

GENERAL SPECIFICATION

GEOMATICS

GS EP POS 008

Aerial Photogrammetric Survey

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1. Scope

The objective of this General Specification is to provide reliable topographical maps when topographical data is acquired using aerial photogrammetric surveys.

This General 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 007	Airborne laser scanning survey (LIDAR)
GS EP LSO 140	Specifications for Aeroplane
GS EP LSO 130	Aeroplane personnel specifications
GS EP LSO 131	Helicopters personnel specification

3. Aerial photogrammetric survey - General principles

Photogrammetry is the technique of measuring objects or earth features in two or three dimensions from photogram, also called stereo pairs of photographic images.

It is called a remote sensing technique insofar as the measurement device (the camera) is located at a distance, so that the objects or earth features can be measured without being touched.

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Aerial photogrammetric surveys allow near-vertical images to be collected from an aircraft. The two photographs of each stereo pair are taken from two distinct positions of the aircraft.

An aerial photogrammetric survey is intended to provide different information types:

- Coordinates of the required objects and points.
- Topographical and thematical maps.
- Ortho rectified photographs (orthophotomaps).

A photographic image is a central perspective. This implies that every light ray, which reached the film surface during exposure, passed through the camera lens perspective centre.

Use of photographs to take precise measurements involves reconstructing the ray bundle. Therefore, the internal geometry of the used camera has to be precisely known.

A camera may be defined by its focal length, the position of the principal point and the lens distortion. The camera focal length is the distance of the projection centre from the image plane's principal point.

The aerial photogrammetry involves implementing a metric camera, characterized by a stable and precisely known internal geometry and a very low lens distortion, essential for precise measurements.

The focal length is constant, which means, that the lens cannot be sharpened when taking photographs. As a result, metric cameras are only usable within a limited range of distances towards the object. The image coordinate system is defined by (mostly) four fiducial marks, which are mounted on the frame of the camera.

If a large area is covered by overlapping photographs, the overlapping part of each stereo pair can be viewed in three dimensions and mapped accordingly using a photogrammetric stereo plotter.

4. Aerial photogrammetry limits

4.1 Weather constraints

Irrespective of the aerial navigation weather constraints, clear visibility is essential to aerial photography.

It is required that no aerial photogrammetric survey occurs in fog, rain, snow or dusty / sandy atmosphere (sand winds...) conditions.

Photographs have to be taken only when the visibility does not significantly impair the image tone. It is required that no relevant ground details be lost as a result of atmospheric haze, dust or atmospheric moisture. The survey area has to be completely free of clouds, dense large shadows or smoke.

4.2 Sun elevation threshold

Aerial photogrammetry relies on sun radiation. Acceptable lighting of the terrains to be photographed is essential. Any shadowed area will provide neither elevation nor planimetric information through the photogrammetric stereo plotting process.

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As a result, shadowed areas will be excluded of the Digital Elevation Model (DEM), and relevant ground details may be poorly positioned or even left out of the charting. Should the survey be intended to provide large scale maps, any DEM blank areas will result in biasing the related longitudinal profile and cross sections.

Therefore, Company does not allow aerial photographs to be taken with a sun elevation below 30°.

Contractor has to provide corresponding calculations of sun elevations for the scheduled period of work in the survey area so as to settle the daily periods usable for survey.

Contractor has to note that the daily maximum acceptable survey duration degrades according to latitude and time interval to the winter solstice.

4.3 Operating range

Contractor has to make sure that the flight parameters comply with the aerial photogrammetry operating range.

For each survey area type (mountainous, urban, presence of high voltage power lines...), the flight height possible range has to be constrained by the aerial navigation safety regulations. These considerations have to lead to set a minimum possible flight height and photograph scale.

4.4 Accuracy

The accuracy of the ground position for each detail displayed on the final maps is constrained by the survey parameters:

- Flight height.
- Flight line straightness.
- Camera metric quality.
- Ground Sampling Distance (GSD).
- Line Of Sight verticality (nadiral orientation).
- Atmospheric clearness.
- Shooting parameters (shutter speed, lens aperture, filtering).
- Ground registration frame scattering and quality.
- Aircraft GPS kinematic processing position accuracy (if applicable).

Due to aerial navigation safety considerations, aerial photogrammetric survey cannot be used for mapping at scales larger than 1/500 (flight height of 300 m).

When setting the survey parameters, Contractor has to make sure that they comply with the survey specifications in term of accuracy.

Contractor has also to refer to **GS EP POS 007**.

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5. Stereo preparation works on the ground

5.1 Geodetic reference network land survey

5.1.1 Network definition

The aerial photogrammetric survey requires setting up a geodetic reference network on the ground, with points scattered through the whole survey area at regular spacing.

The reference network is to be used for land survey and tie-in of the Ground Control Points (GCP) required for image registration and aero triangulation.

Besides this land survey, the reference network is liable to be used for setting up GPS equipment so as to derive the survey aircraft trajectory. If the aero triangulation process has to be carried out using GPS aiding to derive the photographs perspective centre, this option has to allow working out for every aerial photograph the spatial position of its perspective centre.

In this latter case, considering that the survey aircraft spatial position will 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, it is required that the spacing between adjacent stations does not exceed 30 km.

If the aero triangulation process has to be carried out without any GPS aiding, spacing between network points has to be fitted to the image registration frame scattering on the ground.

The geodetic reference network has to be surveyed using carrier phase DGPS implemented in post-processed static mode.

The proposed network has to be submitted at least one (1) week before scheduled commencement of the survey flights for Company approval.

5.1.2 Geodetic Tie-In

PLANIMETRY

The geodetic reference network shall be tied-in to the project Coordinate Reference System (CRS), so as to allow the photogrammetric stereo plotting to be carried out within this datum.

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

In other respects, should the aero triangulation process be GPS aided for deriving the perspective centre of each photograph, the geodetic reference network has to be tied-in to the WGS-84 /ITRS reference system, even though the final post-processing still involves shifting the whole data set from WGS-84 into the project CRS.

ELEVATION

In the same way, **the 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 a function capable of shifting the whole WGS-84 ellipsoidal heights into orthometric elevations complying with the project requirements.

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Alternatively, the network may be connected to the local benchmarks and adjusted within the project vertical datum (least squares adjustment constrained by benchmarks).

Planimetric and elevation tie-in have to be performed in accordance to **GS EP POS 003** and **GS EP POS 004**.

5.2 Stereopreparation

5.2.1 Ground Control Points Distribution

The image registration and aero triangulation process requires determining the ground position of sufficient GCP.

The number and distribution of these GCP have to vary according to the survey area geometry (one or several adjacent runs), as described here after:

ISOLATED STEREO PAIR AREA

Any isolated stereo pair shall be fitted as follows:

- 1 GCP to be surveyed in plane and height on every corner.
- 2 GCP to be determined in height on each one of the Line Of Flight and its parallels on both edges of the stereo pair.

STRIP AREA

Any strip (straight run) has to be fitted as follows:

- 2 distinct GCP to be surveyed in plane and height on every corner.
- 1 GCP to be determined in plane every 3 stereoscopic pair on the whole strip perimeter.
- 1 GCP to be determined in height on every stereoscopic pair.

RECTANGLE BLOCK AREA

Any rectangle block made up of several strips has to be fitted as follows:

- 2 distinct GCP to be surveyed in plane and height on every corner.
- 1 GCP to be determined in plane every 3 stereoscopic pairs on the whole block perimeter.
- 1 GCP to be surveyed in plane every 6 stereo pairs inside the block.
- 1 GCP to be determined in height every stereo pair on every strip axis.

The number of GCP can be reduced significantly with the use of airborne GPS trajectography and orientation parameters provided by an IMU. Contractor has to detail the number and distribution of these GCP and detail the method statement to reach the requested accuracy.

Whether pre-marked or chosen among existing details, the size of the GCP has to be about 25 μ m at the scale of the photograph (0.5 m at 1/20 000, 0.1 m at 1/4000, etc.).

The GCP shall be surveyed from the geodetic reference network points through post-processed DGPS fast-static baselines.