

GENERAL SPECIFICATION

GEOMATICS

GS EP POS 007

Airborne Laser Scanning Survey (LIDAR)

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1. Scope

The objective of this General Specification is to provide reliable topographical maps when topographical data is acquired using Airborne Laser Scanner surveys.

This Specification is to be used in conjunction with the other documents referred to in section 2, as well as the Company project Specification.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
ISO/TS 29001	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

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP POS 003	Onshore land surveying and positioning works
GS EP POS 004	The use of Differential Global Navigation Satellite System
GS EP POS 008	Aerial photogrammetric survey
GS EP LSO 130	Aeroplane personnel specifications
GS EP LSO 131	Helicopters personnel specification
GS EP LSO 140	Specifications for Aeroplane

3. Scope of work

3.1 General principles

LIDAR is the acronym for Light Detection And Ranging. Either LIDAR or laser scanner are names used for radar systems utilizing electromagnetic radiation at optical frequencies.

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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 (IMU) 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.

3.2 Survey

3.2.1 Survey aircraft

3.2.1.1 General requirements

The survey aircraft proposed by Contractor has to be suitable for work performed in the survey area (maneuvering capability), as specified in the particular technical specifications (e.g. mountainous areas).

For geophysical survey without passenger or cargo transportation, single engine equipped with piston engine is acceptable, turboprop is preferred.

The aircraft manufacturer date shall be aged less than 25 years for all the contract duration. (refer to [GS EP LSO 140](#))

The survey aircraft has to be fitted out with suitable arrangement (trapdoor for example), in order to install the whole rack supporting the laser scanner, GPS receiver, IMU and optional nadir / down looking stabilized camera mount.

Any aircraft contracted by Contractor for the performance of the survey has to remain in full, proper and safe working order at any time.

The aeroplane shall be certified under FAR 23/25 or EASA CS 23/25. For other, contact EP/OPS/LSO advisers. (refer to [GS EP LSO 140](#)).

Regarding qualifications and experience required for pilots and mechanics, refer to [GS EP LSO 130](#) and [GS EP LSO 131](#).

3.2.1.2 Particular Equipments

Fully operative radio equipment including HF and VHF radio telephone as well as a satellite phone has to be provided by Contractor to allow uninterrupted contact with the ground station.

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The radio has to be equipped with frequencies authorized in the country of work.

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

Specifications of the aircraft and its equipment have to be provided by Contractor.

3.2.1.3 Maintenance

Aircraft used in the performance of a project has to be maintained in accordance with all regulations of the country of registration and operated in accordance with local country regulations. .

The aircraft should start the operations with full time hours before the next maintenance. Any unexpected maintenance on the aircraft is not to be considered as an excusable cause of delay.

3.2.1.4 Flight authorization

The Contractor is required to obtain the necessary flight clearance before starting any observation.

In certain circumstances, the Contractor may ask assistance of the Company to perform some administrative procedures with the relevant authorities.

3.2.2 Required sensors

3.2.2.1 Positioning and attitude sensors

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

The geodetic GPS receiver has to be capable of recording pseudo-range (Code) and dual L1 and L2 carrier phase GPS data. The recording interval has to be at a one-second basis or faster.

The IMU has to be mounted to the LIDAR housing and to be capable of measuring the aircraft attitude (pitch, Roll and yaw) at a minimum rate of 100 Hz and an accuracy complying with the project requirements.

All sensors have to be calibrated before starting the operations. Refer to paragraph 3.3 for more details.

3.2.2.2 LIDAR Sensor

Today, several scanning techniques, with advantages and disadvantages, are employed in airborne LIDAR systems. The most commons are oscillating mirrors and constant velocity polygon mirrors.

The Contractor is required to propose to the Company the most efficient sensor complying with the project requirements as defined in the technical specifications.

There are various types of LIDAR that can correspond to different project requirements. There are different ways of adjusting these parameters to match the project requirements. The

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Contractor has to configure the following parameters in order to comply with the desired point density and horizontal and height accuracy:

- Scan frequency
- Scan angle
- Pulse repetition frequency
- Beam divergence
- Roll compensation (optional)
- Eye safe altitude

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 swath width)

Contractor has to make sure that, for the selected flight parameters (aircraft speed and flying height), the LIDAR technical features and the GPS and IMU combined accuracy and update rate do comply with the requested final charts accuracy.

3.2.2.3 GPS Base station receivers

As well as the aircraft GPS receiver, the base station GPS receivers have to be capable of collecting pseudo-range (code) and dual L1 and L2 carrier phase GPS data. The recording interval has to be at a one-second basis or better.

It is also preferable that the base station GPS receivers record data at the same time interval as the aircraft GPS receiver.

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

3.2.2.4 Optional photo imagery sensor

In the case of aerial photo imagery requested by company, refer to the requirements of [GS EP POS 008](#).

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The LIDAR assembly system and at least one (1) stabilized camera have to be mounted together on an interface plate to avoid any relative movement during the survey period.

3.2.2.5 Optional video sensor

The survey aircraft may be equipped with one video camera that will operate simultaneously to the collection of LIDAR data.

Depending on the survey area type, the camera may be positioned in such a manner as to take images either in a down looking view or in an oblique forward looking view.

3.3 System calibration and verification

3.3.1 On-board equipment calibration

3.3.1.1 Default calibration

Each sensor on-board the aircraft (LIDAR, GPS, camera and inertial sensor) has to be calibrated in a laboratory by the manufacturer. The calibration certification has to be provided to Company prior to the start of survey.

Contractor shall perform complete calibrations / verifications at least once a week. This operation requires carrying out flights over a dedicated calibration / bore site, which extent is in the range of the project swath width. It is required that the bore site identifiable control points have been surveyed with a relative accuracy not exceeding 1 cm in both plane and height.

The calibration remains valid for the same aircraft and the same LIDAR system. In case of aircraft change or LIDAR system change, a new calibration has to be performed.

The calibration configuration has to match the project parameters and especially the flight height, selected pulse rate and selected scanning rate. The field of view has to encompass the project survey swath width of the whole calibration site.

The calibration has to be carried out flying over the site calibration from four (4) cardinal directions. This process will put to the fore and allow applying corrections for the following:

- IMU pitch, roll and yaw default installation angles with respect to the laser scanner mounting arrangement.
- Vertical bias stemming from any pulse rate error.
- Algorithmic correction making up for any scanning rate error (encoder windup).

3.3.1.2 GPS antenna offset determination

If the system is mobilized for the first time on site, the levers arms between the GPS antenna and the scanning mirror have to be measured. A precise measurement between the reference point of the sensor and the GPS antenna phase centre has to be performed.

The levers arms have to be measured using a Total Station and reflective prism and the 3D accuracy has to be better than one (1) centimeter.

The aircraft reference system has to be determined in accordance with the manufacturer's system. The offset between the reference point on the sensor to the scanning mirror is usually provided by the manufacturer and may be different for each new system.

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The offset has to be measured after each LIDAR system re-installation, even if re-installed at the same location, to insure the validity of the lever arms.

3.3.1.3 On Site calibration

The default calibration parameters have to be confirmed / adjusted prior to survey using a calibration area.

The on-site calibration has to be performed before the beginning of the project and at any change of the system configuration, for example if the system is removed from the aircraft or if any damage occurs during the operations.

The calibration always has to be performed with at least two (2) GPS base stations on the ground in a radius of 15 km away from the calibration site, in order to process the trajectory using GPS kinematics post-processing mode. The GPS base stations have to record data at least at one (1) second interval.

The IMU has to be first adjusted flying, at least five (5) minutes, a straight line then alternating turns to the right and to the left. The IMU installation offset angles have to be carried out as follows:

- Pitch and roll offsets determined by flying in two opposite directions over the axis of the horizontal reference surface (dimensions in the range of the survey swath width); the raw acquisition provides a plane tilted in both longitudinal and transversal directions. The input of the two (2) deflection angles has to correct the surface angle and provide a horizontal plane.
- Yaw offset determined by flying in two opposite directions above the position reference structure (rooftop size about 5 x 5 m).

This procedure allows making up for the laser beam inner misalignment as well.

The laser ranging system has to be checked using the position reference structure or a ground control grid.

Contractor may propose a different calibration procedure, to be approved by Company prior to start the operation.

3.3.1.4 Calibration checks

The overall survey system, including the LIDAR default calibration and main parameters (laser pulse rate, scan rate and scan angle encoder, laser beam divergence), the scanner head relative position and attitude to the GPS antenna and IMU, the IMU setup and installation offsets have to be checked by pointing out the validation / test structure, as defined in paragraph 3.4.3.

Irrespective of the LIDAR integrity verification, this check has to be performed again once the whole collected data set has been transformed into the project horizontal and vertical datum.

The more validation / test structures performed, the better. Contractor has to make sure that the validation structures are scattered across the survey swath, as an extensive terrestrial control network significantly improves the vertical accuracy.