Imagery Product Specification and Description

Source:

Airborne Multi-Spectral Imagery Sensor

No: 1

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Spatial Services, a division
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Document control

Document approval

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1. Introduction

This document describes the specifications and deliverables for airborne multi-spectral imagery surveys undertaken by Spatial Services, a division of the Department of Finance, Services and Innovation.

An airborne multi-spectral imagery survey results in a spatially accurate orthorectified image mosaic as the primary product. The imagery may be captured at varying resolutions and accuracies depending on the use of the imagery and requirements of the products. The products derived from Spatial Service's airborne multi-spectral imagery include; 3-band (Red, Green, Blue) orthorectified mosaic, 4-band (Blue, Green, Red and Near-Infrared) orthorectified mosaic, 4-band uncompressed orthorectified modules and stereo-viewable image strips.

2. Data specification and description

2.1 Ground Sampling Distance

The resolution of a digital image is described as its Ground Sampling Distance (GSD) and is the actual measured 'on ground' width of a pixel. This value is dependent upon the job type of the imagery and defines the level of detail that is visible in the image. Standard Coverage jobs, which cover the area of a NSW 1:100,000 scale mapping block, are captured at a resolution of 50cm GSD. Town imagery, with a coverage area designed to capture the urban environment and surrounding infrastructure, is captured at a resolution of 10cm GSD or 20cm GSD. Rapid response imagery and special project imagery is captured at a resolution that best suits the project's needs whilst ensuring efficiencies in the capture and processing of the imagery to allow for the rapid delivery of products as required.

2.2 Accuracy

The Intergovernmental Committee of Surveying and Mapping (ICSM) have produced a standard for reporting the horizontal accuracy of spatial data – "Australian Map and Spatial Data Horizontal Accuracy Standard". This document states that accuracy must be reported at a threshold level of 95%. This means that 95% of the positions in the dataset must have an error with respect to true ground position that is equal to or smaller than the reported accuracy value.

The horizontal accuracy of imagery products is assessed by comparing the known coordinates of a surveyed ground check point against the location of the same point in the image. Check points are typically marked by either a target placed on the ground or an easily identifiable ground feature.

The accuracy of the image is calculated based on these check points at the 95% confidence level as a function of the horizontal Root Mean Square Error (RMSE). This accuracy assessment takes place after the imagery has been adjusted through an aerial triangulation and orthorectification process. The accuracy assessment ensures that the image is planimetrically and geometrically correct, has a uniform scale and terrain distortions are accounted for.

2.3 Control and Check points

Ground control and check points are surveyed by connection to the local Survey Control Information Management System (SCIMS) with ellipsoidal heights. Where possible, orthometric heights using the local Australian Height Datum (AHD71) are also provided.

Control Points are located in the corners of imagery capture area whilst at least 3 check points are distributed throughout the geographic extent of the area. The ground control points are used in the aerial triangulation of the imagery to accurately locate the imagery to the ground.

2.4 Data specifications

The table below identifies the product specifications required for each product type.

Feature	Standard Coverage	Town	Emergency Response	AD Hoc Imagery	Stereo Imagery
General					
Horizontal Datum	GDA94				
Vertical Datum (Orthometric)	Orthometric heights are referenced to the Australian Height Datum (AHD71)				
Vertical Datum (Ellipsoidal)	Ellipsoidal heights are delivered in terms of the GDA94 reference frame				
Projection	MGA Zones 54-57				
Geoid	AUSGeoid09				
Metadata	ANZLIC Metadata Profile Version 1.1				
Ground Sample Distance					
Resolution	50cm	10cm, 20cm	Job Specific	Job Specific	As per Job (50cm/10cm)
Products					
Orthorectified	Yes	Yes	When Possible	When Possible	N/A
Bands	RGB+NIR	RGB+NIR	RGB+NIR	RGB+NIR	RGB
File Formats	ECW, Jpeg2000	ECW, Jpeg2000	ECW, Jpeg2000	ECW, Jpeg2000	TIFF/Socet Set Support file
Deliverables	Mosaic, 5x5km Modules	Mosaic, 1.25x1.25km (10cm) or 2.5x2.5km (20cm) Modules	Mosaic	Mosaic	Image Strips in Forward & Nadir Look Angles
Typical Uses	Vegetation analysis, environmental compliance, infrastructure management,	Town planning, infrastructure management, environmental management, swimming pool and DA compliance	Analysis to aid Decision making for Emergency Services Organisations during times of emergency (flood, bushfire). ESO's, councils and insurance agencies for post-event recovery.	Vegetation compliance, coastal surveillance for beach erosion, illicit crop detection in support of police operations	Viewing imagery in "3D" to measure the elevation of features, creation of 3D vector files for 3D modelling. Vegetation analysis, erosion monitoring, volume calculations

Feature	Standard Coverage	Town	Emergency Response	AD Hoc Imagery	Stereo Imagery
Accuracy					
Surveyed Control Points Used	Yes	Yes	Where Available	Where Available	Yes
Vertical Accuracy 95% Confidence Interval (1.96 x RMSE)	N/A				RMSE ≤ 4 x GSD on bare open ground. Vertical Accuracy at 95% Confidence Interval ≤ 7.84 x GSD (1.96 x RMSE)
Horizontal Accuracy	RMSEx and RMSEy ≤ 2.5 x GSD, RMSEr ≤ 3.54 x GSD. Horizontal Accuracy at 95% Confidence Interval ≤ 6.12 x GSD (1.73 x RMSEr)		Determined by job type and accuracy requirements	Determined by job type and accuracy requirements	As per job
Control Points					
Number of Control Points	Minimum 8 points. 2 points in each corner of job area	Minimum 6 points. Distributed in corners and centre of job area.	Control points only used if available	Used if required for accuracy	As per job

3. Deliverables

The range of standard products listed below is designed in consideration for user functionality, storage space, production capacity, minimising redundancy and control costs whilst maintaining the potential to create alternate or value-added products as required.

Product	File Format	Description
Primary Products		
RGB Mosaic	ECW	Image mosaic covering the job area consisting of the Red, Green and Blue bands, produced from Level 2 orthorectified imagery
BGRN Mosaic	Jpeg2000	Image mosaic covering the job area consisting of the Blue, Green, Red and Near Infrared bands, produced from Level 2 orthorectified imagery
Modules	GeoTIFF	5km x 5km (50cm Imagery), 2.5km x 2.5km (20cm Imagery) or 1.25km x 1.25km (10cm Imagery) tiles with Blue, Green, Red and Near Infrared bands, produced from Level 2 imagery.
Stereo-Viewable Image Pairs	Socet Set Support File (.sup, .tiff, .ads)	Image pairs consisting of Level 1 RGB image strips for the Nadir and Backwards look angles for each individual flight line to be used for Stereo viewing and measurement.
Supporting Products		
Tile Boundaries	ESRI Shapefile	Tile layout and naming for the tile boundaries used for the modules
Seamlines	ESRI Shapefile	Polygons depicting the location of the seamline used to join adjacent flight lines to create the mosaics and modules. Contains the name of the flight line used.
Metadata	XML	NSW Metadata profile version 1.1

Refer to **Section 4** on page 11 for visual product representations.

Refer to **Appendix B** for information on Image Processing Levels

4. Product details

4.1 RGB Mosaic

An RGB mosaic imagery product is produced by combining the individual orthorectified image strips into a single mosaic that entirely covers the extent of the job area. The mosaic contains Red, Green and Blue bands to enable viewing and analysis of a true-colour image.

The mosaic is produced in an ECW (Enhanced Compressed Wavelet) image format, which is a lossy compression format designed to efficiently compress large images.

50cm RGB Imagery

10cm Imagery

4.2 BGRN Mosaic

A BGRN mosaic imagery product is produced by combining the individual orthorectified image strips into a single mosaic that entirely covers the extent of the job area. The mosaic contains Blue, Green, Red and Near-Infrared bands to enable viewing and analysis of either a true-colour or false-colour infrared image.

The 4-band BGRN mosaic is produced in a Jpeg 2000 image format, which is a lossy compression format designed to appear visually lossless.

50cm BGRN imagery displayed as false-colour infrared with an NRG band combination.

4.3 Modules

Imagery module products are produced from the combined orthorectified imagery strips. The modules vary in spatial extent depending on the GSD of the job; 5km x 5km for 50cm GSD, 2.5km x 2.5km for 20cm GSD and 1.25km x 1.25km for 10cm GSD. Each module has 2.5 pixel overlap with neighbouring modules to ensure that they can be nested together seamlessly.

The modules are produced in a lossless GeoTIFF format to ensure that the actual pixel values are retained when the modules are created and each module is spatially referenced.

5km x 5km module for a 50cm GSD job

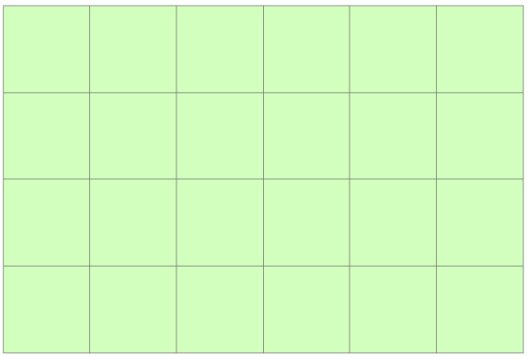
4.4 Stereo-Viewable Image Pairs

Each imagery strip for individual flight lines for a job is available as an image pair consisting of the Nadir and Backwards look angles. With an along track field of view of 16° between the 2 look angles of the image pair specialised software can be used to view the image strips in stereo to determine and measure accurate 3D spatial coordinates.

Each image strip of the image pairs consists of the Red, Green and Blue bands, and they are produced in the Leica-Geosystems ADS Socet Set Support File format.

4.5 Modules Boundaries – Key Diagram

Depicts the modules bounds and locations for the full extent of the imagery job from which the imagery modules have been created as an ESRI Shapefile. Attributes include the module name.



Depiction of module boundaries for 10cm imagery job

4.6 Metadata

A single (xml) metadata statement is provided for each product group. A readable text version is also included.

4.7 Filename Convention

The tables below outline the filename conventions used for imagery products.

Description	Job Name	YYYY	MM	GSD	Bands
	Name of Job. For Standard products this will be the same as the NSW 1:100 000 mapsheet name. Town jobs will reference the town being captured. For other jobs it will be a suitable location descriptor.	Year of capture of first flight	Month of capture of first flight	Ground Sampling Distance	Individual colour bands used
Product Type					
RGB Mosaic	✓	✓	✓	✓	
Example	**Bathurst_2013_08_50cm.ecw**				
BGRN Mosaic	✓	✓	✓	✓	✓
Example	**Bathurst_2013_08_50cm_BGRN.jp2**				
Modules Boundaries	✓	✓	✓	✓	
Example	**Bathurst_2013_08_50cm.shp**				
Seamlines	✓	✓	✓	✓	
Example	**Bathurst_2013_08_50cm_Seamlines.shp**				
Metadata	✓	✓	✓	✓	
Example	**Bathurst_2013_08_50cm.xml**				

Description	Processing Level	Job Name	GSD	Run	Year	Month	Day	Hour	Minute	Bands	Look Angle	Processing Level
	See Appendix B	Name of Job. For Standard products this will be the same as the NSW 1:100 000 mapsheet name. Town jobs will reference the town being captured. For other jobs it will be a suitable location descriptor.	Ground Sampling Distance	Flight Line Number	Year of flight	Month of flight	Day of flight	Hour of start of run capture (UTC Time)	Minute of start of run capture (UTC Time)	Individual colour bands used	Look angle of image strip	See Appendix B
Product Type												
Stereo Viewable	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Example	**L1_Bonalbo_50cm_001_20140910_2310_RGBB16L1.sup**											

5. Appendix A

5.1 Imagery known issues and anomalies

5.1.1 Colour mismatch between flight lines

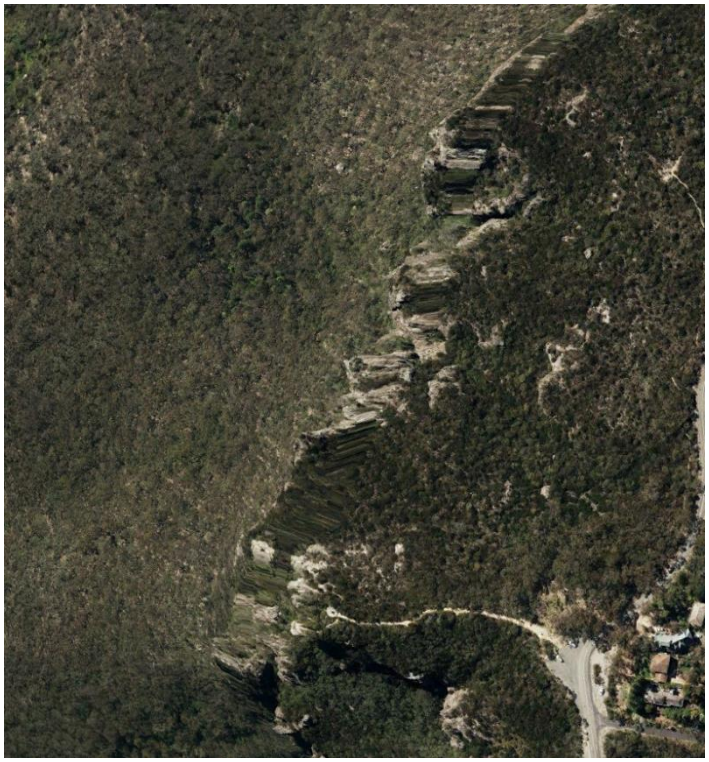
As the individual flight lines have been captured at different times, changes in terrain reflectance can be expected between the image strips due to differing solar illumination, sun angle, ground use, as well as short and long term weather and seasonal conditions. Although much of this colour difference can be removed through the use colour balancing techniques and the placement of seamlines, in some cases it may remain visible.

Mismatch in terrain reflectance due to differing atmospheric conditions between flight lines.

5.1.2 Pixel smearing and distortion

The production of orthorectified imagery requires a Digital Surface Model (DSM), therefore it is possible that pixel smearing or distortions in ground features will be evident in places where the DSM does not adequately correlate to the imagery. Pixel smearing and distortion is most commonly seen along cliff lines and raised features such as bridges and large buildings.

All effort is made during processing to remove instances of pixel smearing and distortion, though some minor occurrences may remain.



An example of pixel smearing along a cliff line

5.1.3 Over- and Under-exposed imagery

Although the captured imagery is subjected to colour corrections to create a visually pleasing image which accurately reflects the actual colour and tone of the ground features, it is possible that there may be some over- or under-exposed pixels retained in the imagery that are caused as a result of conditions during the image capture.

Over-exposure on water bodies due to solar flare can be quite prominent when imagery is captured with a high degree of solar altitude. Every effort is made to capture large water bodies at times when the solar altitude is lower in order to minimise solar flare but this is not always practical.

Over-exposed imagery showing a loss of details of buildings

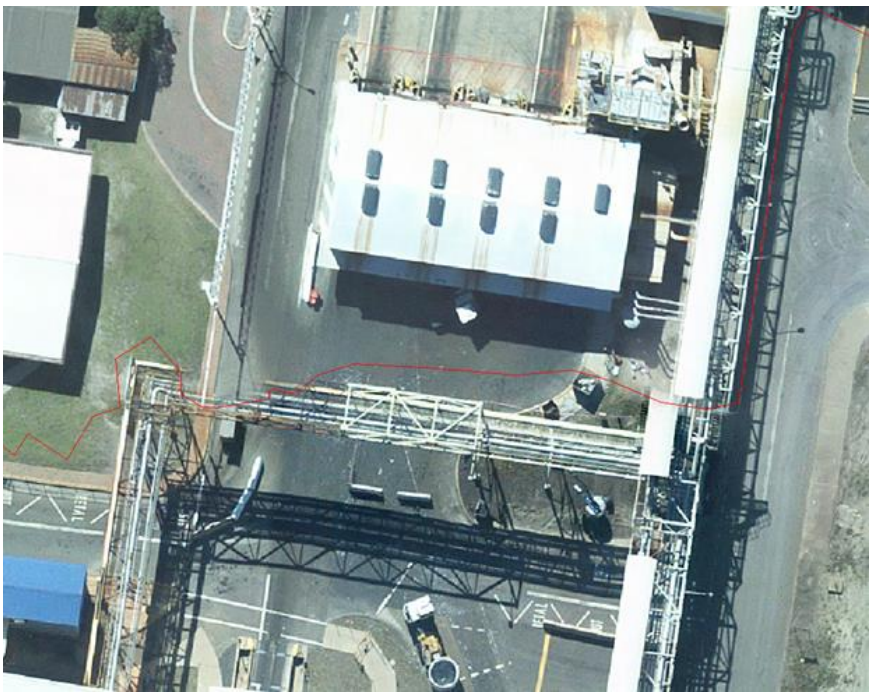
Solar flare from water body

5.1.4 Logical consistency along Seamlines

Although the image strips are combined together using seamlines that are placed along features in the imagery such that visible signs of the join are minimised, it is possible inconsistencies between the separate image strips in the orthorectified mosaics and modules exist along the seamlines. These inconsistencies could include; differing shadow directions, elevated features such as powerlines not joining or opposing lean directions on buildings or trees. Whilst all care is taken when placing seamlines to minimise any differences and ensure logical consistency is maintained, it is not always possible to fully remove them.

Pixel feathering is also used along the seamlines to minimise the visible differences at the join. In some circumstances this feathering may create the appearance of pixels being fuzzy directly either side of a seamline.

Neighbouring pixels along these seamlines will have been captured at different times which should be taken into account if using the imagery to undertake temporal analysis.



Seamline through elevated features

6. Appendix B

6.1 Imagery Processing levels

Level	Description
Raw	Imagery that has been captured and directly downloaded with no further processing is in a Raw state. The imagery has no attached geo-referencing information and it has not been corrected for aircraft and sensor movement during capture.
0	Level 0 imagery has been geo-referenced using processed GNSS and Inertial Measurement Unit data. Distortions from aircraft and sensor movement during flight have not been fully removed. L0 imagery is only viewable as individual bands.
1	Level 1 imagery has been geo-referenced to a plane and distortions caused by aircraft and sensor movement have been removed. Level 1 imagery is suitable for stereo-viewing.
2	Level 2 imagery is orthorectified to a Digital Surface Model to geometrically correct the image strips to ensure that they are planimetrically correct, they have a uniform scale and terrain distortions are accounted for.

7. Appendix C

7.1 Glossary of terms

Accuracy	The closeness of an estimated (for example, measured or computed) value to a standard or accepted [true] value of a particular quantity. Note: Because the true value is not known, but only estimated, the accuracy of the measured quantity is also unknown. Therefore, accuracy of coordinate information can only be estimated
Australian Height Datum (AHD71)	Established in 1971 as a National datum for elevations based on observed mean sea level around the Australian coast line. Determined on the Australian mainland by an adjustment of a national levelling network constrained to mean sea level from continuous tidal observations over a period of 3 years at 30 tide gauges. AHD (Tasmania) was re-established in 1983 by adjusting the Tasmanian levelling network to mean sea level determined from one year of tidal observations at 2 tide gauges
Bands	Discrete wavelengths of light recorded by the sensor. Multiple bands can be combined to produce multi-spectral imagery. The bands captured by Spatial Services include; Blue, Green, Red, Near-Infrared.
Calibration	Procedures used to identify systematic errors in hardware, software, and procedures so that these errors can be corrected in preparing the data derived there from
Check Point	A point in the sample used to estimate the positional accuracy of the dataset against an independent source of higher accuracy
Control Point	A surveyed point with accurate coordinates used to locate the imagery to the ground. Control Points are used in the aerial triangulation process to improve the spatial accuracy of the imagery.
Digital Elevation Model (DEM)	Specifies elevations of the terrain (bare earth z-values) void of vegetation and manmade features. May incorporate a range of data models such as mass point, Triangular Irregular Network, grid or contours and may also include break-lines to better represent discontinuous features thereby improving the overall quality of the DEM
Digital Surface Model (DSM)	Similar to DEMs except that they include various combinations of above ground data such as buildings, trees and other elevated features

Digital Terrain Model (DTM)	A legacy term that refers to a sub-type of DEM
Flight line overlap	Refers to the common coverage between two overlapping flight runs in an aerial imagery survey.
Geocentric Datum of Australia 1994 (GDA94)	Australia's standard horizontal datum. GDA94 is defined by the International Terrestrial Reference Frame (ITRF) at epoch 1st January 1997
Geo-referencing	Associating a spatial reference to imagery such that each location in the image has coordinates that associate it with its physical location. Geo-referencing imagery is distinct from orthorectifying imagery as it does not use a DSM to planimetrically correct the imagery.
GNSS	Global Navigation Satellite System. A constellation of satellite systems used to identify the location of a user's receiver anywhere in the world.
Ground Sample Distance (GSD)	Refers to the resolution of the imagery and is the distance between 2 adjacent pixel centres as measured on the ground. The smaller the GSD value, the higher the spatial resolution and the more detail will be visible in the imagery.
Inertial Measurement Unit	A device that uses gyroscopes and accelerometers to precisely measure linear and angular motion.
Look Angles	Refers to the separate viewing angles captured by a Pushbroom aerial sensor. Spatial Service's sensor captures imagery at 3 look-angles; Nadir, Forward and Backwards. Look-angles can be paired together for Stereo-viewing with Level 1 imagery.
Mosaic	A raster dataset consisting of individual overlapping image strips merged together to create a single image.
Multi-Spectral	Imagery that is constructed from a number of discrete spectral bands.
Orthorectification	The process of geometrically correcting imagery using a Digital Surface Model to create imagery that is planimetrically correct, has uniform scale and with corrected terrain distortion.
Resolution	See Ground Sample Distance.
RMSE	The square root of the mean of squared errors for a sample
Seamline	The location of the join between image strips. Used to mosaic the image strips into a single mosaic.
Survey Control Information Management System (SCIMS)	Contains coordinates and related information for survey marks established under the direction of the Surveyor General and is maintained for the purposes of cadastral boundary definition, engineering surveys, mapping and a variety of other spatial applications.

Triangulation	Also referred to as Aerial-Triangulation, it is the process of precisely determining the position and orientation of each image strip and establishing an accurate relationship between the them and the ground by utilising surveyed ground control points, image tie points and aircraft trajectory data consisting of processed GNSS and Inertial Measurement Unit data .