# Elevation Data Product Specification and Description

## Source:
## Airborne Photogrammetry

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Spatial Services, a division of the Department of Customer Service.

T: 02 6332 8200

E: SS-Environmental@customerservice.nsw.gov.au

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Author: DCS Spatial Services

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Any enquiries relating to the report may be addressed to:
E: SS-Environmental@customerservice.nsw.gov.au

**DCS Spatial Services**

346 Panorama Avenue

Bathurst NSW 2795

T: 02 6332 8200

W: https://www.spatial.nsw.gov.au

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# Contents

# 1. Introduction

This document describes the specifications and deliverables for elevation data photogrammetrically derived from imagery captured by DCS Spatial Services (SS). A large format, push broom style airborne digital sensor was utilised for the creation of the data.

The standard products defined in this document are a spatially accurate unclassified point cloud and five metre resolution bare earth Digital Elevation Model (DEM). All elevation data will be processed to achieve category three products as described by the Inter-Governmental Committee on Surveying and Mapping (ICSM) Guidelines for Digital Elevation Data (2008).

# 2. Data Specification and Description

## 2.1. Point Density

The point density specification is based on the capability of the point generation software. The software uses a semi global matching algorithm to create elevation points from imagery and can generate one point per pixel. In this case, the point cloud is generated from imagery captured at a 50cm ground sampling distance (GSD) and therefore has the potential to generate one point every 50cm. Refer to Section 2.4 for further information.

## 2.2. Accuracy

Vertical accuracy is assessed by comparing elevation points against survey check points on bare open ground. It is calculated at the 95 percent confidence level as a function of vertical Root Mean Square Error (RMSE). This is undertaken after the standard relative adjustment of the point cloud has occurred for example flight line matching. AusGeoid09 is then used to derive orthometric Australian Height Datum (AHD71) height.

Horizontal accuracy is checked by comparing the elevation points viewed by red, green, blue (RGB) point encoding (photo realistic colour) against surveyed ground features such as existing photo point targets.

To date, analysis of ground comparisons show that although the vertical accuracy achieved on bare open ground is within the requirements for ICSM category three DEM products. Local Geoid and height control anomalies may degrade the accuracy on large coastal projects. Refer to **Section 2.4** for further information.

## 2.3. Check Points

Vertical accuracy check points are established at relatively small areas of bare, open ground with minimal slope and a clear view of the sky. This ensures that the elevation data used for comparison is ground only. Check points consist of measured ellipsoid heights and are distributed throughout the geographic extent of the capture area. Refer to the data specifications table on page five for further information.

## 2.4. Data Specifications

The table below identifies the positional requirements and accuracy associated with ICSM Category three Photogrammetric Elevation Data.

| Feature | Category 3 Photogrammetric Elevation Data |
|---|---|
| **General** | |
| **Horizontal Datum** | GDA94 |
| **Vertical Datum (Orthometric)** | AHD71 orthometric height derived by application of a Geoid model to ellipsoid heights of the source data |
| **Vertical Datum (Ellipsoidal)** | GDA94 |
| **Projection** | MGA Zones 54-57 |
| **Geoid** | AUSGeoid09 |
| **Metadata** | ANZLIC Compliant |
| **Point density** | |
| **Point density** | Maximum four points per square metre |
| **Accuracy** | |
| **Typical use** | Hydrological modelling of large catchment areas, preliminary route assessment and 3D modelling |
| **ICSM Point Cloud Vertical Accuracy 95% confidence (1.96 x RMSE)** | +/-0.9 metre on bare open ground |
| **ICSM Point Cloud Horizontal Accuracy 95% confidence (1.73 x RMSE)** | +/-1.25 metres on bare open ground |
| **Recommended Contour Interval** | 2 metres |
| **Minimum Grid Cell Size (DEM)** | 5 metres |
| **Maximum Tile Size** | 2km x 2km |
| **Check Points** | |
| **Number of check points** | Minimum 6 points per 100,000k mapsheet |
| **Check point vertical accuracy** | Ellipsoidal height accurate to 0.3 metre @ 95 percent confidence (1.96 x RMSE) |
| **Check point horizontal accuracy** | Positional uncertainty better than 0.8 metre |
| **Note** | *The unclassified point cloud is also retained in its primary ellipsoid height format to allow for future improvements in the vertical datum and to enable accurate nesting of adjacent elevation data* |

# 3. Deliverables

The range of standard deliverables featured in the table below, was 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.

| Product | File Format | Description |
|---|---|---|
| **Primary Products** | | |
| Unclassified Point Cloud | ASPRS LAS v1.2 | Created from 50cm resolution imagery and includes the attributes of easting and northing coordinates; elevation values; RGB colour values and intensity values; (2km x 2km tiles) |
| **Derived Products: Digital Elevation Models (DEMs)** | | |
| Digital Elevation Model | ESRI ASCII Grid | Five metre resolution bare earth digital elevation model created from photogrammetrically derived point cloud data; (2km x 2km tiles) |
| **Supporting Products** | | |
| Metadata | HTML | ANZLIC Compliant |

Refer to **Appendix B** for a visual representation of unclassified point cloud and DEM products.

# 4. Product Details

## 4.1. Point Cloud

A spatially accurate point cloud is created from imagery using a semi global matching algorithm. This is a raw unclassified dataset. Refer to **Appendix A** for a description of known artefacts found in the data.

## 4.2. Digital Elevation Model (DEM)

The five metre resolution bare earth DEM is derived from the point cloud data. Areas of no data caused by steep slopes, shadow and vegetation have been interpolated or filled-in with another data source and will not be as accurate as the bare open ground areas. The data is not hydrologically enforced (breaklines) 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. Refer to **Appendix A** for a full description of known artefacts found in the data.

## 4.3. Metadata

A single metadata statement (html) is provided for each tile.

## 4.4. Filename Convention

The table below is the filename convention used for photogrammetric elevation data.

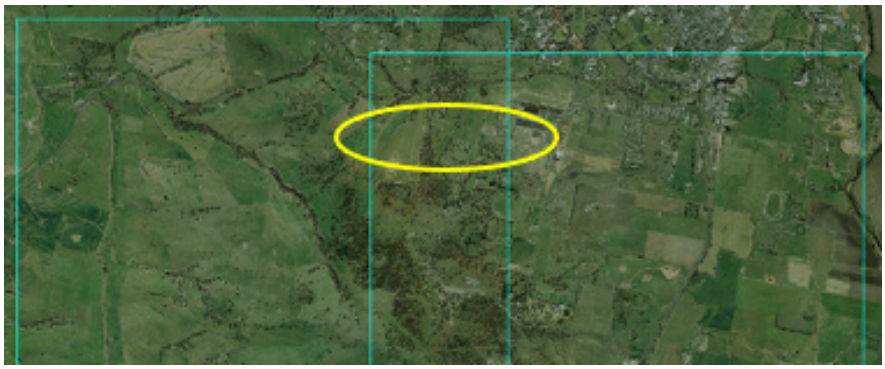
| | Mapsheet Name | YYYY | MM- | SG#- | CL- | DAT_ | eee | nnnn_ | zz_ | wwww_ | hhhh | _res | _Metadata |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mapsheet name | Year of capture | Month of capture | Sensor generated from (LID) followed by ICSM cat (1,2 or 3) | Classification level | Datum (ELL, AHD) | Easting value south-west corner of tile | Northing value south-west corner of data tile | Map grid zone | Tile width in whole kilometres | Tile height in whole kilometres | Resolution or posting in metres | Metadata |
| **Product Type** | | | | | | | | | | | | | |
| **Point Cloud** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| **Example** | Bundarra201306-PHO3-C0-AHD_3106640_56_0002_0002.las | | | | | | | | | | | | |
| **DEM** | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| **Example** | Bundarra201306-PHO3-AHD_3106640_56_0002_0002_5m.asc | | | | | | | | | | | | |
| **LAS Metadata** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| **Example** | Bundarra201306-PHO3-C0-AHD_3106640_56_0002_0002_Metadata.html | | | | | | | | | | | | |
| **DEM Metadata** | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Example** | Bundarra201306-PHO3-AHD_3106640_56_0002_0002_5m_Metadata.html | | | | | | | | | | | | |

# 5. Appendix A

## 5.1. Raw Point Cloud Known Issues and Anomalies

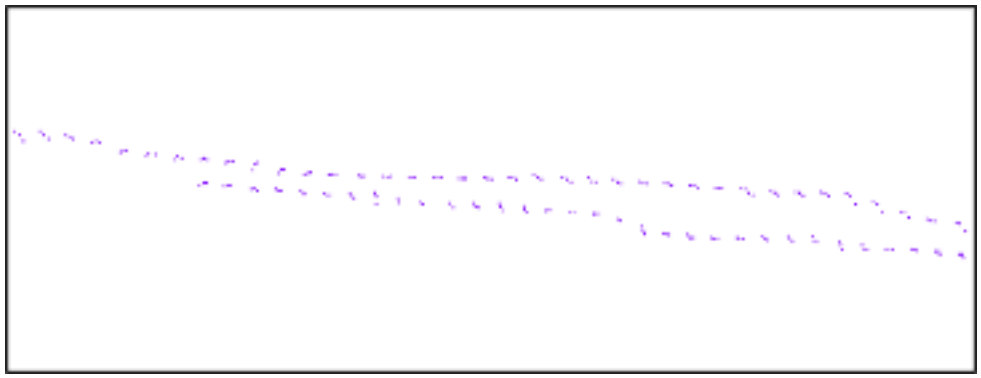
### 5.1.1. Anomaly: Overlap

No overlap exists between the data tiles in the north/south direction and the edge matching shows no anomalies. However in the east/west direction there is significant overlap between flight runs as seen in images below.



*Depiction of overlap between flight runs in East/ West area.*

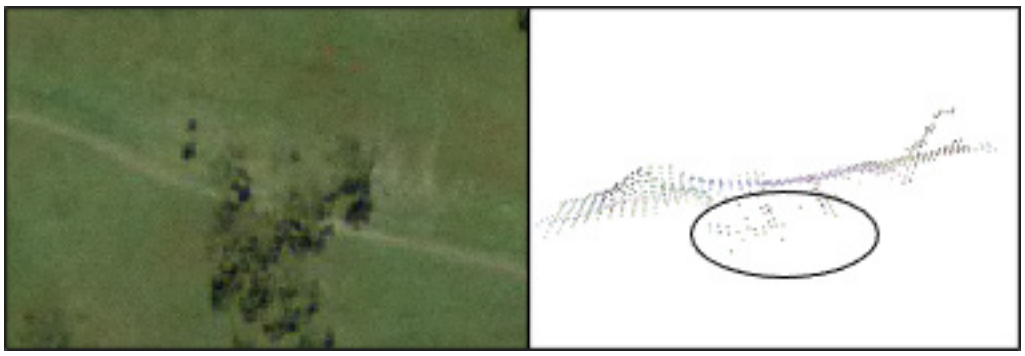
The image below is a typical profile across this overlap and shows a vertical difference between data from separate runs in the order of and sometimes exceeding one pixel (50 cm). If classifying this data, unless it is necessary for feature definition, any such overlap must be removed (class 12) and the edges of flight runs matched. Unlike Light Detection and Ranging (LiDAR), the vertical differences in the overlap are not systematic in any way. Similarly, adjacent map tiles will have significant overlap.



*Representation of overlap data*

### 5.1.2. Anomaly: Ground – Near Vegetation

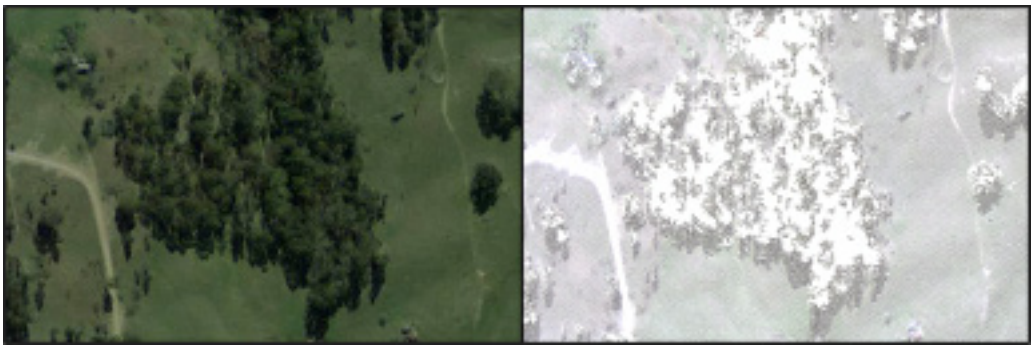
Many spurious, below ground, points exist in the vicinity of vegetation. If classifying this data, these points must be removed as noise (class 7).



*Spurious ground data*

### 5.1.3. Anomaly: Vegetation – Canopy

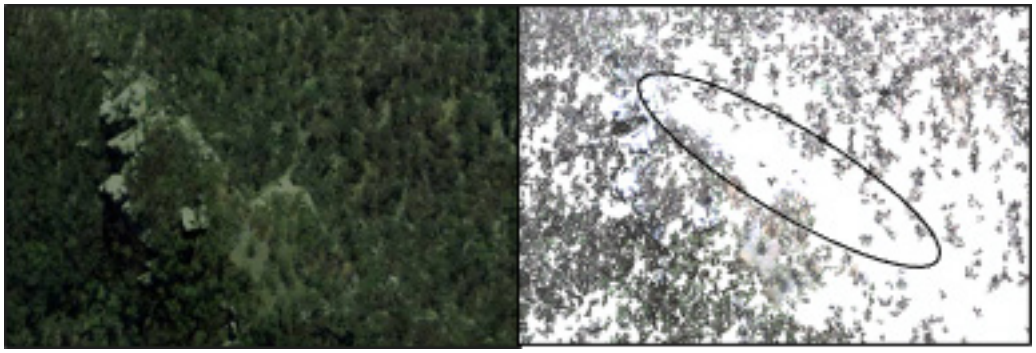
The difficulty of matching pixels amongst the vegetation canopy leads to missing data, therefore any modelling of this above ground data must be undertaken with caution.



*Data voids amongst vegetation*

### 5.1.4. Anomaly: Steep Slopes

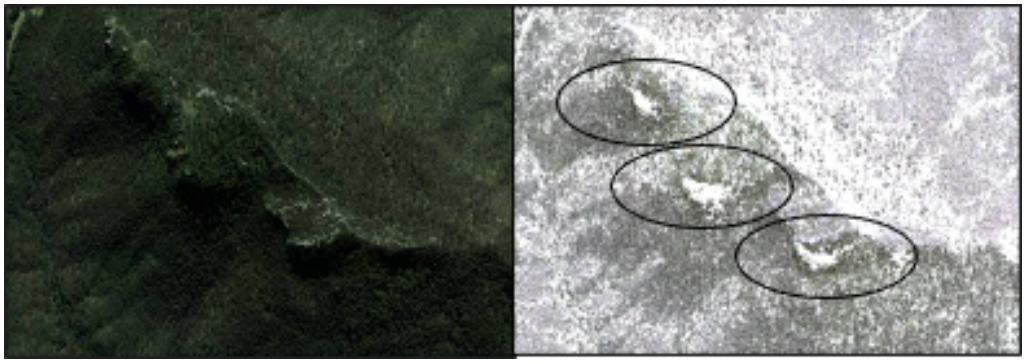
Where the terrain slope is such that pixel matching is not possible, data voids will occur as seen in image below, which is further complicated by vegetation.



*Data voids on steep slopes*

### 5.1.5. Anomaly: Shadows

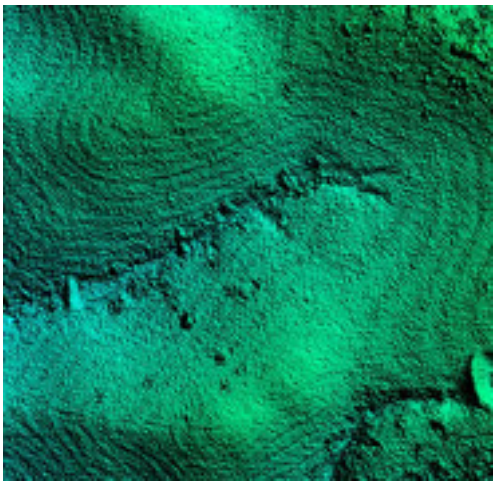
Photogrammetry is such that where there is shadow amongst the terrain, data voids may occur.



*Data voids in shadows*

### 5.1.6. Anomaly: Systematic Noise on Sloping Ground

Currently the XPro DSM processing introduces a systematic contouring anomaly on sloping ground. Although this can be considered as part of the noise within the accuracy expectations it is never the less systematic and may have an effect on the final DEM.



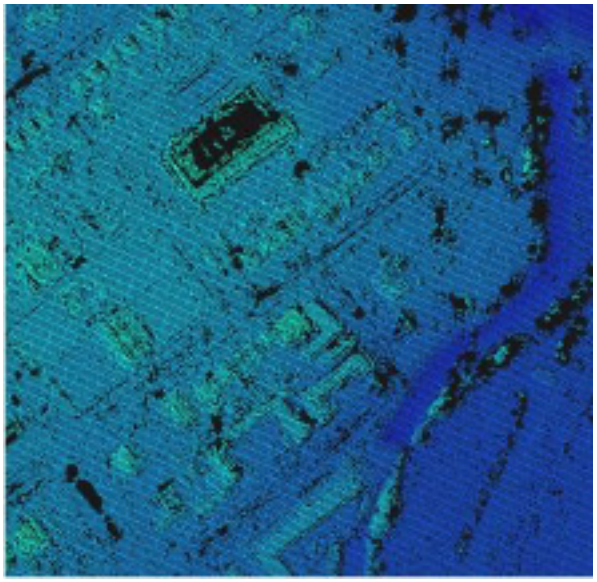
*Systematic contouring effect image*

# 6. Appendix B

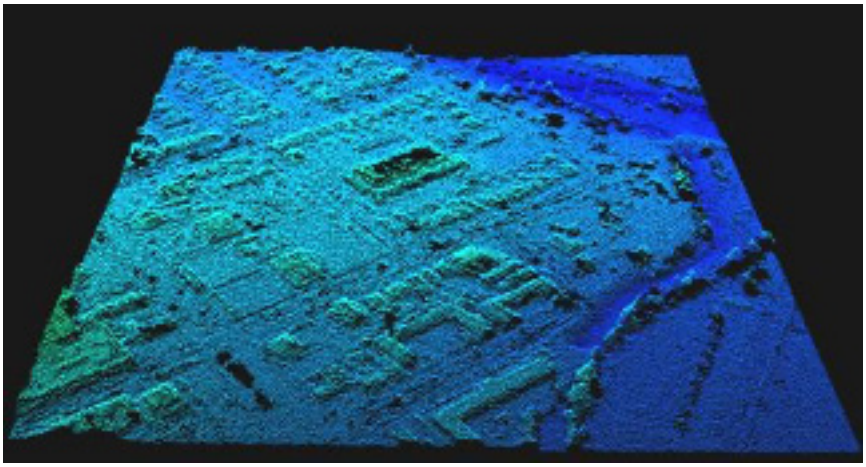
## 6.1. Product Samples

These visualisations were created using FugroViewer software and data generated from 50cm GSD imagery.

### 6.1.1. Unclassified Point Cloud



*2D visualisation of unclassified point cloud*



*3D visualisation of unclassified point cloud*

### 6.1.2. Unclassified Point Cloud Displayed by RGB Values

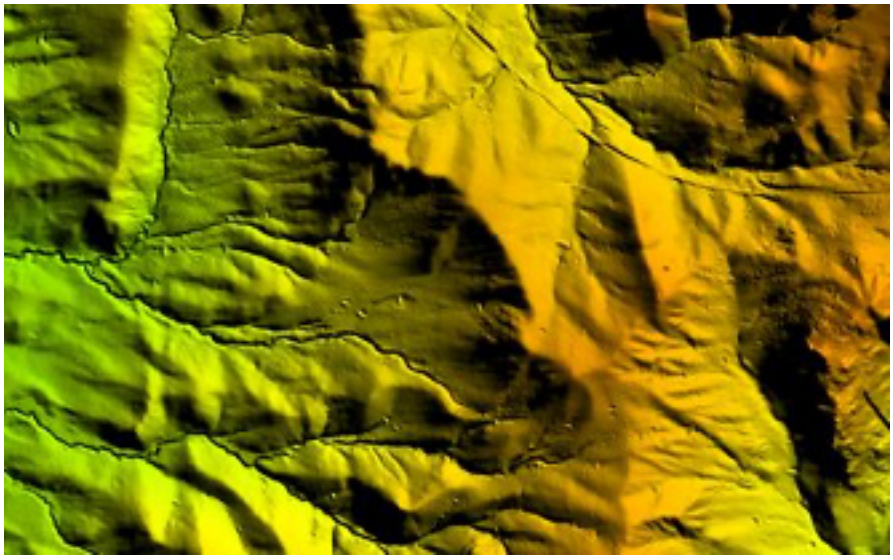
Classification flags are used to indicate special characteristics associated with the point. The bit definitions are:

*2D visualisation of unclassified point cloud displayed by RGB values*

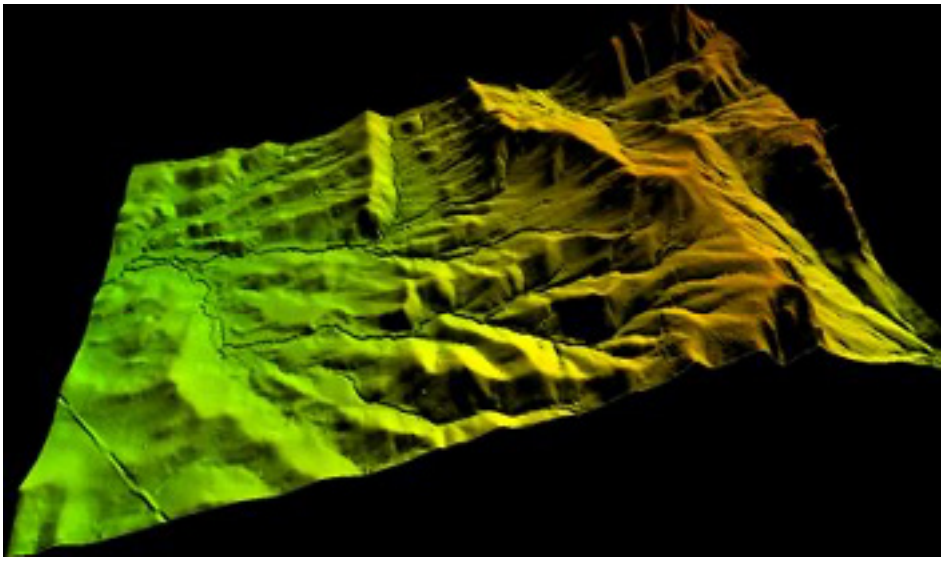
*3D visualisation of unclassified point cloud displayed by RGB values*

### 6.1.3. Digital Elevation Model Data

This visualisation was created using the Global Mapper software package.



*2D visualisation of DEM data*



*3D visualisation of DEM data*

# 7. Appendix C

## 7.1. Glossary of Terms

Definitions are taken from ICSM National Elevation Guidelines where possible. Asterisk (*) indicates that the definition is derived from alternate sources.

| 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 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 DEMs. 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 |
| **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 |
| **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 |
| **Elevation** | Height above a specific vertical reference datum |
| **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 1994 |
| **Ground Sampling Distance (GSD)** | Ground Sampling Distance is a term used to describe the pixel size of an image eg. 50cm GSD |

| | |
|---|---|
| **Hydrological/drainage enforcement** | The removal of elevations from the tops of selected drainage structures (bridges and culverts) in a DEM, Triangular Irregular Networks 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 |
| **LAS** | LAS is 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. See full description at www/lasformat.org/ |
| | 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) |
| **Light Detection and Ranging (LiDAR)** | LiDAR is 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 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 |
| **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 |