



Exploration & Production

GENERAL SPECIFICATION

GEOMATICS

GS EP POS 007

Airborne Laser Scanning Survey (LiDAR)

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1. Scope

The objective of this Specification is to provide reliable topographical maps when topographical data is acquired using Airborne Laser Scanner surveys conducted by companies within the TOTAL Group.

This Specification is to be used in conjunction with the other documents referred to in section 2 as well as the Scope of Work.

2. Reference documents

The reference documents listed below shall be considered by Contractor, as an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

All documents referred to in this section shall be considered as the latest versions and it shall be Contractor's responsibility to ensure that Contractor is in possession of these particular documents and that any qualifications are valid.

Standards

Reference	Title
ISO/TS 29001: 2010	Quality management system requirements for the design, development, production, installation and service of products for the petroleum, petrochemical and natural gas industries, based on ISO 9001:2010

Professional Documents

The Positioning Contractor shall adhere to the following documents and ensure that they are available on the field and fully understood by the senior survey staff.

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	



Total General Specifications

Reference	Title
GS EP POS 003	Onshore Land Surveying & Positioning Works
GS EP POS 004	The use of DGPS
GS EP POS 008	Aerial Photogrammetric Survey

3. Airborne LiDAR Survey – General Principles

LiDAR is the acronym for **L**ight **D**etection **A**nd **R**anging. Either LiDAR or laser scanner are names used for radar systems based on electromagnetic radiation at optical frequencies.

LiDAR technology uses pulses of laser light striking the surface of the earth and measures the time of pulse return. The LiDAR laser scanner is precisely mounted in the bottom of an aircraft along with an Inertial Measuring Unit and airborne GPS.

By measuring the location (in both plane and height) and attitude (pitch, roll and yaw) of the survey aircraft, and the distance-to-ground and scan angle, a ground position for each impact point of laser pulse can be determined.

The LiDAR itself measures the return time for each pulse returned back to the sensor and calculates the variable distances from the sensor and all changes in terrain cover surface.

LiDAR systems are capable to capture intensity reflectance data in addition to the xyz spatial position. Reflectance percentage values differ depending on the type of surface they hit. This LiDAR intensity may be processed to produce a geo-referenced raster file, useful for identification of broad land use or surface features.

In addition to rapid pulsing, recent systems are able to record up to several returns per pulse. This feature allows LIDAR to distinguish not only the canopy and bare ground but also surfaces in between.

LIDAR scanning can occur day or night, as long as clear flying conditions are present.

The LIDAR system requires at least two (2) surveyed ground-base locations to be established in the project area, usable for GPS trajectory post-processing.

4. LiDAR Limits

4.1 Weather Constraints

Irrespective of the aerial navigation constraints, rainfalls, snowfalls or dusty / sandy atmosphere (sand winds..) are likely to degrade the LiDAR maximum operating range and the nominal accuracy.

In other respects, very few or no return pulse shall be expected when the laser beam strikes a flat ice surface.

4.2 Operating Range

Irrespective of the aerial navigation constraints (minimum flight height), the LiDAR can measure slant ranges up to a maximum threshold depending on the laser type and technical features.



Contractor shall define both the flight height and the survey swathe width so that the slant ranges at Field of View edge do not exceed the LiDAR ranging maximum threshold.

4.3 Accuracy

The accuracy of the ground position for each impact point of laser pulse depends on the following:

- Flight height
- Laser Beam Divergence
- Scanner Field Of View
- Aircraft GPS position and attitude (accuracy and update rate)

The scattering of the laser impact points on the ground (resolution) depends on the following:

- Flight height
- Aircraft speed
- Laser pulse rate
- Laser scanning rate
- Scanner Field Of View (to be adjusted to the survey swathe width)

Contractor shall make sure that the flight parameters (aircraft speed and flying height), the LiDAR technical features and the GPS and Inertial Measurement Unit combined accuracy and update rate do comply with the survey specifications regarding the final charts accuracy.

5. Fore work

5.1 Control Network Land Survey

5.1.1 Network Definition

Any Airborne LiDAR survey requires setting up a control network on the ground, with reference points spread over the whole survey area at regular spacing.

Considering that the survey aircraft spatial position shall be post-processed on the whole flight trajectory using dual frequency carrier phase DGPS implemented in kinematic mode from at least two (2) GPS reference stations, the spacing between adjacent stations shall be in the order of 15 to 30 km.

Depending on the accuracy expected for the survey project, other solutions or GPS reference stations spacing can be proposed.

The control network shall be surveyed using carrier phase DGPS implemented in post-processed static mode.

(Refer to General Technical Specification [GS EP POS 003](#) and [GS EP POS 004](#)).

5.1.2 Geodetic Tie-In

The control network shall be tied-in to the WGS-84 /ITRS reference system for both real time navigation and post-processing purposes.

However, the LiDAR final processing will involve shifting the whole laser data set from WGS-84 into the Coordinate Reference System (CRS) defined for the project.

The control network shall be tied-in to the Project CRS for validation purpose, as some control stations are liable to be pointed out on the laser data sets.

This tie-in shall be carried out applying datum shift parameters to be provided by Company or to be worked out using tie-in to local trig points distributed through the Project area.

The control network shall be tied-in to the Project vertical datum so as to derive a vertical reference surface, approximating the local geoid, in order to work out either a geoidal grid or a function capable of shifting the whole WGS-84 ellipsoidal heights into orthometric elevations complying with the Project requirements.

This vertical tie-in shall be performed implementing geometrical (direct) levelling from local benchmarks distributed at regular spacing through the Project area. The geoid model reliability and accuracy will depend on the number and distribution of the levelled points.

5.2 Land Survey of Calibration / Test Areas

Contractor shall carry out a land survey of all ground features required for LiDAR setting calibrations and checks. This normally includes the following:

- At least one (1) position reference remarkable structure, about 5 m x 5 m large or bigger depending on the laser point density (e.g. flat rooftop, horizontal asphalt or concrete plate, etc.). This structure shall be liable to derive the aircraft Inertial Motion Unit / LiDAR sensor misalignment (yaw correction), and to check or adjust the laser ranging system. The optimal solution consists in surveying a 0.5 m spacing grid on the remarkable structure in order to derive an average position and elevation.
- A horizontal reference remarkable surface, which extent is in the range of the Project survey swathe width (e.g. football field, runway, crossroad..), liable to derive the aircraft Inertial Motion Unit / LiDAR sensor vertical angles (pitch and roll corrections), and to check or adjust the laser scan angles.
- At least one (1) test / validation remarkable structure (small rooftop, GPS antenna ground plane, etc.), liable to check the calibration of the LiDAR sensors setting.

6. Survey Aircraft

6.1 General Requirements

The survey aircraft proposed by Contractor shall be suitable for work performed in the survey area (manoeuvring capability), as specified in the particular technical specifications (e.g. mountainous areas). Only multi-engine aircraft (turboprop, turboshaft or turbojet) shall be used unless derogation approved by Company. Two-pilot crew is also mandatory unless derogation approved by Company.

Depending on the aircraft type (aeroplane or helicopter) and the LiDAR type, the aircraft may have to be fitted out with a trapdoor, suitable for installing the whole rack supporting the laser scanner, GPS receiver, IMU and optional nadir / down looking stabilized camera mount.

Any aircraft employed or chartered by Contractor for the performance of the survey shall remain in full, proper and safe working order at any time.



In all cases Aircraft Technical characteristics as well as qualifications and experience required for pilots and mechanics must be validated by Company experts (DGEP/TDO/LSO).

6.2 Particular Equipment

Fully operative radio equipment including HF and VHF radio telephone shall be provided by Contractor to allow uninterrupted contact with the ground station.

The radio shall be equipped with frequencies used in the country of work.

With the exception of aviation fuel, the autonomy of the aircraft (lubricants and all consumable) shall be sufficient to assure the complete performance of the survey taking into account the maximum authorised loading capacity of the aircraft.

Specifications of the aircraft and its equipment shall be provided by Contractor in a separate Appendix.

7. Data Acquisition

7.1 Required Sensors

7.1.1 Positioning and Attitude Sensors

The aircraft shall be fitted out with at least one (1) geodetic GPS receiver and antenna, and one (1) Inertial Motion Unit (IMU).

The GPS receiver shall be capable of recording Pseudo-range (Code) and carrier phase GPS data (5 Observables) so as to work out post-processed kinematic positioning at a rate complying with the Project requirements.

The IMU shall be mounted to the LiDAR housing, and capable of measuring the aircraft attitude (pitch, Roll and yaw) at a rate complying with the Project requirements.

Company recommends that the aircraft GPS post-processed positions are smoothed using the IMU data.

Should the GPS post-processed position interval be insufficient, Contractor may derive additional GPS positions by merging position and attitude data (integrated navigation solution).

7.1.2 LiDAR Sensor

Company recommends that the LiDAR platform is able to measure in forward and backward direction (sensor with rotating or oscillating mirror, two (2) sensors, etc.), in order to minimise shadowing effect in the direction of flight.

Each laser is to collect sufficient points. The laser scanner field of view, scanning rate and pulse rate shall enable complying with the survey swathe width and the point density on the ground, as defined in paragraph 7.2.

The LiDAR time interval counter, encoded scan angle measurement system and laser beam divergence shall allow meeting the ground accuracy required in both plane and height, up to the edge of the selected field of view.

These specifications shall be defined for a LiDAR being implemented at the planned flight height, as defined in paragraph 7.2, and shall apply to a ground target of 10% minimum diffuse reflectivity with a minimum atmospheric visibility of 20 km.