAR acquisition is found on the following page.

Line Index of Flight: Rapid City, 2ppsm LiDAR



3.1.3 LiDAR Production

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 point classification. First the LiDAR data will be cut to production tiles followed by the creation of macros for point classification. The flight line overlap points, noise points and ground points will be classified automatically using the created macros. 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. 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 accurately 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 types 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).

The LAS point cloud data will then be packaged to the project specified tiling scheme, clipped to the project boundary and LAS delivery format, and projected to the specified projection, datum, and unit. The file header will be formatted to meet project specifications. This Classified Point Cloud product will be used for the generation of derived products and will be delivered in fully compliant LAS v1.4, Point Record Format 1 with Adjusted Standard GPS Time. Georeferencing information will be 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.

DEM/DTM and 2-ft contours will be processed from the new LiDAR elevation data, if selected. The 2-ft contour accuracy produced from the DTM will meet a 9.25cm vertical point accuracy. The tiling scheme will match the project tiles and hydro breaklines and topology breaklines will be used to augment the DTM data.

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 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.

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.

The Riegl LMS-680i also incorporates multiple-time-around (MTA) technology which allows for multiple laser pulses in the air at once thus increasing the density of resultant point cloud. The sensor has the ability to transition between multiple points in the air zones automatically thus reducing acquisition costs in high relief terrain and greater collection flexibility. The MTA technology allows for many laser pulses in the air at once within the physical laws of nature. The instrument is typically flown in MTA zone 2 where there are two points in the air at all times however in certain situations the point density can be increased by moving into higher MTA zones given the appropriate environmental conditions.

In addition to discrete point discrimination which can produce up to 4 returns per laser pulse, the Riegl LMS-680i has the ability to collect full waveform data. Full waveform data allows for specialized analysis of each laser pulse return signature for further data extraction. The technology has the potential for further feature extraction based on return signatures in the waveform data. Forestry applications have particular interest in this technology as it allows for extraction of additional information about the underlying forest structure for analysis.

3.1.4 LiDAR Data Verification, Handling, and Processing

All acquired LiDAR data will go through a preliminary review to assure that complete coverage has been obtained and verify that there are no gaps between flight lines before the flight crew leaves the project site. After acquisition, the data is run through a complete iteration of processing by our Geo-positioning team to ensure that it is complete, uncorrupted, and that the entire project area has been covered without gaps between flight lines. Once data from one lift is completed and accepted by internal QA/QC procedures and are found compliant with all technical specifications, the Fugro project manager, Mr. Mike Larson, will contact the RCMPO team for notification of data usability and will proceed with processing.

Steps taken during the data processing phase will ultimately determine if the high resolution elevation data will meet certain accuracy and classification standards. Rigorous quality control steps are taken to ensure that all interim data products used for the classification and bare earth processing exceed technical specifications.

There are essentially four steps to this processing and handling.

1. **GPS/IMU Processing.** Airborne GPS and IMU data will be immediately processed using the airport GPS base station data and the field base station data network which is available to the flight crew upon landing the plane. This ensures the integrity of all the mission data. These results will also be used to perform the initial LiDAR system calibration test.
2. **Raw LiDAR Data Processing.** The technician will first process the raw data to LAS version 1.2 format flight lines with full resolution output before performing QC. A starting configuration file is used in this process, which contain the latest calibration parameters for the sensor. The technician will also generate flight line trajectories for each of the flight lines during this process.
3. **Verification of Coverage and Data Quality.** Technicians will check flight line trajectory files to ensure completeness of acquisition for project flight lines, calibration lines, and cross flight lines.
    - The intensity histogram will be analyzed to ensure the quality of the intensity values.
    - The technician will also thoroughly review the data for any gaps in project area.
    - The technician will generate a sample TIN surface to ensure no anomalies appear in the data.
    - Turbulence will be inspected, and if the quality of the data is affected, the flight line will be rejected and re-flown.
    - The technician will also evaluate the achieved post spacing against project-specified point densities.
4. **Archive of Raw and Processed Data.** Technicians immediately copy the raw data to the server and archive the data once it is received in Fugro's office. The field crew also keeps the original copy of the collected data until the quality of data is fully validated by our GeoPositioning team. The archives are stored off-site to increase safety. This process ensures at least two copies of valid raw data exists.

3.1.5 LiDAR Data Processing

Fugro system-wide has more than 200 digital workstations and over 98 technical staff dedicated to processing raw LiDAR data and performing quality control. Therefore, if the schedule requires ramping up of processing and QA/QC resources because they might have been delayed due to inclement weather, the project manager can assign additional staff and workstations to process the data in order to meet the schedule.

We use a unique method for processing and checking the accuracy of LiDAR mapping data. Our approach involves identifying and classifying the LiDAR points reflected from the bare-earth, vegetation, buildings, and other above-ground structures, as well as water and noise. Data is filtered using proprietary algorithms and commercial software written by TerraSolid™. Fugro's approach allows for the identification of areas where data may be insufficient due to unforeseen gaps or other problems during the acquisition process. The TerraSolid™ software suite provides efficient processing for large-area projects and has been incorporated into production workflows compliant with our ISO9001:2008-Certified Quality Management System.

3.1.6 Steps for Generating the Final Deliverables:

1. Raw Data Processing and Boresight
2. Pre-processing
3. Post-processing
4. Data formatting

3.1.6.1 Raw Data Processing and Calibration (Boresight)

Raw data processing is the reduction of raw LiDAR, IMU, and GPS data into XYZ points. This is a hardware-specific, vendor-proprietary process. The raw LiDAR data processing algorithms use the sensor's complex set of electronic timing signals to compute ranges or distances to a reflective surface. The ranges must be combined with positional information from the GPS/IMU system to orient those ranges in 3D space and to produce XYZ points. As with any

such electronic measuring system, systematic errors can be introduced from a variety of internal and external sources – instrument timing errors, effects of the atmosphere, initialization errors and so on. The GPS times will be processed as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each return.

The calibration flight lines are first processed with the starting configuration file which contains the latest calibration parameters for the sensor. Boresight is for the refinement of the calibration parameters. The boresight for each lift will be done individually as the solution may change slightly from lift to lift.

Lift boresighting is accomplished using the tri-directional calibration flight lines over the project area. One calibration flight line is overlapping bi-directionally with a project flight line within the lift. This bi-directional calibration will also be used as a parallel flight line with the adjacent flight line. There is a cross flight line collected perpendicular to both. All three lines along with the parallel project flight line are examined to ensure that they agree, within project specification, in the overlapping areas. The two bi-directional flight lines are used to diagnose roll and pitch. The two parallel flight lines are used to diagnose and correct heading error. The two perpendicularly overlapping flight lines are used to examine Variable Scan Angle error.

Once the boresighting is done for the calibration flight lines, the adjusted settings will be applied on all of the flight lines on the lift and checked for consistency. The technician selects a series of areas in the dataset to be inspected where adjacent flight lines overlay. A routine is run to calculate the misalignment of the adjacent flight lines and a statistical report is generated. The technician will analyze the result and apply more adjustment if necessary to optimize the result for the entire lift. Color coded elevation difference images will be generated for all flight line overlaps including cross ties in the lift once the boresight adjustment is complete. The technician reviews these images to ensure that systematic errors are minimized for the lift and the results meet project specifications. The final boresight parameters for all lifts are archived in the project database for future reference.

Once all lifts are completed with boresight adjustment individually, the technician will check and correct the vertical misalignment of all flight lines and also the matching between data and ground truth. This process includes calculating the bias 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 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 accuracy check result will then be archived for future reference.

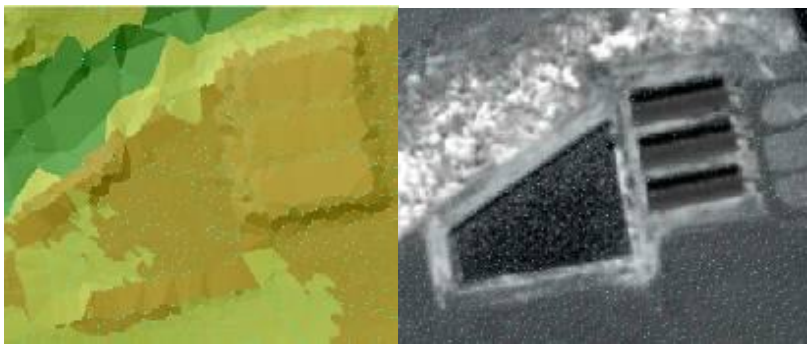
3.1.6.2 Pre-processing

The project will be set up for filtering once boresighting is complete for the project and all lifts are tied to ground control. The LiDAR data will be cut to production tiles and clipped to the project boundary. The geometrically unreliable points near the extreme edge of the swath will be identified using the “Withheld” flag.

3.1.6.3 Post-processing

Fugro has developed a unique, time efficient, and cost effective method for processing LiDAR data. Fugro uses commercial software as well as proprietary software for automatic filtering. The parameters used in the process are customized for each terrain type per project area to obtain optimum results. The algorithm has the ability to process large amounts of elevation point data in batch mode. Conceptually, the goal of automated processing is to filter as many artifacts as possible automatically, thereby reducing the amount of manual editing that is required to produce a Classified LiDAR Point Cloud.

The Automated Process typically reclassifies 90-98% of points falling on vegetation depending on terrain type. 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 features have been filtered out, the data is either run through a different filter or is corrected during the manual filtering process. The following figures illustrate such an instance with the result of an overly aggressive filter and the corrective action taken during the manual filtering stage.



Overly-aggressive automated filter and associated image

Correction after interactive filtering

Interactive editing is completed in 3D visualization software which also provides manual and automatic point classification tools. Fugro uses commercial and proprietary software for this process as well. Vegetation and artifacts remaining after automatic data post-processing are reclassified manually through interactive editing. The hard edges of ground features that were automatically filtered out during the automatic filtering process will be brought back into ground class during manual editing. Auto-filtering routines are utilized as much as possible within fenced areas during interactive editing for efficiency. The technician reviews the LiDAR points with color shaded TINs for anomalies in ground class during interactive filtering. Fugro will use the latest available digital ortho-images for this phase of the processing (2012 Rapid City Orthophotography Project).

3.1.6.4 Data Formatting

Generation of Raw Point Cloud: The boresighted LiDAR flight line LAS V 1.3 files will be reprocessed to the RCMPO's Coordinate System. The reprocessed flight lines will be cut to a maximum file size of 2 GB that store the multiple returns from each pulse in their collected order per swath.

Generation of Classified Point Cloud: Upon the completion of peer review and finalization of the classified LiDAR point cloud work tiles, the tiles will be reprocessed to the requested projection, datum, and unit. The classified LiDAR point cloud data is in LAS format after this process. The technician will check the output LAS files for coverage and format.

Once all of the elevation points are filtered and computed from each of the individual returns, the resulting dataset consists of a "cloud" of points that represent elevations of both ground and above-ground features, including first return surface models. Classification of returns will include processed, but unclassified, bare-earth ground, noise, water, and ignored ground. The data will also be cut, without overlap, to the tiling scheme of choice for the RCMPO.

3.1.7 Bare Earth Surface (DEM)

After the deliverable LAS files are generated for the entire project area, the Bare Earth Surface (DEM) will be generated. LiDAR points that fall within water will be classified as class 9 so that these points are excluded from the DEM generation process.

Once the initial bare earth DEM is generated, the technician checks the tiles to ensure that the grid spacing meets specifications. The entire data set will be checked for completed project coverage to ensure that no VOID areas exist. After the data has been checked, the tiles will be then converted and delivered as with 2-ft contours in an ESRI and/or AutoCAD format. All depressions, natural or man-made will remain in the data.

3.1.8 Bare Earth Model

Once the initial bare-earth DEM is generated, the technician checks the tiles to ensure that the grid spacing meets specifications. The entire data set will be checked for completed project coverage. Once the data has been checked, the tiles will be then converted into an industry-standard, GIS-compatible, 32-bit floating point raster format for delivery.

3.1.9 Classification

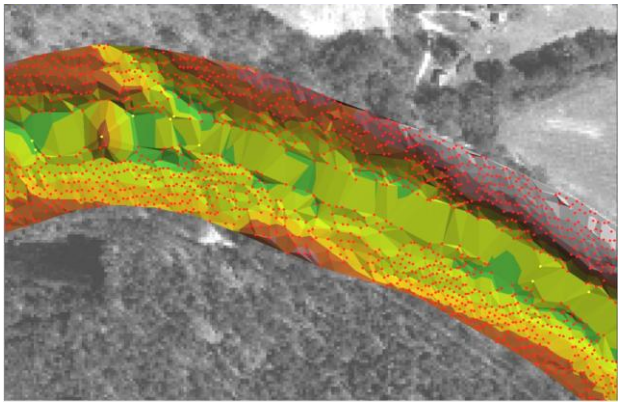
Mass point data shall be delivered in ASPRS .LAS format. The mass point data shall not contain any data voids and overlap between flight lines shall be removed. The classification code for these files will follow the LAS 1.4 format and will include the following:

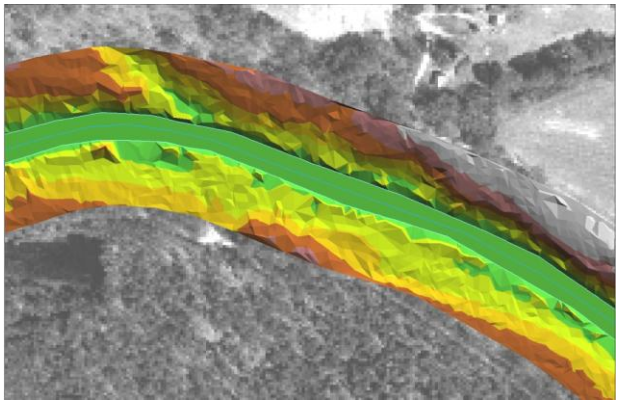
Classification Value	Meaning
1	Unclassified
2	Ground
9	Water

3.1.10 Hydro-Breaklines

Breaklines representing the banks of streams, rivers, ponds, and lakes, are extracted and converted into polygon shapefiles. These are used in the "flattening" process of the LiDAR data where LiDAR points that exist within water bodies are re-classified or tagged to indicate returns off of water. 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 flatten water bodies and may deviate from the underlying LiDAR terrain surface. Please refer below to an illustrated example of why hydro breaklines are important:





3.1.11 LiDAR Data Accuracy

The LiDAR flight and processing procedures are designed to meet or exceed FEMA Specifications for floodplain mapping and USGS LiDAR Base Specification Version 1.0. In order to achieve this standard, the LiDAR point data will meet or exceed the following point accuracy:

The LiDAR mapping procedure is designed to meet the following **Point Accuracy Standard**:
Vertical Point Accuracy: 9.25 cm
Horizontal Point Accuracy: 1 meter
LiDAR data is to meet the US Geological Survey (USGS) LiDAR Base Specification Version 1.0 standards at QL2.

3.1.12 Bare Earth Surface (DEM)

After the deliverable LAS files are generated for the entire project area, the Bare Earth Surface (DEM) will be generated. LiDAR points that fall within water will be classified as class 9 so that these points are excluded from the DEM generation process.

Once the initial bare earth DEM is generated, the technician checks the tiles to ensure that the grid spacing meets specifications. The entire data set will be checked for completed project coverage to ensure that no VOID areas exist. After the data has been checked, the tiles will be then converted and delivered in ASPRS .LAS format. All depressions, natural or man-made will remain in the data.

3.1.13 Processing Quality Control

Data Evaluation: In the data evaluation step, a project or block of strips is examined for collection errors (excessive noise), pre-processing errors (gaps, slivers, missing data, and steps) and AVRO (Automated Vegetation Removal) errors (misclassified banks) and any other anomalies that are unique to the dataset. During the data evaluation step, the general terrain (flat, hilly, steep, swamp) and land cover (forested, agricultural, urban) are also assessed. This allows the technicians to set up classification parameters during the manual filtering that closely match the terrain type. In order to ensure that the manual filtering process is effective and that no rework occurs, the output from the automated processing is checked thoroughly, utilizing a visual check of the data.

Manual Filtering – TIN Surface Checks: Color-shaded TINs simulate the appearance of terrain surface, combining shading and coloration to indicate the elevation, slope and aspect (direction of slope) of the terrain in an artificial view of the landscape. 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 TINs are especially useful in detecting points that would actually have been returns from vegetation that protrude above the surface of the surrounding terrain. Color-shaded TINs are used both during the manual filtering process and during the peer review after manual editing.

Peer Review: Because there are so many steps involved in the filtering process and due to the subjective nature of the task, the peer review offers the opportunity for yet another review of not only the data, but also of the editors' skills and editing abilities. Thus, the peer review becomes part of a process that promotes conformity among the filtering technicians and in the final product and ensures that the editing process produces a dataset that is edited completely and correctly. Every tile of data is subject to review by peers during the QC process.

QC and Tile / Sheet Edge Matching: Another step of the QC process is for the final product to be consistent in quality across the breadth of 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. The lead technician spends time on the front end exploring the strips in the block and making recommendations to the manual filtering technicians based on the content (terrain types). Once strips in the block have completed the peer review process, 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 completed, 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.

Final Delivery Quality Control: The Fugro project manager, Mr. Mike Larson, will be responsible for conducting a final overview 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.

Some of the additional quality control routines that are incorporated into each phase of LiDAR processing are:

- Existing ground control and elevation data can be used to verify the accuracy of the LiDAR data; ensuring that the target accuracies are met.
- The coverage and edge matching of the data are re-checked during the vegetation re-classification process to ensure that the data meets the required accuracy specifications. See process flowcharts below.
- Peer reviews are conducted by the technicians during the entire process. The project manager consistently checks on quality during production.

3.1.14 2-ft Contour Generation and Mapping

Steps for creating 2-ft contour interval mapping from the new LiDAR data set are as follows:

1. Fugro's vector department will review the project area and hydro features. Fugro's compilers will have collected hydro flattened breaklines of water features that are inside of the base project scope to properly route the contours for a more cartographically correct dataset.
2. LiDAR technicians will bring LAS and breakline data into MicroStation using the software overlay package of TerraSolid (TerraScan and TerraModeler modules) and create contour key points (different than a model key point typically used for DEM creation), ultimately selecting those LiDAR points that best represent the 2-ft interval contour lines vs. a grid.

3. Contour key points are created in batch mode to ensure the tying of all contours from edge to edge.
4. Contours key points run through a quality and completeness check prior to running the contour feature class.
5. Contours are now generated over the entire project area in tied tiles before converting to an Arc geodatabase.
6. Final edit is accomplished on the project wide dataset and converted to the desired geodatabase.

   Contour index: intermediate, index depression and intermediate depression are represented in the geodatabase.
7. Contour data is reviewed in Arc for topology errors, spikes, alignments, etc. and adjusted manually for best terrain representation.
8. Contour data runs through topology checks until all topology errors pass QC.
9. Elevation values shall be assigned to contour lines as attributes.

3.1.15 LiDAR Deliverables

Raw LiDAR datasets

- Classified Point Cloud
  - All project swaths, returns and collected points, fully calibrated, adjusted to ground, and classified
  - Fully compliant ASPRS .LAS format
  - Correct and properly formatted geo-reference information must be included in all LAS file headers
  - GPS times are to be recorded as Adjusted GPS Time
  - Intensity values (rescaled to 8-bit)
  - Tiled delivery, without overlap
- 2-ft digital elevation contours with attributes of z-values.
- Spot elevations
- Bare-earth digital elevation model raster with hydro-flattened breaklines
- FGDC-compliant metadata for each product

3.2 Component 2: Aerial Photography Acquisition

After close review of the acquisition parameters including several flight plan scenarios, Fugro proposes that the entire project area of 484 square miles be collected in one data collection mission at 6-inch pixel resolution. This approach provides RCMPO higher resolution mapping and a consistent pixel resolution throughout the entire project. Efficiencies gained in acquisition result in no additional cost.

The following section explains Fugro's overall approach and methodology to provide all products requested in the orthophotography portion of the RFP.

Upon confirmation of ground control network and airborne GPS base station installation, and a flight Notice to Proceed from the RCMPO, we propose to conduct aerial imagery acquisition in the spring of 2015 in leaf-off, snow-off, fog/cloud/smoke free with minimal flood ground conditions and controlled by airborne GPS with one (1) or more of our Leica ADS80-SH82 direct digital sensors mounted aboard one of our nine (9) aircraft approved by the FAA. The collection missions will be flown at a nominal altitude of 4,823-ft AMT for 6" pixel GSD for the new digital 3 band (R/G/B) color orthoimagery deliverables. A matching aircraft and ADS80-SH82 sensor will be allocated at our Rapid City aviation center in a support position to mitigate possible delays in data acquisition and to provide a significant reduction in risk assessment for primary imagery collection or re-flight. Acquisition of imagery is scheduled to be completed in 4-8 days to insure sufficient lift duration for a minimum 30 degree sun angle during each sortie.

Fugro's Leica ADS digital image sensors have been upgraded with the Sensor Head 82 configuration (ADS80-SH82) and incorporate the most current developments in sensor technology, optics, electronics, data transfer, and storage. Fugro has been operating the Leica ADS line of digital imagery sensors for over 10 years, and has recently completed the latest upgrades. The Leica manufacturer's calibration reports reflect these improvements for each sensor.

The ADS80-SH82 configuration will allow for the simultaneous collection of the Red, Green, Blue, Near Infrared, and Panchromatic bands and will be used for the production of the 3-band natural color digital orthophotography. CIR data will be archived in Rapid City in the event that the RCMPO wishes to process CIR imagery.

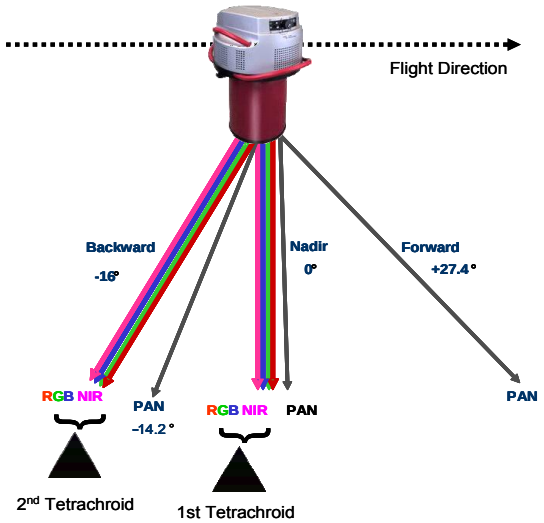
Digital imagery data from each sortie will be downloaded at our Rapid City flight base used for the acquisition block and reviewed to verify image quality and that complete project area coverage has been acquired. Airborne GPS and IMU data will be field processed within 48 hours of acquisition to ensure that the GPS satellite geometry and that IMU data will support the mapping accuracy requirements.

3.2.1 ADS80-SH82 Sensor Specifications

The ADS80-SH82 is capable of data collection at a wide range of ground sample distances (GSD), depending on the altitude and air speed of the mission. The typical GSD range for digital orthoimagery or rectified imagery produced from ADS80-SH82 data is 5 cm – 2 m.

This version of the ADS80-SH82 sensor (right) collects a total of 12 bands of imagery simultaneously, with 12,000 pixels per band and pixel size of 6.5 microns. Two tetrachroid beam splitters (NADIR and -16° backward viewing angles) allow acquisition of red, green, blue, and near-infrared bands at the same viewing angle for perfect co-registration. Radiometric resolution of compressed data (10-bit and 12-bit) dramatically improves image quality in shadow and highlight areas.

The ADS80-SH82 is also equipped with an Applanix POS inertial measurement unit (IMU) mounted on a PAV80 gyro-stabilized platform.



ADS80-SH82 Sensor Configuration

The digital imagery, GPS, and IMU position and orientation data are recorded during each sortie and are written to the flash-disk based mass memory unit (MMU) that is part of the sensor control system. Using flash disk technology provides higher reliability and significantly reduces payload weight. The flash disk MMU has a capacity of 480gb per

unit or 980gb joint volume. This equates to 9.7 hours of recording the 3 panchromatic and 4 spectral bands of ADS80-SH82 data.

After completion of the aerotriangulation (AT), the ADS80 bands can be exported as stereo imagery in all commonly read formats to develop planimetric, topographic, and other types of photogrammetrically-derived data products (ie Leica Stereo Analyist software). The stereo models are accompanied by a digital file containing the exterior orientation parameters derived from the bundle triangulation adjustment and their coverage is controllable by the technician; a typical model size is 12,000 by 5,000 pixels with a 200 pixel overlap between models along track.

It should be noted that all of the CCD arrays are uniform in pixel resolution. All spectral bands are collected at the same native pixel resolution; therefore pan-sharpening of color and IR bands is unnecessary. This system array provides greater radiometric integrity for image classification and thematic mapping applications. There are also no dead pixels in any of the CCD arrays. Digital imagery from the ADS80-SH82 is processed using the Leica XPro processing suite, combined with Fugro's large parallel processing capacity (96 parallel processors of 3GHz each). With the Leica system's powerful DEM Extraction auto-correlation algorithms, imagery from the ADS80-SH82 can be rapidly developed into orthophotography and DEM products with pixel-to-pixel accuracy.

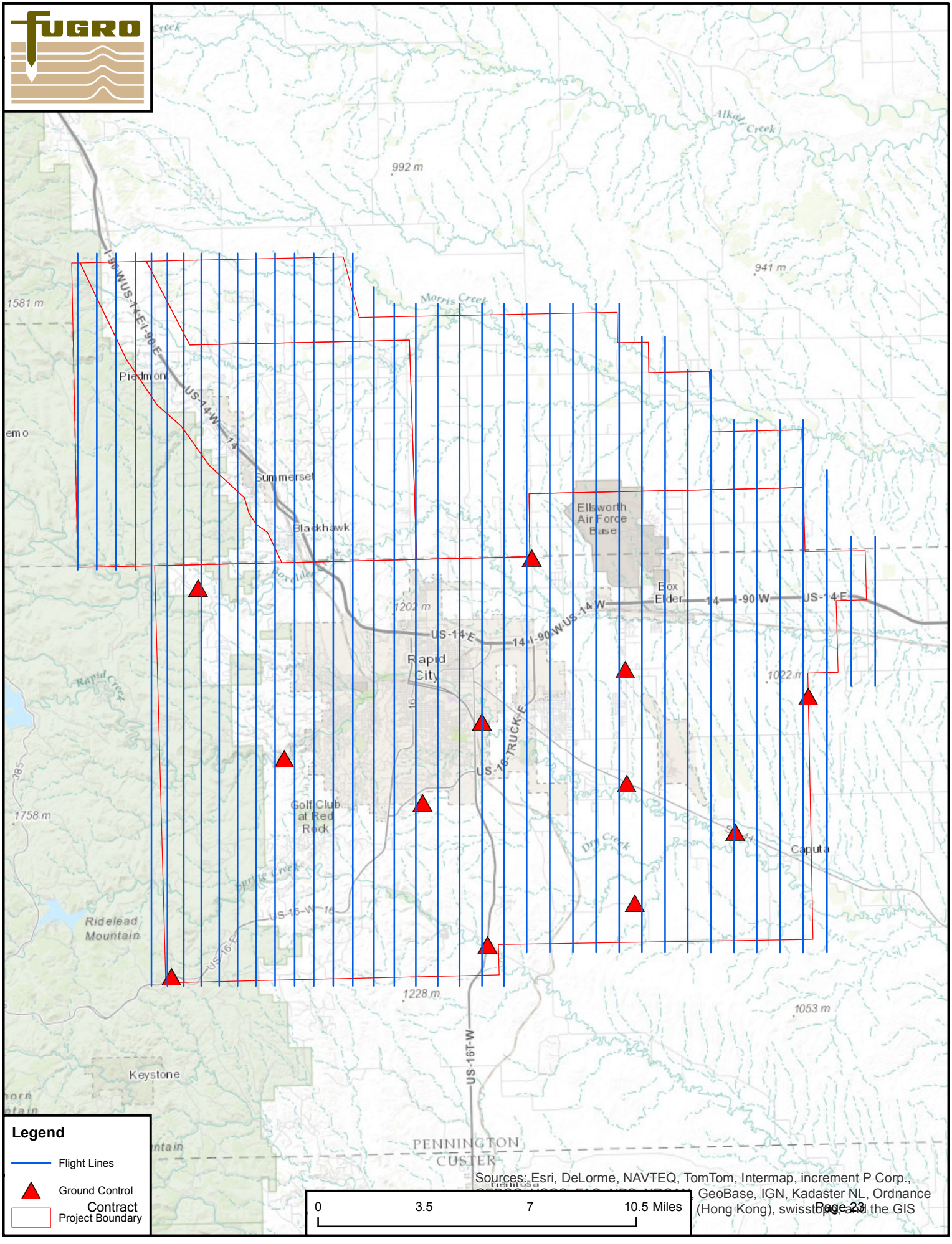
During the flight window (3-6 days), it is expected that the frequency of communications will greatly increase. Participant staff will be notified by phone and by email when aircraft are mobilized within the area. The project manager will provide frequent verbal and email status reports to the designated points-of-contact as imagery is collected. At the completion of the acquisition phase, prior to production, Fugro will submit a quality control report demonstrating compliance with the aerial imagery collection specifications.

Acquisition Specifications	
Digital Airborne Sensor System	Leica ADS80-SH82
Pixel Resolution	6"
Flight Height (Above Mean Terrain)	4,823'
Speed Over Ground (SOG)	160kts
Flight Height Deviation	<5%
Band Capture	Pan; R,G,B; IR
Capture Width across track	12,000 pixels
Captured Radiometric Resolution	12 bits/pixel/band
Processed Image Type	3 band R/G/B
Sensor Spectral Bands: Near-infrared	833-887nm
Red	604-664nm
Green	533-587nm
Blue	420-492nm
Number of Flight Lines	39
Flight Line Miles	826
Forward Overlap Percent	100%
Side Overlap Percent (Minimum)	30%
Sun Angle	≥30°
Number of Lifts	3

3.2.2 Preliminary Imagery Flight Maps for Aerial Photography Acquisition

The preliminary flight plan and ground control layout for orthophotography is found on the next page.

Line Index of Flight: Rapid City, 6 inch Ortho



3.3 Component 3 – Digital Orthophoto Production

3.3.1 Fully Analytical Aerial Triangulation

Fugro performs aerotriangulation adjustments for imagery acquired from the ADS80-SH82 sensor using softcopy and photogrammetric workstations. Fugro will provide documentation to the RCMPO of the results of the aerotriangulation adjustment in the form of a report and a series of digital files showing the final values assigned to the pass and tie points as well as the final RMSE of the final adjustment. The digital file containing the orientation parameters derived from the aerotriangulation adjustment can be read by both softcopy and analytical stereo plotting instruments directly. Once the ADS80-SH82 data has been collected and accepted, Fugro's production center will begin the orthoimagery process. Following is a step-by-step description of the pre-production QC steps and aerotriangulation (AT) process prior to stereo-compilation. Documentation of this methodology and results of the aerotriangulation adjustment will be prepared and delivered to the RCMPO for review.

Step 1. The unprocessed ADS80-SH82 data and accompanying GPS and inertial measurement unit (IMU) data for one or more collections are downloaded from the portable hard disks and checked to verify that no files are corrupted and that all data can be sent through production. Sample segments of the imagery are inspected in an uncorrected state to verify the integrity of each data collection.

Step 2. The AT is performed on the panchromatic channels using all 3 look angles; facing Forward, Back and Nadir. After the bundle adjustment is processed, the resulting parameters are propagated to all remaining channels in the collection/block.

Step 3. Aerotriangulation is accomplished as a component of Fugro's XPro process. The GCPs, GPS, and IMU information are imported and tie points between imagery strips are identified either manually or through an automated matching process.

Step 4. The AT produces a bundle adjustment for each data block (consisting of one or multiple collections, averaging 5 to 10). The results of the bundle adjustment are verified through an inspection of the derived residuals for each GCP and tie point. In addition, orthophoto samples are generated over the GCPs to assess the absolute accuracy, while orthophoto samples between adjacent tracks are generated to assess the relative accuracy.

Step 5. Final AT results are inspected by the photogrammetric technician to confirm the accuracy meets the proposed specification.

All AT processes will be performed under the supervision of an ASPRS-certified Photogrammetrist to ensure compliance with accuracy standards.

Processing Specifications	6" Pixel Delivery
Source of the elevation model	New DEM produced from 2015 LiDAR elevation data
Processed Image Type	3-band color
Orthophoto Spatial Accuracy in x or y	2-ft at 95% confidence
Orthophoto Pixel Resolution	6"
Estimated Orthophoto Sheet Layout	Approximately 1 square mile
Estimated Image File Size	335mb
Estimated Number of Image Sheets	≈600
Void Pixels Displayed As	white
Delivery Format	Tiff w/.tfw

The core application for ADS80-SH82 digital image sensor processing is the XPro software package from Leica. XPro was developed in parallel with the ADS sensor and designed to take the data from the raw state to an intermediate product that can be exploited by more traditional photogrammetry software. Typical intermediate products are stereomodels and strip orthophotos. In XPro terminology, the raw images from the camera are called L0 images, stereo viewable images are called L1 images and strip orthophoto images are called L2 images.

A key feature in XPro is the ability to apply the factory radiometric calibration along with the recorded integration interval to yield imagery with DN (grayscale) values scaled to true at-sensor radiances. This simply means minimal edits to color contrast which results in more consistent color imagery delivery to the RCMPO.

The XPro software suite provides the tools necessary to perform the following seven processing steps:

Step 1 -- Raw Image Download

On completion of each image acquisition mission, the system operator removes the ADS80 MM80 (mass memory) storage container from the aircraft and using a field workstation, downloads the data using XPro. This enables an immediate real-time look at image quality and coverage. The data is then copied to removable hard drives for shipment to our main processing facility. A duplicate copy of the data is maintained in the field until the data is received and archived. The data is run through a complete iteration of processing to ensure that it is complete, uncorrupted, and that the entire project area has been covered without gaps between flight-lines. If any issues are discovered with the data, the imagery will be re-flown immediately.

Step 2 -- Differential GPS and IMU Processing

Along with evaluating the RAW imagery, Fugro's GEO-Positioning team processes the airborne GPS and IMU data. The simultaneous collection of airborne GPS and IMU data with the aerial imagery ensures an exceptional level of accuracy in the final product. Download of the sensor data in Step 1 includes the data from the integrated GPS and IMU. Those data sets are differentially post-processed with the Applanix POS GPS software package against one or more ground base stations. GPS base station(s) will be located at the Fugro aviation center and operated by the flight crew. After the differential GPS solution has been checked and verified, the Applanix POSproc program is used to compute an integrated GPS/IMU navigation solution at one-second intervals.

Step 3 -- Georeference of Raw L0 Imagery

Using the GPS/IMU trajectory and orientations computed in Step 2, plus the scan line times recorded by the sensor and the sensor calibration, XPro interpolates x,y,z, omega,phi,kappa exterior orientation for each scan line and each CCD array. The data is written to the Orientation Data File (ODF).

Step 4 -- Creation of L1 Imagery and Stereo Model Files

Using the ODF produced in Step 3 and the L0 imagery, the XPro quick rectifier is run to produce L1 images which are, in effect, "flat-plane" orthos scaled to the project's average terrain elevation. The processing removes most aircraft motion and provides epipolar geometry for stereo viewing, automated aerotriangulation and automated DEM extraction (if required).

At this point in the process, a parallel work flow is run to export the 4-band and panchromatic stereo imagery that will be suitable for direct input into Leica's Stereo Analyst software. In this format, the Client would be able to view the imagery in 3D for the collection of hydrological, planimetric and other topographic features.

Step 5 -- Aerotriangulation

The aerotriangulation process is an invaluable tool in the production work-flow because it ensures that the underlying GPS ground control, airborne GPS and IMU data are sound and will support the accuracy specifications of the mapping project. The AT process is accomplished within the Leica XPro suite of processing software and is based on the Intergraph Orima work-flow software design.

IMU systems are subject to gravitational drift when flown in a straight line for extended periods. To remove such biases and increase the overall accuracy of the orientation data, an aerotriangulation step is performed. Our preferred approach is to use the BAE Socet Set APM program to select many pass points to tie each band of a flight strip together. These become 3-ray points because each unique ground position is imaged at three different times in each of the pan channels. The three "look angles" of, 26.4° forward, 0° at Nadir, and 16° back provide rigid geometry. In a second APM run, the points are transferred to the adjacent flight strips. Typically several thousand points are transferred between strips. The APM process is computer intensive and is therefore run on up to 10 nodes of the Condor® computer cluster. Once the pass points have been successfully transferred, the Leica Orima bundle adjustment program is run to compute the adjusted ODF for all bands and CCD arrays.

Step 6 -- DSM

A Digital Elevation Model (DEM) is required for orthophoto production. A new DSM will be produced from the 2015 LiDAR elevation data and used to rectify the new 2015 imagery. The process for creation of the DEM is covered in the Product Procedures - Component 1 (LiDAR) section of this proposal

Step 7 – Creation of L2 strip ortho images

With the refined ODF from aerotriangulation and the new DSM, XPro is again used to produce a strip orthophoto for each of the flight line datasets. This task is extremely computer intensive. Processing this quantity of data in an efficient and timely manner requires careful workflow planning and a significant software and hardware investment. Fugro's central processing facility in Rapid City, SD is home to a 140 terabyte Storage Area Network (SAN) and a Condor® computer cluster capable of processing multiple flight strips in parallel. Both the Condor® computer cluster and the SAN can be incrementally expanded to match workloads. Additional computing capacity is available throughout Fugro's global network of processing facilities.

Several processing options are available including creation of single band: RGB, FCIR, Panchromatic, and/or 4-band orthophoto images. The factory radiometric calibration is applied and optionally the modified Chavez Atmospheric (haze removal) correction may be subsequently utilized. The output image is segmented so as to stay under a 4GB tiff file XPro system size limit. Each of the segments carries its own geo-reference so further processing may be done on individual segments, if required.

3.3.2 Step-by-Step Production of the Orthophotography

Step 1 Digital imagery from the ADS80-SH82 sensor is loaded on to the orthophoto production workstation and visually re-checked for completeness, cleanliness, and image quality on the workstation.

Step 2 The new DSM is imported and written to the correct subdirectory on disk. The coordinate/projection system is verified at this stage in the process.

Step 3 The surface model is re-inspected for missing or erroneous data points. The digital orthophoto workstation has the ability to add breaklines or additional points interactively while in stereo mode. The orthophoto engineer can modify the DEM/DSM files, as needed, which saves considerable production time. Any interactive modifications to the DEM/DSM data will be saved and will overwrite the previous file to ensure that the most up-to-date version of the elevation data is utilized.

Step 4 A complete differential rectification process will be carried out using a cubic convolution algorithm that removes image displacement due to topographic relief, tip and tilt of the aircraft at the moment of exposure and that removes radial distortion within the camera. Each final orthophoto is produced at the required pixel resolution. In the initial stages of production the digital orthophotos will cover the maximum extent of each aerial image footprint.

Step 5 Each digital orthophoto image will be visually checked for accuracy on the workstation screen. The absolute accuracy of paneled control that is visible on the image will be compared against a CADD file containing the point locations of the orthos. Accuracy is verified by overlaying and comparing the locations of the control in vector form. The digital orthophotos are edge-matched. Dependent on the outcome of this inspection, the input material is corrected and the ortho is re-run immediately or the input material is returned to the production unit responsible for correction.

Step 6 As a block of digital orthophotos are being inspected and approved for accuracy, the files are copied to the network and transferred to the ortho finishing team. This production unit is charged with radiometrically correcting the orthophotos prior to completing the mosaic and clipping of the final tiles. The image-processing technician performs a histogram analysis of several images that contain different land forms (urban, agricultural, forested, etc.) and establishes a histogram that best preserves detail in highlight and shadow areas. Fugro has developed a proprietary piece of software called "Image Dodging." This radiometric correction algorithm is used in batch and interactive modes. Used in this fashion, this routine eliminates density changes due to sun angle and changes in flight direction.

Step 7 At this point, the images have been balanced internally, but there remain global differences in color and brightness that are adjusted interactively. The technician assigns correction values for each orthophoto then displays the corrected files to assess the effectiveness of the adjustment. This process is repeated until the match is considered near seamless. These files are then returned to digital orthophoto production to mosaic the images.

Images are mosaicked using automated processing but the location of seam lines are set up interactively by the technician to ensure that mosaic lines are placed in areas that avoid buildings, bridges, elevated roadways, or other features that would highlight the seam lines. The mosaic lines can be feathered using a Fugro proprietary software routine that was developed to further improve the transition from frame to frame. Mosaics are produced in sections that correspond to a block of final orthophoto tiles. The final tiles are clipped from the mosaics.

Step 8 The ortho-finishing department performs final visual checks for orthophoto image quality. Image smear caused by the sheer steep terrain of mountain edges will be processed to minimize this effect in the isolated areas where it may appear. Depending on the size and location of the flaw, Photoshop provides several tools to remove the flaw

Step 9 The final orthophoto images also are written out in uncompressed TIFF format containing the full 16-bit (per band) radiometric values per pixel and wavelength.

Step 10 FGDC compliant metadata files in XML file format are created and will incorporate individual requirements set forth by the RFP.

3.3.3 DELIVERABLES:

- Natural color 0.5-ft digital orthophotography uncompressed images in .tiff files with .tfw header.
- Digital Elevation Model (DEM) used in the orthophoto rectification and data development processes.
- FGDC-compliant metadata for each product.

3.4 Component 4 (Option A) – Digital Color Oblique Aerial Imagery with Viewer

The GIS and Appraisal industry rely on geospatial data (specifically oblique imagery) for mass appraisal duties. Benefits of implementing oblique imagery include:

- Update and assess properties without leaving the office
- Cover more area in less time
- Easy access for visual inspections in hard-to-reach areas
- Increased productivity
- Increased accuracy of assessment
- Easy integration to already developed work-flow and CAMA software
- Generate product reports, area measurements, and documentation for individual properties

Fugro's global resources can support this contract with airborne data acquisition, processing and mapping needs.

3.4.1 Equipment: PanoramiX Camera Array

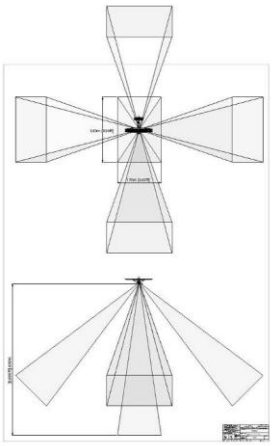
The PanoramiX system consists of four tilted and one vertical camera connected to a dedicated data acquisition computer. The five-cameras are installed in a special platform which fits in or above standard 19 inch or larger camera holes typically found in mapping aircraft. The flight management and cameras are controlled by the Track Air XTRACK Flight Management System (FMS). XTRACK has been in use worldwide for 15 years and is the core of the Applanix POSTRACK integrated IMU/FMS system. Applanix is the industry leader in the manufacture and development of precision aerial mapping systems and solutions.

To ensure the perfect rigidity of the lens and the camera body, each camera is fitted with a specially designed exoskeleton. This system prevents any movements of the lens relative to the camera body and is essential to the geometric quality of the PanoramiX system. To ensure the imagery is of the highest quality, the camera bodies and lenses are tested, and fully calibrated following installation in the aircraft platform. Optical distortions are precisely computed and a calibration report is generated for each lens.

- Tile boundaries
- GPS base station locations
- Flight line locations with start/stop points for each acquisition block

The digital files created by the *J-Flight* application are readable by the flight control management system (FCMS) that is used for operation of the camera system. The configuration of acquisition blocks may require modification due to weather or air traffic considerations, and these changes can be easily incorporated into the overall acquisition design using *J-Flight* and FCMS. In accordance with Fugro's ISO9001:2008-certified quality management plan, copies of the acquisition plans will be reviewed by our project manager and approved by the County prior to the airborne mission.

PanoramiX Camera Array: *The camera system is configured with four oblique cameras (mounted at 45 degrees) and one nadir facing camera.*



Field of View: *The 5 camera array provides simultaneous nadir and oblique image capture in a single pass.*

3.4.2 Imagery Acquisition

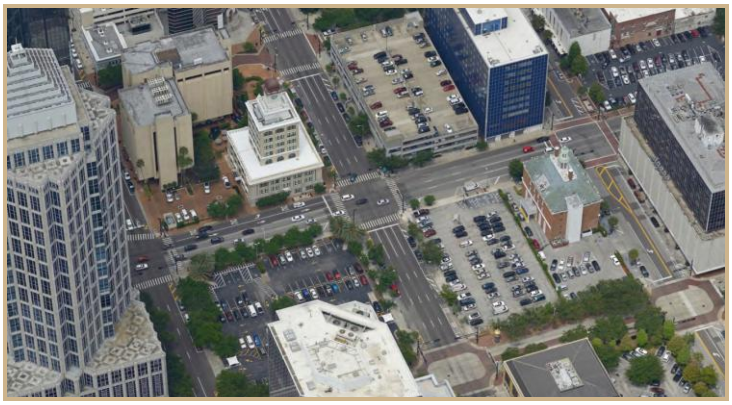
3.4.2.1 Planning

Aerial acquisition planning includes timing of missions to coincide with the strength of the GPS constellation; flight line length is designed to ensure peak performance of the IMU and the use of CORS; and the deployment of GPS base stations will incorporate sufficient flexibility to allow for weather and air traffic restrictions.

Fugro has designed a flight plan to represent 6-inch natural color nadir and oblique imagery. Fugro's Project Staging and Controls department includes ASPRS Certified Photogrammetrists (CP) and Certified Mapping Scientists (CMS) and has extensive experience designing flight plans and ground control layouts to achieve the client desired resolutions, and accuracy at any requested scale.

To achieve four (4) oblique views across the entire project area, Fugro applies a buffered boundary to the client supplied deliverable boundary. This buffered boundary represents the total flight area required to achieve the requested five (5) views within the project boundary. The buffered boundary is determined by the ground sample distance (GSD) or pixel resolution requested by the RCMPO, the flight altitude and look angle (45° in to the project area). Below is the proposed GSD for this project, our recommended buffer distance to the deliverable boundary and additional project specifications:

Ortho Pixel Resolution:	6 Inch
Buffer Distance:	6,408 feet
Flying Altitude:	6,158 feet
Oblique Resolution @ 45°	6 inch
Flight Lines:	32
Line Miles:	740
Photo Centers:	3,331



6" Pixel Resolution PanoramiX Imagery

3.4.2.2 Oblique Imagery Aerial Acquisition

Following the receipt of the Flight Authorization and the successive establishment of active GPS base stations by the Fugro flight crew, we propose to conduct aerial acquisition for the 6-Inch pixel resolution controlled by airborne GPS and IMU with the support of the developed ground control network. We will utilize one of our identical PanoramiX oblique systems aboard its dedicated twin-engine aircraft. An additional matched sensor and aerial platform will be maintained in a back-up, mission ready position to provide data collection continuity if it becomes necessary to mitigate possible mechanical or weather delays during data acquisition.

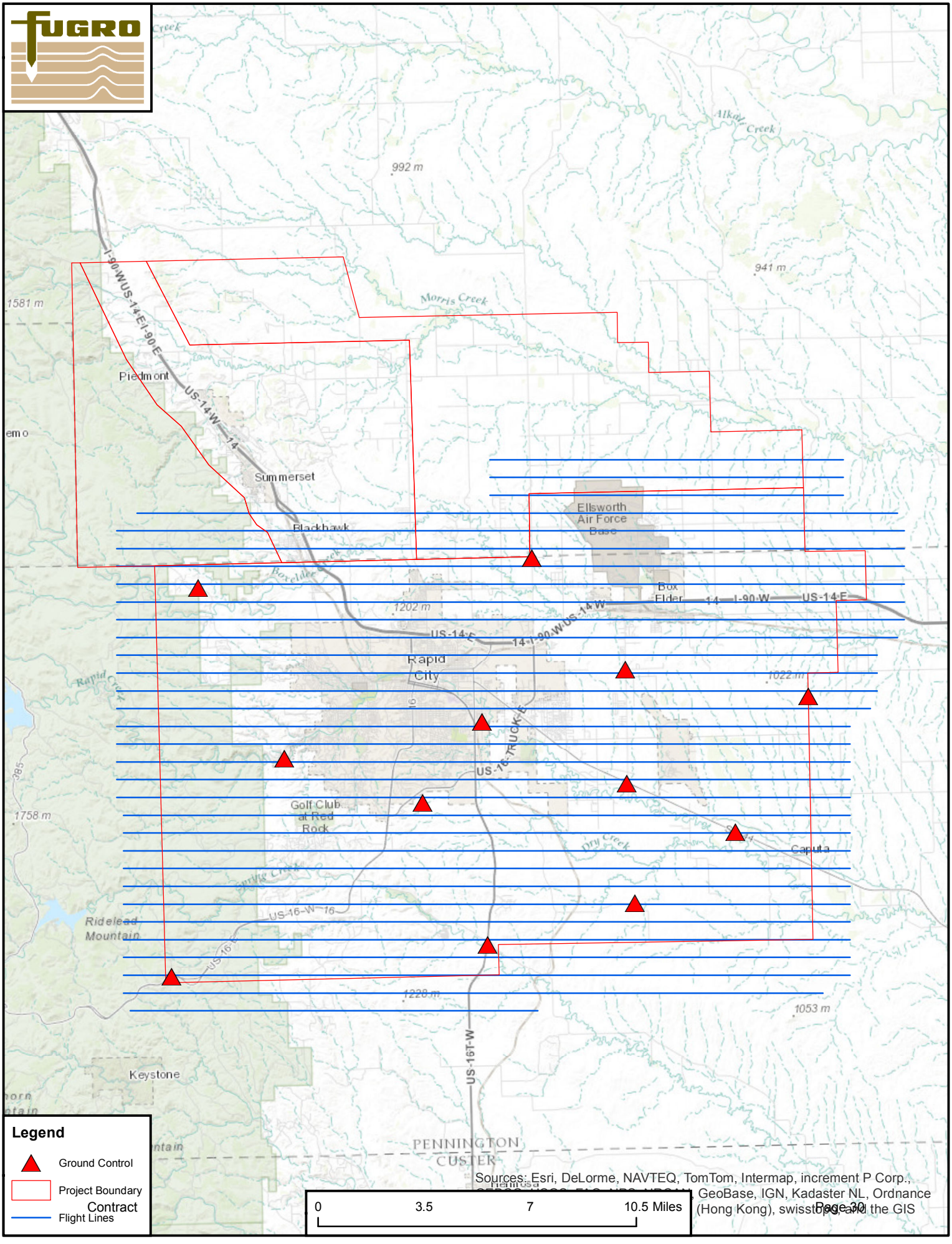
The PanoramiX photo unit includes a display which continuously shows the five (5) thumbnails of all photos being taken. This display provides the operator with a real time view of image quality, acquisition continuity, and exposure on the fly. **PanoramiX can acquire approximately 75 mi^2 (194 km^2) per day or 4-6 days for this Project.**

After each day's acquisition flight, the lead sensor operator performs a visual inspection of the raw digital imagery to check compliance with acceptance criteria (cloud cover, smoke/haze, turbulence, image anomalies, gaps/coverage, etc.) Additionally, all raw data acquired is submitted to Fugro's production center for detailed review and acceptance. Following the completion and quality check of all imagery, processing will commence at our global facilities. Steps taken during the data processing phase will ultimately determine if the high resolution imagery data will meet certain accuracy standards.

3.4.3 Flight Line Design

Preliminary flight plan for oblique imagery is on the following page.

Line Index of Flight: Rapid City, 6inch Oblique



3.4.4 Processing Approach

3.4.4.1 Processing Software

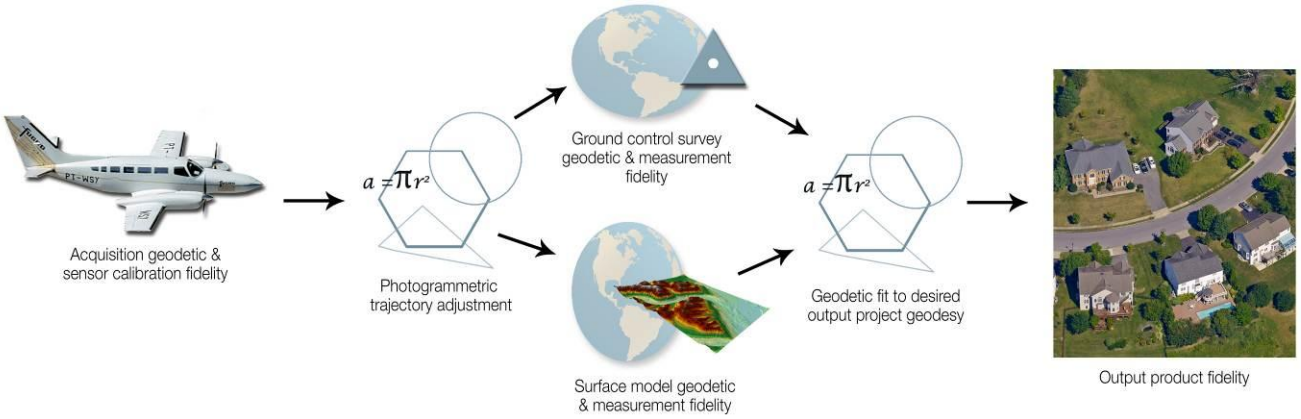
Once the data has been collected and accepted in the field, it is transferred to Fugro's production center for processing. Fugro has chosen the state-of-the-art and sophisticated software package, PictoVera™, a robust oblique processing solution developed by Stellacore Corporation to process data.

Step 1 PictoVera will ingest the platform trajectory data captured during aerial acquisition (i.e. navigation and camera data). The software analyzes the sensor data and uses the derived information to match sensor features between multiple images (along track, cross track, and above/below track simultaneously).

Step 2 The image data matches are utilized as generalized "tie points" in a photogrammetric bundle adjustment which computes "best-fit" corrections to the nominal (drift and otherwise biased) trajectory data. This results in a much higher fidelity trajectory, one with which images can be geo-referenced within about one pixel.

Step 3 PictoVera preserves the integrity of the photogrammetric adjustment from the GPS-based acquisition data and uses the planimetric and vertical control to fit the output products to the desired output geodesy. Thus, the effects of the systemic influence on fidelity are lessened.

Step 4 The results of the adjustment are further verified through the development of rectified image samples for the platform trajectory. These images are inspected by the photogrammetric technician to identify any gross errors in the adjustment, as well as the identification of any voids or image quality problems.



The image above illustrates PictoVera separating the navigation, from the photogrammetry, the geodesy, and the cartography. PictoVera then solves each of these independent and orthogonal problems separately.

3.4.4.2 PictoVera includes the following capabilities:

- Ingest source data from arbitrary payload packages, multiple navigation/trajectory systems, different modality sensors (e.g. GNSS, IMU, Imaging, LiDAR, Tilt/Rotation).
- Utilize sensor data to detect, analyze and model trajectory errors.
- Provide a "best-fit" trajectory most consistent with entire sensor payload (including, but no longer limited to the original payload trajectory system).
- Provide transformation between global horizontal datums.
- Provide best fit of data to local vertical-datum.

3.4.5 Quality Control

Fugro is committed to providing the RCMPO with timely delivery of high-quality geospatial products and services. The success of the project will be realized through a combination of comprehensive planning and a structured approach to quality control. With an emphasis on identifying potential risks, mitigations and preventing errors, our planning and assessment procedures ensure that all products delivered under this contract meet the highest possible quality standards.

3.4.5.1 Quality Control Systems

All of Fugro's management processes and procedures meet or exceed ISO9001:2008 standards for quality project management, a very rigorous, industry-based standard, which requires annual audit and certification compliance with project management processes and procedures. All procedures that will be used in the completion of this project have been documented and are audited in accordance with ISO9001:2008 project management requirements. Fugro's investment in these quality management standards is designed to ensure that product quality and project metrics (i.e. schedule, performance) are rigorously evaluated and maintained throughout every stage of the project's lifecycle.

Each of our key personnel listed for this project are responsible for defining and communicating quality procedures and standards within their departments, and ensuring that their staff take the appropriate steps to monitor and maintain quality during every phase, from data acquisition through production and final delivery. In a business where technology and the associated production processes are constantly changing and improving, it is imperative that procedures, forms, and metrics are constantly reviewed and updated. The following bullets are key components to Fugro's quality management system that will be an integral part of Fugro's approach to this project.

- **Criteria for Remedial Action** - Production processes are based on decades of successful completion of projects and contain elements that have been incorporated in response to both internal and customer specified requests. Anytime a new specification or new production process is introduced, the criteria for remedial action must be reviewed and modified to reflect a change in approach. The Fugro team will work with the RCMPO to identify any specific requirements where criteria must be added or modified to ensure the success of this project.
- **Remedial Actions** - Any quality issue is of immediate concern and must be mitigated at the earliest possible opportunity in order to maintain the project's production schedule. The quality management system has procedures that are part of the project management process to verify that the project plan has addressed all of the project's specifications, which eliminates many quality-related issues as the project progresses. The RCMPO will be an integral part of the planning process and will have input into the quality control routines that must be part of plan for imagery production using any of the selected digital imagery sensors.
- **Verification Criteria** - The quality management system contains an array of metrics which are used to monitor cycle times for each production process as well as time expended for rework. These existing tools will provide a means to verify that the quality issue has been successfully mitigated. The level of inspection can also be varied throughout the life of the project in response to different issues that may arise.
- **Notification** - Every large-scale, digital land base mapping effort presents challenges and contains minor technical issues that must be addressed. Technical staff members will evaluate and solve an array of problems that will occur throughout the life of any project and will document the nature of the problem and the process used to resolve the problem. In the vast majority of these cases, the quality of the end product is not affected and the delivery schedule is not disrupted. Open communication is a key element of Fugro's procedure for project management and the RCMPO will be immediately informed of any quality issues that will affect the project schedule. Fugro is committed to the delivery of data products that meet all aspects of the project specifications for quality and accuracy.
- **Commitment to Quality** - Each aspect of Fugro's quality management plan addresses issues that affect the project schedule as opposed to the quality of the resulting products. Fugro is committed to providing the RCMPO with products that are of the highest possible standards regardless of any issues that may arise. Therefore, the RCMPO may be assured that any products that are delivered will be fully supported and any product found to be deficient at any time in the future will be corrected or replaced.

3.4.6 Image Viewing Software Service: PX Mapper

Fugro's PX Mapper software is delivered as an integral part of the PanoramiX solution, providing robust capabilities for image viewing and exploitation. PX Mapper is available in both **desktop and online versions**. This ESRI ArcGIS compatible software also combines other geospatial data sources to serve a wide range of decision-making needs.

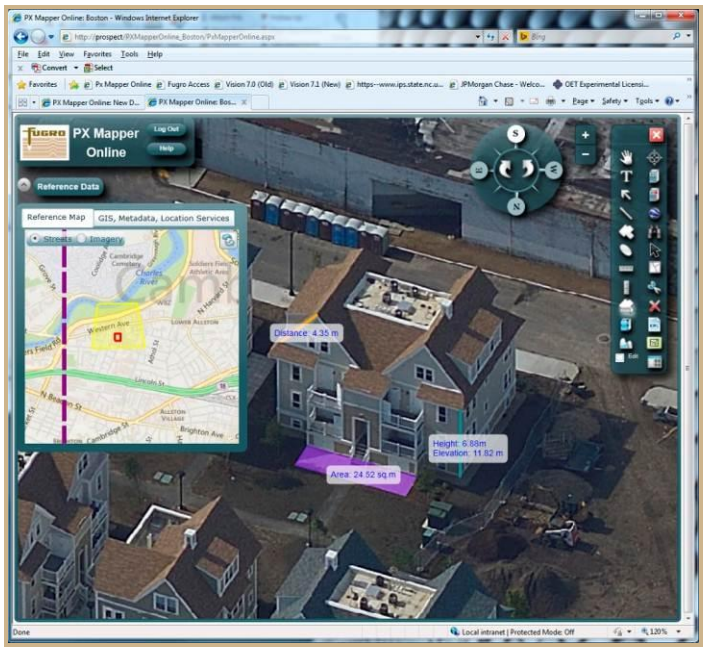
Fugro's PX Mapper software enables the user to view oblique imagery at very high resolutions through our 5-camera system. Our PanoramiX oblique system provides up to 2-Inch GSD resolution, and can easily meet 3-inch, 6-Inch, 9-inch and 12-inch GSD specifications.

3.4.7 Functionality and Operation

PX Mapper Online provides the ability to overlap all corresponding vector data (sketch, parcels, streets, etc.), quickly reference the pertinent metadata for the imagery, and use our interactive tool bar to calculate horizontal, vertical, and area measurements. All measurements are held to an absolute accuracy of within two (2) pixels horizontally, and three (3) pixels vertically. Features of PX Mapper Online include:

- View every angle of every building, structure, or ground point quickly and efficiently.
- Conduct horizontal, vertical, vertical terrain, and facade measurements.
- Load shapefiles over data for query and extraction of 3D geospatial information.
- Generate 3D models easily and accurately and easily export them to Google Earth as a .kml for easy sharing.
- Locate and annotate building and ground features.
- Integrate with existing ArcGIS databases to fully exploit geospatial data.
- PX Mapper Online is fully integrated with ArcGIS.

Fugro will provide user manuals and on-line demonstrations of software functionality to the RCMPO prior to receiving the image dataset.



PX Mapper Online Web Browser Graphical User Interface.

Compatible with Most Hand-Held Devices, PX Mapper Online is Field-Ready

3.4.8 Implementation and Access

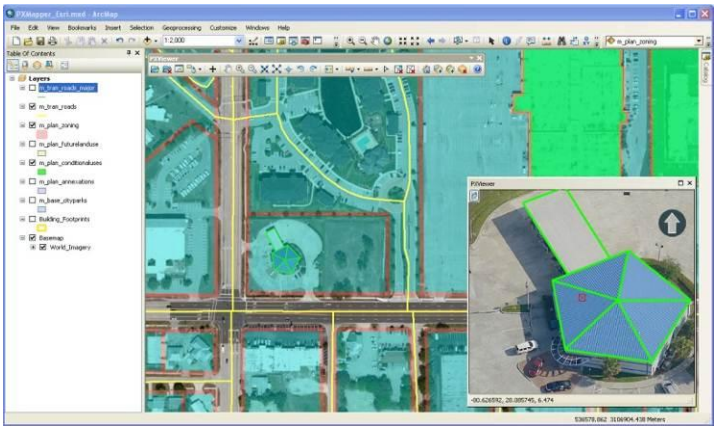
Digital orthoimagery and oblique data can be provided to the RCMPO on hard drives (to be stored on-site) or hosted on secure servers. The estimated data size at 6-Inch GSD is approximately 0.5 Terabyte.

PX Mapper Online is accessed on common web-based tools (desktop and mobile devices) like Internet Explorer, Firefox, and Safari. Demo sites will be created for the RCMPO to become familiar with the functionality of the application in advance of product delivery to ensure a seamless integration to daily operations. Additionally, Fugro has created an easy to use API that will integrate with any CAMA software. Prior to data delivery, Fugro will work with the RCMPO's CAMA software providers on integration.

3.4.9 Compatibility and Integration with ESRI products

The Fugro PX Mapper plug-in for ArcGIS extends oblique viewing and measurement to the ESRI ArcMap environment. Oblique imagery is displayed in a separate dock-able window within ArcMap. Within a given location, the oblique view can be rotated between the four cardinal view directions - north, south, east, and west. The users can then seamlessly pan and zoom between oblique images.

The Oblique view can be synchronized to the main ArcMap view. As the main view location is changed, the oblique view will be updated to match the current ArcMap view. Conversely, the main ArcMap view can be synchronized to the oblique view. As the oblique view location is changed, the ArcMap view will be updated to match the current Oblique view.



ArcGIS / PX Mapper Plug-In User Interface

PX Mapper plug-in for ArcGIS functionality includes:

- Measurement of horizontal and vertical oblique distances and areas
- Creation of building facades
- Creation of roof edge lines at height for 3D models
- Creation of terrain lines following ground heights
- Creation of point, line, polygon and text graphics within the oblique view.
- Oblique graphics can be annotated with user notes or measurement information.
- Oblique graphics can be saved to a separate shapefile and later loaded back into the oblique viewer.
- ArcMap feature layers are projected and displayed in the oblique view

A separate oblique layer table of contents is available to adjust the ArcMap feature layer display within the oblique view.

The PX Mapper software ingests the oblique imagery through web services either locally over intranet or remotely over internet.

3.4.10 Oblique Imagery Deliverables

- Aerotriangulation Report
- PX-Mapper Software Install, API, Training and Support
- 4-way, 6-Inch Color Oblique Frame Imagery at 45° angle

3.5 COMPONENT 5 (Option B): Building Footprints/AVG HT.

The RCMPO has requested an option for building print and elevation collection to up-date to the Rapid City 2012 project area data. All data produced will conform to the RCMPO's GIS data standards, and metadata will be provided for all planimetric data in accordance with Federal Geographic Data Committee (FGDC) standards. Fugro has extensive experience in the collection of digital planimetric features using stereo compilation and 2D orthoimagery techniques to meet National Map Accuracy Standards. 95% of all planimetric features that are well defined in the image shall be horizontally accurate to at least ±2.0 feet of its true coordinate position.

Fugro proposes that the existing building planimetric mapping be manually inspected for change areas and that those areas be up-dated to reflect new building, and to eliminate those from the dataset that may no longer exist. The up-date process includes the displaying our newly collected stereo imagery over the existing planimetric mapping from the 2012 project and identifying areas (polygons) of change/no change. The areas showing changes in features are then remapped to reflect the current existing or changed features.

The new digital imagery is imported and oriented onto softcopy workstations for stereo collection of the specified planimetric features using KLT/Atlas data capture software. Prior to compilation, the project orientation will be verified using existing ground control data. The coordinate system for the project delivery will be consistent with Area of Interest.

Photogrammetric team members will be instructed on project requirements. As elevation data is collected, the photogrammetric team leader will monitor and review data to insure the requested specifications are met.

Primary data collection occurs in the KLT/Atlas software environment. Several data collection and editing routines have been customized and automated using established macro routines, as well as by in-house programming staff, resulting in faster throughput and improved quality. The cartographic edit process also takes advantage of the MicroStation environment to verify topologic structure of data. Fugro has developed routines to check data and to create MicroStation readable point files identifying topologic issues that must be corrected. All production processes are documented and all forms are standardized as part of the ISO9001:2009 Quality Certification plan which ensures consistent results from project-to-project.

Fugro uses digital softcopy photogrammetric workstations that contain a comprehensive set of applications to accomplish the entire range of photogrammetric mapping requirements, including topographic mapping, impervious surface collection, planimetric mapping (i.e. building footprint data), and other forms of feature extraction. Where there is existing data, we intend to perform an up-date process. Where there are only new features, a new collection will be performed.

3.5.1 Planimetric Collection Process

The following is a step-by-step description of the planimetric vector compilation and editing process.

Step 1 Digital imagery is imported and oriented on the softcopy workstation and written to hard disk into a pre-defined subdirectory. Prior to the initiation of compilation, a data capture matrix is set up in KLT/Atlas on the soft copy photogrammetric and data edit stations by the photogrammetric and edit team members who are assigned to the project.

Step 2 The compilation setup is verified through collection and formatting of several test stereo models. Cartographic editors review the data to identify any systematic errors or inconsistencies between the newly collected data and the project's feature table. The datasets are further tested to verify that the conversion routine to produce the final required deliverable format (ESRI,AutoCAD) correctly converts all layers of the digital files. The photogrammetric team leader will review the test results.

Step 3 A specific production workflow is used when a mapping project requires the development of polygon topology. The photogrammetric technician collects features to be depicted as closed polygons and adds a label point within each feature. As the technician completes each stereo model, the CAD file is given a unique name. The photogrammetric technician calls up the adjacent stereo models and performs a preliminary edge match to determine that features tie across model boundaries and to ensure that no features are omitted. The completed file is written to the appropriate network subdirectory.

Step 4 As progressive stereo models are compiled, the operator conducts ongoing checks of the X, Y and Z coincidence between stereo models (sidelap and overlap) verifying that no vertical shift occurs at model boundaries. This is a visual examination that can identify any offsets that can be attributed to the aerotriangulation adjustment. If the operator is compiling a stereo model on the boundary of the project area, the operator will confirm that the data collection extends to the project limits as defined by the project scope of work.

Continuing the process, the following steps detail the cartographic editing steps and preparation of the planimetric map data in the MicroStation environment for the final format deliverable.

Step 5 The cartographic edit technician copies the datasets to a local workstation disk and begins the edit process. The planimetric data is collected as separate files delimited by the extents of each stereo model. These datasets are merged together in the KLT/Atlas environment. The editor opens the project boundary file and verifies that the planimetric data fully covers the required area. An automated QC routine is run in MicroStation that creates a CAD readable file indicating the locations of any dangles in the digital file. The editor inspects all of these flagged features and determines if the dangle is permissible and further verifies that no line linear features terminate at model boundaries. If necessary, omissions are reported to the photogrammetric technician who will re-set the affected model and collect any missing data.

Step 6 The content of the digital file is verified to ensure that each feature is represented on the correct level in accordance with the feature capture table. The consistency of the content of the digital files is verified through completion of several global QC routines that check consistency of line, text and symbology elements. The editor repairs features that were not correctly snapped or where there are over or undershoots.

Step 7 The editor verifies the integrity of the data in the third dimension by inspection in profile view to identify any points or elements with an incorrect elevation value. A quality control routine is performed to locate any elements in the digital files containing a zero elevation value.

Step 8 If planimetric features are to be used as components of the DTM, they are separated for subsequent processing.

Step 9 The editor then locates corrections or omissions in the digital data and makes corrections as necessary. Edit Supervisor will conduct an independent review of the corrected dataset prior to the start-up of conversion to ESRI and AutoCAD. The pertinent layers to be delivered to the RCMPO will be further processed to add or remove any coding or labeling necessary to create the ESRI or AutoCAD.dwg formatted deliverable.

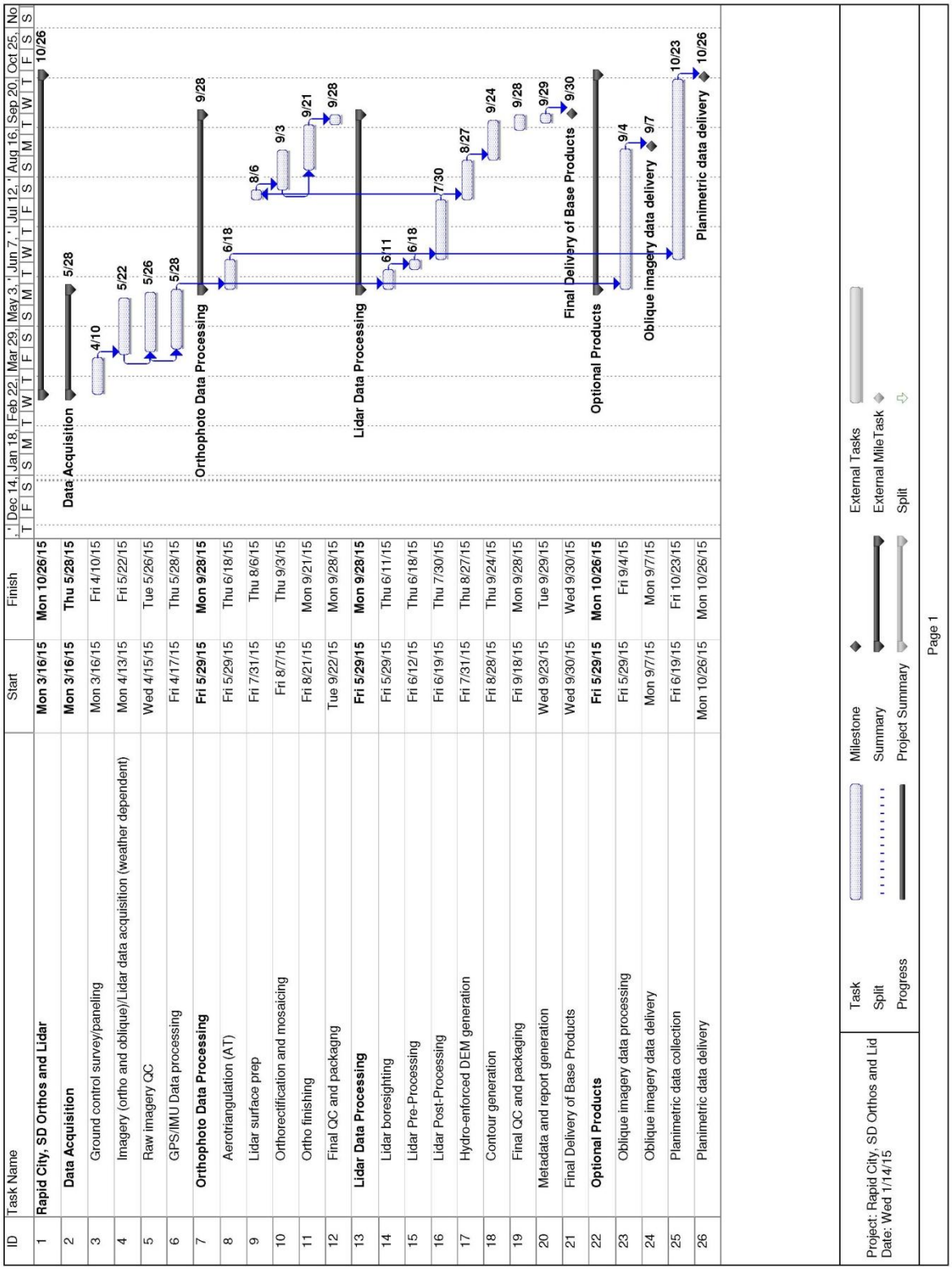
Step 10 All of the necessary quality control checks verifying the content and accuracy of the planimetric mapping are completed while the digital data resides in MicroStation format. ArcInfo routines are utilized that import the MicroStation data and then create CAD readable files highlighting inconsistencies, dangles and other quality issues that may adversely affect topological integrity and connectivity. These CAD readable "flag" files are then used by the editor to perform inspection and interactive editing of the MicroStation data. The cartographic editor creates a series of ASCII files containing line, polygon and point elements for each of the major planimetric feature groups. The content and design of the ASCII file (.dxf) is compatible with ESRI and AutoCAD formats and will be used as the basis of the final mapping delivery.

Step 11 The editor will create a final set of files for up-dated building footprints and building heights that will be dispatched to the RCMPO on media specified as USB 2.0 portable hardrives.

3.5.2 Building Footprint Deliverables

- A polygon building footprint feature class in a project-wide ArcGIS personal or file geodatabase.
- FGDC-compliant metadata for the building footprint feature class

5 PROJECT SCHEDULE



9 BUDGET / PRICING

Component 1	6 Inch Orthos Whole Area Acquisition	$25,967.48
Component 2	6 Inch Orthos Whole Processing	$19,215.96
Component 3	2 ppsm LiDAR Non-Engineering Contours	$82,815.49
Component 4	6 inch Oblique Imagery	$56,099.26
Component 5	Building Footprints Update	$15,827.13
	Total:	**$199,925.32**

Appendix A
Professional Services Agreement
COMPLIANCE WITH TITLE VI OF THE CIVIL RIGHTS ACT OF 1964
FOR FEDERAL-AID CONTRACTS
Assurances

During the performance of this contract, the contractor, for itself, its assignees and successors in interest (hereinafter referred to as the "contractor") agrees as follows:

(1) Compliance with Regulations: The contractor shall comply with the Regulations relative to nondiscrimination in Federally-assisted programs of the Department of Transportation, Title 49, Code of Federal Regulations, Part 21, as they may be amended (hereinafter referred to as the "Regulations"), incorporated by reference and made a part of this contract.

(2) Nondiscrimination: The contractor, with regard to the work performed by it during the contract, shall not discriminate on the grounds of race, color, religion, national origin, sex, age or disability in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor shall not participate either directly or indirectly in the discrimination prohibited by section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Title VI Regulations.

(3) Solicitations for Subcontracts, Including Procurements of Materials and Equipment: In all solicitations either by competitive bidding or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by the contractor of the contractor's obligations under this contract and the Regulations relative to nondiscrimination on the grounds of race, color, religion, national original, sex, age or disability.

(4) Information and Reports: The contractor shall provide all information and reports required by the Regulations, or directives issued pursuant thereto, and shall permit access to its books, records, accounts, other sources of information, and its facilities as may be determined by the South Dakota Department of Transportation or the Federal Highway Administration to be pertinent to ascertain compliance with such Regulations or directives. Where any information required of a contractor is in the exclusive possession of another who fails or refuses to furnish this information, the contractor shall so certify to the South Dakota Department of Transportation, or the Federal Highway Administration as appropriate, and shall set forth what efforts it has made to obtain this information.

(5) Sanctions for Noncompliance: In the event of the contractor's noncompliance with the nondiscrimination provisions of this contract, the South Dakota Department of Transportation shall impose such contract sanctions as it or the Federal Highway Administration may determine to be appropriate, including but not limited to:

(a) withholding of payments to the contractor under the contract until the

contractor complies, and/or

(b) cancellation, termination or suspension of the contract, in whole or in part.

(6) Incorporation of Provisions: The contractor shall include the provisions of paragraphs (1) through (6) in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Regulations, or directives pursuant thereto.

The contractor shall take such action with respect to any subcontract or procurement as the South Dakota Department of Transportation or the Federal Highway Administration may direct as a means of enforcing such provisions including sanctions for non- compliance. Provided, however, that, in the event of a contractor becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, the contractor may request the South Dakota Department of Transportation to enter into such litigation to protect the interest of the State, and, in addition, the contractor may request the United States to enter such litigation to protect the interests of the United States.

Appendix B
Professional Services Agreement
Debarment

CERTIFICATION FOR DEBARMENT, SUSPENSION
AND OTHER RESPONSIBILITY MATTERS

The CONSULTANT certifies to the best of its knowledge and belief that it and its principals:

1. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any federal department or agency;

2. Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (federal, state or local) transaction or contract under a public transaction; violation of federal or state antitrust statutes; or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statement, or receiving stolen property;

3. Are not presently indicted for or otherwise criminally or civilly charged by a governmental agency(federal, state or local) with commission of any of the offenses listed in paragraph (2) of this certification; and

4. Have not within a three-year period preceding this application had one or more public transactions (federal, state or local) terminated for cause or default.

The CONSULTANT certifies that if it becomes aware of any later information that contradicts the statements of paragraph (1) through (4) above, it will promptly inform the City of Rapid City.