Asset and Geospatial Information Branch
Survey and Mapping Section

Mobile Laser Scanning Standard D14#152062

D14#152062 **Revision 66**
May 2026

Contents

Document Control

Owner	Survey and Mapping Manager
Custodian	Senior Engineering Surveyor
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Amendments

Revision Number	Revision Date	Description of Key Changes	Section / Page No.
30	March 2018	Initial Release	All
36	July 2019	Review, revisions.	All
46	Dec 2020	Added “3.3.1 NETWORK ADJUSTMENT CHECK OF MLS BASE STATIONS”	3.3.1
48	Dec 2020	Check and amend all hyperlinks, other minor edits, change “2.1 ENTRY ONTO LAND / QUERIES FROM THE PUBLIC”	All
50	Jun 2021	File naming convention clarification. Addition of tile numbers.	21
51	Feb 2022	Removed .las as delivery option – must be .laz	Sect 4.1
53	June 2022	Update for defining Concept and Asset Grade MLS survey, revised structure, other minor amendments	All
54	July 2022	Update to wording for supply of imagery & point cloud, update to LAZ 1.4, revised structure, other minor amendments.	All
57	September 2022	Update to document wording and requirements.	Sections 3.4.1, 7, 10.2 & 11.3
58	August 2023	Specified requirement for index file for point cloud to be “alignment-based”.	10.1.8
62	16 August 2023	Amended Safety Requirements	Section 2.3
63	July 2025	Amended incorrect wording in 3.3.1 regarding datum transformation	Sect 3.3.1
64	November 2025	Change laz 10.1.6 Point Number Limits to 3Gb *AND* 100M points	Sect 10.1.6
65	December 2025	Various changes regarding Asset Grade. Equipment section added with min requirements. Lat / long GDA2020/ellipsoidal as Asset Grade deliverable.	Various
66	May 2026	Remove General Requirements	

1 INTRODUCTION

The purpose of this document is to establish Main Roads WA requirements for delivery of mobile laser scan surveys.

1.1 SCOPE

This document will apply to all work related to mobile laser scanning that is procured by Main Roads WA.

Advice and further information on this delivery document can be obtained by contacting the Survey and Mapping Manager, Survey and Mapping section, Main Roads WA (Phone 138 138) or surveying@mainroads.wa.gov.au.

1.2 OWNERSHIP OF DATA

All materials and information as part of undertaking projects for Main Roads WA shall become the property of Main Roads WA. It shall not be used, copied or reproduced for any other purpose without the prior written approval by Main Roads WA.

1.3 REFERENCES AND RELATED DOCUMENTS

Document Number	Description
D12#434824	67-08-43 “Digital Ground Survey” Standard
D17#301448	Survey Report, MRWA template
D17#307405	Feature Codes, Digital Ground Surveys
D22#371770	MRWA “Geodetic Control Survey” Standard
D14#152062	MRWA Standard “D14#152062 Mobile Laser Scanning”
D15#321963	MRWA Standard “D15#321963 Survey Metadata Standard"
N.A.	MRWA Metadata Statement Form – Detail Ground Surveys
N.A.	MRWA Metadata Statement Form – Point Cloud
N.A.	MRWA Metadata Statement Forms – Underground Utilities
N.A.	MRWA Guideline “Digital Ground Surveys”
N.A.	MRWA Guideline “Data Lodgement”
D18#554805	67-08-121 "Underground Utilities Survey Standard"
D15#224538	MRWA Aerial LiDAR Data Delivery Document
	Landgate Standards and Guidelines
	Land Administration Act 1997

Main Road survey standards, guidelines and documents can be found by searching on the www.mainroads.wa.gov.au website.

1.4 DEFINITIONS

The following terms used in this procedure have the specific meanings indicated:

Term	Definition
AHD	Australian Height Datum.
Asset Grade MLS	A mobile scan point cloud capture and model that is positioned only based on GNSS position, post-processed from base stations (placed or CORS), VRS or Satellite-base correction services – no MLS Ground Targets used/processed. MLS verification survey is not required.
BM	Landgate survey control mark - Bench Mark
Contractor	The party named in the contract to perform the Services
Contract Manager	The Main Roads WA individual who has a responsibility to provide a specific service through a contract for the Project Manager.
Design Grade MLS	A mobile scan point cloud model that is positioned to levelled MLS Ground Targets, and MLS verification survey undertaken.
DGS	MRWA 67-08-43 "Digital Ground Survey" Standard
DTM	Digital Terrain Model – Digital 3D model of the terrain surface
GNSS	Global Navigation Satellite Systems
Local Project Zone	A local transverse Mercator projected coordinate system created by Main Roads WA to meet tolerances for building roads and bridges on the earths curved surface.
MCP	Minor Control Mark.
MLS	Mobile Laser Scan. A point cloud generated from a survey grade laser scanner attached to a moving vehicle.
MRWA	Main Roads Western Australia
MVCM	MRWA Minor Vertical Control Mark
PDOP	Positional (3D) dilution of precision value for navigation satellite geometry
Project Manager	The Main Roads WA individual that is responsible for the overall road project.
RRM	Road Reference Mark. A Main Roads WA survey control mark.
SSM	Standard Survey Mark. A Landgate survey control mark.
Survey Control	Survey control points that can consist of SSMs, RRMs, BMs and MCPs
Survey Portal	A web application within the Main Roads Western Australia web site that contains information on MRWA's local project zones, road reference marks and outlines of existing project survey areas.
TIN	Triangulated irregular network (Delaunay triangulation)
TLS	Terrestrial Laser Scan. A point cloud generated from a fixed point laser scanner

Concept Grade MLS	A mobile scan point cloud capture and model that is positioned only based on GNSS position, post-processed from base stations – no MLS Ground Targets used/processed. MLS verification survey is required.
Verified Control	Located and checked for physical stability and quality Verified vertical/level to its reference marks where applicable, or levelled to at least one adjacent control point of suitable quality in a closed/2-way loop Static GNSS baseline, RTK GNSS, or total station connection (from RTK temporary points is acceptable) for horizontal verification to adjacent/nearby control point(s).
VCM	MRWA Vertical Control Mark
VRS	Virtual Reference Station

2 MOBILE LASER SCAN SURVEYS

Main Roads WA requires mobile laser scan surveys to be of quality, accuracy, and formats as defined herein.

2.1 EQUIPEMENT

All MLS equipment is to be maintained in good condition and calibrated in accordance with the manufacturer's requirements.

As a minimum, the specifications of the equipment shall meet or exceed the below:

LiDAR Accuracy / Precision	5mm
GNSS Absolute Accuracy	50mm
IMU Requirements	Roll/Pitch 0.01°, Heading 0.02°
Scan Heads	Dual-scanner system
Camera	60 MP

2.2 SURVEY TYPES

This document defines different requirements for three classes of mobile laser scan surveys – **Design Grade, Concept Grade (formerly "Untargeted" + validation points)** and **Asset Grade**.

2.2.1 DESIGN GRADE

For **Design Grade** MLS surveys, the contractor must ensure that the resulting point cloud is of suitable accuracy and quality to meet Main Roads WA requirements of 67-08-43 "Digital Ground Survey" Standard for extracted/modelled features.

MLS Ground Targets are required.

Validation points are required as per the "Survey Verification" section of this document.

2.2.2 CONCEPT GRADE (FORMERLY UNTARGETED + VALIDATION POINTS)

Concept Grade MLS surveys result in a point cloud with position based on GNSS and other sensors, post-processed from local base stations.

MLS Ground Targets are not required.

Validation points are required as per the "Survey Verification" section of this document.

2.2.3 ASSET GRADE

Asset Grade MLS surveys result in a point cloud with position based on GNSS and other sensors, post processed from local base stations or virtual base stations. Despite the relaxation of these requirements, it is imperative that the Asset Grade data adheres to the MLS Flight Comparison requirements as detailed in 11.3 (50mm).

Asset Grade MLS surveys are primarily used to extract and code AusRAP features for safety star rating assessments. Additional use cases are being explored and implemented, so the data provided should, as far as practicable, meet a quality standard comparable to Concept and Design Grade MLS.

MLS Ground Targets and validation points are not required.

2.3 SURVEY EXTENTS

The project survey extents will be defined geographically by Main Roads WA.

Where a 67-08-43 “Digital Ground Survey” Standard model is defined as the required output, the final model must be comprehensive and complete for the survey extents. This will typically require supplementary survey via other appropriate methods to infill areas or features that cannot or are not suitably modelled from the MLS.

For MLS surveys defined as “Concept Grade” and "Asset Grade", survey extents will generally be defined only by longitudinal extents.

2.4 COORDINATE SYSTEM / PROJECT ZONE / SURVEY DATUM

2.4.1 DESIGN GRADE AND CONCEPT GRADE

Digital Ground Survey models are to be supplied in the Main Roads WA Project Zone coordinate system.

The correct/appropriate zone should be specified in the request for survey.

Where more than one zone may appear applicable, the most appropriate zone is to be defined by the MRWA Senior Geodetic Surveyor or Surveying & Mapping specialist.

Where a project spans multiple zones, the areas for each zone are to be clearly defined.

Project zone parameters are available online via the Main Roads WA online Surveying GIS web-page known as "Survey Portal".

Or from the Senior Geodetic Surveyor (Ph: 138 138).
surveying@mainroads.wa.gov.au

Heights are to be relative to the Australian Height Datum (AHD).

To derive AHD height from GNSS, the following geoid models must be used:

- AUSGeoid09 for GDA94 datum surveys,
- AUSGeoid2020 for GDA2020 datum surveys

AUSGeoid models are available from the Geoscience Australia website (http://www.ga.gov.au). ***Transformation between datums must not be carried out without first consulting with the Main Roads WA Senior Geodetic Surveyor.***

The Project zone, height datum and Geoid model used must be specified on the metadata statement.

2.4.2 ASSET GRADE

Unless otherwise specified, point cloud supplied for **Asset Grade** MLS surveys is to in GDA2020 coordinate system (latitude, longitude & ellipsoid height).

2.5 GNSS BASE STATIONS FOR MLS

When more than one base station is used for MLS capture/processing, static GNSS sessions must be captured to result in connected baselines/network throughout the project area.

A minimally constrained Least Squares Adjustment of the control used for MLS base stations must be performed to check consistency. The constraint should utilise the mark with the lowest PU and at least 12RootK AHD as the singular fixed point.

Where this adjustment identifies discrepancies in published Easting/Northing control position greater than 30mm, Main Roads WA Survey Manager or Senior Geodetic Surveyor must be consulted.

2.5.1 DESIGN GRADE AND CONCEPT GRADE

Existing control points with the best available positional uncertainty and suitable sky visibility are to be used as base stations.

All GNSS base stations used for processing the MLS must be defined in the survey report, including the adopted coordinates, if applicable.

Control used as local base stations must be “Verified”:

In this context, “Verified” control means the control point is:

- Located and checked for physical stability from its reference marks
- Any damage or disturbance to be documented.
- Where no reference marks exist for the control point a Static GNSS baseline, total station or differential levelling connection to adjacent control points can be used to verify the selected control mark. RTK GNSS can only be used for validations of Concept Grade MLS survey control.

The following apply for **Design Grade** and **Concept Grade** MLS surveys.

> Existing control points with the best available positional uncertainty and suitable sky visibility are to be used as base stations.
>
> Range from base station to captured point cloud must not exceed 10km.
>
> Virtual Reference Station (VRS) positions/systems and Virtual Base Stations must not be used.

2.5.2 ASSET GRADE

If local base stations are utilised, baseline length must not exceed 30km.

If VRS, virtual base stations or satellite based correction services are utilised, details of the service must be included in the survey report, including estimated position accuracies.

3 DESIGN GRADE MLS

Design Grade MLS must comply with the following control requirements.

3.1.1 EXISTING SURVEY CONTROL

All other existing control within or adjacent to the survey extents must be sought on site, and details noted in the "Survey Report".

Details are to include:

- Physical condition (Good / Poor / Destroyed)
- GNSS suitability with respect to physical obstructions to satellite signal (Good / Poor).

3.1.2 VERTICAL CONTROL NETWORK

A differential level traverse is to be undertaken for the extents of the survey area and must include all existing control within or adjacent to the survey extents and all newly created control. Control outside the extents of the survey area that must be included in level network will be specified in project scope.

This requirement may be waived for freeways and major highways, as directed by the survey project manager and defined in the survey project scope.

Differential levelling is to be in accordance with the differential levelling section of MRWA "Geodetic Control Survey" Standard, with the exception that two-way levelling is not required, provided the levelling run closes to better than 12rootK against existing verified control.

Aluminium staves must not be used.

Any new control required or stipulated in survey scope/request is to be established in accordance with the relevant Main Roads WA standards.

3.1.3 MLS SURVEY CONTROL

3.1.3.1 MLS Survey Control Marks

An RRM, SSM with levelled height, or benchmark upgraded with RRM quality XY position is to exist throughout the survey extents at no more than 4km intervals. New RRM control must be constructed in accordance with Main Roads WA Standard "Geodetic Control Survey"

A description of control survey methodology, vertically and horizontally, must be presented in the survey report. Any issues are to be documented.

The Main Roads WA Senior Geodetic Surveyor can be contacted for advice on:

- Additional work relating to control outside the immediate scope of work.
- The quality and consistency of the existing survey control in and around the project area.
- Supply of new Road Reference Mark (RRM) numbers, plaques (for built up areas) and witness plates for the establishment of new control points.
- The principles to establishing new Road Reference Marks in the field if required.

3.1.3.2 Vertical Control Marks (VCM)

Vertical control marks are to be established at no more than **1200m** interval. VCMs must be constructed as per the Main Roads WA RRM requirements, (MRWA "Geodetic Control Survey" Standard) with the exception that reference marks are not required. The following requirements apply:

- Specific naming for new marks must be used, as allocated by Main Roads WA
- VCMs are to be established on site a minimum of 15 metres (preferably >25 metres) from the existing centreline.
- Approximate XY position required ~10m accuracy is acceptable (eg float GNSS position, or smartphone GNSS location…). Vertical accuracy is to be in accordance with the differential levelling section of MRWA "Geodetic Control Survey" Standard
- VCM specific blue witness plate on star iron picket **is** required, **or** a pair of stakes/fence droppers may be used (available from Main Roads WA)
- Summary sheets or diagrams are **not** required
- Name, coordinates, description of type of mark and location description/measurements must be reported and delivered in comma-delimited csv, and in survey report.

3.1.3.3 Minor Vertical Control Marks (MVCM)

Minor Vertical Control Marks must be established with no more than 400m spacing along the MLS survey extent and must be included in the level traverse.

Any existing control point (being SSM, BM, RRM or MCP) that is suitably spaced removes the requirement for an MVCM.

Examples for the physical mark established for MVCM's are:

- Star iron picket, with or without concrete
- Steel spike, Cooke's nail (set in bitumen where possible)
- Nail and plate
- Ramset nail in concrete

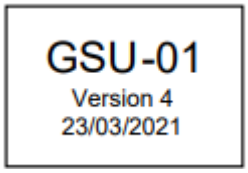
The following requirements apply:

- Approximate XY position required ~10m accuracy acceptable. (eg float GNSS position, or smartphone GNSS location…) Vertical accuracy is to be in accordance with the differential levelling section of MRWA "Geodetic Control Survey" Standard
- Name, coordinates, description of type of mark and location description/measurements must be reported and delivered in comma-delimited csv, and in survey report.
- Specific naming for new marks must be used, as allocated by Main Roads WA

3.1.4 STATIC GNSS AND LEVELLING SURVEY DATA

3.1.4.1 Static GNSS

Static GNSS data at base stations is to be logged/recorded in accordance with Landgate Guideline for GNSS Geodetic Surveys, with the exceptions/variations below. Static GNSS data must be lodged to Main Roads WA as part of the deliverables, **with the following exceptions/variations** (these refer to Landgate's document version:



- **2.6** - Do not need to repair or replace damaged reference marks (RM)
- **3.8** - Specific log sheets etc not required, as long as other details and records are met/supplied (in Main Roads WA survey report or other lodgement)
- **6.3** - Use coordinate values/datum as stipulated by MAIN ROADS WA (Contractor to request if required)
- **7** - Network adjustment is to be least squares, constrained to existing RRM/Landgate based values
- **8** - Use data formats/naming from MAIN ROADS WA standards as first preference, and revert to Landgate when there is no specific MAIN ROADS WA definition.
- **9** – Generate and provide documentation as per MAIN ROADS WA requirements

NB - Antenna heights: Record and Provide details and images/photos as per Landgate Standard, section **3.7 & 8.3/Appendix D, E & F**.

3.1.4.2 Levelling

In the case of **Design Grade** MLS, where levelling of the site is included, raw digital level data file(s) and ASCII file of digital level data is to be lodged with deliverables.

The level Instrument and staff make/model/type is to be noted in the survey report.

Levelling to be in accordance with the relevant sections of MRWA "Geodetic Control Survey" Standard

3.1.5 SURVEY CONTROL TABLE / FILE

A list of all survey control must be included within the survey report and lodged as a .csv/excel spreadsheet. At a minimum this must contain coordinates, description of the type of mark, physical condition (Good / Poor / Destroyed / New) and GNSS sky visibility/suitability. (Good / Poor)

All SSMs, BMs, RRMs, VCM'S, MVCM's, MLS ground target points and MLS verification survey/validation points must be included.

3.1.6 MLS GROUND TARGETS REQUIREMENTS

Control and ground targets used to tie down/register the MLS survey will be at the discretion of the consultant. The amount/spacing of MLS control targets may differ depending on the consultant's equipment and methodology.

The MLS ground target spacing proposed by the consultant must be documented within the consultant's offer.

Consultant must ensure that the quality and distribution of MLS ground targets is sufficient to produce a point cloud of suitable accuracy for any area where relevant features would be extracted for DGS GenIO modelling in accordance with 67-08-43 Digital Ground Survey Standard.

Main Roads WA may prescribe a specific MLS ground target density interval in the project scope.

3.1.7 MLS GROUND TARGETS AND THE WORKSITE

MLS ground targets or other control marks ***must not be permanently marked or painted on roads or paths.***

MLS ground targets must be kept to a minimum in size. MLS ground target locations can be in the shoulder of the road, located within line markings or within the centreline of the road. Use of existing features or objects already on site is encouraged.

Due care must be taken to ensure that any material or substances used for targeting will not damage the road, environment or cause any harm to humans, animals or machinery.

Survey points such as coordinated nails flush with the surface, deck spikes flush with the surface and buried pins may be retained but all target material and fastenings (i.e. plastic, paper, pins, wire, nails etc) must be removed from the site as soon as possible after scanning and before the completion of the project.

4 CONCEPT GRADE MLS

Concept Grade MLS surveys result in a point cloud with position based on GNSS only, post-processed from local base stations. Requirements are the same as **Design Grade** MLS, with the following exceptions/difference:

- Existing control within or adjacent to the survey extents does not need to be sought
- Differential level traverse for extents of the survey area is not required
- 4km interval control is not required
- VCMs and MVCMs are not required

  Required:
- Validation points are required as per the "Survey Verification" section of this document.

5 ASSET GRADE MLS

Asset Grade MLS survey requirements are the same as **Concept Grade** MLS surveys, with the following exceptions/difference:

- Virtual base stations, VRS or Satellite Based correction services may be used in place of local base stations
- Multiple run requirements as per below / "Multiple Run Requirements" section of this document:
    - 1 pass in each lane on carriageways with 1 lane in each direction
    - 1 pass in outside lanes on carriageways with 2 or more lanes in the same direction

  Not Required:
    - Validation points are not required.

6 MULTIPLE RUN REQUIREMENTS

Multiple runs of mobile laser scanning over the project area or site are required.

6.1 DESIGN GRADE AND CONCEPT GRADE

For **Design Grade** and **Concept Grade** MLS Main Roads WA requires the project area, site or road surface must be scanned a minimum of three separate times. On carriageways with 2 or more lanes, runs must by driven in the two outside lanes of each carriageway.

6.2 ASSET GRADE

For **Asset Grade** MLS, multiple run requirements are:

- 1 pass in each lane on carriageways/roads with 1 lane in each direction
- On carriageways with 2 or more lanes, runs must by driven in the two outside lanes of each carriageway, as shown by the green and yellow arrows in the above image

7 REPORTING, EQUIPMENT DETAILS AND QUALITY ASSURANCE

The “Equipment used” section of the D17#301448 Survey Report Template is to contain the following information at a minimum:

- Scanner model name and number
- Scanner range
- Scanner frequency
- Capture height above ground
- Software used and details or documentation of ground classification methodology

The following Quality Assurance information must be supplied

- Boresight calibration report
- Graph of X Y Z RMS values vs GPS time based on processed GNSS IMU trajectories.
- Graph of PDOP vs GPS time
- A graph of GPS time vs the base line lengths over the project area.

8 ENVIRONMENTAL CONDITIONS FOR DATA CAPTURE

Main Roads WA requires that all MLS surveys are carried out with consideration and mitigation of the following environmental factors:

- Road surfaces to be dry, or as dry as possible at time of scanning
- Avoid scanning in high heat, significant dust or rain
- Asset-Grade capture is to avoid scanning early morning or evenings (sunrise/sunset).

Timing of scanning is to be considered to reduce undesirable physical obstructions captured in the point cloud (e.g. traffic)

9 DATA SUPPLY REQUIREMENTS

9.1 POINT CLOUD

Design Grade MLS point clouds must be processed to be suitable to meet Main Roads WA 67-08-43 Digital Ground Survey Standard extraction/modelling accuracy and quality specifications.

Point clouds must conform to the following requirements.

9.1.1 FILE FORMAT AND NAMING

The point cloud data must be supplied in **.laz** file format, version 1.4.

Filenames must not contain spaces. (Use underscore "_" instead)

9.1.2 COORDINATE DECIMAL PLACES

9.1.2.1 Design and Concept Grade

Coordinates within the lodged .laz files must be **3** decimal places.

9.1.2.2 Asset Grade

Coordinates within the lodged .laz files in lat/long coordinates must be **8** decimal places.

9.1.3 RGB COLOUR

RGB colour point cloud is not required for **Design Grade** and **Concept Grade** MLS surveys unless specified in the project scope.

RGB colour point cloud **is** required for **Asset Grade** MLS surveys.

9.1.4 REQUIRED POINT CLOUD ATTRIBUTES

As a minimum for all MLS surveys, the following attributes are required within the delivered point cloud data.

- Flightline/run number
- Intensity
- Return number
- Number of returns
- GPS time
- Scan angle

9.1.5 CLASSIFICATION

As a minimum, the point cloud must be classified into ground and non-ground points.

9.1.6 POINT NUMBER LIMITS

For MLS surveys, lodged point clouds must be tiled into separate files that must not exceed 100 million points and 3 GB.

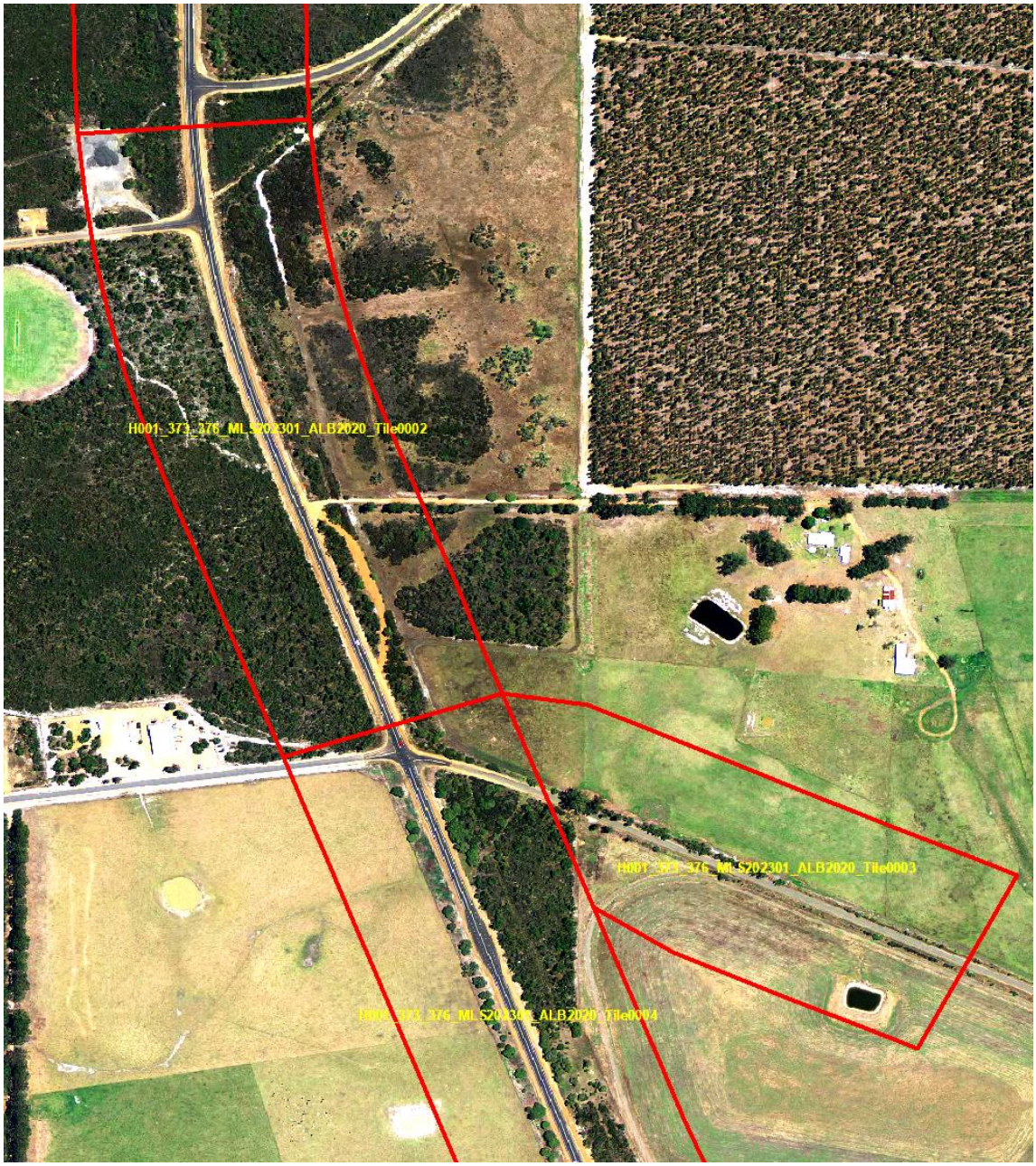
9.1.7 MERGED RUNS

Lodged point clouds are to be of all runs merged.

9.1.8 INDEX FILE FOR POINT CLOUD TILES

A coordinated index file of the point cloud tile extents must be supplied in .dxf format. The index file must reference the lodged point cloud filenames and use the same coordinate system/project zone.

The tiles and index file must be in an alignment-based arrangement. Refer to example image below.



9.2 IMAGERY

360º imagery captured at the same time as point cloud is required as a deliverable for all MLS surveys, unless stated otherwise in the request for survey.

Imagery must meet the following criteria:

- Captured at a maximum of 10m spacing, unless specified otherwise
- Georeferenced to enable viewing in a spatially correct position and orientation
- Calibrated to reliably align with corresponding point cloud
- Minimum resolution of 24MP per image
- Be free of blurring and/or distortion due to water on lenses etc
- JPEG format
- Supplied with a CSV file with imagery naming, location and positioning information

- Information on date and time of capture to be included in Point Cloud metadata statement

Imagery shall be supplied on a per lane basis, i.e. where a lane has multiple passes, imagery from only one of the passes is required. All images to be contained in a single zip file with naming as per below Section 13 of this document.

Each image is to have a unique filename, cross referenced to the supplied CSV.

10 SURVEY VERIFICATION

10.1 VALIDATION POINTS

Validation points are to be established in cross-section (minimum 3 points) on the sealed road surface at the intervals detailed below, for the extents of survey.

Design Grade – 350m intervals
Concept Grade – 5km intervals, or 2 sites if <5km
Asset Grade – not required

Additional validation points are to be obtained in areas with sub-optimal satellite sky visibility.

These validation points must **not** be used as part of the MLS adjustment, and must be more than 50m in distance from any control points or sites used or constrained in the MLS registration or adjustment.

Validation points must be captured in the field and must not be included or used in the processing or generation of any other project deliverables.

Validation points must have height that is spirit levelled, or by total station from spirit levelled control. They must be horizontally positioned to +/-30mm horizontal accuracy.

The vertical component of validation points is to be compared against the adjusted MLS point cloud. Height difference is to be reported.

Validation points are to be lodged as a comma-delimited text file, with XYZ coordinates, and description of type/feature.

The Survey report is to include reporting/comparison of validation points vs final point cloud and include list/table of verification point coordinates. Include details of the control points upon which the validation points were based/connected.

10.2 Statistical Analysis

The verification survey data and the MLS Point Cloud data are to be statistically analysed.

The minimum statistics to be included in the survey report are:

- Number of validation points
- Mean
- Standard Deviation
- Range
- Maximum Residual Value

10.3 MLS FLIGHTLINE COMPARISON

Mobile mapping data captured in individual passes along a corridor are termed 'flightlines', or 'runs', with the point cloud and imagery generated from an individual flightline referenced to the unique flightline number. Lodged point clouds are to be of all flightlines merged.

Alignment deviations between flightlines should not exceed the values for each type of survey shown below.

Survey Type	Horizontal (mm)	Vertical (mm)
Design Grade	20	10
Concept Grade	20	10
Asset Grade	50	50

11 LODGED INFORMATION / DELIVERABLES

Deliverables must be lodged to the nominated Main Roads WA officer **and** via surveying@mainroads.wa.gov.au. Asset Grade MLS can be uploaded directly to the Network Lidar Portal.

The Main Roads WA officer/project manager in receipt of survey data must deliver all the information to the Main Roads WA Asset and Geospatial Data Manager or Senior Spatial Analyst (Engineering).

The following items must be lodged:

- MLS point cloud data set(s) in **.laz** format, version 1.4, as defined in this document.
- Survey report, with contents as defined within this document, and based on document template D17#301448 Survey Report Template
- Verification survey data; Validation points are to be lodged as a comma-delimited text file, with XYZ coordinates and description.
- A statistical analysis of the verification survey compared to the MLS data, as per 10.2
- Metadata statement in accordance with D15#321963 "Survey Metadata Standard",
- Using pdf template form D15#329516 Metadata Statement Form - Point Cloud
- Index file for point cloud tiles; dxf format.
- Details of survey control as defined in 0
- Geodetic outputs in accordance with Landgate Guideline for GNSS Geodetic Surveys with the exceptions as specified in section "STATIC GNSS AND LEVELLING SURVEY DATA"
- 360º Imagery, as per "Imagery" section of this document.

12 FILE NAMING CONVENTION

Lodged .laz files, metadata, verification and report must comply with the following naming convention.

Road number_SLK Range_Descriptor_Zone_Tile Number*.ext*

Where;

Road number is the number associated with the Main Road or the local road. The Main Roads WA number must start with an H or M letter and have 4 characters (example H001). A local road number will consist of 7 digits. (Example 2080024)

SLK Range is the start and end SLKs for the entire survey;

Descriptor must be one of the following.

"MLSYYYYMM" point cloud data; .laz format, year and month descriptor;
"MLSYYYYMM" imagery data; .zip format, year and month descriptor;
"MLSVER" the verification survey, validation points; .txt/.csv
"MLSMTD" Metadata, .pdf;
"MLSREP" Survey Report, .pdf/.doc/.docx;
"MLSINDEX" MLS tile index, .dxf;

Zone is the Project Zone / coordinate system and must reference 94 or 20.

Tile Number is to start at 0001 and ascend.

.ext is the file type extension.

.csv / .txt or comma-delimited validation point coordinate file.
.pdf for metadata, in accordance with MRWA metadata requirements and template format
.doc / .docx / .pdf for survey report – "Word" or portable document format (pdf)
.dxf for point cloud .laz index file
.***laz*** point cloud format.