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ARTC Mobile Laser Scanning (MLS) Guideline

AMT-GL-103

Applicability

ARTC Network Wide

Publication Requirement

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EGH-11-01

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1.0	08 Jan 2025	LRS Lead	Manager Asset Management Systems	Manager Asset Development	General Manager Asset Services 12/06/2025

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	08 Jan 2025		Issued for Consultation as EGH-11-01 21 May 2019 but never published. Renumbered as AMT-GL-103. New Issue. Updated to GDA2020 Updated to include Xerra Platform Requirements Updated with lessons learnt from Asset Capture Projects

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this document is to establish ARTC requirements for the recording and delivery of mobile laser scan survey services and derived products including asset database and LiDAR data.

This output specified by this document is not suitable for Detailed Design work and a relevant document should be consulted.

ARTC requires accurate track centreline and asset feature data of the network for use by a number of ARTC projects and/or systems including ANCO, Inland Rail (IR), ATMS, Ellipse and the AK Car.

This document provides guidance on the minimum requirements for the capture of track data and the output formats required when engaging contractors to undertake this work.

1.2 Scope

This document will apply to all work related to mobile laser scanning (MLS) that is produced or procured by ARTC. This document does not preclude the use of equivalent performing technologies but rather details the requirements if MLS technologies are utilised.

This document currently applies to ARTC's infrastructure assets as follows;

- The entire ARTC Network
- All Track & Civil, Structures, Signals and Wayside assets

This document currently excludes the following components of ARTC's infrastructure assets;

- Definition and capture of Operation specific locations to align with ARTC Operations systems

This document applies to the following aspects of Mobile Laser Scanning (MLS) utilising Light Detection and Ranging (LiDAR):

- Road and Rail Vehicle mounted MLS (i.e. Hi-Rail, Locomotive);
- Accuracies and sample rates of data capture;
- Performance requirements of Centreline data (detailed information in AMT-GL-102);
- Assets features to be captured (detailed information in AMT-SP-101);
- Data formats and outputs;

This document excludes the following aspects of Mobile Laser Scanning:

- Aerial Mobile Laser Scanning (MLS)

Note: While this document aims to identify ARTC's requirements some systems or project may have additional requirements beyond this guideline. It is important that prior to engaging a contractor to undertake Mobile Laser Scanning works, the Project Manager speak with representatives from the business for each affected project or system to determine if these additional requirements apply.

The current key contacts for ARTC projects requiring MLS Data are as follows:

- Safety and Systems: AMS GIS Specialist
- Operations: Development Manager HV
- Inland Rail: Digital Engineering and Systems Manager, Inland Rail

1.3 Document Owner

The AMS Asset Management Systems Manager is the Document Owner and is the initial point of contact for all queries relating to this document.

Advice and further information on the delivery of this document can be obtained by contacting AMS GIS Specialist, Safety and Systems, ARTC.

1.4 Responsibilities

It is the responsibility of ARTC personnel managing Mobile Laser Scanning works to ensure all Scopes of Work meet the minimum requirements specified in this document. ARTC MLS Project Managers must ensure they communicate with representatives responsible for ARTC's systems and projects that rely on accurate Track Data Information, to ensure all required outputs meet ARTC's requirements and are provided in a timely manner following Mobile Laser Survey works.

Key systems include but are not limited to:

- Enterprise Asset Management System (Ellipse)
- ARTC Enterprise GIS System (ESRI ArcGIS)
- Electronic Track Worker – ETap
- Decision Support Platform – DSP

1.5 Reference Documents

This procedure supports the following documents and systems:

- ARTC Safety Management System (SMS)
- EGP-03-01 Rail Network Configuration Management
- EGP-20-01 Project Management
- EGW-20-01 Managing Complex Projects
- EGW-20-02 Managing Simple Projects

The following documents support this document:

- AMT-SP-101 Technical Specification for Field Data Collection
- AMT-GL-102 ARTC Centreline Guideline

The following templates support this document:

- AMT-FM-103 LiDAR Metadata Template
- AMT-FM-104 Imagery Metadata Template
- AMT-FM-101 Field Data Collection Geodatabase (GDB) Template

1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
AHD	The Australian Height Datum (AHD71) is the official national vertical datum for Australia. Note: Heights from GNSS are derived from ellipsoidal height values with the geoid-ellipsoid separation applied and are therefore not strictly AHD71.
AK Car	ARTC's automated track geometry recording vehicle
AMIP	Asset Management Improvement Project
AMS	Asset Management Systems
ANCO	ARTC Network Control Optimisation Project
ARTC	Australian Rail Track Corporation Ltd.
ArcGIS (ESRI ArcGIS)	ESRI's mapping and analytics platform used by ARTC. ArcGIS provides contextual tools for mapping and spatial reasoning.
ATMS	ARTC's Automated Train Management System Project
Attribute	Single component of a record. Similar to a database field.
CORS	Continuously Operating Reference Stations
Contractor	The party named in the contract to perform the Services
Contract Manager	The ARTC individual who has a responsibility to provide a specific service through a contract for the Project Manager.
Curve	Curve track are circular curve sections of track with approximately constant radius to allow the change in direction of train traffic.
Data Mine	The process of digitising information from the Project Pointcloud at a time after the capture of the Pointcloud, sometimes much later, when required by some other process than the one that caused the initial capture.
Design Grade MLS	A mobile scan point cloud model that is positioned to levelled MLS Ground Targets, and MLS verification survey undertaken.
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EAMS	Enterprise Asset Management System (Ellipse)
Ellipsoid	Mathematical representation of the Earth's surface

Term or acronym	Description
Ellipsoidal Height	Distance from the ellipsoid to a point of interest measured perpendicular to the ellipsoid
Feature Class	[ESRI software] In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads." In a geodatabase, feature classes can also store annotation and dimensions.
GDA94	The Geocentric Datum of Australia (GDA94) a historic geodetic datum and a coordinate reference system whose origin coincides with a determination of the centre of mass of the earth, hence the term ‘geocentric’. GDA94 is a ‘plate-fixed’ or ‘static’ coordinate datum based on the International Terrestrial Reference Frame 1992 (ITRF92)
GDA2020	The Geocentric Datum of Australia 2020 (GDA2020) is Australia's new national datum which replaces GDA94. GDA2020 is of higher-accuracy than GDA94, aligns more closely with GPS and GNSS positioning services and supports nationally consistent datasets, free of the known distortions of GDA94.
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
Geoid	The equipotential surface of the Earth’s gravity field which best fits mean sea level.
Geoid-Ellipsoid Separation	Distance from the surface of the ellipsoid used, to the surface of the geoid. It is measured along the normal to the ellipsoid. This separation is positive if the geoid is above the ellipsoid and negative if the geoid is below the ellipsoid.
GPS	Global Positioning System, a satellite-based navigation system
IMU	Inertial Measurement Unit
ISG	Integrated Survey Grid. A projection used in NSW only - ISG was introduced to minimise scale factor corrections (mainly in cadastral surveys). Coordinates are derived from the Australian Geodetic Datum 1966 (AGD66) Many of ARTCs existing survey marks and alignments still use this system however, new marks should be created in line with AS 7634 Railway Infrastructure Survey
LiDAR	Light Detection and Ranging
Location referenced Imagery	Imagery captured at the same time as the capture of the single Pointclouds and the principal point is encoded with the location.
MCPPC	Minimally Constrained Project Pointcloud - This is aligning and combining of individual Pointclouds from multiple passes to a best fit location without the aid of ground targets. The MCPPC is generally aligned to the Project Reference Frame (where utilised) using GNSS observations only and is represented as a singular Pointcloud with minimal feathering in position

Term or acronym	Description
	and height.
MGA	Map Grid of Australia, a mapping system based on the Universal Transverse Mercator coordinate system
MLS	Mobile Laser Scanning - A moving platform that collects Point clouds using Laser Scanner/s, GNSS instrument/s and other sensors which are combined and mounted on a constantly moving ground-based vehicle. Excludes “stop and go” Terrestrial Laser Scanning.
MLS Contractor	Mobile Laser Scanning Contractor
PDOP	Positional (3D) dilution of precision value for navigation satellite geometry
Pointcloud	Data collected by a Mobile Laser Scanner that has been adjusted for position from GNSS location and IMU corrections for each vehicle pass resulting in vertices with x, y, z coordinates and associated properties (eg intensity, RGB values). From a single pass only.
Project Manager	The ARTC individual that is responsible for the overall project.
Project Proposal	Document detailing project scope and specifications that may be used as part of an Invitation to Offer or Request for Quote.
Tangent	A section of straight track continuous between transition curves. ARTC defines these as sections of track with radius greater than 20000m.
TLS	Terrestrial laser scanning is a ground-based version of the airborne LIDAR frequently used for terrain and landscape mapping. Terrestrial laser scanners are a relatively recent development for high-resolution mapping. These scanners, originally developed for as-built modeling of architectural and engineering structures, can also be used for high-resolution mapping of terrain, vegetation, and other landscape features over limited distances in the range of 50–300 m.
Track Features	Assets and Associated Rail Features located within the Rail Corridor that require spatially locating
Transition	Transition, or transition curves, are a section of cubic parabola or a clothoid transition track from a tangent to a circular curve or between curves of similar flexure with no intervening straight (i.e. compound curves) which allows the ramping of superelevation from flat tangent track to the superelevation required for curving.
Untargeted MLS Point Cloud	A mobile scan point cloud capture and model that is positioned only based on GNSS and IMU position, post-processed from base stations – no MLS Ground Targets used/processed. MLS verification survey is not required.
Verified Control	Located and checked for physical stability and quality. Survey Control might be needed for 2 reasons (1) so that the supplier (or ARTC at a later data) can test the accuracy of its pointcloud or integrated pointcloud +imagery using verifiable targets within the MLS FOV, and (2) so that the absolute spatial accuracy of the pointcloud can be improved beyond that afforded by the recorded IMU + GNSS data. (s).

2 General

This guideline sets out the requirements for the following data capture options;

- Terrestrial or Mobile Laser Scanning
- Mobile Imagery Capture including spherical and discrete image capture

This guideline should also guide deliverables and performance requirements if other equivalent technologies can provide performance parity to the technologies above.

2.1 Standards and Guidance

The Service Provider must undertake the Services in accordance with the relevant Australian and ARTC Standards. As a minimum, the following standards must be complied with in the below order of precedence;

- AMT-SP-101 Technical Specification for Field Data Collection
- AS Survey Standards as applicable (AS 7634 Railway Infrastructure Survey)
- ARTC Standard ETD-00-04 Control Surveys

All metadata should be captured in the appropriate below metadata forms:

- AMT-FM-104 Imagery Metadata Statement
- AMT-FM-103 LiDAR Metadata Statement

3 Coordinate Systems and Datums

3.1 Coordinate Systems

Data is to be supplied in the geographic coordinate systems of;

- GDA2020 Latitude & Longitude in the relevant datum \ epoch. The data must contain seven decimal places to derive centimetre (cm) accuracy

Where Survey Control is required, the use of existing or the creation of new survey control locations is executed in line with ARTC standard ETD-00-04 Control Surveys.

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

3.2 Datums

3.2.1 Horizontal Datum

The horizontal datum shall be GDA2020.

All data files shall have a referenced coordinate system.

3.2.2 Vertical Datum

Datasets containing elevation values shall adopt the Australian Height Datum (AHD) as the vertical datum using AusGeiod2020 for GNSS observations

4 Data Accuracy

Fundamental spatial accuracy of the survey must conform to the following;

- Fundamental Horizontal Accuracy (FHA) <= +/- 200mm @ 95% confidence interval (1.73 x RMSE)
- Fundamental Vertical Accuracy (FVA) <= +/- 200mm @ 95% confidence interval (1.96 x RMSE)

4.1 Control Check Requirements

Control stations for model checks shall be located using either total station and conventional traversing techniques with connections using at least 3rd order registered control marks or by using geodetic grade GNSS equipment.

GNSS equipment will utilise either a real time corrected signal from Continuously Operating Reference Stations (CORS) or by using classic static GNSS surveying techniques.

Static control observations where a Realtime corrected signal is not available shall record observations for at least 1 hour, recording at 15-30s epoch intervals.

Localised Base stations will have a maximum range of 50kms.

Marks shall be coordinated using GDA2020 latitude, longitude and spheroidal height, and AusGeoid2020, reduced heights shall be in AHD71.

4.2 Fundamental Spatial Accuracy Validation (FSA)

4.2.1 Horizontal Accuracy Validation

The fundamental horizontal accuracy of the dataset must be determined with check points located only in open, relatively flat terrain, where there is a very high probability that the sensor will have detected the ground surface.

Check points are to be surveyed independently of any system GPS observations.

The number of check points (locations) is dependent on the extent of the survey. The following strategy should be used as a guide:

- Check points must be established to adequately cover the full extent of the survey area, and be representative of the project area landscape.
- A minimum of 20 check points (locations), then 1 per 50km where project coverage exceeds 400km. When 20 points are tested, the 95 percent confidence interval would generally allow 1 point to fail the threshold given in product specifications

The proposed check point survey design must be submitted with the quotation and approved by the Contract Manager prior to implementation. Acceptance of the post-survey spatial accuracy report discussed above is dependent on the quality, number and distribution of these check points.

If additional independent validation is required, data should be assessed in accordance with ASPRS Accuracy Reporting Guidelines.

4.2.2 Vertical Accuracy Validation

- The vertical accuracy of the point cloud dataset is to be tested using a TIN surface constructed from bare-earth LiDAR points compared against ground survey check points.
- The onus for reaching the required accuracy lies with the data supplier. Independent accuracy assessments may also be carried out by the Contract Manager.
- Independent testing of vertical accuracy for LiDAR products is not required as part of this base guideline. Instead data producers are required to report on the expected vertical accuracy of elevation products as determined from system and sensor calibration studies.
- In the above circumstances a “compiled to meet” statement of vertical accuracy at 95 percent confidence should be reported.
- As an alternative, the producer may demonstrate compliance through analysis of distinct features which are identifiable in the elevation data (e.g fences) or intensity images with other data sources such as high-resolution imagery with known vertical accuracy.
- If additional independent validation is required, data should be assessed in accordance with ASPRS Accuracy Reporting Guidelines.

4.3 Classification Consistency Validation

- Point classification is to be consistent across the entire project.
- Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions will be cause for rejection of the entire deliverable.

4.4 Documenting Data Accuracy

Accuracy statements shall be documented in the appropriate metadata template and project transmittal report.

Accuracy claims shall be supported with evidence appropriate to the method of capture which shall include separate checks on the model surface covering both horizontal and vertical positioning residuals.

Data Accuracy statements shall also document the methodology used for verification.

Where local base stations are utilised, data showing observation baseline must be presented.

5 Requirements

5.1 Centreline Capture Requirements

To an accuracy of within 200mm at 95% confidence level with data logged at;

- 5m intervals on tangents; and
- 1m on curves and transitions.

5.1.1 GIS Centreline Construction

The construction and hierarchy of quality is defined in;

AMT-GL-102 ARTC GIS Centreline Guideline

5.2 Track Feature Data Requirements

Track feature data will adhere to the following;

- Where visual data collection is utilised (eg, LIDAR, Photogrammetry, etc) surveys will capture a minimum of 30m each side of furthest outside track or to the closest limiting factor that will supply a return/capture from the instrument (e.g. embankments/noise barrier/retaining walls) ensuring location within the corridor is accurately represented.
- Track Features are to be presented as Feature Class entries within the supplied Geodatabase (GDB) templates with associated attributes completed as defined in AMT-SP-101 Technical Specification for Field Data Collection
- Where track features are offset from track centreline the km will be determined by measuring perpendicular to track centreline.

5.3 Laser Scanned and Remote Data Capture

5.3.1 LiDAR Point Cloud Requirements

- All returns, all collected points, fully calibrated and adjusted to specified vertical datum, and referenced by Basecode.
- RGB colourised point cloud using captured imagery
- Fully compliant LAS no later than v1.2, point record format with all standard attributes including:
  - Intensity values (native radiometric resolution)
  - Return number

  - Number of returns
  - Georeferencing information in all LAS file headers
  - GPS times recorded as adjusted GPS time, at a precision sufficient to allow unique timestamps for each pulse.
  - Scan angle
- LAS v1.3 deliverables with waveform data are to use external “auxiliary” files with the extension “.wdp” for the storage of waveform packet data.
- LAS File Headers are to be populated.
- ARTC require the density of the Pointcloud to be sufficient so that points, lines and surfaces meet the accuracy requirements specified and derive the required features and datasets.
- The Pointcloud from each pass will extend at least 30m outside the field face of the external tracks or to the closest limiting factor that will supply a return from the laser (e.g. embankments/noise barrier/retaining walls). Any data 50m outside the field face of the external tracks shall be removed.

Characteristics that should be considered when capturing LiDAR Point Cloud information;

- **Path or Flightline Alignment** (ie mobile or airborne data associated with a flight path or driven trajectory) – Alignment shape file detailing the trajectory taken when recording LiDAR and imagery for the purpose of post-processing and accuracy assurance.
- **Survey Control Alignment** – Detailed information for the survey control locations developed for a specific LiDAR capture.
- **Calibrated images** – each image should include metadata attached to it describing: the Camera lens / model, Camera location (project co-ords for each image), Camera Orientation. Image quality needs to be consistent as the images will be used by downstream applications offering the capability to import calibrated images.
- **Random Noise** – Random noise should be identified, classified and removed from final processed LiDAR point clouds.
- **Point Density** – The correct density for a project depends upon the size of the smallest object (surface area) to be extracted

  Recommended minimum density for Asset Capture works:

System Platform	Minimum Density
Airborne	>5 points/ft^2 (>45 points/m^2)
Mobile	>20 points/ft^2 (>180 points/m^2)
Static	>20 points/ft^2 (>180 points/m^2)

- **Coverage** – The coverage assures the appropriate LiDAR data requirements are meet for the project. Requirements for resolution and precision outside the track edges might be considerably lower than those requirements along the track surface or higher where bridges or tunnels are involved. In the example below the red sections were captured with a mobile scanner, the yellow areas captured aerially and the green sections captured with static LiDAR all combined to generate your model. It would be anticipated that track sections be tiled at 1km increments or similar. It is important to ensure coverage is adequate for the project objective.

5.3.1.1 LiDAR Point Cloud Classification Scheme

- All classified point cloud data must adhere to the following modified ASPRS classification scheme.
- The minimum number of point classes to be delivered according to this scheme is defined by the Classification Level specified below.

Classification Value	***Meaning***
0	Created, never classified
1	Unclassified[5]
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Reserved
9	Water
10	Rail
11	Road Surface
12	Reserved
13	Wire – Guard (Shield)
14	Wire – Conductor (Phase)
15	Transmission Tower
16	Wire-structure Connector (e.g., Insulator)
17	Bridge Deck
18	High Noise
19-63	Reserved
64-255	User definable

- Class 1 (default) are points which have been subjected to a classification process but emerged in an undefined state. Class 0 have never been subjected to a classification process. This definition is necessary to maintain compatibility with common LiDAR processing suites.
- Class 8 “model key points” is a subset of class 2 and so is created as a separate product.

5.3.2 Multiple Pass Requirements

If the accuracy requirements of ARTC cannot be met by a single pass, multiple passes or another suitable operational methodology for capture is required. This method shall be explained in detail in the MLS Contractors proposal.

On dual (or greater) tracks, if the scans from each track does not fully overlap the adjoining track, then each track shall be scanned multiple times to meet the accuracy requirements.

Horizontal or vertical steps in the delivered point cloud are unacceptable.

If there are multi-track in any direction, then the most appropriate track(s) for reducing multipathing and shadowing; whilst also providing maximum coverage should be utilised.

On MLS vehicles using multiple scanners to give the multiple aspect coverage in one pass by capturing two or more scans at the one time, these scans do not use independent GNSS constellations *for the purpose of improved locational accuracy*. In this case, a minimum of two independent passes are still generally required by ARTC.

It is the responsibility of the MLS contractor to increase the number of passes or implement other strategies in poor accuracy environments. These areas should be reported to the Project Manager and noted in the survey report to explain what measures have been implemented to ensure the required accuracies have been met.

5.3.3 Dual Track/Dual Running Lines

In regions with multiple tracks, the centreline of each track must be captured (direction) and a *Minimally Constrained Project Pointcloud (*MCPPC) should be compiled for the region.

5.3.4 File Size, Completeness And Cloud Viewing

Lodged point clouds must be tiled into separate files that should be no greater than 2Gb (must not exceed 4Gb). Where this may impact on usability and rendering performance in the intended applications the contractor is to negotiate with ARTC prior to project commencement. Point cloud files must not cross main line Basecode boundaries.

ARTC Prefers that LiDAR Point Clouds are tiled in 1km sections with 15m overlap. Ideally this is done between km posts.

5.3.5 Collection Requirements

5.3.5.1 Operating Speed

Centreline and Feature data must be captured without impeding normal track operations, must comply to dedicated track speeds and be undertaken under appropriate track possession/protection.

Optimal Scanning speed is 40 km/h. All efforts should be made to not exceed 60km/h.

5.3.5.2 Environmental Factors

The MLS contractor shall identify the environmental conditions (heat, rain, dust, time of day) that cause degradation to the Pointcloud for their particular MLS system. A suitable methodology shall be presented with each project that mitigates each of these factors.

ARTC requires at a minimum the following environmental conditions to be met for data capture;

- Cloud and fog free between the MLS, ground and features.
- Runs should not be undertaken during periods of heavy smoke haze.
- Time of capture should take into account the shadowing effects of sunset and sunrise times and be adjusted to eliminate the impact on data quality

5.3.5.3 Shadowing Or Low Resolution Areas

Endeavours must be made to eliminate the effects of shadowing and subsequent accuracy loss by adopting a suitable operational methodology in capture. Low accuracy areas and shadowing are to be detailed in an exception report where present and delivered by exception to ARTC project manager. Areas may be requested to be depicted in the model by a closed loop string or completed as subsequent recapture.

5.3.5.4 Poor GPS and Control Points

Endeavours must be made to eliminate the poor GPS location and subsequent accuracy loss by adopting a suitable operational methodology in capture. Low accuracy areas are to be detailed in an exception report where present and delivered to the ARTC project manager. Areas may be requested to be depicted in the model by a closed loop string or completed as subsequent recapture.

Additionally, a report of loss of GPS, any repeater locations used for accuracy or post-processing and validation control points are to be detailed within the Survey Report and presented to ARTC within an excel document.

5.3.6 Data Tiling

A Tile Index is to be provided by the contractor in ESRI shapefile format. The tile name must be included as an attribute in the Tile Index file.

5.3.7 Run (Trajectory) Shape File

All runs completed (excluding failed/corrupted data) for the capture will be supplied in ESRI Shape files. The shape file table’s must include the date of capture, local start time, local end time and which reference station was used for each run.

5.4 Imagery

ARTC requires a full catalogue of imagery for current operational areas and may require a discrete image of each asset. Spherical or 360-degree imagery is required to be captured at 10 metre intervals. Georeferenced discrete and spherical imagery is mandatory to allow integration into ARTC's GIS. All imagery capture must:

- Be of a quality and resolution in which km posts and other signage is legible and associated signage information can be verified when viewed in parallel with other captured data
- The imagery must be in focus with no associated motion blur, flaring or exposure issues to allow the kilometrage of a km post or signal number on a signal post to be read clearly
- Allow for virtual site visits to be conducted with confidence that all information that could be obtained on site can still be obtained via the virtual site visit
- Be georeferenced to enable viewing in a spatially correct position and orientation
- Be of a frequency and suitability for the use of producing a colourised LiDAR Point Cloud.

Georeferenced Imagery will be acquired over the project area at the same time as the capture of the Pointcloud/s as a visual record of the project area at the time of pointcloud capture. There may be times when an exception can be made with the prior agreement of ARTC.

The Imagery will cover the entire length and width of the project. Images shall be delivered on a per basecode basis and be appropriately named to differentiate individual ARTC tracks. The Imagery must contain image capture attributes and metadata, as specified in AMT-SP-101, and be cross-referenced to a coordinate. Ie, camera number, frame number, coordinate and file name or supplied with specific software with prior agreement from ARTC.

Acceptance of imagery will be based on the completeness and quality of the images supplied. Images that are under or over exposed, blurry or not fit for purpose will be rejected and the MLS contractor will be asked to resupply. The MLS Contractor is responsible for ensuring all images are of acceptable quality.

5.4.1.1 Operating Speed

Imagery must be captured without impeding normal track operations, must comply to dedicated track speeds and be undertaken under appropriate track possession/protection.

Imagery must be captured at a speed at which;

- Signage and asset labels are legible and do not contain motion blurring.
- avoids "flaring" where there are sudden changes in lighting conditions (eg tunnels, overbridges). This may require slowing down to allow time for camera to adjust.

5.4.1.2 Environmental Factors

The contractor shall identify the environmental conditions (heat, rain, dust, time of day) that cause degradation to the Imagery for their particular system. A suitable methodology shall be presented with each project that mitigates each of these factors.

ARTC requires at a minimum the following environmental conditions to be met for data capture;

- Cloud and fog free between the camera, ground and features.
- Runs should not be undertaken during periods of heavy smoke haze.
- The contractor will endeavour to avoid early morning and late afternoon where under and over exposure of photos is likely to be an issue (8am to 4pm is usually ideal).
- Blurred or distorted images caused by water on the camera lens are also unacceptable.
- Time of capture should take into account the shadowing effects of sunset and sunrise times and be adjusted to eliminate the impact on data quality
- The capture vehicle should be fitted with lighting to allow at least basic imagery within tunnels.

5.4.1.3 Coverage

In regions of multiple tracks, imagery beyond the immediate adjacent track is not acceptable as “full” coverage alone (ie. In a region with 4 tracks, imagery from every alternate track must be captured – as per figure below), as imagery must capture all asset elements within the rail corridor and meet the defined locational accuracy requirements of this document.

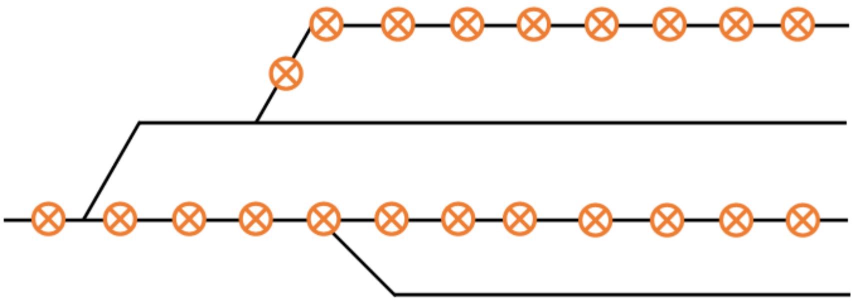

Diagram of imagery that qualifies as full coverage when capturing spherical imagery.

6 Data Supply

The Contractor shall supply the following items:

- Digital data as specified above
  - Survey Rectified Imagery and Colourised LiDAR delivered to Xerra Platform
    - Xerra Processing to include Gauge Point Definition and Curve Fitting.
  - Rectified, Classified,Colourised LAS Files in Non-Proprietary Formats
  - Rectified Imagery in Non-Proprietary Formats
- Metadata Files
- Delivery File Index Document

- Project Reports (as detailed below)
  - Post-Survey Spatial Accuracy Report
  - Survey Report

6.1 Intellectual Property Agreement

All data supplied by the contractor under the Agreement shall become the property of ARTC and shall not be copied or reproduced by the contractor without prior written approval by the principal.

6.2 Digital File Formats

6.2.1 ARTC's Hosted Imagery and LiDAR Platform

Survey Rectified Colourised LiDAR and Imagery data shall be coordinated and delivered in a compliant manner that allows it to be added to ARTC's nominated Imagery and LiDAR Platform, currently this is Agonic's Xerra.

Data shall be processed that allows the following;

- Gauge Points Identified and Stored within Xerra so that users do not need to define these for analysis to take place.
- LiDAR is processed through the Xerra Curve Fitting Algorithm to assign Radius and facilitate Corridor Clearance analytics.

6.2.2 LIDAR Derived Data

All LiDAR Data shall be supplied in the following file formats and requirements;

- Point cloud data shall be provided in a processed RGB colourised .las.
- Point cloud data shall be classified to meet the requirements of 5.3.1.1 LiDAR Point Cloud Classification Scheme
- Optional Deliverables to be confirmed with project:
  - A 0.5m bare earth DEM in ESRI ASCII Grid Format.

6.2.3 Imagery Data

All Georeferenced Imagery shall be supplied in the following file formats and requirements;

- Spherical (360 degree) imagery shall be supplied in a georeferenced open-source format with an index to allow cross-referencing to a coordinate or provided as a photo feature class.
- Standard discrete imagery shall be supplied for each asset in a georeferenced .JPG format with an index to allow cross-referencing to a coordinate or provided as a photo feature class.
- Panoramic JPG imagery is unacceptable

- True Colour (24 bit)

6.2.4 Track Feature Data

Track Feature Data is to be presented as a Feature Class within the supplied Geodatabase (GDB) templates provided by ARTC and in line with AMT-SP-101 Technical Specification for Field Data Collection.

6.2.5 Report Formats

All reports are to be provided in Word (.doc) format, Excel spreadsheet (.xls) or appropriate digital format approved by the Contract Authority.

Finalised reports are to be marked as “FINAL_” and presented as PDF (.pdf) format supplementary to the above.

6.3 Metadata

Metadata Statements are to be supplied with their appropriate data deliverables.

- Lidar Metadata Template
- Imagery Metadata Template
- Track Feature (GIS) Metadata Template

6.4 Delivery File Index Document

- Data delivered shall be accompanied by a single File Index kept at the highest folder level containing the following with a new row for each file delivered;
    - File Name
    - File Path
    - Data Type
    - Data Description
    - Basecode
    - Recording Date
    - Version Number

6.5 File Naming

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

Basecode_KM Range_Descriptor _YYYYMMDD.ext

Where;

Basecode is the Track Basecode listed in the ARTC Basecode list. The Basecode number will consist of a 5-digit number.

KM Range is the start and end km locations in relative kilometrage;

Descriptor must be one of the following.

"MLSPCD" point cloud data; .las/.laz 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;

"IMGSPH" Spherical Imagery, .sph;

"IMGDIS" Discrete Georeferenced Image, .jpg;

YYYYMMDD is the capture date / report publishing date of the file.

.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 .las / .laz index file

.las / .laz point cloud format.

6.6 Project Reports

6.6.1 Post-Survey Spatial Accuracy Report

Acceptance of the Post-Survey Spatial Accuracy Report and related information is required before point classification and other product derivation is to proceed.

The absolute and relative accuracy of the data, both horizontal and vertical, and relative to known control, shall be verified prior to classification and subsequent product development.

This validation is limited to the Fundamental Spatial Accuracy (defined below), measured in clear, open areas. A detailed report of this validation is a required deliverable.

6.6.2 Survey Report

A Survey Report shall be prepared outlining the successful completion of the project and any problems that have been encountered along the way.

The Survey Report should comprise a technical discussion addressing how each of the contract specifications has been met, a statement of consistency with any specified standards, results of independent accuracy and validation tests, metadata statements and extra-ordinary issues that may have affected the nature or delivery of the project.

All aspects of the project operations must be adequately reported.

Project Report Example Format:

- Date
- Job Title, Number & Description
- Project Lead & Manager
- Contact Details
- Data Files, Revision & Format
- Horizontal Coordinate System
- Vertical Datum
- Nominated Data Accuracy
- Metadata Standard
- Capture Scale
    - Methodology statements shall include the captured scale range of datasets for Data Quality. Details shall be noted in the Project Report.
- Data Origin
    - Methodology statements shall include the origin of datasets. The contractor shall nominate whether information has been captured via GPS, digitised/ drafted or via automated feature extraction techniques etc. Details shall be noted in the Project Report.
- Production Methodology
    - In order to achieve the required standards, methodology used shall be documented to support accuracy statements and provide context for the use/ application of GIS information. Details of this shall be included as a brief summary in the Geospatial Project Report.
- Exception Report: details of any abnormalities relating to the project.