

4. AERIAL PHOTOGRAPHY

This chapter covers all requirements regarding aerial photography for the different applications such as photogrammetric mapping, Orthophotos, GPS supported aerial photography and aerial photography for Lidar surveys.

4.1. Large Format Aerial photography for photogrammetric mapping and the production of Orthophotos (Not applicable to Aerial Photography for Lidar Surveys)

This Chapter deals with the production of vertical aerial photography for the photogrammetric compilation of topographical maps and for the compilation of Orthophotos.

Aerial photography shall adhere to the following specifications:

NB: In case of digital photography the terms 'aerial film', 'canisters' and 'diapositives' may be ignored.

4.1.1 Project definition

- a) The scale of conventional Aerial Photography must be defined by the Client and/or must be chosen so as to achieve the required accuracy for the survey project;
- b) The Ground Sample Distance (GSD) for digital cameras must be defined by the Client;
- c) Panchromatic, colour or infrared Aerial Photography must be defined by the Client; and
- d) The aerial photography coverage must be sufficient to produce Orthophotos or photogrammetric mapping of the area required by the Client.

4.1.2 Camera

- a) Conventional Analogue Aerial Survey Camera
 - i) The aerial photography shall be done with an approved, nominally distortion free, standard wide-angle (152mm) photogrammetric camera of 230x230 mm format.
 - ii) A full calibration report shall be submitted which confirms that the radial distortion of image points with reference to the principal point of auto-collimation does not exceed 0,02mm measured in the focal plane and confirms the lens type, make and manufacturer's number and date when the calibration was done. The validity of this certificate may not exceed 3 years. Should any part of the camera that is affected by the calibration be dismantled, then a new calibration must be carried out after the reassembly of the camera and the relevant certificate issued.

- iii) Any filters used shall be 'plane parallel' to within 10 seconds and be coated to compensate for loss of illumination towards the outer field.
- b) Digital aerial survey cameras
- i) The aerial photography shall be done using a large format digital frame camera.
 - ii) The camera shall have digital frame sensors based on Charge-Coupled Device (CCD) arrays using square or rectangular CCD arrays and shall have geometric characteristics similar to a film based camera.
 - iii) The camera shall be able to use Time Delayed Integration (TDI) methodology to control image movement. The Surveyor shall ensure that no image smear is caused during this process.
 - iv) The camera shall have the ability to photograph four colour channels.
 - v) The camera shall be equipped with a sensor of at least 12 000 Pixels at 12 micron CCD. The focal length shall be 120mm.
 - vi) Within Flight Lines the largest Ground Sample Distance (GSD) should not exceed two times the size of the smallest GSD. This is of particular importance in mountainous areas.

4.1.3 Operational requirements for large format aerial photography – digital and conventional

- a) Flight lines
- i) Each flight line shall be continuous for its entire length over the area being photographed. 'Breaks' in strip continuity may be allowed if necessitated by unfavourable weather conditions or when a change in altitude is required to comply with side Overlap or scale requirements. When a 'break' in strip continuity occurs, the separate sections of the strip shall Overlap by at least five exposures.
 - ii) Coverage beyond the limits of the area to be mapped and parallel to the Flight Lines shall not be less than 20% of the width of the photographic strip. The first two and the last two exposures of each strip, including the required Overlap, shall be completely outside of the area being mapped.
 - iii) Photographs reflecting more than 25% non-stereoscopic area will not be acceptable.

b) Overlap

- i) The 'fore and aft' Overlap shall generally average 60% and where any Overlap less than 55% or greater than 65% will be sufficient grounds for a rejection of the entire strip. In the event of extreme variations in elevation in an area, deviations from the above requirement may be permitted. Deviations shall be limited to the area where such conditions prevail provided that complete stereoscopic coverage is maintained at all times.
- ii) Unless otherwise specified, the side Overlap (Overlap between parallel strips) must average 30% and any side Overlap less than 20% or greater than 40% will be sufficient grounds for a rejection of the entire strip.

c) Flight Altitude

The actual flying height must correlate with the specified flying height in such a manner that a lower actual flying height is within a 2% tolerance or a higher actual flying height is within a 5% tolerance.

i) Photographic Conditions

Photography must be undertaken only when conditions are such that acceptable images can be produced. Photography must not be attempted when the ground is obscured by haze, smoke, dust or when clouds or cloud shadows could appear on any photograph.

d) Solar Altitude

Unless otherwise specified, photography must be undertaken with a Solar Altitude of not less than 30 degrees. (The Client may place an upper limit on the Solar Altitude in which case this will be defined in the project requirements).

e) Crabbing

During flight, the camera must be compensated for the Crabbing effect of the aircraft in order to ensure that the edges of the photographs in the strip are parallel to within 5 degrees to the line of flight.

f) Tilt

Departure of the camera lens axis from the vertical must normally not exceed 2 degrees. Isolated exposures up to 4 degrees may be allowed in turbulent conditions. Relative Tilt shall not exceed 6 degrees.

g) Course Corrections

Corrections to the aircraft's course between successive photographs shall not exceed 3°.

4.1.4 Photographic Quality

a) The photography shall be clear and sharp in detail, be of uniform density and have the proper degree of contrast for all detail in order to clearly define detail in both shadow and bright areas. Photography reflecting excessive contrast or are low in contrast may be rejected. The photography shall be free of clouds and cloud or ground shadows, smoke, haze, excessive snow, marks due to processing and handling and any other blemishes.

b) Standard recorded data for Analogue Aerial Photography

The film, contact prints and diapositives/photo scans (whichever is applicable) shall clearly reflect the following data in respect of each exposure:

- i) The allocated Photographic Job Number on the right of the photo frame as supplied by the Client;
- ii) A standard four digit photo number on the left of the photo frame which must correlate with that of the feeder counter and where the number must comprise of at least four digits with zeroes being used ahead of the digits of a number below 1000;
- iii) The strip number;
- iv) The calibrated principal distance corresponding with the latest Calibration Certificate;
- v) The camera altimeter reading, which must be synchronized with the aircraft's altimeter;
- vi) The chronometer which must record South African Standard Time;
- vii) The approximate contact scale of the photography;
- viii) The date(s) of the photography;
- ix) The number of the lens cone;
- x) Any other useful data such as a reflection of the face of the circular bubble; and
- xi) The job description.

c) Any of the above items not photographically recorded must then be added afterwards and where no such data shall encroach onto the image area or obscure any fiducial marks.

- d) Film Index/Digital Image Index
- i) A digital and hard copy index, as per **Annexure 8**, where applicable, must be submitted with every project and must contain the following information: job number, strip number, photo numbers and the date(s) of the photography. This information shall also appear on the film canister if conventional photography has been used and on the DVD and the Flight Plan.
- e) Contact Prints and Diapositives/Scans
- i) The Surveyor shall submit the following to the Client:
- Two (2) sets of Contact prints (whether conventional or digital photography);
 - One (1) set of Diapositives (where analogue mapping is undertaken);
 - One (1) set of digital scans or images (where digital mapping is undertaken);
 - Aerial film (if applicable); and
 - Where contact paper prints must be on double weight, semi matt, waterproof paper or printed on high quality matt photographic paper.
- ii) If digital mapping is undertaken no Diapositives need to be submitted. The contact prints must be clean and free from all blemishes and must be thoroughly washed in the case where a chemical process for the development thereof was used.
- iii) The contact prints shall be uniform in tone and density and the degree of contrast shall be such that all detail in both dark and bright areas will still be clear.
- iv) Unless otherwise specified Diapositives, if required, shall be of a film material which is stable and not subject to any variations in dimension arising from external factors ordinarily affecting film and where differences between the calibrated distance when measured across the fiducial marks must be within 20 microns. Diapositives may be produced by an electronic printer with an automatic balancing of contrast facility. Each diapositive shall reflect all the information as specified for the negative film.

4.1.5 Flight Plan

- a) A Flight Plan, drawn on durable paper and supplied in digital PDF and digital CAD formats as specified and with a 1:50 000 Topo Cadastral Map included as a 'backdrop', must reflect the following:

The Flight Plan must show the following information:

- i) The approximate contact scale of the photography;
- ii) The date(s) of photography;
- iii) The make of camera, number of the lens cone, its focal length and type of film used;

- iv) Route number, title and Job Number;
- v) The scale of the Flight Plan, coordinate grid system and North sign;
- vi) The strip positions and extent of coverage;
- vii) Photo centres shall be plotted as accurately as possible. Every fifth or more photo centre must be shown on each strip. The photo centres shall be marked with a cross and labelled with their full exposure number;
- viii) The acceptable number of photographs beyond the specified requirement shall be numbered and indicated on the Flight Plan by a broken line;
- ix) The numbers of the first and last exposure of each strip shall be reflected and noted in tabular form on the film index; and
- x) The contractor's identification mark.

4.1.6 Photography for aerial triangulation

- a) When planning the photographic coverage of an area to be mapped and where aerial triangulation is to be used to obtain planimetric and height control, the following shall be borne in mind:
 - i) In the aerial triangulation block adjustment the largest errors occur along the edges of the block. It is therefore imperative that the photo coverage be extended beyond the borders of the area to be mapped by at least one model at the start and one model at the end of each strip and at least half a strip width along the borders. The perimeter Photo Control Points will, as a result of the above planned photo coverage, fall outside the borders of the area to be mapped, thus maintaining a rigid control network over the photographic block, with the largest errors occurring outside the area being mapped.

4.1.7 GPS supported aerial triangulation

- a) The camera's principal point (at the time of exposure) may be determined by GPS. This then results in the reduction of Photo Control Points required for the aerial triangulation. The Client's prior approval must be obtained before using this method. The Client may impose additional specifications to be adhered to when employing such method.
- b) This method may however not be used for large scale surveys, as defined in paragraphs 6.6 "Requirements for photogrammetric topographical surveys: 1:500 to 1:2000 scale" and 6.7 "Orthophoto production and DTM surveys".

4.2 Digital Scanning of Analogue Aerial Photographs

4.2.1 The scanning of Analogue Aerial Photographs for use in digital photogrammetry must be undertaken with a high-resolution aerial photography scanner where the output is 8-bits for black and white or 24-bits for colour photography and must be in TIFF or JPEG format or as otherwise specified.

4.2.2 The works then comprises of the following:

- a) The digital scanning of all Analogue Aerial Photographs to a specified resolution; and
- b) Subject to the rough accuracy guideline tabled below the scanning must be done to a resolution of 21 Micron unless otherwise specified.

ACCURACY GUIDELINE			
PHOTO SCALE	PIXEL SIZE (MICRON)	REQUIRED DISK SPACE (MEGABYTES) FOR GREY SCALE TIFF IMAGE	PIXEL SIZE ON GROUND (METRES)
1:2500	12.5	320	0.03
1:2500	25	80	0.06
1:2500	32	49	0.08
1:5000	12.5	320	0.06
1:5000	25	80	0.13
1:5000	32	49	0.16
1:7500	12.5	320	0.09
1:7500	25	80	0.19
1:7500	32	49	0.24
1:10000	12.5	320	0.125
1:10000	25	80	0.25
1:10000	32	49	0.32
1:15000	12.5	320	0.19
1:15000	25	80	0.38
1:15000	32	49	0.48
1:20000	12.5	320	0.25
1:20000	25	80	0.5
1:20000	32	49	0.64

- c) Digital data shall be supplied on clearly labelled DVDs, CDs or removable hard drives which medium will be determined by the data magnitude of the scanned images.
- d) All scanned images must be checked prior to submitting same to the Client and where the checking must relate to the actual data transmission medium chosen and submitted.

4.3 Aerial photography for large scale Lidar surveys

4.3.1 Imagery specifications:

- a) Cloud free, 24 bit colour digital imagery:
 - i) If cloud shadows are evident, then these must be 'smoothed out' by radiometric techniques;
- b) Image Resolution: 10cm Pixel Ground Sample Distance (GSD) or smaller at the time of exposure:
 - i) 10cm Pixel GSD offers double the resolution of the 15cm Pixel GSD common to standard aerial photography. This is made possible by modern, higher resolution digital cameras;
- c) Forward motion compensation must be used or the forward motion should be kept to below 50% of a Pixel;
- d) Images shall be 100% suitable to produce high quality orthophotos.