Department of Customer Service

Elevation Data Product Specification and Description

Version 1.0
October 2024

Airborne Multi-Spectral Hybrid Sensor

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NSW GOVERNMENT

LiDAR Data Product Specification and Description
ISSN 2205-0191 (Printed)

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Document Version Control

Version	Date	Prepared by	Comments
1.0	October 2024	ESP	Endorsed for Publication

Contents

1. Introduction

This document describes the specifications and deliverables for airborne Light Detection and Ranging (LiDAR) surveys undertaken by DCS Spatial Services (Spatial Services) using Leica CityMapper-2 (CM2) and Leica TerrainMapper-2 (TM2) sensors.

The LiDAR survey produces a spatially accurate point cloud as the primary product. It will be classified and captured at varying point densities and accuracies as described by the Inter-Governmental Committee on Surveying and Mapping (ICSM) Guidelines for Digital Elevation Data (2008). The derived product is a bare earth Digital Elevation Model (DEM).

Spatial Services will continue to utilise Geoscience Australia's Elevation Information System (ELVIS) platform for the distribution of point cloud and DEM data.

2. Data Specification and Description

2.1 Point Density

The point density of a LiDAR dataset can vary depending on the purpose of the capture. It is a representation of the laser returns received within a 1x1m grid on a ground surface (e.g. 4pt/m^2).

2.2 Accuracy

Vertical Accuracy is assessed by comparing LiDAR point returns against survey check points in bare open ground. It is calculated at the 95 per cent confidence level as a function of the vertical Root Mean Square Error (RMSE). This is undertaken after the standard relative adjustments of the point cloud have taken place. For example, flight line matching.

Horizontal accuracy is checked by comparing the LiDAR data, viewed as a Triangular Irregular Network (TIN) surface against existing imagery and known locations.

2.3 Check Points

Check points are surveyed by connection to the local Survey Control Information Management System (SCIMS) with 'accurate' height (class LD/B or better). Where possible, levelled marks are used to establish the local Australian Height Datum (AHD) in preference to Global Positioning System (GPS) derived heights. Check points are distributed throughout the geographic extent of the LiDAR capture area and are used to provide a best fit by way of a block shift adjustment.

2.4 Point Classification

The LiDAR product is a classified point cloud which contains all points measured during the flight (except for points that have been filtered as 'sensor noise'). Initially, every point is allocated to the 'default' class. Automated algorithms and manual processes then attribute the points with a more meaningful classification, such as ground, vegetation, water, building or structures. Refer to Appendix B for the Standard Point Classifications.

2.5 Classification Levels

Point cloud information created will have a classification level. Refer to **Appendix C** for Spatial Services Classification levels defining completeness and effort.

2.6 Data Specifications

The table below identifies the positional requirements and accuracy associated with the three categories of LiDAR capture.

Feature	Standard Program (ICSM Category 1 – LID1)	Project LiDAR (PL)	Emergency Response (ER)
General			
Description	Data capture specifications to suit a wide range of applications. ie. Modelling of inundation from floods or storm surges in areas of high value assets. Planning of large infrastructure projects.	Project specific capture to satisfy NSW Government agency requirements.	Data capture to aid decision making for Government Agencies during time of emergencies.
Horizontal Datum	GDA2020	GDA2020 / GDA94	GDA2020
Vertical Datum (Orthometric)	AHD71	AHD71 / ELL	AHD71
Projection	MGA Zones 54-57	MGA Zones 54-57	MGA Zones 54-57
Geoid	AUSGeoid2020	As Requested	AUSGeoid2020
Metadata	ANZLIC Compliant	As Requested	–
Point density			
Point density	Minimum 4 point per square metre	As Requested	As Requested
Accuracy			
ICSM Vertical Accuracy 95% confidence (1.96 x RMSE)	+/-0.30 metres on bare open ground	+/-0.30 metres on bare open ground (may not be ground control validated)	+/-0.30 metres on bare open ground (not ground control validated)
ICSM Horizontal Accuracy 95% confidence (1.73 x RMSE)	+/-0.80 metres on bare open ground	+/-0.80 metres on bare open ground	+/-0.80 metres on bare open ground
Check Points			
Number of Check Points	Minimum 4 points equally distributed throughout the job extent	Job Specific	–
Check Point Vertical Accuracy	Direct connection to a local SCIMS mark with an accurate AHD height (Class LD/B or better) – where possible	Job Specific	–
Check Point Horizontal Accuracy	Positional uncertainty better than 0.9m	Job Specific	–
Processing			
Methods	Best practices followed to ensure accurate data. Classified to Classification Level 3 (C3). Accuracy confirmed against check points.	Best practices followed to ensure accurate data that meets the agency's needs. Classified as per agency requirements and products created as per agency requirements.	Processed using rapid response methodologies to ensure timely delivery of data while providing a product that is suitable for use in an emergency. Data has ground classification only.
Delivery	ELVIS Platform (complete tiles only)	Supplied directly to customer. If data meets the specifications of Standard Program data will be made available through ELVIS Platform (complete tiles only).	Supplied directly to customer.

3. Standard Deliverables

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

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

Classified Point Clouds and DEMs will be delivered as 1x1km tiled data.

Product	File Format	Description	Standard Program
Primary Product			
Classified Point Cloud	LAZ v1.4	Compressed LAS v1.4 (PDRF8)	✓
Derived Product: Digital Elevation Models (DEMs)			
DEM	Cloud Optimised GeoTIFF	1 metre resolution 'bare earth' (artefact free) DEM (derived from LAS file)	✓
Supporting Product			
Metadata	HTML	ANZLIC Compliant	✓

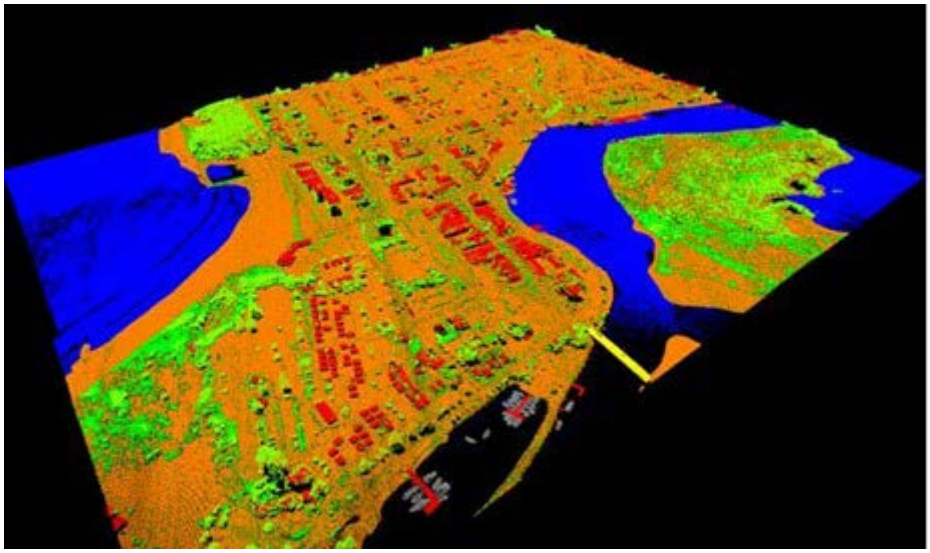
4. Product Details

4.1 Point Cloud

Point cloud data products apply to all capture categories. Every point captured (that has not been filtered out as 'sensor noise') is supplied within a tiled grid in LAZ format (compressed LAS 1.4 (PDRF 8) files). Points that are deemed 'overlap' are flagged as Overlap with their classification value retained. Ground points that are deemed 'key points' are flagged as Key Points with their classification value retained.

When 4-band concurrent imagery is captured with the LIDAR, the point cloud data will be RGBN encoded using this imagery. There is no accuracy guaranteed with the positioning or colour of the imagery used for the RGBN encoding and therefore should only be used as an indicative visual representation of the landscape during capture.

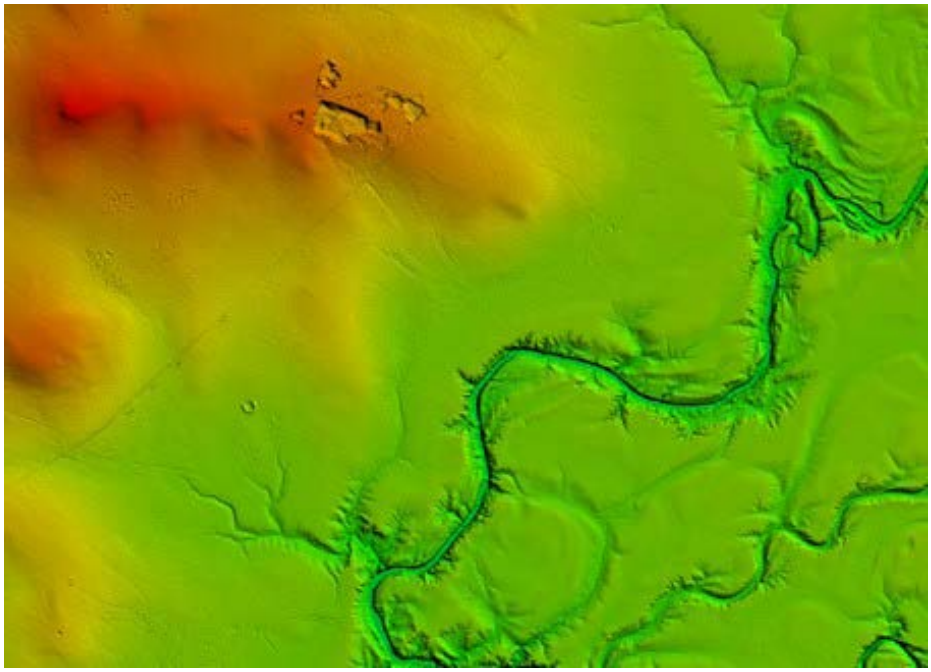
Refer to **Appendix A** for product known issues and anomalies. Refer to **Appendix B** for point cloud classification details.



Level 3 Classified Point Cloud

4.2 Digital Elevation Model (DEM)

The bare earth DEM is derived from point cloud data. The data is not hydrologically enforced (break lines) or hydrologically conditioned (identification and analysis of sinks). It is anticipated stakeholders will become involved in value-adding activities to produce other applications and specific products such as hydrologically sound data.



One metre bare earth digital elevation model

4.3 Metadata

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

4.4 Standard Program Product File Naming Convention

The table below is the filename convention used for Standard Program products. Filenames for Project LiDAR or Emergency Response captures will follow as similar format where possible.

	ProjectName_	YYYYMM_	ProductCategory_	CL_	DAT_	##ppm	res	_#km	_zz	_eee	nnnn	_Metadata
	Project Name	Year & Month of capture	Product category – standard is 'LID1'. Alternate may be used for Project LiDAR (PL) or Emergency Response (ER)	Classification level	Datum (AHD or ELL)	Planned LiDAR Capture point density	Resolution or posting in metres	Tile size in kilometres	Map grid zone	Easting value south-west corner of tile	Northing value south-west corner of data tile	Metadata
Product Type												
Point Cloud	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
Example	LakeMacquarie_202004_LID1_C3_AHD_4ppm_1km_56_3106640.laz											
DEM	✓	✓	✓		✓		✓	✓	✓	✓	✓	
Example	LakeMacquarie_202004_LID1_AHD_1m_1km_56_3106640.tif											
Point Cloud Metadata	✓	✓	✓	✓	✓	✓						✓
Example	LakeMacquarie_202004_LID1_C3_AHD_4ppm_Metadata.html											
DEM Metadata	✓	✓	✓		✓		✓					✓
Example	LakeMacquarie_202004_LID1_AHD_1m_Metadata.html											

5. Appendix A

5.1 Product Known Issues and Anomalies

5.1.1 Anomaly: DEM Triangulation Interpolation (DEM)

Interpolation lines can be seen across the waterway in areas where the DEM is created using a triangulation process. Where ground points are not available during the TIN process across adjoining tiles holes may be present within a DEM.

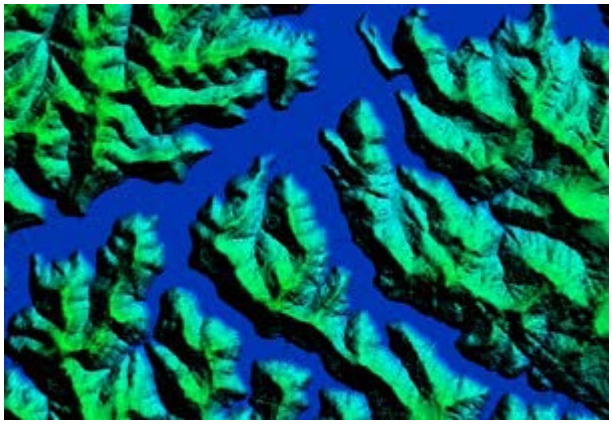
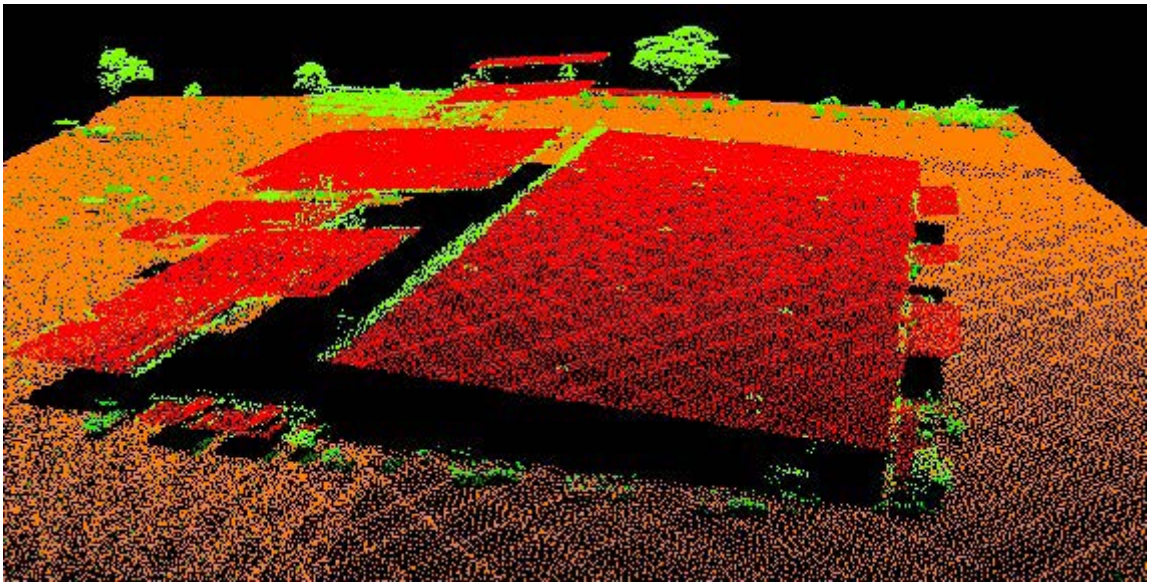


Image of triangulation issue in waterway

Image of missing data

5.1.2 Anomaly: Vegetation in Buildings (Point Cloud)

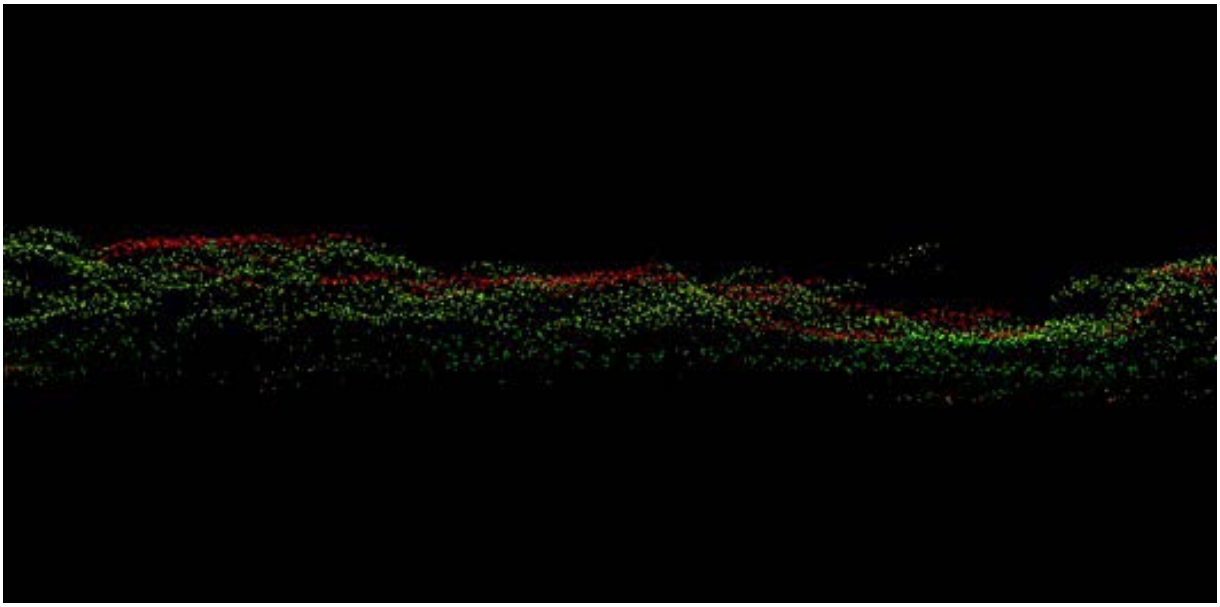
Parts of buildings may remain in a vegetation class after automatic classification, this is not rectified by manual C3 classification check.



Building misclassified as vegetation

5.1.3 Anomaly: Building Points in Vegetation (Point Cloud)

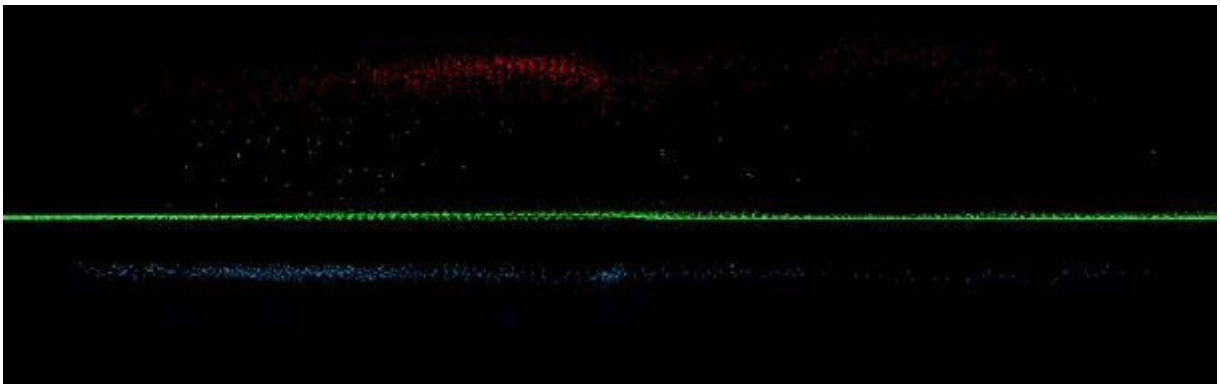
Linear surfaces in tree canopies may be classified as building due to the automated building classification process, this is not rectified by manual C3 classification check.



Misclassified vegetation as building

5.1.4 Anomaly: Spurious Points (Point Cloud)

Spurious points that may be present over water caused from the intense reflection of the laser along with excessive solar glare.



Depiction of excessive reflection error

5.1.5 Noise

The CM2 and TM2 sensors do create a lot of noise during capture. The majority of this data is filtered out during the processing however some may remain in the final classified point cloud. Depending on the location of the noise it may end up in the high vegetation, low point / noise or high point / noise classes through the automated classification routines.

6. Appendix B

6.1 Standard Point Cloud Classification

Standard Point Classes (derived from the LAS 1.4 specifications and ASPRS guidelines) are:

Number	Point class	Description
1	Unclassified	Unclassified
2	Ground	Bare ground
3	Low Vegetation	0 – 0.3m (essentially 'noise')
4	Medium Vegetation	0.3 – 2m
5	High Vegetation	2m >
6	Building	Buildings, sheds, silos, wharfs, jetties etc.
7	Low Point/Noise	Spurious low point returns (not useable)
9	Water	Any point in water
17	Bridge Deck	Any bridge or overpass
18	High Point/Noise	Spurious high point returns (not usable)

6.2 Classification Flags

Classification flags are used to indicate special characteristics associated with the point. The bit definitions are:

Bit	Field Name	Description
1	Key-point	If set, this point is considered to be a model key-point and thus generally should not be withheld in a thinning algorithm.
3	Overlap	If set, this point is within the overlap region of two or more swaths or takes. If used, all points in the overlap region must have this bit set. Note that "primary" data in an overlap region may then be identified by using a combination of Point Source ID and Overlap bit.

7. Appendix C

7.1 Spatial Services Classification Levels

Level	Description
0	**Undefined** All points allocated classes 0 (unclassified) or 1 (default) by LiDAR processing software with no classification algorithms applied.
1	Automated Classification Data is subjected to automated algorithms which, as a minimum, will classify the points into classes 2 (ground), 3-5 (vegetation), 6 (building/structures) and 7 (low points/noise).
2	**Ground Anomaly Removal** Level 1 classified data is further enhanced by the removal of significant anomalies which remain in the ground class (2). Typically, this editing will re-classify points into class 7 (low points/noise) or class 18 (high points/noise). The overall intent here is to create a ground surface suitable for orthorectification of imagery, with a minimum of effort.
3	**Manual Ground Correction** Significant (usually manual) effort is required here to ensure that only actual ground points are assigned class 2. Typically, this editing will both remove and add points to the ground class derived using the automated algorithms. Any points observed in water are to be re-classified into class 9, and other features which may require special attention include dense or low vegetation, rocky outcrops/boulders, pontoons/jetties, contour/levee banks, wood/rubbish piles and islands. Ideally, to assist with the creation of hydrologically sound data, 'bridge-like' structures will be identified at this level and classified accordingly. This manual task is best undertaken with reference to associated imagery.
4	**Full Classification** All data is classified according to the specified classes in Appendix B. Development of a hydrologically conditioned DEM will generally require this level of classification to properly identify buildings and other man-made structures which are likely to have an impact on water flow.

8. 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.
Artefacts	Buildings, trees, towers, telephone poles or other elevated features that should be removed when depicting a Digital Elevation Model (DEM) of the bare-earth terrain. Artefacts are not just limited to real features that need to be removed. They also include unintentional by-products of the production process, such as stripes in manually profiled DEM's. Any feature, whether man-made or system-made, that unintentionally exists in a digital elevation model.
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.

Term	Definition
Breakline	Linear features that describe a change in the smoothness or continuity of the surface.
Check point	A point in the sample used to estimate the positional accuracy of the dataset against an independent source of higher accuracy.
Classification	Refers to the class membership of a LiDAR point return. All points begin as 'default', i.e. have no classification and are then allocated a meaningful value (i.e. ground, vegetation, building, etc.) by either automated or manual methods (or a mix of both).
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 breaklines to better represent discontinuous features thereby improving the overall quality of the DEM.
Elevation	Height above a specific vertical reference datum.
Geocentric Datum of Australia 2020 (GDA2020)	GDA2020 is defined by the International Terrestrial Reference Frame (ITRF) at epoch 1st January 2020.
Hydrological/drainage enforcement	The removal of elevations from the tops of selected drainage structures (bridges and culverts) in a DEM, Triangular Irregular Network or topographic dataset to depict the terrain under those structures.
ICSM	Inter-Governmental Committee on Surveying and Mapping.
Interpolation	The estimation of z-values at a point with x, y coordinates based on the known z-values of surrounding points.
Key Points (model key points)	Also referred to as 'thinned ground points'. A sample of the full (classified) point cloud representing bare earth elevations are flagged as Key Points. The point thinning factor is set during processing, with the accuracy of the flagged dataset within ±15cm of the full point cloud.
LAS	A standard LiDAR file format, defined by the American Society of Photogrammetry and Remote Sensing (ASPRS). LAS defines, amongst other things, mandatory data fields and point categories. This includes mandatory metadata documentation.
LAZ	A LAZ file is a compressed .LAS file. It has been compressed so it can more easily be stored and shared with others. LAZ files are typically less than 20 percent the size of the LAS file from which they were created.
Light Detection and Ranging (LiDAR)	Light Detection and Ranging (LiDAR). A technology that determines distance to a surface using laser pulses. Distance is computed by measuring the time delay between transmission and detection of the reflected signal. Also referred to Airborne Laser Scanning (ALS) and Airborne Laser Bathymetry (ALB).
Overlap	Refers to the common coverage between two overlapping flight runs in an aerial LiDAR survey. Overlapping points are removed (re-classified) during processing as points measured towards the extreme of the laser swath (in the case of an oscillating scanner) contain a large amount of data noise.
Point Cloud	Set of irregularly spaced points derived from LiDAR survey, each with an X, Y, Z value. Depending on the level of processing, points may also have a classification value, i.e. ground, vegetation, etc.
Point Density	The number of points contained within a grid square of given size. Usually expressed as points per square metre, i.e. the number of points contained in a 1m x 1m grid.
Primary Data	Elevation data that has been corrected using Global Positioning System and Inertial Measurement Unit data is calibrated against test points on the ground. Includes LiDAR returns in LAS format.
RGBN encoding	Adding a colour value to a point cloud dataset from an imagery dataset.

Term	Definition
Root Mean Square Error (RMSE)	The square root of the mean of squared errors for a sample.
Survey Control Information Management System (SCIMS)	All datasets related to the Survey Control Network.
Triangular Irregular Network (TIN)	A set of adjacent, non-overlapping triangles computed from irregularly spaced points with xyz coordinates. The data structure may be based on point, line and polygon data interpreted as mass points and breaklines. The TIN stores the topological relationship between triangles and their adjacent neighbours.

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