



Northern
Territory
Government

DEPARTMENT OF
PLANNING AND INFRASTRUCTURE

**AERIAL PHOTOGRAPHY
TECHNICAL SPECIFICATIONS
2010**

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Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
1	8/09/2009	Ralph Lante	Tony Gill		Revision for digital

1. Acquisition Requirements

1.1 Platform

Aircraft may be required to operate at altitudes from 1200 feet to 27000 feet above ground level and have a range to access remote communities. Check projects contained in this tender to ensure the aircraft is suitable for the tasks required. Refer to tender response schedule.

The Contractor will deploy an aircraft maintained in accordance with manufacturer and statutory requirements and have current airworthiness certification. Refer to tender response schedule.

Department of Planning and Infrastructure (DPI) will also require written acknowledgement from the Contractor that all aircraft operations and clearances will be the responsibility of the Contractor and will be undertaken in accordance with Australian Air Safety Regulations. Refer to tender response schedule.

1.2 Flight Planning

DPI will provide location data, polygons and maps to assist Contractors with flight planning and cost estimates. The successful Contractor will be supplied with final polygons of the coverage areas as text files for input into flight planning software.

It is the responsibility of the Contractor to flight plan each photographic sortie to meet the project requirements and specifications outlined in this document. This includes managing situations such as arranging permission to enter property to survey ground control points, or to locate a GPS base station, etc.

DPI is responsible for obtaining permission to acquire aerial photography over restricted locations such as military zones or cultural sites.

Project area calculations and distances from project site to nearest airport provided on the project proforma are approximate and should not be used for quoting. Area polygons define the precise project area.

Draft flight plans are not required during the tender bidding process, however, it will be expected that the successful Contractor will cover proposed polygons in accordance with Section 1.2.

1.3 Flight Coverage

Each run will extend outside the specified area by a minimum of two principal points at the beginning and end of each run.

The first and last runs will have a minimum of 20% of each photograph extending laterally outside of the boundaries of the specified area.

Over main town areas we require additional runs over main roads to minimise building lean effects.

The successful tenderer will be requested to submit final flights plans prior to the commencement of aerial capture for approval by DPI so flight coverage can be confirmed.

1.4 Camera

Our required format is digital imagery delivered as overlapping frames with a single perspective centre. We may consider (scanned) film capture where there is a significant price advantage, or digital capture is not available.

Vertical photography will be exposed using a calibrated photogrammetric digital camera. Details of all proposed cameras and associated current calibration certificates to be used for this contract must be included in the tender submission.

A camera calibration certificate must be issued by the manufacturer or an approved standardising laboratory for any camera lens that will be used. The certificate will be no older than 2 years.

A new calibration will be carried out if the camera has been physically disturbed such that its metric properties may be affected.

Oblique photography may be exposed with smaller format, side mounted camera where appropriate and acceptable to DPI. The Contractor will supply specifications for this type of camera in the tender submission

All vertical imagery will be crisp, clear and sharp and should not show the effects of forward motion of the aircraft. Image movement must not exceed 20 microns. Aircraft tips and tilts and crabbing effect must be minimised. (See section 1.10 Camera Tilts)

Details of equipment to minimise all image motion must be included in the tender submission.

For each exposure the Contractor will record metadata as discussed in Section 5.2.

For film imagery, camera fiducial marks must be clearly visible.

1.5 Image Deliverables

The Contractor must deliver colour balanced frame based digital imagery stored as uncompressed TIFF files at the pixel resolution specified in the tender schedule.

DPI may have a requirement for an infrared (IR) imagery. Contractors must state their ability to deliver IR imagery where this is a requirement of the project. The requirement for IR imagery will be stated in the project proforma.

DPI may have a requirement for four band imagery for remote sensing purposes. Contractors must state their ability to deliver four band frame imagery where this is a requirement of the project. The requirement for four band imagery will be stated in the project proforma.

For film aerial photography, digital image delivery will require scanning of film frames.

1.6 Contact Prints

There is no requirement for contact prints unless specially requested for a project.

1.7 Mosaic Deliverables

DPI will require a basic red, blue, green (RGB) mosaic of all frames over each project area delivered as a geo-referenced Jpeg 2000 file at the same pixel size of the captured frames.

Contractors are expected to apply automatic colour balance algorithms to provide a mosaic with good colour balance between adjoining frames and runs.

Contractors bidding for the aerial photography tender must provide an example of their mosaiced product as a benchmark for future deliverables. Where a Contractor has previously delivered satisfactory image mosaics to DPI, these may be referred to as examples. Refer to tender response schedule.

DPI may have a requirement for an IR mosaic. Contractors must state their ability to produce IR mosaics where this is a requirement of the project. The requirement for IR mosaics will be stated in the project proforma.

1.8 Exposure

Exposure settings must provide optimum image qualities for the prevailing light conditions such that adjoining runs will not be visible on an Orthophoto mosaic and the colour balance closely matches actual ground conditions. Where requested by the Contractor, colour balanced samples will be provided by DPI.

1.9 Image Resolution

The photography requirement for projects will be specified as ground sampled distance/pixel size in the Tender schedule. Where film scanning is used to create digital imagery the maximum scanning resolution is 15 microns. The preferred scanning resolution is 20 microns.

The Contractor is responsible for selecting a suitable focal length and flying height to achieve the required ground sampling distance and minimise the lean effect in built up areas to enable easy identification of ground features.

Tolerance for image resolution is + or – 10%

1.10 Overlaps

The required forward overlap between consecutive photographs in each flight strip must not be less than 60% unless otherwise specified.

The deviation range in forward overlap will not exceed +/- 5%.

The lateral overlap shall be not less than 25%.

Image metadata is required by DPI after image capture to ensure overlaps are within specification.

1.11 Camera Tilts

Photography will not be undertaken when atmospheric conditions are likely to produce excessive tilts in the aerial photographs or deviation from flight paths.

The camera attitude will be monitored and adjusted by a gyro stabilised platform. Rotation angles are to be recorded in the "Omega, Phi, Kappa" system as part of the photo metadata required to be supplied to DPI.

The contractor will provide a statement regarding the accuracy of gyro stabilised platform. Refer to tender response schedule.

For angular rotation about the longitudinal, transverse and vertical axes (Omega, Phi, and Kappa):

- the average angular rotation within a run about any axis will not exceed one (1) degree,
- the maximum angular rotation for any frame about any axis will not exceed two (2) degrees, and
- the change in angle between consecutive frames about any axis will not exceed three (3) degrees.

Compensation is to be made for crabbing and drift by rotating the camera about the vertical axis such that the lateral edges of each frame are parallel to and not displaced laterally from the intended flight path by more than 5% of the specified side overlap.

1.12 Flying Conditions

Photography will not be attempted when cloud or cloud shadow, smoke, haze or any other conditions would impair the quality of the photographic image.

If the Contractor believes conditions will not improve once on site, contact must be made with DPI to decide the future of the project. Failure to consult with DPI before proceeding with the photography under marginal conditions could lead to rejection of the imagery captured.

Photography over open terrain with low relief will not be attempted when the solar altitude is less than 25 degrees, or less than 35 degrees over steep or timbered country.

Where water surfaces are extensive over the area being photographed, the solar altitude will be such that the sun's reflection does not appear in the photographs. In general this will be no greater than 60 degrees.

If a project cannot be completed in one sortie or on the same day, every effort must be made to complete the outstanding runs at the next weather window of opportunity with overlapping runs captured as near as possible to the same time as the previous runs.

1.13 Tidal Conditions

The range in tide height in the Northern Territory may be high and extensive inter-tidal flats can be exposed at low tide. For projects that include the capture of aerial photography over coastal water bodies every effort must be made to complete the inter-tidal zone in one sortie.

If it cannot be completed in one sortie then any appending runs must be flown at a similar tide height and sun angle if logistically possible.

2. Image Requirements

2.1 Digital Image Registration

The Project Number (i.e. 2008/123) will be used as the film identifier for digitally captured imagery. This is followed by an underscore character and the frame number with no leading zeros. For example: 2008123_120.

For film imagery DPI will issue the next sequential range of film numbers for film identification purposes. For example: NTc1234.

No more than five digits should be used for the frame number.

For each project, frame numbers must commence at 1.

The Contractor must record metadata for digital exposures including date of capture, camera operator, post processing operator and other relevant details to provide an audit trail for all work.

Digital imagery will be supplied to the Department in numerical frame order on hard drive. Hard drives must be new, quality external hard drives with a USB2 connector. Unless otherwise specified, hard drives are provided by the Contractor as part of the deliverables and will not be returned to the Contractor.

When identifying frames, the following naming convention is to apply, (Film Number, UNDERSCORE Frame Number DOT file extension). For example;

2008123_2.tif

2.2 Image Quality and Colour Balance

The Contractor will be responsible for the supply of raw metric digital imagery of uniform colour balance and consistency over the entire project area.

2.3 Image Proofing

The Contractor will be responsible for checking the alignment, overlap and coverage in accordance with the specifications and provide certification for each run. (See section 5.4)

There is no requirements for digital imagery to be delivered with North at the top of the digital file, however the associated image metadata file must show the rotation required to view image with north facing up on a digital file.

See section 5.2 to for image metadata requirements.

3. Control Requirements

GPS technology offers new opportunities for achieving high accuracy ground control with minimal survey requirement. Contractors will assess mapping projects and recommend for the best method of achieving suitable positional accuracy.

Precise Point Positioning (PPP) technology has been successfully used in the past and is an accepted methodology for DPI. Other similar technologies will also be considered.

Whatever technology is offered, it is the Contractor's responsibility to achieve the required accuracy outcomes.

3.1 Control Targeting

Flying projects may require ground control points for the production of accurate mapping and orthophotography.

The use of targets for ground control is not a preferred option unless targets can be painted on a stable surface so they remain in place for a number of years.

Temporary targets do not have any use for future mapping and in the event of a ground control error, cannot be re-visited for field validation.

The placement of temporary targets will be accepted in any situation where mapping photography is to be captured and it is judged by the Contractor that the image subject matter will not provide sufficient, clearly defined and unambiguous image features suitable for co-ordination as ground control points.

The responsibility for the placement of targets and removal of temporary target materials will be the responsibility of the Contractor.

Temporary targets may be any suitable material which provides a sharp, well defined, mark on the image.

Temporary and permanent targets will consist of 3 or 4 intersecting arms with each arm width measuring 0.04 mm and length 0.1 mm on the resultant image.

Where a target is painted on a stable surface, a nail will be used to mark the exact point of measurement in the centre of the target.

3.2 Ground Control Points (GCPs)

Where ground points are used, suitable points must be selected and their location fixed accurately. All points selected should be at ground level and the location must be readily identifiable on the resolution of captured aerial photography.

To minimise the possibility of miss-identification of ground control points we require the following:

- Distance and bearing to three other nearby features to confirm the location of the primary point
- A locality diagram
- One or more digital photographs of the point taken at the site,
- An image chip provided from aerial photography

Neat and unambiguous field sketches are required. Sketches must have sufficient detail to positively identify the selected points using the aerial photographs and orientated by a north point.

A copy of all GCP diagrams, locality sketches, image chips, site photographs and co-ordinate values are to be supplied to the DPI. Information on survey equipment used and the expected absolute accuracy of the GCP values must also be included.

Ground control points should be positioned so that they can be reused in future. If this is not possible the Contractor must provide an explanation.

3.3 Survey Requirements

All field survey work undertaken to establish the ground control points must be undertaken by, or under the direct supervision of, a Licensed Surveyor who has qualifications that are recognised by the Northern Territory Surveyor's Board. Ground control points are to be certified by a Licensed Surveyor.

The final ground control configuration for each project will be determined by the Contractor based on the vertical and horizontal mapping accuracy specified by the DPI. If a large block of photography encompasses several adjacent mapping projects then the complete block should be controlled and aero triangulated rather than individual mapping projects.

The extent and configuration of ground control will generally be determined by the final absolute mapping accuracy required and DGPS air stations included in the adjustment. As a minimum, it is expected GCPs will encompass the block with sufficient internal points to ensure the specified accuracies will be met. Any extrapolation of stereo observations outside the control will not be accepted.

3.4 Airborne Differential GPS Control

Unless otherwise directed, all projects require the use of Differential dual frequency airborne GPS control or similar technology to provide precise determination of image centre coordinates. For projects involving Digital Mapping and Digital Terrain Modelling, DGPS may be used to minimise the requirements for ground control points.

It is the Contractor's responsibility to show technological solutions that require less ground control and previous examples of where this methodology has been used successfully.

3.5 Use of Base Stations for Aircraft GPS

If a cadastral reference mark (CRM) exists in an area to be mapped mapping, this point must be used as the GPS base station (or provide a survey connection to the CRM).

The distance from the base station to the aircraft should not exceed 100 kilometres.

4. Triangulation

4.1 Accuracy Specification

It should be noted DPI will carry out internal Acceptance Quality Level checks on all projects delivered to confirm accuracy specifications have been met.

DPI triangulation quality assurance evaluates the absolute residual error value of pass and tie points used in two or more models.

For example:

- If the residual error of a pass point in one model is 0.2 metre and the residual error of the same point is -0.2 metre in the next model, then the absolute error is 0.4 metre.
- If the residual error of a pass point in one model is 0.2 metre and the residual error of the same point is 0.5 metre in the next model, then the absolute error is 0.3 metre

For triangulation to pass our quality assurance requirements, 95% of all pass and tie points shall have an absolute residual error less than one third of a required contour interval, with points above this value being evenly distributed throughout the project.

The absolute error of no pass or tie point will be above one required contour interval.

The required contour interval will be specified in the project proforma.

Contractors bidding for aerial photography requiring triangulation for mapping purposes must supply sample triangulated project (not necessarily in the NT) with a minimum of three runs and twenty frames, which meets DPI required specifications, detailed in the Technical Specifications. (See Appendix B).

NOTE we DO NOT require imagery to perform an assessment of the triangulation data.

An assessment of the triangulation data will be carried out by DPI. If triangulation fails to meet our specification for accuracy or no data is submitted, the Contractors bid may be deemed non-complying.

Contractors who have previously delivered triangulation data meeting DPI specifications may refer to a previous project in place of the sample data set.

The Contractor must provide ground control and triangulation results that will meet the expected accuracy specification for mapping projects. Contractors must maintain an audit trail to back up claims for meeting project accuracy and quality specifications.

Unless otherwise directed, it shall be the Contractors responsibility to adopt appropriate photo scale, GPS data collection rate, ground control density and acceptable block adjustment residuals which will enable achievement of the required mapping accuracy specification.

4.2 Triangulation Observations

Stereo model observations will be performed using digital (soft copy) photogrammetric software

For scanned film, all fiducial marks shall be observed in every photograph

All identifiable ground control points must be observed in every model in which it is clearly visible

Where automatic point selection is used for triangulation, the distribution of points must be generally located in the von Gruber positions with no noticeable point clusters.

A minimum of six pass/tie points is required for each model.

4.3 Block Adjustment

A three dimensional bundle adjustment of the aero triangulation observations which includes the DGPS air station coordinates is to be used.

The statistical estimates of accuracy should indicate the accuracy of the internal geometry, i.e. the photogrammetric accuracy and the accuracy relative to the GCP co-ordinates.

The triangulation results must show an error residual for each ground control point, whether used or not and a list of pass/tie point errors

Reasons for rejection of GCPs from the block must be included in the triangulation report

The overall residuals on the GCPs values for the adjusted block of photography will be expressed as a Root Mean Square Error, (RMSE).

The RMSE values should be within 0.020mm at photo scale for planimetry and 0.01% of the flying height for altimetry. Any residuals on individual control points within the block that are greater than twice the RMSE are to be investigated and a report supplied to DPI.

4.4 Triangulation Deliverables

ASCII text files or Microsoft Word documents are to be supplied showing computed results as follows:

- Adjustment Showing all tie, pass and control points with calculated residuals
- Plate Coordinates (Format given in Appendix B)*
- Photo Airstation Coordinates (Format given in Appendix B)**
- Adjusted Terrain Point Coordinates (Format given in Appendix B)
- Graphic Model Layout showing direction of flight for each run, photo centres and control point layout
- Summary report giving details of the triangulation task and detailing any issues arising
- Copy of latest camera calibration file

The Department can supply samples of the above documents upon request.

* Plate coordinates should be with reference to the fiducial centre not the collimated fiducial centre.

** Contractors must state if Earth curvature and atmospheric refraction have been applied to the air station data.

5. Aerial Acquisition Records and Conformance

5.1 Records

The Contractor will maintain GPS and photogrammetric records for at least two years after completion of the project. These records will be made available to DPI if requested at no additional cost.

5.2 Image Metadata Reports and Spreadsheets

Stage 1 Reporting

The Contractor is required to supply to DPI a weekly report of flying activity, post processing and provide a digital list of unprocessed photo metadata as an Excel spreadsheet with fields showing:

- Project Name
- Film Number
- Run Number
- Frame Number
- Date / Time (CST)
- Photo Scale (1:20,000) or pixel size (15cm)
- Coordinate System for photo centres
- Approximate Image Photo Centres as
 - Latitude decimal degrees (with negative sign)
 - Longitude decimal degrees

Confirmed Delivery Schedule for the Project including

- Elapsed days for delivery of digital images
- Elapsed days for delivery of mosaics
- Elapsed days for Triangulation completed
- Elapsed days for delivery of final report and conformance certificates

NOTE: Once where a confirmed delivery schedule is not provided, DPI will use the delivery schedule supplied in the original tender bid.

The confirmed delivery schedule provides an opportunity to schedule delivery times taking into account other imagery that has recently been captured.

Stage 2 Reporting

The Contractor is required to supply to DPI, **within 14 days of delivery of un-processed Photo Metadata**, a digital excel spreadsheet of processed image metadata.

The spreadsheet will be imported into our image metadata database and must conform to DPI specifications. A sample spreadsheet (**Image_Metadata_Spreadsheet.xls**) is provided in the tender package.

Fields in the spreadsheet are ordered as follows:

- Project (Project name including the year. For example – '2010 Darwin CBD')
- Film_Type (Year for digital or Prefix for film. For example '2010' or 'NTc')
- Film (Project Number for digital or allocated number for film. For example '02' or '1455')
- Run (Run Number. For example '22')
- Run_Ext (Run extension such as for run 22A. For example 'A')
- Frame (Frame number. For example '12345')
- Date (Date in format dd/mm/yyyy. For example '12/05/2010')
- Scale_Factor (pixel size for digital or flying scale for film. For example '15' or '10,000')
- Type (Film type. For example 'Colour' 'B&W')
- Camera (Film or Digital)
- Focal (105.2 – Real number only)
- Lat (Latitude as negative decimal degrees. For example -12.876342)
- Long (Longitude as decimal degrees. For example 130.465734)
- Height (Number of height pixels for standard digital frame or 23mm for film)
- Width (Number of width pixels for standard digital frame or 23mm for film)
- Contractor (Name of Contractor)
- Omega (Omega rotation for frame at moment of capture. For example 0.367483)
- Phi (Phi rotation for frame at moment of capture. For example 0.2758463)
- Kappa (Kappa rotation for frame at moment of capture. Kappa is used to calculate required rotation to display frame showing north up. For example -0.543422)

5.3 Project Report

A project report will be supplied on delivery of each project. It will contain project details under the following headings:

- Title
- Certification of Conformance
- Introduction
- Background Information
- Scope of Work
- Survey
 - Surveyor Details
 - Design & Placement Ground Control
 - Control Survey & Data Processing
- Aerial Photography
 - Photography
 - Airborne GPS Observation & Data Processing
 - GPS Base Station Details
- Aero Triangulation
 - Measurement
 - Adjustment
 - Issues with ground control and airborne GPS
 - Statement of Certification

The first page after the title page will be the certification of conformance specified in **Appendix A**.

If ground survey is required for the project, all new GCPs and CRMs established shall be marked in accordance with DPI standards. A recovery sketch, for each shall be included in the project report. The output of the least squares adjustment of the control shall also be provided as an appendix.

Control shall be observed to the standards outlined in the ICSM Standards and Practices for Control Surveys (SP1). SP1 is currently available from the web at <http://www.icsm.gov.au/icsm/publications/sp1/sp1.html>

DPI may withhold final full payment if projects are delivered without project reports.

5.4 Certification of Conformance

The Contractor will complete the appropriate Conformance Certificates for delivery within 7 days of the completion of image or film processing. For airborne GPS projects these will be the Aerial Photography Conformance Certificate and the Airborne GPS Control Conformance Certificate.

Projects delivered without Conformance Certificates will not be accepted.

The DPI will examine all deliverables and reserves the right to reject work if it is non-conforming. Such rejection will be made in writing to the Contractor within 30 days of the delivery of the project to DPI, clearly setting out the reasons for rejection.

5.5 Non Conformance

It will be the responsibility of the Contractor to assess conformance of deliverables with specifications. In the event of non conformance the Contractor will inform DPI in writing by delivery of a report with sufficient of the deliverables to clearly illustrate the nature of and the extent of non conformance.

DPI will assess the extent and effect of non conformance in relation to its needs or the needs of other government agencies and:

- accept the non conforming work in recognition of the prevailing circumstances; or
- agree to accept the work for a reduced cost; or
- not accept the work until conformance is achieved, which may require undertaking re-work and returning to the project site.

The DPI will make its decision within one week of written notification of non conforming work. The Contractor should not undertake any re-work without the prior approval of DPI.

A Appendix Conformance Certificates

Certification of Conformance

The Contractor will complete the appropriate Conformance Certificates and Statements for delivery within 7 days of the completion of image processing. This will include the Aerial Photography Conformance Certificate, and Airborne GPS Control Conformance Certificate.

Projects delivered without Conformance documentation will not be accepted.

A sample of conformance certificates is provided:

Northern Territory Department of Planning & Infrastructure

Airborne GPS Control Conformance Certificate

Project Name.....Film No.....
 Date of PhotographyContract/Instn.....
 Contractor.....Accuracy Specification.....
 Surveyor.....
 Base Station Type of Receivers.....
 Base Coords (MGA94/AHD).....

	Passed Y/N	Comment
Coverage		
Point Transfer		
Adjustment		
Validation		

Indicate Y/N to achieving specification. If no, please make comment.

This Certificate is to be completed and delivered with the project included in the complete bound manuscript and digital data of the adjustment.

Signed:.....Dated.....

Northern Territory Department of Planning & Infrastructure

Imagery Conformance Certificate

Page of

Contractor : **Contract :** **Film No :** NT
Camera : **Lens No :** **Calibrated Focal Length :** **Date of calibration :**
Filter/s : **Image Type :** **GPS Receiver/s :**
GPS Method : **Expected Accuracy :**
Base Station : **Coords (GDA-AHD) :**

Line	Date	Project Name	Run No	Frame Nos	Alt AMSL	Ground Datum	Scale or Pixel size	Direction	Forward Overlap	Side Lap	Coverage	Solar Alt	Cloud Smoke Cover	Image Quality	Image Shape & Size	Accept
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																

Remarks (against line No) :

.....

.....

Inspected by :

Date :

B Appendix Aero Triangulation Report Format

The prescribed formats for reports are as shown below.

As a guide, reports are to include the following information;

Plate Coordinates:

Run No (Runs to be issued as separate text files if possible)

Frame No

Point No	X Coordinate (mm)	Y Coordinate (mm)

-99

Plate coordinates will also be accepted in microns

Photo Air Station Coordinates

Run No	Frame No	Easting(mm)	Northing(mm)	Reduced Level (m AHD)	Omega (dec deg)	Phi (dec deg)	Kappa (dec deg)

Note: Angular units to be given in decimal degrees

Adjusted Terrain Point Coordinates:

Projection, Zone

Point No	Easting(m)	Northing(m)	Reduced Level(AHD m)