Department of Customer Service

2D Imagery Product Specification and Description

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Airborne Multi-Spectral Hybrid Sensor
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NSW GOVERNMENT

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1. Introduction

This document describes the specifications and deliverables for airborne multi-spectral hybrid imagery surveys undertaken by DCS Spatial Services using Leica CityMapper-2 (CM2) and Leica TerrianMapper-2 (TM2) sensors.

A Spatial Services airborne multi-spectral imagery survey allows the creation of orthorectified images. These images are primarily delivered as 1km x 1km tiled Cloud-Optimised GeoTiff (COG) images, allowing them to be imported to most Geographic Information Systems (GIS). The imagery may be captured at varying resolutions and accuracies depending on the purpose, use of the imagery and requirements of the products. The products derived from Spatial Service's airborne multi-spectral imagery include:

- 4-band (Red, Green, Blue and Near-Infrared) orthorectified tiles
- ad hoc products as requested.

2. Data Specification and Description

2.1 Ground Sampling Distance

The spatial 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 project type of the imagery and defines the level of detail that is visible in the image.

Project type will be determined based on size and purpose for capture. For example, Standard Program imagery of a Town is designed to capture the urban environment and surrounding infrastructure and will be captured at a resolution of 50mm or 100mm. Emergency response (occasionally called Rapid Response) imagery and Project imagery is captured at a resolution that best suits the project's needs whilst ensuring efficiencies in capture and processing of the imagery. This allows for the 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, known as the "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.

Control Points are typically located near the corners and centre of the imagery capture area whilst 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 Capture and Data Specifications

The table below identifies the product specifications required for each Imagery product types.

Feature	Standard Program	Project Imagery	Minimal Processing
General			
Description	Digital Twin, Town planning, infrastructure management, environmental management, swimming pool and DA compliance.	Standard program examples as well as vegetation compliance, coastal surveillance for beach erosion, invasive weed detection, environmental monitoring, asset, and infrastructure detection.	Aerial imagery capturing exact conditions with minimal to no post-processing. Designed for initial project assessments and emergency response, it provides quick access to high-resolution data without seamline editing, color balancing, or surface model adjustments. With a fast turnaround, it supports Emergency Services Organisations (ESOs) during critical events such as floods and bushfires, as well as councils and insurance agencies for post-event recovery.
Horizontal Datum	GDA2020	GDA2020	GDA2020
Vertical Datum (Ellipsoidal)	Ellipsoidal heights are delivered in terms of the GDA2020 reference frame		
Projection	MGA Zones 54-57		
Ellipsoid	GRS80		
Metadata	ANZLIC compliant	As Requested	–
Ground Sample Distance			
Resolution	50mm, 100mm, 200mm	As Requested	As Requested
Products			
Orthorectified	Yes	As Requested	As Requested
Bands	RGB+NIR	RGB+NIR (Project Specific)	RGB+NIR
Bit Depth	8 or 16*	8 or 16	8 or 16
File Formats	Cloud-Optimised GeoTiffs (tiles)	Cloud-Optimised GeoTiffs (alternatives by negotiation)	Cloud-Optimised GeoTiffs (alternatives by negotiation)
Deliverables	1x1km Tiles	1x1km Tiles (alternatives by negotiation)	1x1km Tiles (alternatives by negotiation)

*Infrastructure dependent

2.5 Processing Workflows and Accuracy Specifications

The table below defines the processing workflows, accuracy specifications and quality assurance (QA) considerations used for the processing of imagery by DCS Spatial Services.

These processing standards match the Capture and Data specifications in 2.4.

Processing Workflow Stream	Standard Program	Project Imagery	Minimal Processing
Workflow Stream Code	**SP**	**PI**	**MP**
Accuracy			
Vertical Accuracy 95% Confidence Interval (1.96 x RMSE)	N/A		
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 project type and accuracy requirements. Accuracy statement can be provided with product delivery.	Determined by project type and accuracy requirements.
Control Points			
Surveyed Control Points Used	Yes	Determined by project type and accuracy requirements. Measured photo points may replace ground control targets. (If no survey control points available other gross accuracy checks applied).	Where available, but typically not used.
Number of Ground Control Points	Minimum 5	Control points may be used depending on project requirements.	Control Points typically not used
Processing			
Methods	Standard Program (SP) Imagery follows best practice documented workflows. Manual intervention is undertaken with a focus on essential areas within the tiles, including urban centres, key infrastructure, and significant natural features. QA procedures balance the visual aesthetics with capture accuracy and image currency. There may be visual inconsistencies between separate image frames. Please see details and examples in Appendix A.	Project Imagery (PI) refers to non-standard capture requests by and for NSW Government and Local Council. Project Imagery methodology adheres, where possible, to the best practice methodology of Standard Program capture. Deviations from this are due to the purpose of capture and may result due to less - or minimal - manual intervention during the processing workflow. QA procedures balance the visual aesthetics with capture accuracy and image currency. Project capture purpose may result in visual inconsistencies between separate image frames. Cloud, shadow or different capture times may mean parts of the Imagery appear mismatched due to colour. Distortions may appear in some features. See details and examples in Appendix A.	MP imagery is primarily used for initial project assessments and Emergency response captures. These projects follow a near fully automated processing workflow with minimal manual intervention. This approach enables rapid turnaround but can result in significant distortions and artifacts. Users should expect the presence of cloud, cloud shadow, smoke, or haze, as well as color mismatches between flight lines. Unlike Standard Program (SP) imagery, no seamline editing, color balancing, or surface model adjustments are applied. Please see details and examples in Appendix A.
Delivery	Capture areas supplied to Spatial Services NSW Web Imagery API Service. Spatial Services Customer Experience & Insights (CX&I) team may also supply products directly to appropriate customers.	RGB+NIR (Project Specific) Delivered directly to the customer. If it meets specifications of SP capture will be delivered via SP channels.	RGB+NIR Delivered directly to the customer.

3. Standard Deliverables

Standard Program capture products are listed below. These have been designed with consideration for user functionality, storage, production capacity, minimising redundancy and controlling costs whilst maintaining the potential to create alternate or value-added products as required. For further information on the imagery processing Levels see 2.5.

For Project Imagery and Emergency Response capture the deliverables may be negotiated or amended to meet client requirements.

Product	File Format	Description
Standard Product		
Tiles	Cloud Optimised GeoTIFF (COG) (.tif)	1km x 1km tiles with Red, Green, Blue and Near Infrared bands.
Metadata	HTML	ANZLIC Compliant
Negotiated Non-Standard Products		
Tile Boundaries	OGC Compliant Vector Format (.gpkg)	Tile layout and naming for the tile boundaries in GDA2020. Available on request.
RGBN Mosaic	Jpeg2000 (.jp2)	Image mosaic covering the project area consisting of the Red, Green, Blue and Near Infrared bands, produced from orthorectified imagery.

4. Product Details

4.1 Tiles

Imagery tile products are produced from the orthorectified imagery frames. All capture types will deliver tiles in 1km x 1km output. Alternative products may be made via negotiation for Project or Emergency Products.

The tiles contain Red, Green, Blue and Near-Infrared bands to enable viewing and analysis of either a true-colour or false-colour infrared image.

The tiles are produced in a lossless COG (.tif) format to ensure the pixel values are retained when the tiles are created, each tile is spatially referenced.

Image 1: 100mm RGBN tiles with tile index overlay

Tile Boundaries

The tile boundaries are consistent across the State of NSW. Imagery tiles (where possible) will match Spatial Services LiDAR tile boundaries and naming convention. All tiles have unique naming and remain the same for each project captured. Tiles will be generated based on a 1km x 1km grid.

4.2 Metadata

A single metadata statement (html) is provided for each project capture area.

4.3 RGBN Mosaic

An RGBN mosaic imagery product is produced by combining the individual orthorectified image tiles into a larger single mosaic which covers the extent of the project area. The mosaic contains Red, Green, Blue and Near-Infrared bands to enable viewing and analysis of either a true-colour or false-colour infrared image.

A 4-band RGBN mosaic tile is produced in a COG image format, with no compression. For project and emergency response imagery other formats are available upon request to meet client requirements.

Image 2: 50mm RGBN imagery

Image 3: 150mm RGBN imagery displayed as false-colour infrared with an NRG band combination

4.4 Filename Convention

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

Description	Project Name	YYYYMM_	GSD_	Bands_	Bit Depth_	Workflow Stream Code	1km	zz_	eee	nnnn
	Name of Project. Imagery product naming will reference the purpose of capture, a significant feature or suitable location descriptor. For example: • an emergency response i.e., Bushfire • a major Town i.e., Bathurst • key infrastructure i.e., Copeton Dam • a significant natural feature i.e., Macquarie Marshes	Year of capture of first flight Month of capture of first flight	Ground Sampling Distance (millimetres)	Individual colour bands used	8 or 16 bit	Workflow Stream used for processing (SP, PI, ER) All Imagery will follow the same naming, where those details exist.	Tile size (1km x 1km)	Map grid zone	Easting Value south-west corner of tile	Northing value south-west corner of tile
Product Type										
Tiles	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Example	BrokenHill_202308_50mm_RGBN_08_SP_1km_54_5436461.tif									
Mosaic	✓	✓	✓	✓	✓	✓		✓		
Example	BrokenHill_202308_50mm_RGBN_16_PI_54.jp2									
Metadata	✓	✓	✓	✓	✓	✓		✓		
Example	BrokenHill_202308_50mm_RGBN_08_SP_54.html									

5. Appendix A

5.1 Common Image distortions and artefacts

5.1.1 Colour mismatch between flight lines

Changes in terrain reflectance my impact image frames where projects have been captured at different times. This is due to differing solar illumination, sun angle, ground use, short- and long-term weather impacts on landscape and seasonal conditions.

This colour difference can be removed using colour balancing techniques and the placement of seamlines, however there will still be cases in which it will remain visible.

Image 4: Mismatch in terrain reflectance due to differing atmospheric conditions between flight lines

This colour difference can be removed using colour balancing techniques and the placement of seamlines, however there will still be cases in which it will remain visible.

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 with significant elevation changes. Pixel smearing and distortion is often seen along cliff lines and raised features such as bridges and large buildings.

Although effort is made during processing to remove instances of pixel smearing and distortion, occurrences may remain within the imagery products. Data products processed to the Emergency Response specification are likely to contain instances of pixel smearing and distortion.

Image 5a and Image 5b: Examples of distortion

5.1.3 Over- and Under-exposed imagery

Imagery products undergo colour corrections to create visually accurate and appealing images which aim to represent the true colours and tones of ground features. However, despite these corrections, there may still be instances of over- or under-exposed pixels present in the imagery. These anomalies are a result of conditions during the image capture process.

Image 6: Over-exposed imagery showing a loss of details of buildings

Image 7: Over-exposed imagery leading to strong contrast and bright whites

5.1.4 Solar Flare

Over-exposure of water bodies can become pronounced due to solar flares, particularly when imagery is taken at a high solar altitude. Although every effort is made to capture images of large water bodies when the solar altitude is lower (minimizing solar flare), this is not always possible.

Frame-based capture may cause a ‘checkerboard’ style patterning on water surfaces due to solar flare.

Image 8: Solar flare from water body

5.1.5 Logical consistency along Seamlines

Due to frame based sensor our Image Tiles are made up of hundreds of individual Image frames. Seamlines are automatically generated, programmed to follow pixel matching and where possible, avoid pre-identified building polygons. QA procedures try to ensure that these seamlines are placed along features in the imagery to reduce visible signs of the join.

Image 9: Frame based seamlines

However, it is possible inconsistencies between the separate image frames in the orthorectified tiles 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.

Minor manual seamline editing may be undertaken during the Standard processing workflow when placing seamlines to minimise any significant differences to ensure logical consistency is maintained around places such as urban areas, important infrastructure, or points of interest. Imagery processed under Project or Emergency response specifications is likely to contain visual seamline artefacts, particularly around non-focus areas, buildings, vegetation, and/or roadways.

Pixel feathering is used along seamlines to minimise visible differences at the join. In certain scenarios, this feathering technique might lead to the appearance of slightly blurred pixels or the illusion of objects appearing faintly on either side of the seamline.

As flight runs are conducted at varying times, it's important to recognise that adjacent pixels along seamlines could have been captured during different times. This should be considered, especially when utilising the imagery for temporal analysis purposes.

Image 10: Seamline through elevated features

5.1.6 Cloud & Cloud Shadow

See 5.1.1. Cloud and Cloud shadow is likely only for Emergency Response (ER) capture when the currency of the imagery is paramount.

Standard Program Imagery (SP) capture will have little to no cloud shadow present.

5.1.7 Black Holes

Imagery which contains areas of no pixel values which appear 'black' will be due to an error in processing or capture. Black holes may only be tolerated if acceptable under Project or Emergency capture project specifications.

Standard Program Imagery (SP) capture will have no 'black holes'.

6. Appendix C

6.1 Glossary of Terms

Term	Definition
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.
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 Red, Green, Blue, Near-Infrared.
Bit Depth	Bit depth refers to the number of bits used to represent each pixel in an image. The value refers to the number of binary digits used to store a value, such as a pixel's colour. Higher bit-depths offer greater accuracy. An 8-bit image can display 256 colour values for red, green, and blue, equalling ~16.7 million colours. A 16-bit image raises that number to ~4.3 trillion colours. A higher bit depth allows for greater analysis and potential for machine learning.
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.
Flight line/s	Refers to the line of flight planned. Depending on requirements, these flight lines are planned to ensure varying levels of common coverage between two overlapping flight runs in an aerial imagery survey.
Geocentric Datum of Australia 2020 (GDA2020)	Australia's standard horizontal datum. GDA2020 is based on a realisation of the ITRF2014 at epoch 2020.0, or 1 January 2020. This means the coordinates in Australia are projected forward to the date of 1 January 2020.
GNSS	Global Navigation Satellite System. A constellation of satellite systems used to identify the location of a user's receiver anywhere in the world.

Term	Definition
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.
Mosaic	A raster dataset consisting of individual orthorectified image frames merged to create a single image dataset.
Multi-Spectral	Imagery that is constructed from a number of discrete spectral bands.
OGC	Open Geospatial Consortium
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.
Quality Assurance (QA)	The internal process used to determine if a product or service meets specific quality standards.
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 frames. Used to mosaic the image frames.
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 (AT) - the process of precisely determining the position and orientation of each image frame and establishing an accurate relationship between them and the ground by using surveyed ground control points, image tie points and aircraft trajectory data consisting of processed GNSS and Inertial Measurement Unit data.

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