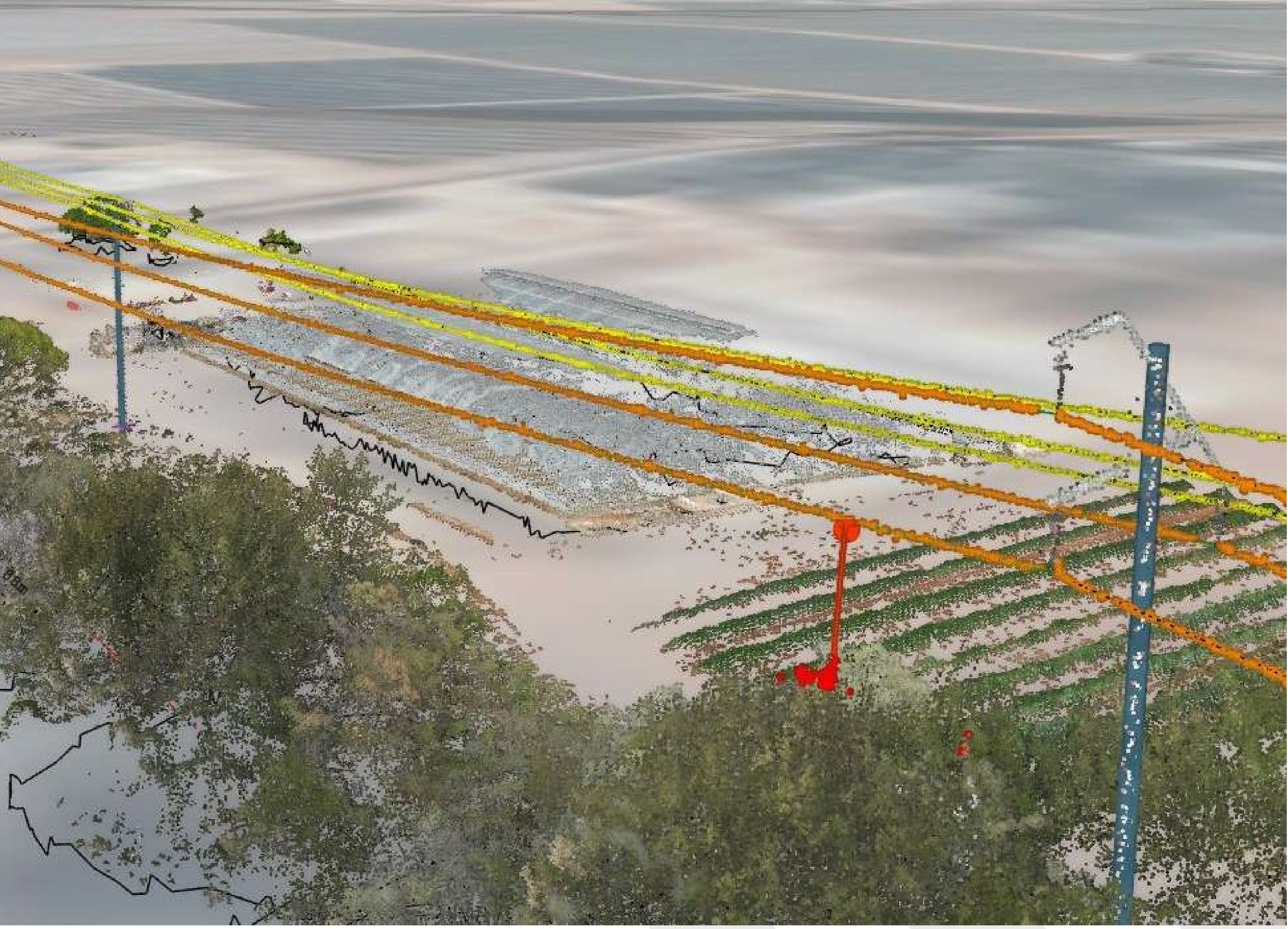

Technical Standard – TS095

Light Detection and Ranging (LiDAR) Technical Requirements

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1. Introduction

1.1 Purpose and Scope

This Technical Standard describes the technical requirements for Light Detection and Ranging (LiDAR) surveys of:

- SA Power Networks above ground infrastructure; and
- above ground objects required to support the identified use cases.
  The requirements described in this Technical Standard apply to LiDAR activities conducted in-house by SA Power Networks in addition to LiDAR activities procured from third party service providers.

The purpose of this standard is to ensure that LiDAR data is captured at a quality aligned with the identified use cases in a consistent, reliable and cost-effective manner.

Where LiDAR activities are procured from third party service providers, all underground assets and the terrestrial based capture of substation assets, are excluded from the scope of this Standard.

1.2 Relationship with Other Documents

This Technical Standard is supported by the following documents:

- LiDAR Reference Document: An **internal only** SA Power Networks document that captures the rationale and decisions that underpin the requirements set out in this Standard.

2. Definitions and Abbreviations

2.1 Definitions

Aerial Based Inspections	Inspections of powerlines carried out from an aircraft, usually a helicopter or a fixed wing aeroplane, or drone/UAV in appropriate conditions.
Cable	Means a fibre optic Cable, a communications Cable or other Cable, line or wire that is attached to: • a Pole; or • a customer's premises from a Pole or from a private Pole and excludes any type of Cable, line or wire that is a Primary Conductor.
Capture Zone	SA Power Networks' boundaries of LiDAR data capture derived from the location of HV feeders. Each HV feeder represents an individual Capture Zone.
Checkpoints	Checkpoints are locations with known coordinates that can be used to validate the accuracy of a LiDAR capture.
Data Enrichment	Refers to techniques for manipulating data quality, using additional information that may be sourced either supplementarily or by alternative means to the raw dataset. This definition is irrespective of how the data quality is manipulated, be it manually by a person, algorithmically by a process, or through Artificial Intelligence.
Guy Wire	A tensioned wire that is used to provide support to a freestanding Pole.
High Voltage	Voltage exceeding low voltage
LiDAR	Short for Light Detection and Ranging, is a remote sensing technology that uses laser light to measure distances and generate three-dimensional information about the shape and surface characteristics of objects and environments. It is widely used across various industries for mapping, modelling, and analysis purposes.
Low Voltage	Voltage exceeding 50V ac or 120V ripple free dc and not exceeding 1,000V ac or 1,500V dc
Pole	Wood, concrete or steel Pole which supports electricity distribution network LV and/or HV apparatus, plant and conductors. Towers and Structures are included infrastructure in the definition of Pole.
Primary Conductor	An electric wire used to transmit electricity that forms part of the electricity distribution network, and that is not affixed to a customer's premises.
RGB	An additive colour model.
Service Wire	An electric wire, including a connection to the service fuse, serving a Customer's premises from the point of supply to the customer's terminals, and for the avoidance of doubt includes an electric wire connected to a service fuse for a streetlight.
Span	A grouping of one or more Primary Conductors between two Poles where all grouped Primary Conductors operate together in the balanced delivery of electricity.
Temporal Accuracy	Measurement of how well data or predictions reflect the actual timing of events or processes over time.

2.2 Abbreviations

3D	Three dimensions
AEMC	Australian Energy Market Commission
AHD	Australian Height Datum
AIRZ	Aerial Inspection Restriction Zone
ASPRS	American Society for Photogrammetry and Remote Sensing
BARS	Basic Aviation Risk Standard
BOM	Australian Government Bureau of Meteorology
CORS	Continuously Operating Reference Stations
DEM	Digital Elevation Model

DSA	Depot Service Area
DTM	Digital Terrain Models
ESCOSA	Essential Services Commission of South Australia
EMP	Environmental Management Plan
EMS	Environmental Management System
ENA	Energy Networks Australia
EPA	Environmental Protection Agency
GCP	Ground Control Point
GDA	Geocentric Datum of Australia
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
HV	High Voltage
ICSM	Intergovernmental Committee for Surveying and Mapping
ID	Identity
IEC	International Electrotechnical Commission
IMU	Inertial Measurement Unit
ISO	International Standards Authority
IT	Information Technology
LiDAR	Light Detection and Ranging
LV	Low Voltage
MGA	Map Grid of Australia
NIR	Near-infrared
PPSM	Points Per Square Metre
QMP	Quality Management Plan
QMS	Quality Management System
RGB	Red Blue Green
RPA	Remotely Piloted Aircraft
ReOC	Remotely Piloted Aircraft Operator's Certificate
RePL	Remote Pilot License
RMSE	Root Mean Square Error
SA	South Australia
SAPN	SA Power Networks
SAPS	Standalone Power Systems
SMP	Safety Management Plan
SMS	Safety Management System
TS	The SA Power Networks Technical Standard
UAV	Uncrewed Aerial Vehicle

2.3 Terminology

May	Indicates a requirement that will not be mandatorily imposed.
Must	Indicates a mandatory requirement.
Shall	Indicates a mandatory requirement.
Should	Indicates a recommendation that will not be mandatorily imposed.

3. Relevant Rules, Regulations, Standards and Codes

3.1 Standards and Codes

The following listed documents are for additional information and other documentation may be required on a project specific basis. Note that it is the responsibility of the reader to ensure you have complied with all applicable, South Australian and Commonwealth legislative regulations (under Acts), ESCOSA/ENA/AEMC/IEC documents, relevant AS/NZS standards, relevant ISO standards, and SA Power Networks publications, and that you have ensured they are current publications, before implementing them.

Standards Australia Publications:

AS/NZS ISO 9001	2016	Quality management systems
AS/NZS ISO 14001	2016	Environmental management systems

International Organization for Standardization (ISO) Publications:

ISO 19115	2023	Geographic information — Metadata
ISO 19157	2023	Geographic information — Data Quality

American Society for Photogrammetry and Remote Sensing (ASPRS):

LAS 1.4	July 2019	ASPRS LAS 1.4 Format Specification R15

SA Power Networks Documents:

Manual 37	Vegetation Management Manual
Manual 28	Bushfire Risk Management Manual
Manual 11	Line Inspection Manual
Manual 12	Network Maintenance Manual

3.2 Legislation and Regulations

The following relevant legislation and regulations shall apply to LiDAR activity in relation to SA Power Networks related works. In an event where there is any inconsistency between legislation and regulations and these technical requirements, the legislation and regulations shall prevail.

- Electricity Act 1996
- Electricity (General) Regulations 2012
- National Electricity Rules (Cth)
- Electricity Distribution Code (ESCOSA)
- Work Health & Safety Act 2012
- Work Health & Safety Regulations 2012
- Civil Aviation Safety Regulations (CASR) 1998 (Cth)
- Environment Protection Act 1993
- Environment Protection Regulations 2023
- Native Vegetation Act 1991
- Native Vegetation Regulations 2017
- Planning, Development and Infrastructure Act 2016
- Planning, Development and Infrastructure (General) Regulations 2017
- Requirements of the Office of the Technical Regulator

4. Data Governance and Responsibilities

4.1 Data Ownership

SA Power Networks shall maintain ownership of all LiDAR scans and capture data of:

- the electricity distribution network owned by SA Power Networks;
- above ground objects and terrain within the coverage specified in Section 6.3.6;
- above ground terrain not otherwise covered by the above points; and
- any data related outputs in relation to these points.

SA Power Networks reserves the right to utilise and share this data with third parties as it sees fit.

4.2 Data Management – Security, Hosting and Vendor Access

LiDAR data, outputs and associated documents shall be stored and managed securely within IT infrastructure in compliance with the following SA Power Networks IT standards, policies and directives.

4.2.1 Data Governance Principles

The use and storage of SA Power Networks LiDAR data should align to the following key data governance principles, as outlined in the SA Power Networks Data Governance Directive:

- Data is an enterprise asset with a lifecycle and must be protected and secured;
- Data must have a single authoritative source, with data copies being minimised; and
- Data must be compliant and secured to required levels based on classification and sensitivity as deemed by SA Power Networks.

4.2.2 Data Encryption Standards

Data must be encrypted in line with SA Power Networks Data Security Standards, such that:

- All LiDAR data in transit between vendor systems and SA Power Networks shall be encrypted using Transport Layer Security (TLS) version 1.2 or higher.
- All LiDAR data at rest within vendor infrastructure shall be encrypted using Advanced Encryption Standard (AES) with a 256-bit key.

4.2.3 Security, Identity and Compliance Requirements

Vendors must implement controls to prevent unauthorised access, modification or disclosure of LiDAR data in accordance with the SA Power Networks Data Security Standard.

Role-based access control (RBAC) should be enforced and the principle of 'least privilege' for all personnel accessing LiDAR data must apply. Multi-Factor Authentication (MFA) shall be implemented for all vendor personnel with access to systems storing LiDAR data, in alignment with the SA Power Networks Cyber Security Standard.

Where SA Power Networks-owned data is to be stored, managed or processed by vendors, these vendors shall complete all security questionnaires and provide evidence of compliance against SA Power Networks' Cyber Security requirements prior to commencement of LiDAR capture activities.

These requirements shall also apply to all third-party service providers who are engaged by SA Power Networks for the delivery and management of LiDAR activities.

4.3 Data Utilisation

LiDAR capture datasets may be used for different use cases that could include, but are not limited to:

- vegetation management;
- flood management;
- asset clearance analysis;
- asset management risk analysis; and
- detailed network auditing.
-

LiDAR data collected in accordance with this standard is intended to provide a dataset that will be single source of truth than can be applied to multiple use cases. Future use cases that could utilise LiDAR datasets will be developed on an as-needs basis.

5. General Considerations

The following general considerations shall be applicable to this Standard.

5.1 Resources

All LiDAR activities shall be performed by appropriately qualified and experienced personnel. Examples of such activities include:

- Checking of LiDAR dataset accuracy, including with reference to Ground Control Points (GCPs).
- Making go/no-go decisions in relation to any air or ground operation associated with LiDAR capture.
- Using LiDAR data to make decisions or assessments about:
- the clearance of vegetation around overhead infrastructure;
- the clearance of objects in the vicinity of overhead infrastructure;
- the identification and mitigation of risks;
- conducting condition assessment of SA Power Networks assets.
- Integrating LiDAR data into IT platforms and systems, including providing secure and reliable storage and access of such data.
- Ensuring the integrity, accuracy and usability of LiDAR data.

5.2 Data Quality

There shall be a documented Plan that captures the methodology for quality assurance and risk management. The Plan shall be developed by the external service provider providing the LiDAR capture services, or by SA Power Networks where the LiDAR capture services are to be performed inhouse. The Plan documents shall be structured to include measures to achieve data within reasonable thresholds for acceptance.

A data quality verification will be performed for all captures within scope of work by an independent verifier, different from the acquisition or data processing vendor. A separate quote will be required from external verifiers to perform quality verification on processing activities. In the future, however data verification will be performed by skilled SA Power Networks staff.

Data Enrichment of LiDAR capture data will not be permitted at any time. Poor enrichment using incorrect or incomplete historic data creates a risk that a resultant dataset may contain incorrect assets or misinterpreted assets (for example, due to historic discrepancies and changes).

The following minimum requirements in relation to accuracy validation must be considered, including that:

- Capture paths, including aerial flight plans, trajectories, and terrestrial paths of travel, shall be checked and verified;
- Outputs and associated metadata for all calibration flights, where aerial surveys are conducted, must be reviewed and approved prior to proceeding with further survey activities;
- Captured data shall be compared against independent GCPs measured by a GPS, checkpoints, or by other appropriate surveying techniques, to ensure that the data accuracy required by this Standard will be achieved;
- All data captured shall be aligned with the surveyed GCPs;
- Captured data point density and the consistency of spacing shall be checked to ensure it complies with the requirements of this Standard (refer Section 6.3.1);
- The overlap between flight lines shall be checked to ensure there is seamless coverage without loss of any information;
- Any artificial shifting of data points to enhance the quality of data shall be checked and verified against the requirements of this Standard, noting that Data Enrichment is not permitted, and that the addition of created data points either inferred or interpolated from other data points is not permitted;
- Through visual verification that the model is fit for purpose and does not have any noise levels, anomalies or misalignment and missing data; and
- There is an indication of the captured data quality included in the Metadata.
- If the captured data fails to meet the minimum quality requirements:
- Gaps and errors must be documented
- Severity of the inconsistencies must be assessed
- Correction will be applied and data will be reprocessed where applicable
- Data must be re-captured and verified if required
- Additional CORS (Continuously Operating Reference Stations) may need to be established to achieve the accuracy requirements specified in this document.
-

5.3 Capture Methodology

The data capture methodology determined for a specific LiDAR capture shall be the most appropriate to the use case (or group of use cases) being undertaken. As a minimum, the capture methodology shall consider:

- Use case requirements
- Data collection method and type of vehicle/aircraft required
- Competency requirements of personnel
- Schedule and operational requirements
- Communication protocols
- Safety requirements
- Quality assurance requirements
- Environmental requirements; and
- Legislative requirements.

5.4 Reporting

Each LiDAR capture activity conducted shall be appropriately reported, such that datasets can easily be correlated to the specific capture activity. As a minimum, these reports shall include:

- Identification of LiDAR scanner used
- Identification of LiDAR scan settings used
- Details of calibration checks and evidence of calibration
- Journey details including speed and height (if aerial) or elevation (if ground based);
- Flight trajectories (Track file) captured at 5 seconds interval

- All flight trajectories used for the capture of the delivered LiDAR data will be in ESRI Shape files. The shape file tables must include the date of capture, local start time, local end time and which reference station is used for each trajectory.
- Flight tracking
- Quality of the data captured as a result of the journey;
- Point cloud density per capture zone
- A map of point density spread across the capture zone
- Assessment and compliance of accuracy per capture zone
- Accuracy of data classification
- Details of checkpoints and controls used for assessing and validating accuracy
- Details of any artificial manipulation of data points
- A summary of the processing activities used to create the correct LAS/LAZ files
- Weather conditions during the capture, and including time of data capture for each zone adjusted to local time and date
- Start time and End time from structure to structure
- Latitude and Longitude of weather station location if applicable
- Ambient air temperature (degrees Celsius)
- Wind speed (m/s)
- Wind direction (degrees)
- Solar insolation, if available
- Date

Capture progress reports shall be produced at a regular interval. As a minimum, these reports shall include:

- Overview of current activities
- Percentage completion of network area being surveyed
- Variations
- Safety updates; and
- Schedule of capture days.

5.5 Weather Considerations

Local weather conditions can significantly impact the ability to acquire LiDAR data, and therefore presents a risk to completing essential risk management activities by required dates. It is expected that historic weather patterns will be considered and that modern weather data sources will be utilised to proactively forecast challenges to capturing LiDAR data, to ensure that captures will be completed by required dates.

Weather data shall be collected and ultimately associated to a Capture Zone on a span-to-span basis from dead-end to dead-end for all assets in scope. A suitable methodology shall be applied and the nearest BOM ground weather station shall be selected to record weather information during the LiDAR capture activity, with this weather information to be associated to each specific span in the Capture Zone.

Where a ground weather station is unavailable, or the ground weather station is located more than 20km from the centre point of the Capture Zone, a temporary ground weather station shall be setup to record weather conditions. The recorded weather data must be of sufficient quality to allow for cable and conductor rating, sag and sway calculations that are consistent with industry best practise levels of accuracy and precision.

The following accuracy requirement must be met for weather data:

- Measured temperature must be within 2 degrees Celsius of actual temperature.
- Measured wind speed must be within 10 km/hour of actual wind speed.

6. LiDAR Data Quality Standards

All LiDAR surveys are to be conducted with the resolution, accuracy and density that is most suitable for the use case, as per Table 1 below, and shall utilise the most appropriate platform and remote sensing technologies. LiDAR data that is not collected correctly or is below the quality standards outlined in this Standard will not be accepted, given that the resultant dataset would have negative flow-on effects to subsequent modelling and accuracy of defect detection.

LiDAR data Quality Assurance and supporting reporting summaries, metadata and data extracts shall be the basis to confirm the accuracy of captured data point clouds and hence the accuracy of captured network assets, nearby objects and terrain.

6.1 Asset Information

The LiDAR system must be sufficient to capture all assets and report defects and/or encroachments. The asset identification information that is required for LiDAR surveys will be taken from GIS data managed by SA Power Networks. This GIS data will be available in the geojson format.

The information recorded in the GIS database includes:

- locations of poles (including a unique identifier)
- location, voltage and conductor type of all spans
- locations of relevant geographic features, and
- AIRZ (Aerial Inspection Restriction Zone) objects.

6.2 LiDAR Sensor

The LiDAR sensor used shall be capable of reliably providing the required accuracy and point density specified in this document in relation to the use cases to be utilised. In particular, the sensor shall be capable of detecting multiple discrete returns from each outgoing laser pulse. No returns are to be omitted from the final data set without specific technical reasons. The sensor must ensure proper penetration and capture of the intensity of each reflection with adequate sensitivity and wide dynamic range such that detailed human visual analysis of the point cloud can be performed.

The LiDAR scanner used must be calibrated and accurate before and after each scan, such that it continues to provide consistent and accurate LiDAR scans, meeting the requirements of this Standard. Where a change to the system/LiDAR scanner calibration is required, effective mitigations and pre-emptive checks must be put in place to prevent data being delivered that is outside the requirements of this Standard.

The sensor shall support high-precision 3D point cloud data in compliance with ASPRS industry-standard formats. It shall have compatibility with cameras (RGB/NIR) for generating colourised point clouds and must integrate seamlessly with GNSS (Global Navigation Satellite System) and IMU (Inertial Measurement Unit) for accurate geo-referencing and positioning. A sensor stack calibration report shall be provided every time a need for re-calibration is triggered.

6.3 LiDAR Capture

6.3.1 Point Density

LiDAR point density is a critical factor for ensuring datasets provide suitable detail to meet the operational and analysis needs of SA Power Networks. The ideal point density varies based on the survey approach and use case.

The minimum acceptable point density to be applied shall be determined in consideration of the factors relevant to undertaking a survey, such as flight altitude, sensor quality, use cases and desired accuracy. Minimum point density must enable accurate identification of assets, modelling of the captured data, and assessment of vegetation clearances specified in Vegetation Management Manual 37.

Table 1 describes the minimum acceptable point density requirements for different use cases. Hence, the point density for a capture needs to be set appropriately to realise the required outcome for the use case.

Table 1: Minimum Acceptable Point Density for Different Use Cases

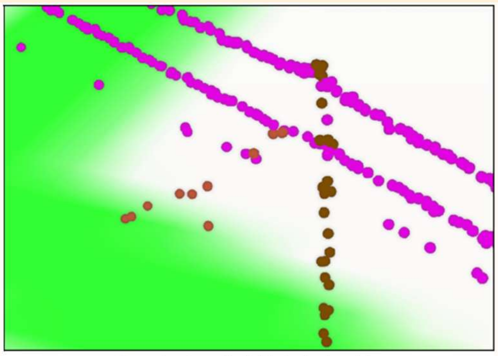
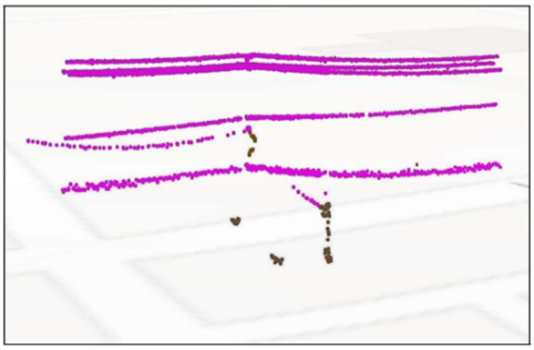
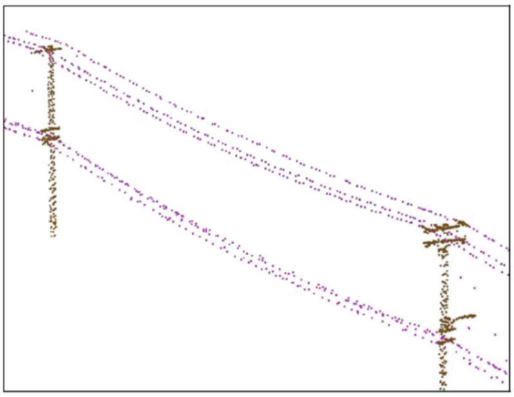
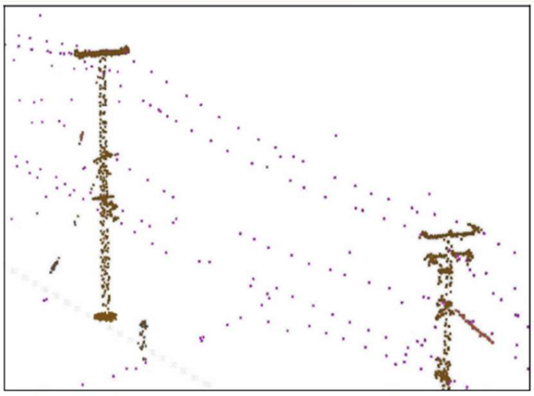
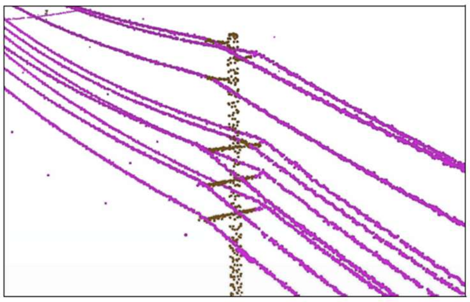
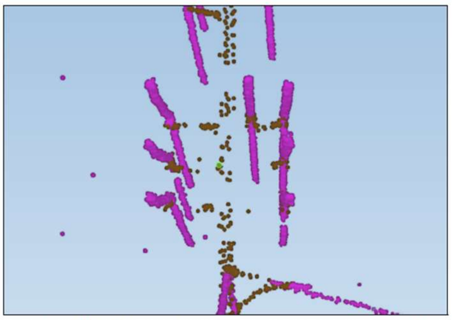
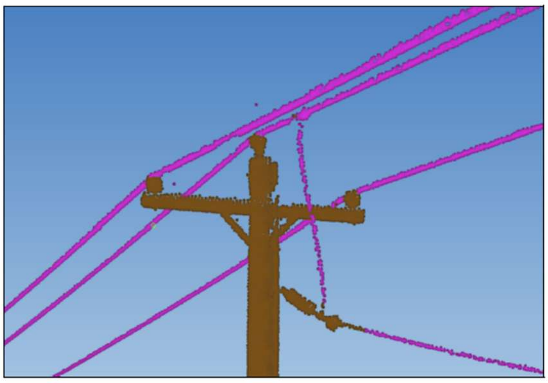
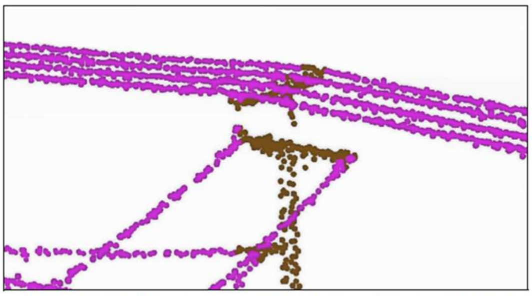
Required point density	Use case	Minimum Acceptable
Point Density shall be sufficient that all primary conductors and poles are clearly visible and well-defined in the LiDAR data.	• Risk impact scoring* • Vegetation management • Dynamic line rating • Clearance analysis • Bushfire/wildfire management* • Hurricane and storm management* • Flood management* • Snow & Ice management* • Transmission design and optimisation* • Renewable energy integration* • LiDAR & GIS Reconciliation	• 20 points per structure • Structure points should be evenly distributed along the structure such that the lean and precise location can be easily discerned. • 1 point per 50cm per conductor
Point density shall be sufficient to clearly resolve cross-arm configurations, bundled telecommunications cables, and all guy wires.	• Risk impact scoring • Forecast and backcast analysis • Equipment inspections • Bushfire/wildfire management • Hurricane and storm management • Flood management • Snow and ice management • Transmission design and optimisation	• 150 points per structure • 20 points per cross arm • Clear identification of cross arm, stain, pin, post, or suspension type • 1 point per 20cm of conductor • Clear identification of jumper cables, and guy wires attached to the pole including slack
Point density must be sufficient to identify transformer types, reclosers, insulator disc counts, and assess physical integrity.	• A very detailed network analysis and asset auditing.	• Greater than the minimum acceptable above, and sufficient that a human should easily and confidently identify these assets and their characteristics

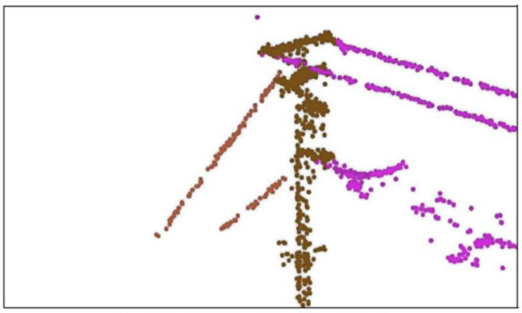
* Use case can be achieved, except for the structural analysis components of the use case.

For all LiDAR acquisitions, point density must remain uniform across the project area for assets in scope, avoiding any clustering or data gaps. This requirement is critical to being able to confidently perform analysis that relies on LiDAR datasets.

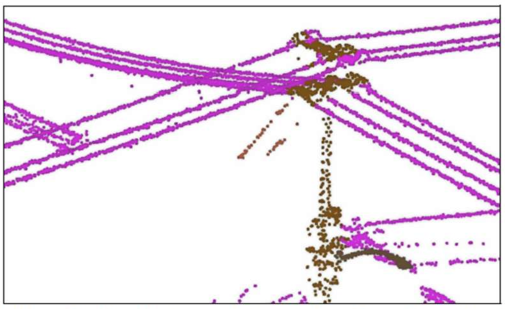
Table 2 shows examples that illustrate minimum acceptable vs unacceptable outcomes.

Table 2: Acceptable vs Insufficient Point Density Examples

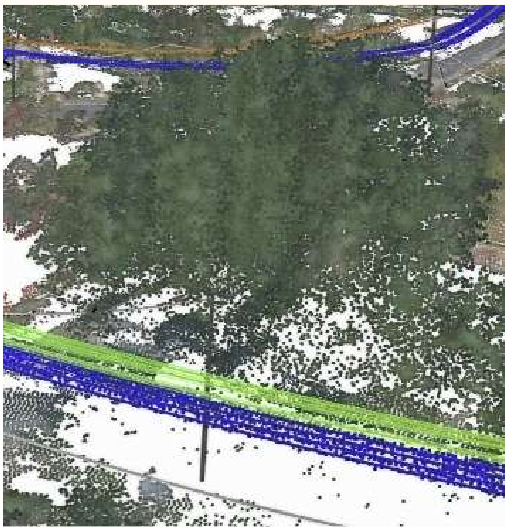
Acceptable Point Density	Insufficient Point Density
 *Example of evenly distributed pole points.*	 *Example of **insufficient** and poorly distributed pole points. It is not possible to tell the lean or exact location of the structure.*
 *Example of evenly distributed LiDAR with sufficient conductor points.*	 *Example of **insufficiently** distributed LiDAR that **cannot** be used for use-cases listed above.*
 *Example of **sufficiently** captured cross-arms. It is possible to identify any leaning/cantering or deformation in all cross-arms.*	 *Example of **insufficiently** captured cross-arms. It is not possible to identify whether this cross-arm is perfectly level, nor make comment on its orientation.*
 *Example of clearly and sufficiently captured jumper cables*	 *Example of **insufficiently** captured jumper cables - it is not possible to discern which conductors branch-off from the primary line.*



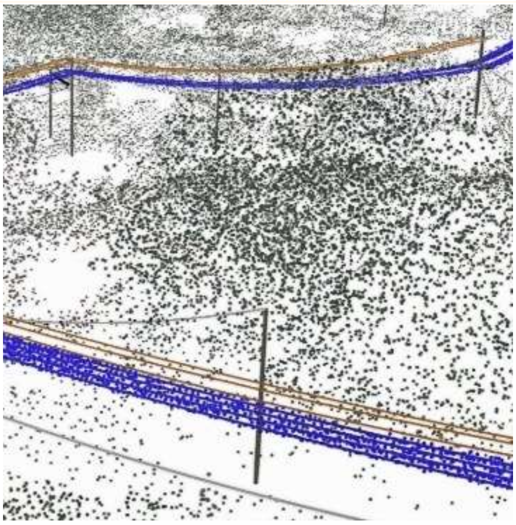
*Example of **sufficiently** captured guy wires.*



*Examples of **insufficiently** captured guy wires. It is not possible to confidently discern the count or tension of the wires.*



Example of sufficiently captured vegetation



Example of insufficiently captured vegetation

This requirement must be met irrespective of scanner patterns, and points must not cluster where a different setting is required to detect different asset types. Any instances where this is not achievable due to technical and/or environmental limitations, must be documented and approved by the nominated SA Power Networks stakeholder that has requested the LiDAR survey, prior to conducting the survey.

All individual data files shall be free from misalignment, mismatch or edge artefacts, and must provide a seamless transition, when imported in full together. Overlapping, ghosting or a quilted appearance in the overall model, whether caused by differences in processing quality or character between tiles, scan accuracy, swaths, lifts, or other non-natural divisions, will cause errors in vegetation defect identification.

The amount of low/high isolated outliers or other types of clustered noise shall be as low as practicable to allow for the identification of assets within scope, as described in Table 1. In the instance where retainment of noise is to the detriment of the dataset it shall be removed rather than classified as noise. Denoising must ensure that assets in scope are not removed from the scan.

6.3.2 Accuracy

The accuracy of LiDAR data is essential to ensuring reliable analysis, and adherence with SA Power Networks standards and industry benchmarks.

For all LiDAR acquisitions, the absolute horizontal accuracy shall be within ±0.2 metres at a 95% confidence interval. Absolute vertical accuracy shall be within ±0.15 metres at a 95% confidence interval.

Table 3: Accuracy Requirements

Absolute Vertical Accuracy 95% Confidence	Absolute Horizontal Accuracy 95% Confidence	Number of Check Points
±0.15m	±0.2m	Minimum of 12 per capture zone, evenly distributed

In addition to the above accuracy requirements, relative accuracy quantifies the consistency between individual LiDAR points in localised areas, ensuring that adjacent data points align with high precision.

The relative accuracy between individual LiDAR survey points shall comply with the requirements in Table 4:

Table 4: Relative Accuracy Requirements

Relative Accuracy 95% Confidence
±0.05m measured point to point

6.3.3 Ground Control Points and Checkpoints

Sufficient horizontal and vertical control surveys shall be established and/or identified to ensure that data accuracy requirements are met. It is expected that any existing ground control points (GCPs) will be considered and utilised wherever appropriate. The estimated total number of photo identifiable horizontal and vertical control points shall be identified that will meet the requirements of this Standard.

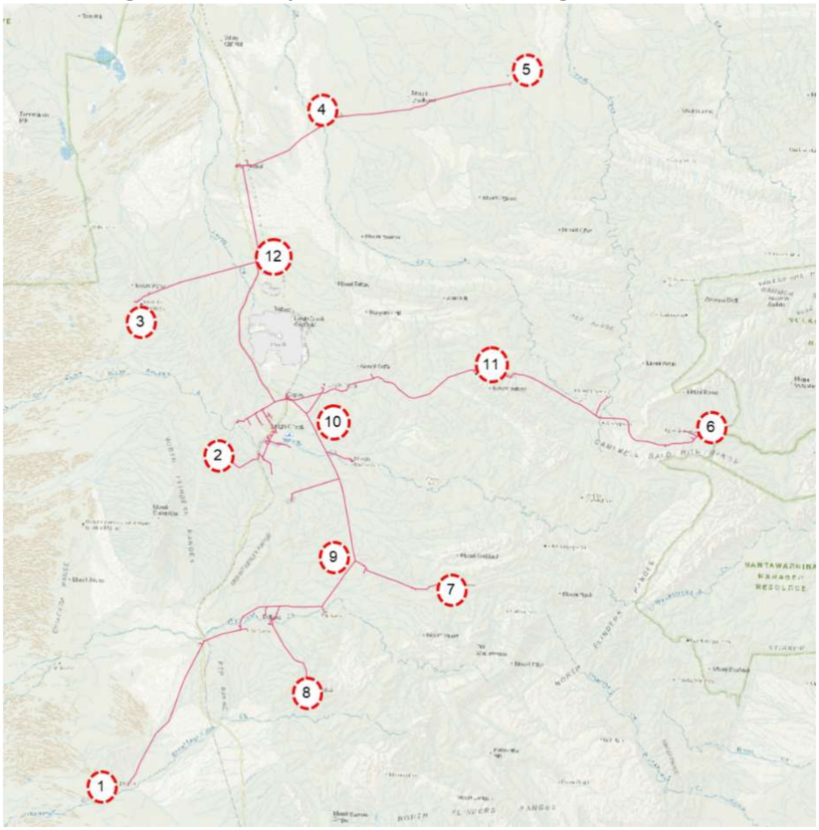
GCPs should have accuracy higher than the expected accuracy of the capture to avoid introducing error into the dataset. GCP spacing shall be determined based on geographic location, platform and project scope. The proposed GCPs shall be reviewed and approved by qualified personnel before acceptance. At least one GCP must be placed where the corridor changes direction to ensure accurate alignment between segments. Where available a permanent survey monument located within a substation shall be used as a GCP or checkpoint.

Checkpoints are locations with known coordinates that can be used to validate the accuracy of a LiDAR capture. The number of 2D/3D checkpoints shall be determined based on the geographic location, platform and project scope to include non-vegetated and vegetated areas (as relevant) for each scope item. The actual number of checkpoints for the project area shall meet or exceed the recommended number described in the ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014).

Several checkpoints shall be located at the end of paint stripes or 90-degree corners with different reflectivity in order to be visible in the LiDAR intensity image to verify horizontal accuracy. Checkpoints shall be placed at the beginning and end of each swath. Additional checkpoint placement shall be determined based on geographical area, platform and project scope.

Ideally, checkpoints shall be placed such that they effectively cover the entire survey area. As a rule, checkpoints shall be distributed such that when a polygon is made using outermost checkpoints the entire survey area is covered. An example checkpoints distribution is shown in Figure 1.

Figure 1: Checkpoints Distribution Leigh Creek Area



6.3.4 Coordinate and Level Datum

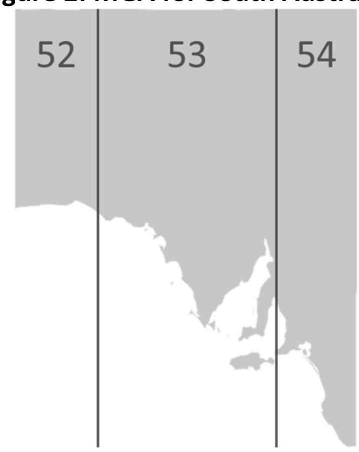
This geocentric datum ensures alignment with national standards and compatibility across various spatial datasets.

6.3.4.1 Horizontal Coordinate System

The horizontal coordinate system for the delivery of all LiDAR datasets shall conform to Geocentric Datum of Australia 2020 (GDA2020) with coordinates specified in Map Grid Australia (MGA) zones 52, 53 and 54 as shown in Figure 2. SA Power Network assets are currently situated in zones 53 and 54 only.

Datasets shall be converted from Projected Coordinate System (GDA2020) to Geographic Coordinate Systems (Latitude and Longitude degrees) as and when required by SA Power Networks. This conversion shall be performed by either the external service provider upon request or by SA Power Networks.

Figure 2: MGA for South Australia



6.3.4.2 Vertical Datum

The vertical coordinate system for elevation data shall adopt the Australian Height Datum (AHD) standard using the latest available Geoid model approved by the Australian Intergovernmental Committee for Surveying and Mapping (ICSM).

6.3.5 Metadata and Documentation

LiDAR metadata shall adhere to the ISO 19115 standard to ensure consistency, operability, and accuracy. To understand, process, and use LiDAR datasets, requirements for metadata and documentation shall be determined for each use case.

As a minimum, the following parameters shall be recorded as metadata for each survey:

Metadata	Fields
Identification Information	• Name, description, and purpose of the survey project. • Local date and local time when the LiDAR data was collected. • Defines the area covered in the survey, usually represented by corner coordinates (latitude/longitude) or a polygonal boundary. • Start and end time of data collection. (local time)
Data Quality and Accuracy Information	• Categories and codes for point classification (e.g. wires, ground, vegetation, buildings, water, etc.) including percentages of classified points in various categories. • Reference system and datum used for georeferencing. • Any CORS reference stations utilised. • Ground control points (GCPs) and their accuracy. • Specifications for derived Digital Elevation Models (DEM) generated from the LiDAR point cloud (e.g. resolution, grid size, interpolation method). • Any transformations or adjustments to the original LiDAR data and the steps in processing, such as denoising or point classifications. • Reports of errors and quality checks (e.g. vertical accuracy, horizontal residual errors, RMSE values). • Metadata must specify if the QC has been validated against ground-truth data.
Spatial Reference Information	• The geographic or projected coordinate system used (GDA2020). • Zone details usually MGA zones MGA53, MGA54, MGA55, etc., linear unit (e.g. metres), and ellipsoid or spheroid for reference. • Horizontal Datum (GDA2020). • Vertical Datum (AHD71) • Reference units for elevation data (e.g., metres or feet) • Vertical accuracy (absolute and relative) • Horizontal accuracy • RMSE values, typically reported in metres
LiDAR System Information	• Specifies the type of LiDAR system and the platform used (e.g. drone, aeroplane, satellite, vehicle, or tripod-mounted). • Manufacturer name and model of the specific LiDAR sensor used for data acquisition, and other relevant details • Sensor Specifications: > Pulse repetition frequency. > Beam divergence. > Wavelength of the laser. > Scan rate and field of view. > Line spacing (spacing between scanning laser lines)
Flight or Survey Settings	• Aircraft or drone altitude during the LiDAR survey. • Details about flight lines, including overlaps and directions.

	• The ground area covered by each LiDAR scan/swath. • Number of LiDAR measurement points per square metre (e.g. 25 PPSM or higher as required).
File Information	• Commonly LAS, LAZ (compressed LAS), or ASCII files. • LAS format (LAS 1.4). • File size (in MB or GB) along with details of how the data is tiled for large datasets. • Includes details about what attributes are present for each LiDAR point. Common attributes include: > Point coordinates (X, Y, Z). > Intensity. > Classification. > Return number. > RGB or multispectral values. > Time stamp - GPS times recorded as adjusted GPS time (no truncation to this record is allowed), at a precision sufficient to allow unique timestamps for each pulse. > Point source ID.
Environmental and Acquisition Conditions	• Information about visibility, weather conditions (e.g. wind at ground level, temperature at ground level, cloud cover) during data acquisition. • A description of the area's general land cover, such as rural, urban, or forested.

6.3.6 Minimum Coverage Requirement

With respect to aerial LiDAR capture, the minimum coverage required is the horizontal distance relative to SA Power Networks assets that must be surveyed. Table 5 outlines this requirement with respect to different types of assets.

Table 5: Minimum Coverage

Asset	Minimum distance (metres)	Comment
Regular span powerlines (i.e. spans with length less than 500 m)	200	A rounded buffer extending 100 m on each side of the powerline centreline.
Long span powerlines (i.e. spans with length equal to or greater than 500 m)	300	A rounded buffer extending 150 m on each side of the powerline centreline.
Poles and Towers	50	A uniform 50 m buffer shall be included around all surveyed poles/towers, independent of the presence of overhead conductors.
Substations	50	Surveys shall cover the entire substation yard and include a 50 m buffer beyond the substation yard or fence, irrespective of property boundaries.

6.3.7 Point Classification

All classified point cloud data shall adhere to the modified ASPRS classification scheme (version 1.4). The minimum number of point classes to be derived and delivered according to this scheme is defined by the Classification Level specified below.

Captured LiDAR points shall be appropriately classified, in accordance with the requirements described in Table 6: Point Classification Framework below, which provides a framework for different classes of captured points. R/G/B columns refer to the red, blue, green values used in the RGB colour model to denote colours. The colour palette described in Table 6: Point Classification Framework is the typical palette used in utility models and has been provided for reference and can be changed to suit specific SA Power Networks requirements.

Table 6: Point Classification Framework

Code	Description	Application	R	G	B
1	Unclassified	Unproven points not yet classified	255	255	255
2	Ground	Used for terrain creation	255	204	153
3	Water	All water bodies	0	0	255
4	Road	Used for clearance specification	128	128	128
5	Vegetation	Used for clearance specification	0	128	0
6	Building	All Structures that are not power poles	128	128	128
7	Fence	Used for clearance specification	0	0	128
8	Vehicle	Used for clearance specification	0	255	255
9	Railway	Used for clearance specification	255	0	255
10	Pipeline	Generic pipeline infrastructure just above ground	0	0	128
11	Special	Generic object above ground	192	192	192
12	Noise	Points that are above ground and unidentified	255	255	255
13	Structure	Electricity structures	128	0	0
14	Stay	Wires supporting Structures non-current carrying	255	102	0
15	Conductor	Powerlines - current carrying	0	0	0

LiDAR classification shall be consistent across the complete project for all assets in scope. At no point shall the classification methodology be changed nor classification differ across project datasets without SA Power Networks prior approval. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other nonnatural divisions must not occur and must have appropriate mitigations (unless agreed by SA Power Networks).

6.3.8 Point Cloud Tiling

The point cloud shall be delivered as non-overlapping tiles each measuring 500 metres × 500 metres. The origin of each tile will be from south-west corner and shall be aligned to the MGA kilometre grid, meaning its easting and northing coordinates must be exact multiples of 1,000 metres.

6.3.9 Data Accessibility and Interoperability

All LiDAR data shall be in an interoperable format as per ASPRS industry standards to facilitate seamless integration, sharing, and usage of the data across different teams, applications, and systems.

6.3.10 Temporal Consistency

Where a LiDAR capture is a repeat survey, all data shall meet the accuracy requirements of Table 7 to ensure that temporal consistency is maintained between LiDAR captures.

Table 7: Temporal Consistency Accuracy Requirements

Temporal Parameter	Accuracy Requirement
Horizontal accuracy difference	5-10 cm
Vertical accuracy difference	5-10 cm
Feature change detection (e.g. Vegetation Growth or Sag)	Consistently detectable at a resolution of 1-2 cm

7. Data File Standards

7.1 LiDAR File Format

All LiDAR data shall be received and maintained by using a standard nomenclature and file format. Table 8 below captures file formats associated with different aspects of LiDAR artifacts.

Table 8: File Format

Item	Format	Comment
Point cloud data	LAS/LAZ version 1.4	LAZ is preferred due to its lossless compression.
Checkpoints	SHP	Provide the full list of survey control point coordinates, with site IDs for each control point, and supply the accuracy results obtained from the independent check point validation.
Survey coverage area	SHP	Polygons shall represent the swath coverage for each flight and clearly indicate areas where data was not acquired within the SAPN network corridor. The dataset must also include polygons identifying sections of the network that were not surveyed.
Survey coverage tile	SHP	Polygons shall outline the tile boundaries.

7.2 Naming Convention

LiDAR point cloud data shall be provided in a fully compliant ASPRS LAS 1.4 format. All files shall be named as per a standard naming convention below. The naming convention for point clouds shall follow the following style:

- CaptureZone-YYYY-CLA-DAT_XXXyyyy_ZZ_GG.ext

Table 9 explains the different elements of the above naming convention.

Table 9: File Naming Convention

Element	Description
CaptureZone	Identification of the capture zone. The LiDAR Capture Zones have been determined by SA Power Networks, with each HV feeder representing a Capture Zone.
YYYY	Year that the survey was undertaken
CLA	Captures the classification style of data: **SWATH (unclassified point cloud):** fully calibrated and georeferenced full-swath LiDAR data, delivered unclassified and adjusted to the specified horizontal and vertical datums. **ENG (engineering classified point cloud):** fully classified point cloud suitable for engineering applications, with ground, vegetation, buildings, structures, and noise classes applied to ASPRS standards. **VEG (vegetation classified point cloud):** basic classification applied for vegetation management.
DAT	Vertical datum (AHD)
XXXyyyy	The origin of each tile (south-west corner) must correspond to an easting and northing coordinate that is an exact multiple of 1,000 metres, ensuring alignment with the standard kilometre grid (e.g., XXX000 mE, yyyy0000 mN).
ZZ	MGA zone of file (which would be either 52, 53 or 54)
GG	Horizontal datum GDA2020 (ie. 20)
ext	LAS – data point cloud LAZ – compressed LAS xyz – ascii format for easting, northing, elevation, intensity asc – ESRI ascii GRID format shp – Shape file dxf – drawing exchange format

Example: LeighCreek-2025-ENG-AHD_2506620_54_20.LAZ