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Function:	All Disciplines
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ARTC GIS Centreline Guideline

AMT-GL-102

Applicability

ARTC Network Wide

Publication Requirement

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Primary Source

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1.6	14 Jul 2021	AMS GIS Specialist	GIS Working Group	Asset Management Systems Manager, Interstate Network	Manager Asset Planning & Investment, Interstate Network

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	21 May 2019		Issued for Consultation
1.1	05 Nov 2019		Modification based on Consultation Review
1.2	09 Dec 2019	3.8	Change of Resource Metadata requirements from Optional to Mandatory to align with Inland Rail Requirements based on Approval Review
1.3	25 Jun 2020	3.5.1	Addition of Section 3.5.1 to account for network topology required for DSP. Change of Publication from Internal to External
1.4	18 Oct 2020	3.6.1	Issued to GIS Working Group for Review Issued to IR A2I and S2P Projects as Working Draft

			Addition of requirement for Track Design derived centreline to align with Esri Roads and Highways topology requirements
1.5	17 Dec 2020		Formalising Working Draft. No changes occurred from V1.4
1.6	29 Jun 2021		Document Number change from INF-GL-102 to AMT-GL-102 due to addition of Asset Management to Document Library.
		3.2	Update of ArcGIS Pro version from 2.5.2 to 2.7.2
		3.4	Update of Track Centreline Vertex Frequency to 1m
		4.1.1, 4.1.2	Update of 4.1.1 and 4.1.2 to reflect AMT-SP-101 Definitions

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this document is to provide a standard specification for the storage and maintenance of the centreline data in ARTC GIS. The GIS centreline is an important part of the ARTC master data representing the network and acting as a reference for locating assets, planning works, visualising and analysing condition, maintenance and other characteristics of the network.

Centreline data as specified in this document is required as the framework for linear referencing. It can be used as a baseline for both design kilometrage and kilometre post reference routes.

1.2 Scope

This document provides specifications for the processing, format, structure and data schema for the centreline maintained in GIS. It is a live document and must be reviewed and updated when circumstances change to reflect current activities, processes and resources applicable to the reporting, storage and management of the data.

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, AMS Team Interstate Network.

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. They must 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.

1.5 Reference Documents

The ARTC disciplines interrelate in technical areas. The requirements and specifications for these can be found in the related documents listed in Table 2 below.

Document Number	Title	Discipline
ARTC		
AMT-SP-101	ARTC Technical Specification for Field Data Collection	GIS
ETD-00-03	Alignment Surveys	Track Alignment
ETD-00-01	Drawing Standard for Plans Showing Horizontal Alignment	Track Alignment
CoP Section 5	Track Geometry	Track Alignment
ETD-00-04	Control Surveys	Surveying

ETG-09-01	Structures Inventory	Structures
Inland Rail Specific		
0-9000-PEN-00-SP-0002	GIS Specification	GIS
0-9000-PEN-00-SP-0003	Survey Specification	Survey
0-0000-900-PAD-00-SD-0001	Document Numbering Standard	Document Management
0-0000-900-PAD-00-GU-0001	Programme Aconex User Guide	Document Management
EGP-04-01	Engineering Drawings and Documentation	Document Management
0-0000-900-PSY-00-GU-0012	Cartographic Mapping Style Guide	GIS
0-900-PQU-00-MN-1000	Inland Rail Engineering Drawings and Documentation	Design and Drawings
0-900-PEN-00-PL-1000	BIM Implementation Requirements Plan	BIM

Table 1: The relationships of the Centreline GIS Specification with other key standards and documents

1.6 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
ARTC	Australian Rail Track Corporation Ltd.
ARTC GIS	ARTC Corporate GIS and the GIS teams working on the Inland Rail Programme and Projects.
Centreline	The track centreline. Centreline can be derived from rail heads by collapsing the dual-line into one line. Complete centreline includes lines for main lines (up and down in case of multiple tracks), passing loops, sidings, balloon loops and cross overs. On conventional alignment the track centreline is defined by the coordinated design horizontal alignment geometry.
Measuring centreline	There are several methods to determine the track centreline for existing track. Each method has strengths and weaknesses: 1) Half the design gauge from the low rail (0.7175m) 2) Half the design gauge from the high rail (0.7175m) 3) In the centre of the actual measured gauge When utilising method 1 or 2 on tangent track, it is usual to adopt the same rail as the one used in the previously measured curve. It is preferred by ARTC to use method (3) however, where significant gauge wear is present the centreline can be measured based on the midpoint of the toe of the rail on the gauge side.
Gauge	Gauge is the distance between adjacent rail running faces measured 16mm below Top of Rail. Standard gauge is 1435mm Wide gauge is 1600mm Narrow gauge is 1067mm
Linear Referencing	Linear referencing is a method of spatial referencing, in which the

Term or acronym	Description
	locations of features are described in terms of measurements along a linear element, from a defined starting point, for example a milestone along a road. Each feature is located by either a point or a line. The system is designed so that if a segment of a route is changed, only those kilometerage points on the changed segment need to be updated. Linear referencing is suitable for management of data related to linear features like roads, railways, oil and gas transmission pipelines, power and data transmission lines, and rivers.
Geodatabase	A collection of geographic datasets of various types held in a common file system folder, a Microsoft Access database or a multiuser relational Database Management System (DBMS), such as Oracle, Microsoft SQL Server, PostgreSQL, Informix or IBM DB2. The format is. gdb and is the native data structure for ArcGIS.
IP	Intellectual Property
QA	Quality Assurance
RFI	Request for Information
SME	Subject Matter Expert
The Contractor	External organisation providing service to the ARTC.
Vendor	Commercial organisation providing software or data services.
Web Map	A web-based, interactive map including layers that allows varying displays and queries.
Web Service	An internet-based software component for use in other applications. These web services are built using industry standards such as XML and SOAP and are not dependent on any particular operating system or programming language, allowing access through a wide range of applications.

2 ARTC GIS Environment

ARTC's GIS is built on the ESRI ArcGIS platform.

All data, map templates, symbology files and style files supplied to ARTC are to be delivered in the ESRI geodatabase format and it is recommended all GIS work is conducted using ESRI software. Data supplied to the Contractor by sub-contractors in non-ESRI format will need to be converted to an ESRI format by the Contractor, adhering to the specifications outlined in this document.

2.1 Hierarchy

Alignment information obtained from track designers is of a higher quality and accuracy than alignment stored in GIS systems.

2.2 Updating

Splicing of new design alignment into existing systems must only be undertaken by persons competent in track alignment and, in particular, kilometrage adjustments.

Modification of route kilometrages must only be undertaken in consultation with all stakeholders. This includes, but is not limited to:

- Operations
- Signals
- Routine Maintenance
- Geotech
- Enviro
- Surveying
- Track Design
- Assets
- GIS

3 General Data Specifications

3.1 Introduction

This section defines the general data specification and standards that apply to:

- Data format
- Coordinate systems
- General data structure
- Topology rules
- Simplification algorithm
- Attribute requirements

- Metadata

3.2 Data Format

All data shall be supplied in compliant GDA94 with AHD(Ellipsoid09) with latitude/longitude supplied to 8 decimal places minimum.

ARTC maintains an Enterprise Esri GIS environment with multiple business units utilising this platform. Therefore, the spatial data deliverables are required to be submitted in an ArcGIS file geodatabase (.gdb) format. A blank template geodatabase compliant with AMT-SP-101 will be provided for all data capture projects to facilitate the efficient and robust capture of the data detailed in this specification. To obtain a copy of a blank template geodatabase, please contact the relevant Project Manager.

It is preferred for the Delivery Party to use ARTC's current version of ArcGIS products to minimise risk and potential incompatibility with ARTC's systems. The Delivery Party should consult with the ARTC Project Manager and GIS Technical Lead to ensure the current operating version of:

- ArcGIS Pro;
- ArcGIS Desktop; and
- ArcGIS Enterprise.

Should the Delivery Party wish to operate and deliver in an alternative version of ArcGIS (such as version 10.5.1), a request must be lodged with the ARTC Project Manager and the GIS technical lead for consideration and response before the start-up meeting. Upon negotiation an accepted alternative is an Esri Shapefile, the formatting and schema of this alternative deliverable must comply with the appropriate field definitions in AMT-SP-101.

3.3 Coordinate system

The coordinate system to be used for centreline data is Geocentric Datum of Australia 1994 GDA(94), WKID 4283ITRF92 (Epoch 2010.0).

The adopted height datum is Australian Height Datum.

The coordinate systems used by ARTC are described in the Survey Specification (0-9000-PEN-00-SP0003).

3.4 General data structure

The following rules apply for the centreline data structure:

- 3D line in the specified coordinate system and height datum
- Track centrelines should be one continuous line the extent of a track Basecode.
- Line can terminate or begin at Basecode start and end locations (as nodes), sometimes signified by change kilometre boards
- Track centreline vertex frequency should be no less frequent than 1m spacing.
- Kilometre adjustments to be located away from any infrastructure especially kilometre posts
- One continuous line from a turnout to the next turnout, unless the above applies
- Turnout location is defined as the toe of switch location
- Line ends need to be snapped together at turnout (no gaps, no overlap)
- Overlapping lines are only allowed for overpass and underpass (aka flyovers) and spirals.

- Line direction is towards increasing kilometrage
- Centreline includes all main lines (up and down), passing loops, balloon loops, sidings, cross overs, yards (ARTC owned), and yard entries (if owned by operator other than ARTC).

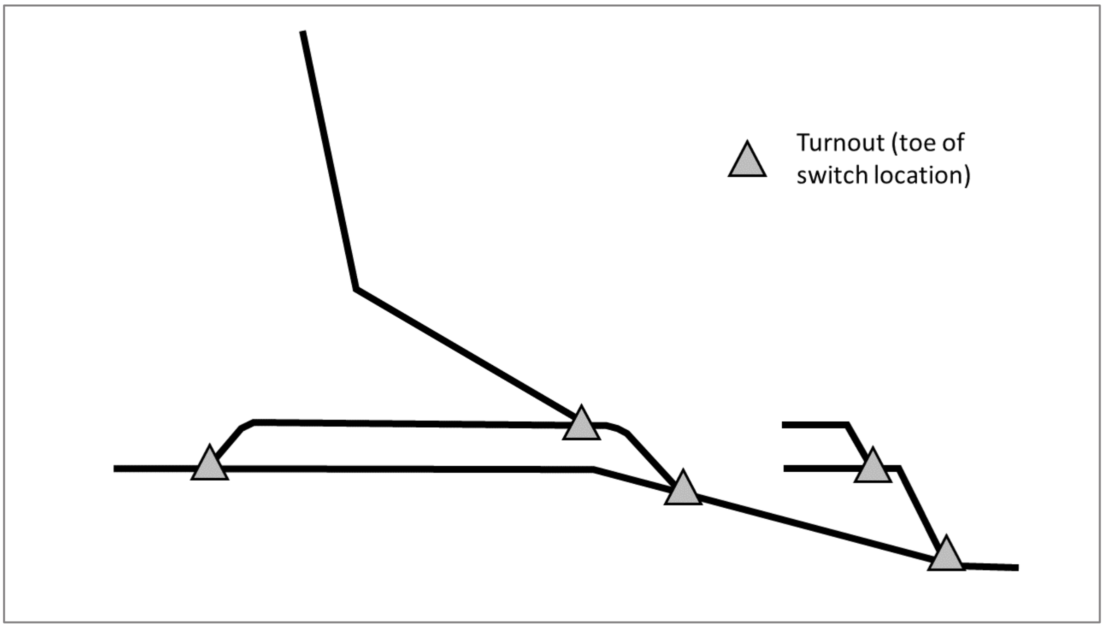
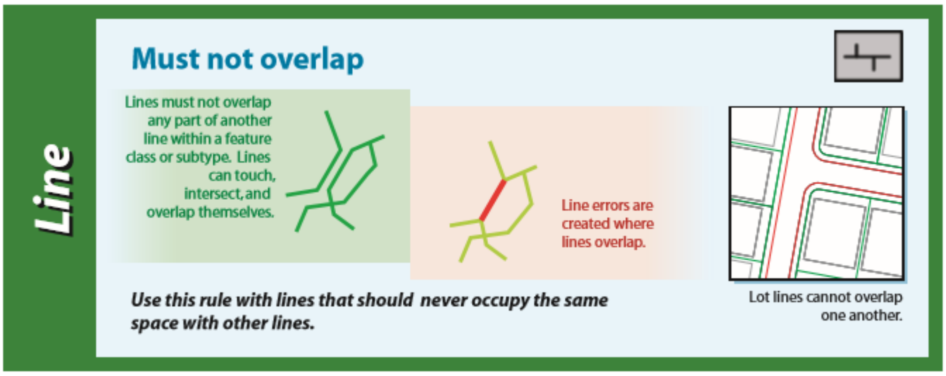
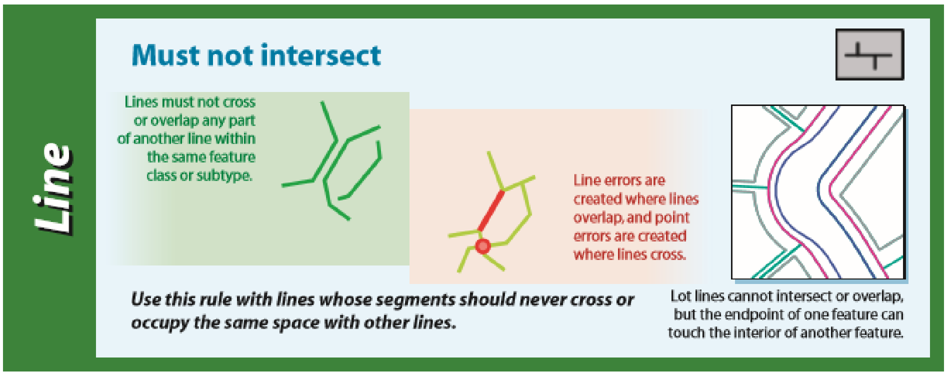


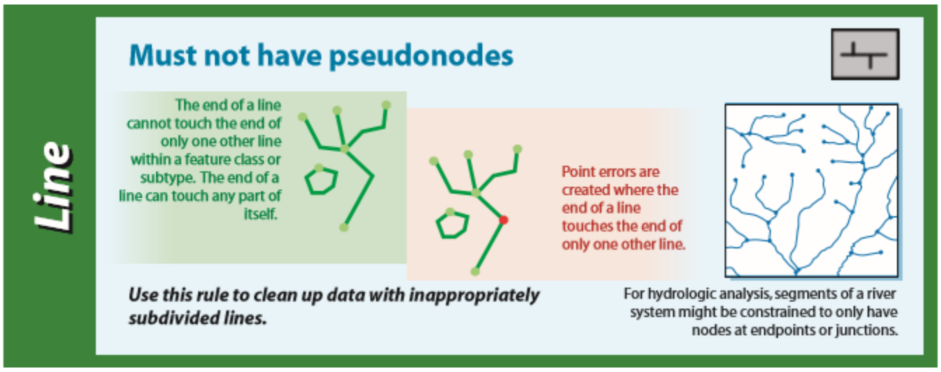
Figure 1: Centreline structure showing turnout locations

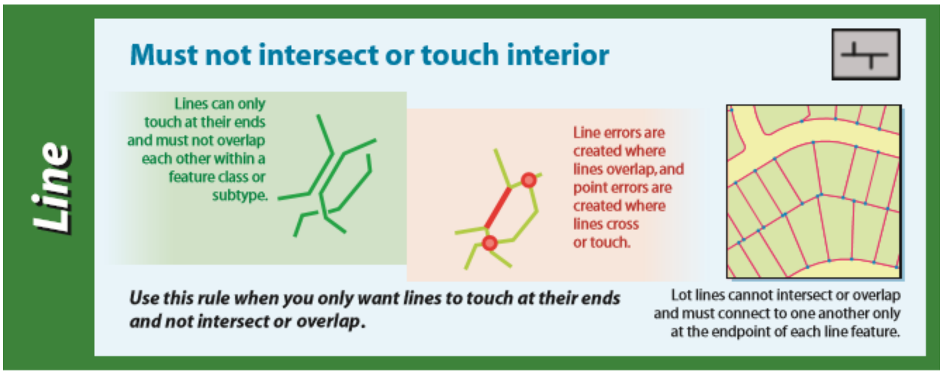
3.5 Topology rules

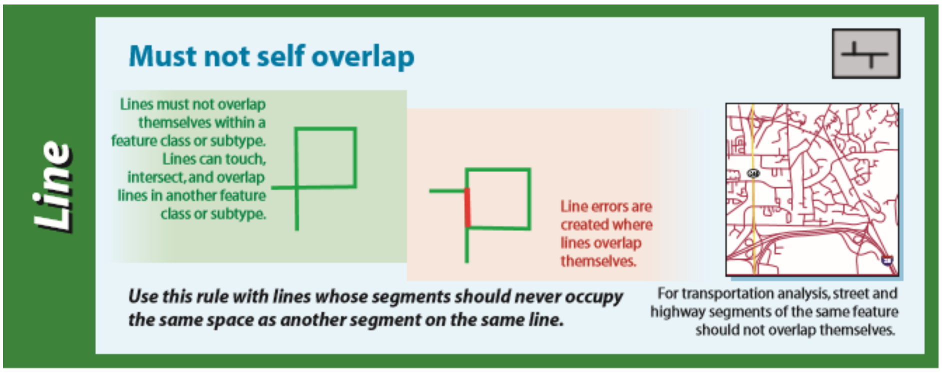
The following topology rules apply for the centreline data:

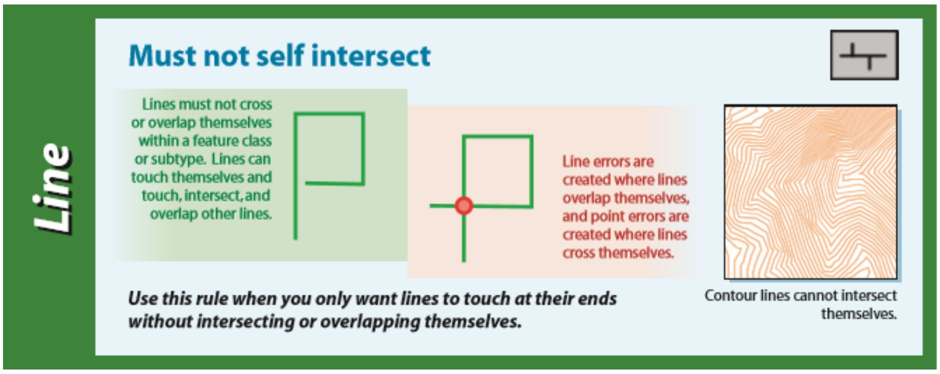












Exception: This rule does not apply for spiral track, i.e.. Bethungra spiral, etc.

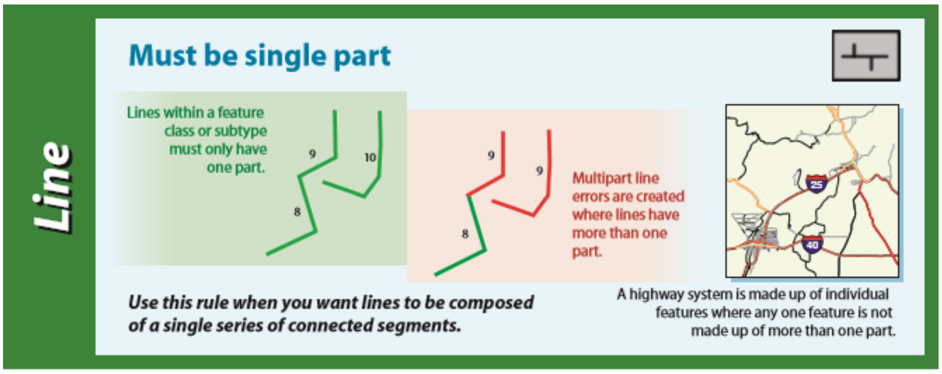


Figure 2: Topology rules to be applied to centreline

The data will be checked against these rules and rejected if topology errors are found. Example of a topology error that will result in the data being rejected in figure 3.

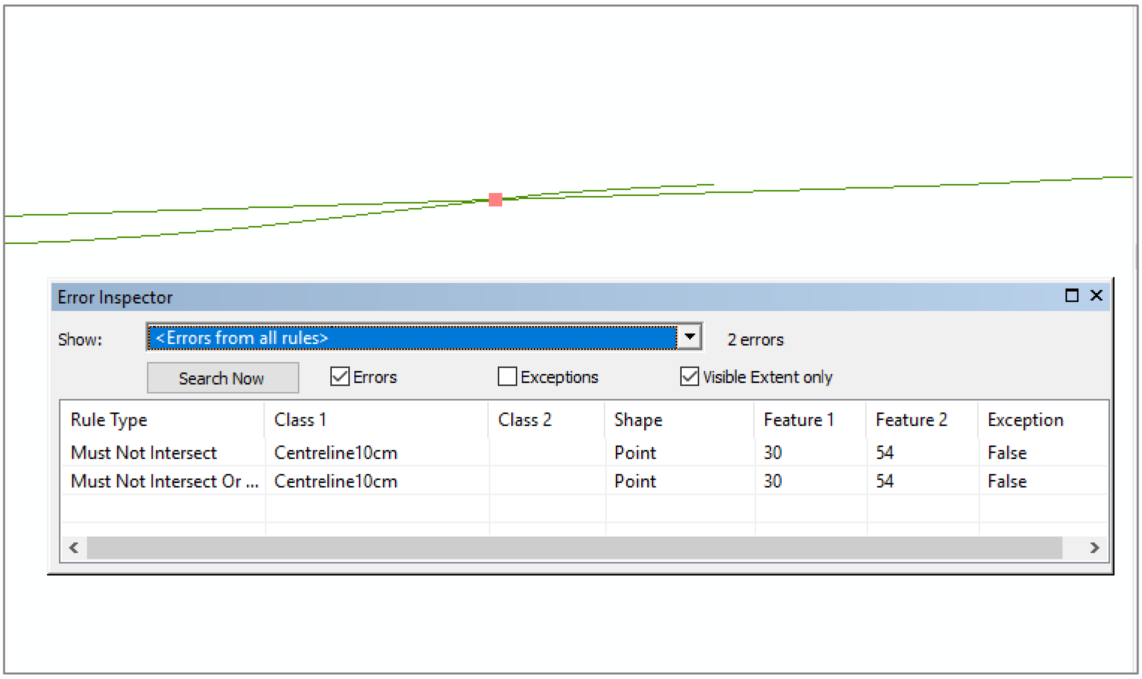


Figure 3: Topology rules to be applied to centreline

3.5.1 Common Node Topology

To ensure network topology integrity, at track deviation locations (turnouts) the turnout node, mainline and departure road must all share a common node.

In some instances, this will require creating an additional node on the mainline centreline between the automatically generated 1m nodes.

These common nodes must be present in all centrelines, including simplified centrelines.

3.6 Centreline Derivation Methodology

3.6.1 Track Design

The highest classification for alignment is “design” alignment. Design alignment has a mathematical accuracy to 12 decimal places to allow for use in design packages such as Bentley Rail Track (InRail) and 12d.

Design alignment has mathematical/geometrical representations for tangents, arcs, transitions and compound transition elements that make up the alignment. The track designer also assigns a kilometrage to the frame points of each element. Kilometrage adjustments notwithstanding, the survey kilometrage of any frame point is the cumulative total from the Capital City (or 0km) in each State of the individual component lengths. (ETD-00-03)

ARTC requires Track Centreline data to be delivered as X,Y,Z vertices forming a polyline, also known as 3d line types, which are free from design geometry such as arcs, spirals and Bezier curves. This can be achieved through multiple decimation processes available in products such as 12d, Bentley InRail, AutoDesk and Esri ArcGIS. This is mandatory of all deliverables due to the distortion caused by displaying alignment information in a projected coordinate system.

3.6.2 Regression Analysis using survey information

Design alignment for existing track can be developed from track survey data, including Mobile Laser Scanning. ARTC's current method is to undertake a regression analysis of the reduced survey data to obtain a "best fit' while remaining within the design parameters required by the track design standards. Once an alignment has been designed it should be maintained such that it doesn't require subsequent re-surveying and re-designing.

3.6.3 Simplification Algorithm from GNSS

NOTE: TRAN_TrackCentreline_Ln is a RAW 3D track centreline and must not be simplified. ARTC maintains a product centreline called TRAN_TrackCentrelineSimp_Ln which is a simplified representation for mapping activities.

If a centreline is created from point data a simplification algorithm can be used to reduce the number of vertices. A tool like the ESRI Simplify Line with Point Remove algorithm can be used to achieve the desired result.

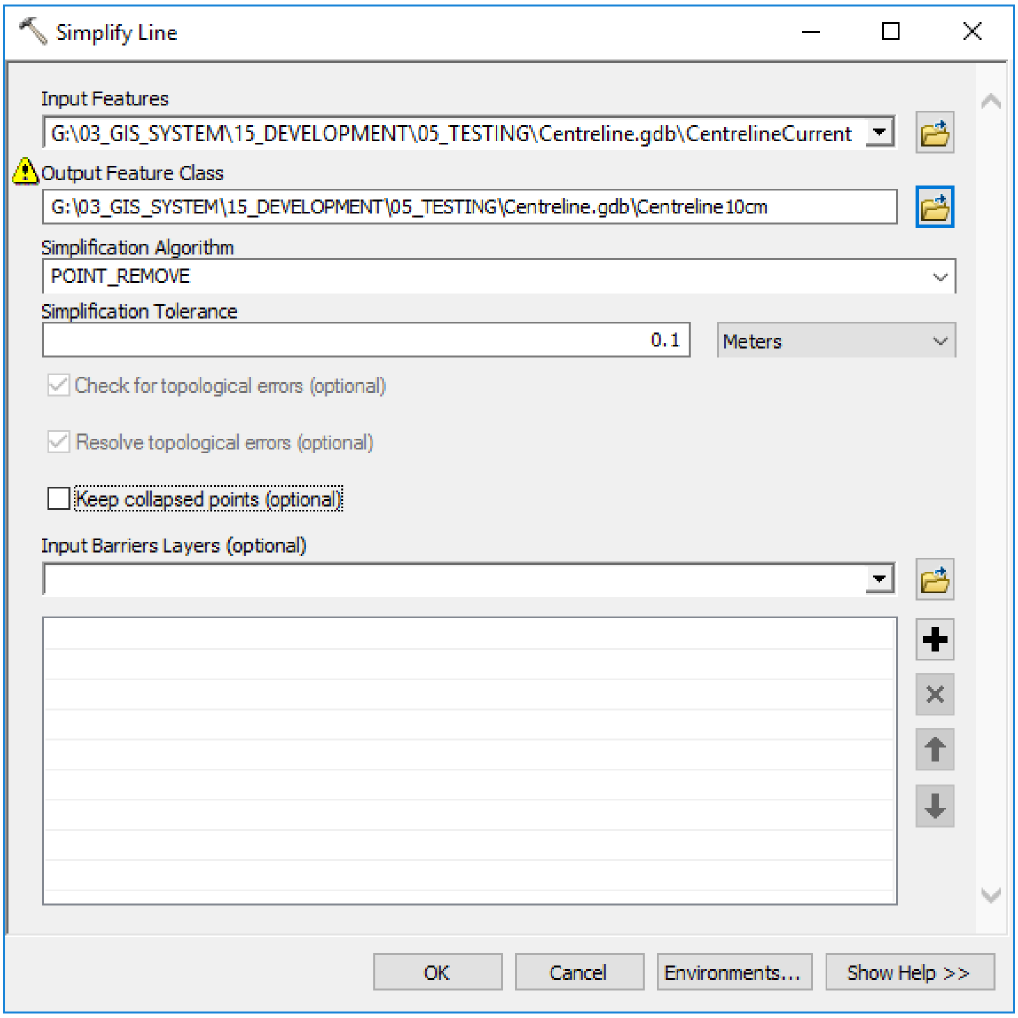


Figure 4: ESRI Simplify line tool

The simplification algorithm to be used is Point Remove.

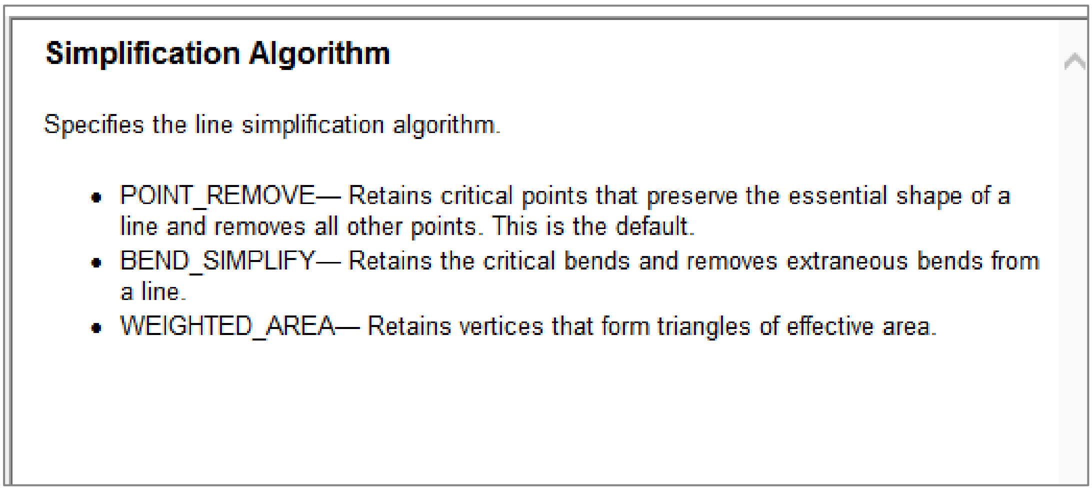
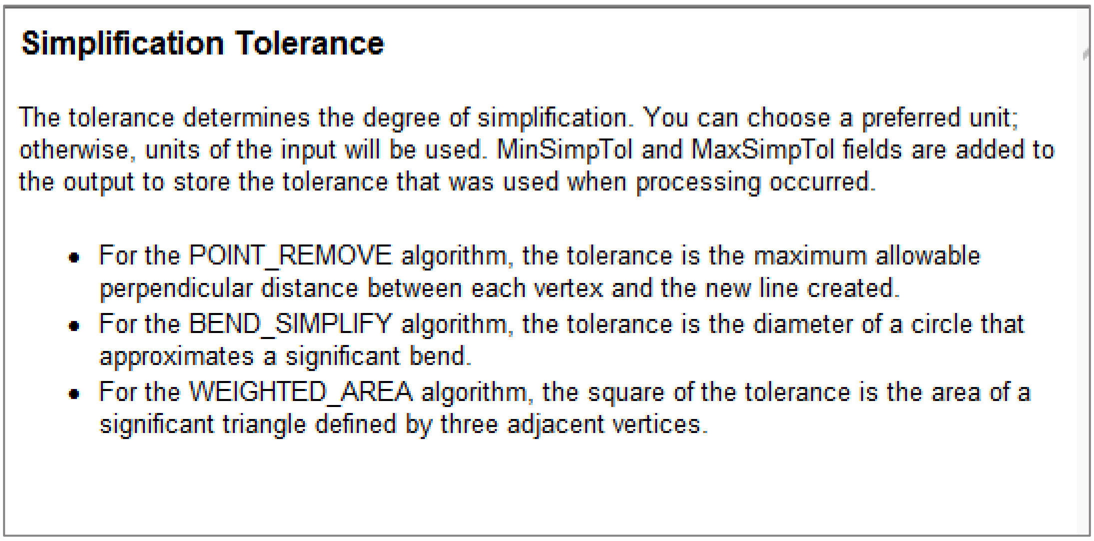


Figure 5: Simplification algorithm to be used is POINT REMOVE

The maximum allowed tolerance for perpendicular distance between each vertex and the new line created is 0.1m.


Simplification Tolerance

The tolerance determines the degree of simplification. You can choose a preferred unit; otherwise, units of the input will be used. MinSimpTol and MaxSimpTol fields are added to the output to store the tolerance that was used when processing occurred.

- For the POINT_REMOVE algorithm, the tolerance is the maximum allowable perpendicular distance between each vertex and the new line created.
- For the BEND_SIMPLIFY algorithm, the tolerance is the diameter of a circle that approximates a significant bend.
- For the WEIGHTED_AREA algorithm, the square of the tolerance is the area of a significant triangle defined by three adjacent vertices.

Figure 6: The maximum simplification tolerance to be used is 0.1m

The simplification algorithm will retain the shape but reduce the number of vertices especially in tangent sections.

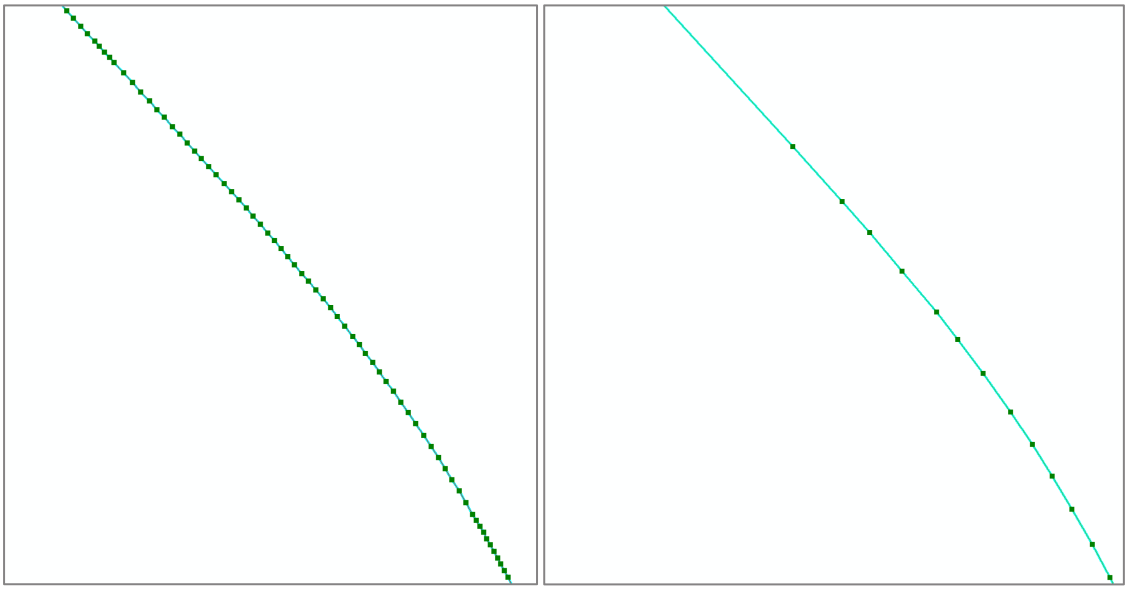


Figure 7: Centreline vertices before and after running the Simplify Line tool

3.7 Attribute requirements

The centreline data must be provided as a 3D feature class with the attributes specified in the ***Track Centreline Feature Class*** within AMT-SP-101 Technical Specification for Asset Field Data Collection. A file geodatabase with the centreline data schema template will be provided to the Contractor at the commencement of a project.

3.8 Metadata

ARTC's GIS metadata specifications are designed to promote an efficient system through an integrated delivery approach. Metadata must be part of an ArcGIS item and embedded in the ArcGIS software being used to create the data. When the item is copied in ArcGIS, its metadata is also copied. When the item is imported into a geodatabase, its metadata is also imported. When creating metadata, the following practices are mandatory:

- all information is to appear in the main metadata page
- layer / alias names must be the same
- reference data must credit the custodian
- newly created data must credit the creator with the description of how the data has been produced.

All data deliverables require metadata to be populated. Deliverables with incomplete metadata will fail ARTC quality assurance processes.

The ISO 19139 standard is to be applied, with the fields to be completed detailed in the table below and in line with requirements within AMT-SP-101.

Section	Group	Element	Requirement	Description
Overview	**Item Description**	Title	Mandatory	The name by which the cited resource is known. This must be the same as the layer / file name.
		Summary	Mandatory	A summary of the intentions with which the resource was developed. Also known as the purpose.
		Description	Mandatory	A summary of the resources content. Also known as the abstract.
		Tags	Mandatory	Keywords to aid in data searches.
		Thumbnail	Mandatory	Thumbnail image of the content.
		Bounding Box	Mandatory	Coordinate extents of the dataset.
	Topics and Keywords	Topic Category	Mandatory	A high-level geographic data thematic classification to assist in the grouping and searching of available geographic data sets. Can be used to group keywords as well. Only one category to be selected.
		Theme Keywords	Optional	
	Citation	Date	Mandatory	The date when the resource was created, published or revised YYYYMMDD (derived from Item Description and Title).
Resource	**Constraints**	General	Mandatory	Identifies any handling restrictions of the resource or metadata.
		Legal	Mandatory	
		Security	Mandatory	
	Lineage	Statement	Mandatory	Provides a general description of the resource's lineage. A lineage statement must be provided if process steps or sources aren't provided, and the resource described has a 'dataset' or 'series' hierarchy level.
	Distribution	Format	Mandatory	File format used to distribute the resource.

3.8.1 ARTC Data Categories (ISO 19139)

The following data categories based on ISO 19139 Geographical Information Metadata Standard shall be used for track centreline data.

Name	Code	Description	Prefix
transportation	**18**	**means and aids for conveying persons and/or goods**	**TRAN**

4 Kilometrage

4.1 Kilometrage

For determining track distance, every rail track has an assigned direction, with an assigned start of track and end of track.

The assigned direction of a track kilometrage predominately steadily increases when moving away from Capital Cities however there are places on the network where there are step changes in the kilometrage that have been brought about due to spirals or deviations or because of interfaces between either existing or past corridors that utilised a different route and therefore notable anomalies. For more information, consult AMT-SP-101 Technical Specification for Asset Field Data Collection.

4.1.1 Relative Kilometrage

Relative kilometrage is the historical location reference system used on the ARTC network measuring location based on the meterage from the *preceding* kilometre post. This methodology has seen multiple data and asset management issues due to the presence of long (kilometres containing more than 1000m) and short (kilometres containing less than 1000m) kilometrage. This is the current location reference methodology used by Track Recording vehicles and field data collection by ARTC staff.

4.1.2 Absolute Kilometrage

Absolute Kilometrage is the primary location referencing value to be used across the ARTC business and provides a whole decimal kilometrage value. This methodology is derived from the master LRS model and incorporates all known kilometrage adjustments and anomalies. Kilometrage adjustments can be both positive and negative and scale may be applied to compensate for long and short kilometre discrepancies between kilometrage monuments.

Within this specification Absolute Kilometrage is stored within the field AbsKm as a double formatted numeric field.

4.2 Kilometrage markers/posts

Along most rail corridors, kilometre posts and ½ kilometre posts have been installed. These posts help train drivers and infrastructure workers identify where they are along a corridor. The kilometre posts are often adopted as “gospel” and subsequent measurements from the posts are quoted and used in all sorts of infrastructure documentation registers. For various reasons kilometre & ½ kilometre posts are often not exactly 500m apart. Some states have mandated that metrages are only measured forward but this methodology has not always been rigorously followed so many inconsistencies exist across the various registers.

4.3 Kilometrage adjustments

Corridor metrages are usually reset so that they align with existing kilometre post kilometrages. This process is known as a kilometrage adjustment. The adjustments can be short or long adjustments.

Where the kilometrage of parallel tracks and routes become staggered, their kilometrages are reset to the corridor through metrage as soon as practicable, e.g. Coals v Mains in the Hunter Valley.

Some locations have parallel tracks/routes that subsequently diverge into separate corridors, e.g. Maitland and Muswellbrook. At these locations, the diverging route's kilometrage may be adjusted to the through kilometrage just prior to the divergence. The metrage of that new corridor usually commences with the through metrage at the theoretical crossing point of the turnout on the down main (or single main).

- kilometre adjustments should be located away from any infrastructure especially kilometre posts
- kilometre adjustments should only be placed in tangent track which is also on constant grade

4.4 Turnouts/crossovers

The common kilometrage location for diverging tracks is usually at the turnout theoretical crossing point. There is only one running kilometrage between the theoretical point and the turnout tangent point (i.e. the geometric tangent point of a tangential turnout)/point of blade (i.e. the physical end/tip of the turnout switch) and it is usually on the straight road.

The common kilometrage is sometimes at the 'e' point on non-tangential turnouts/crossovers.

4.5 Design Alignment kilometrage

Conventional design alignment has mathematical/geometrical representations for the tangents, arcs, transitions and compound transition elements that make up the alignment. The ends of each element are known as a frame point. Frame points have known coordinates, but the track designer assigns a kilometrage to the frame points of each element. Kilometrage adjustments notwithstanding, the survey kilometrage of any frame point is the cumulative total from the Capital City (0km) of the individual component lengths.

NB. Changing the kilometrage of a frame point does not move the actual location of the frame point.

4.6 Vertical Intersection Point kilometrage

Vertical alignment is comprised of constant grade and changing grade (vertical curves). The location of the intersection of these grades are known as vertical Intersection Points (IPs). These IPs are defined by their kilometrage and their reduced level (RL). Kilometrage adjustments in tracks can impact on the actual location of IPs if not managed carefully.

NB. Changing the kilometrage of an IP will move the actual location of the IP.