Innovations in LiDAR Processing and Clearance Benchmarking

RICA 2025

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D/GAUGE Cordel

Cordel and D/Gauge have worked closely together since 2019. We use or prepare trusted high quality survey records to provide our customers with reliable and accurate clearance information. We have long term contracts together to support Network Rail, Amtrak and Saudi Arabia Railways.

Whilst our systems work independently, through cloud integration we can seamlessly link to support those customers who require a complete 'capture to clearance' solution.

NetworkRail

- Capture of gauge clearance surveys for structures and overhead lines.
- Automated processing of 3rd party LiDAR
- Management of all Network Rail's clearance surveys (circa 280,000 structures).
- Management of all Network Rail's clearances (100+ vehicles for 550+ maintainers)

AMTRAK

- Capture of gauge clearance surveys for full network (1,400 miles)
- Management of all gauge clearance surveys, LiDAR and video.
- Management of all clearances to standard plates
- Assessment tools for High-and-Wide (exceptional load) movements

Our Combined Offering

1

Measurement and Processing

- Bespoke hardware for simple ‘fit and forget’ installation.
- Suitable for one-off benchmarking or continual recording activities.
- AI-powered automated data processing and analytics, can also be applied to existing data.

2

Manage Records

- Centralised storage of all records and LiDAR point clouds
- Intuitive data management, editing, and administration
- Processing and handling of 3rd party surveys and LiDAR

3

Understand and Optimise Clearances

- Insight into network-wide clearance risks and localised problem assets.
- Feasibility into moving ‘exceptional’ loads such as high wides
- Investigate and assess infrastructure upgrades and maintenance

Examples – Surveys and Data Management

ARTC
- Australia

Processing, managing and storing 4,500km of survey records per month covering the full ARTC freight network (8,500km).

Network Rail
- United Kingdom

Managing and storing the national survey database that is used for assessing clearances. Includes over 1Million records for 280,000 structures with around 5% of the dataset updated every 4 weeks.

Glasgow Subway
– Scotland

Processing and storing surveys captured using traditional survey methods for an underground urban railway (circa 25km). Populated over several weeks with quality assurance checks.

Examples - Clearances

ARTC
- Australia

Monitoring of full ARTC Freight network (8,500 km) against the standard gauges and plates critical to the network operations.

Network Rail
– United Kingdom

Monitoring of full UK network clearances (20,000 miles) against all standard and timetabled traffic (over 100 different shapes). 5,000 passenger and crew platforms are also monitored for passenger safety.

London Underground
– United Kingdom

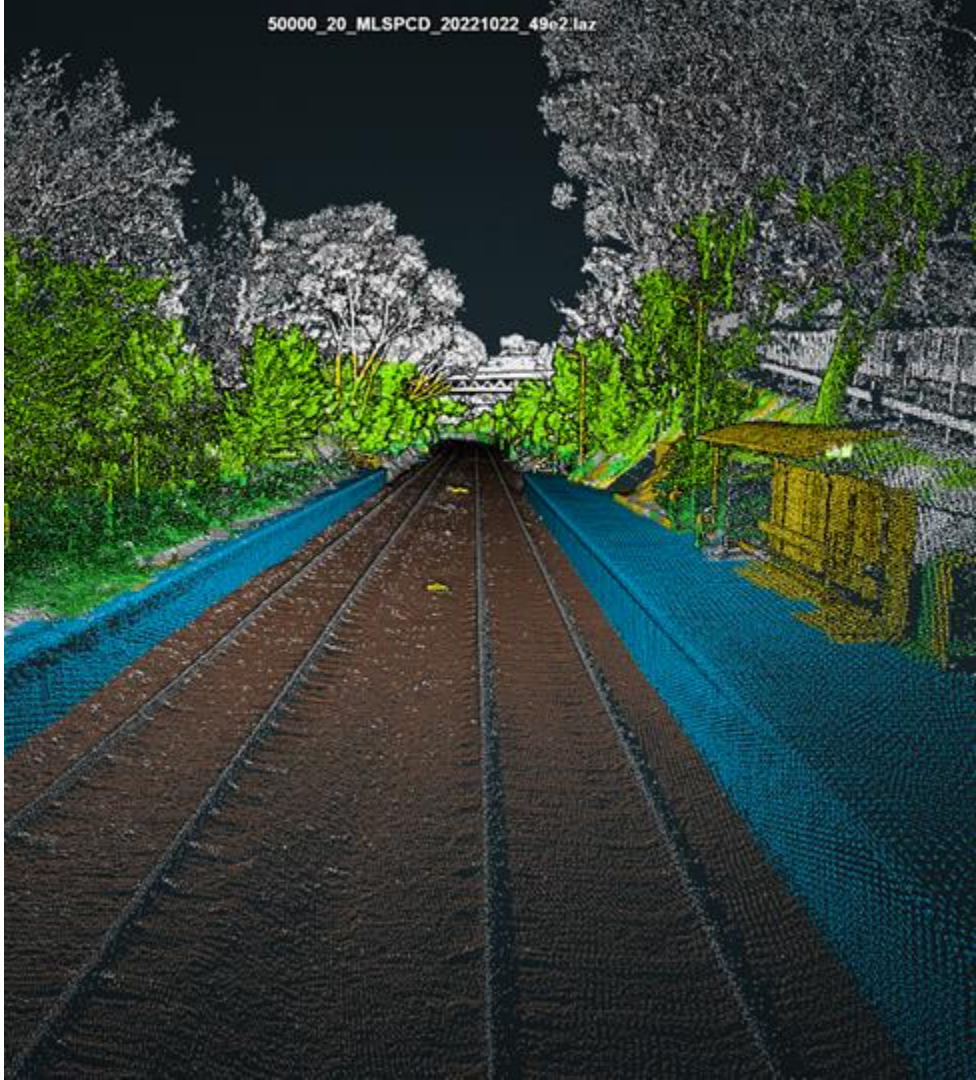
Clearance assessment of tight areas on the network to support upgrades and new vehicle introductions. Specialising in areas of highly changeable track geometry.

LiDAR Processing

Negin Shafie

LiDAR Data - Introduction

- What is LiDAR?
  - Laser based technology
  - Distance measurement using time-of-flight
- 3D Point Clouds
  - Three-dimensional spatial data
  - Geospatially positioned
- Why classify point clouds?
  - Feature detection
  - Object identification



Artificial Intelligence - Definitions

- Machine Learning (ML)
  - Definition: AI technique where systems learn from data without explicit programming.
  - Comparison: Subset of AI; uses algorithms to identify patterns and make decisions.

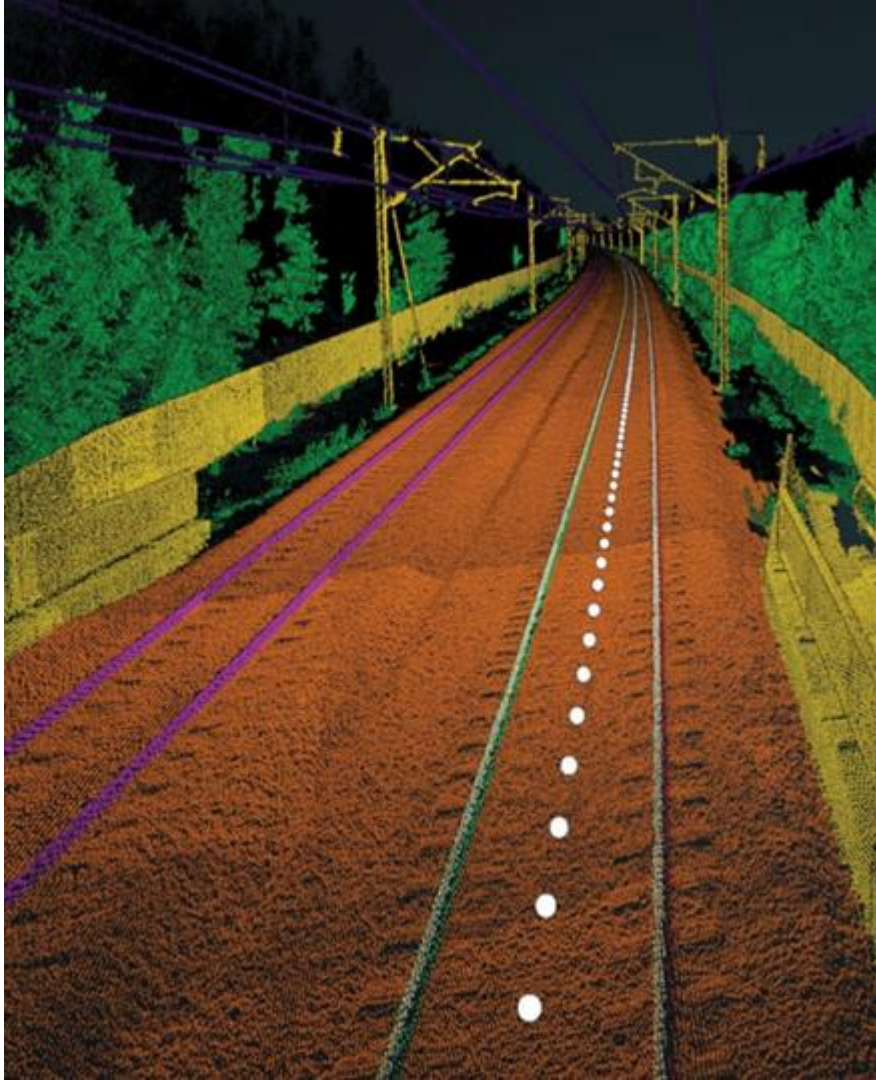
- Deep Learning (DL)
  - Definition: ML using neural networks with many layers for high-level feature extraction.
  - Comparison: Subset of ML; excels in image, speech, and complex data processing.

- Artificial Intelligence (AI)
  - Definition: Broad field enabling machines to mimic human intelligence.
  - Comparison: Encompasses all intelligent behavior - ML and DL are subsets.

Jeff Crume [IBM Technology]. (2023, April 10). *AI vs machine learning* [Video]. YouTube. from https://www.youtube.com/watch?v=4RixMPF4xis

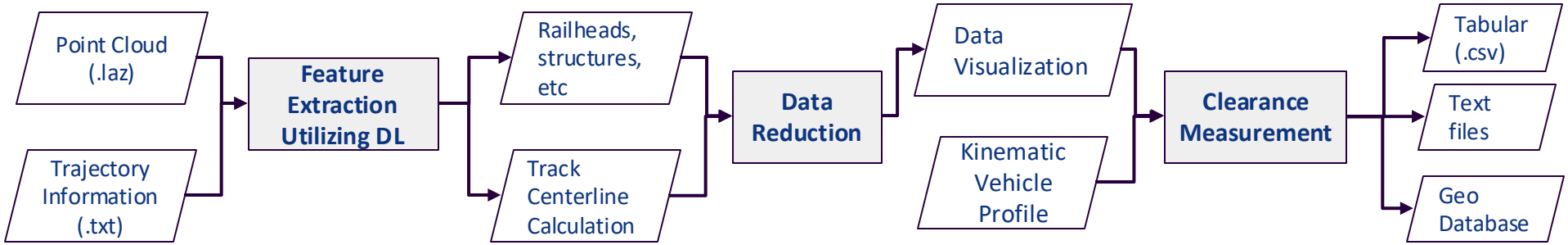
Point Cloud Classification

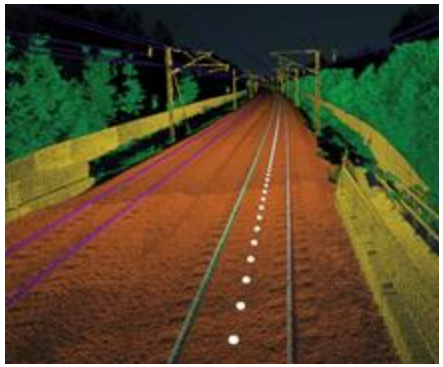
- Advances in capture technology
  - More data
  - Less time
- Traditional ML
  - Manual feature extraction
  - Poor adaptive ability and prone to noise
  - Speed and data volume limitations
- Deep Learning
  - Self-taught feature extraction
  - Automated feature extraction
  - Dependant on training data



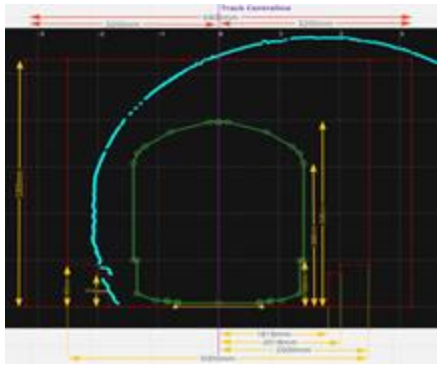
Huang Zhang, Changshuo Wang, Shengwei Tian, Baoli Lu, Liping Zhang, Xin Ning, Xiao Bai, Deep learning-based 3D point cloud classification: A systematic survey and outlook, ISSN 0141-9382, https://doi.org/10.1016/j.displa.2023.102456.

LiDAR Data Processing - Workflow

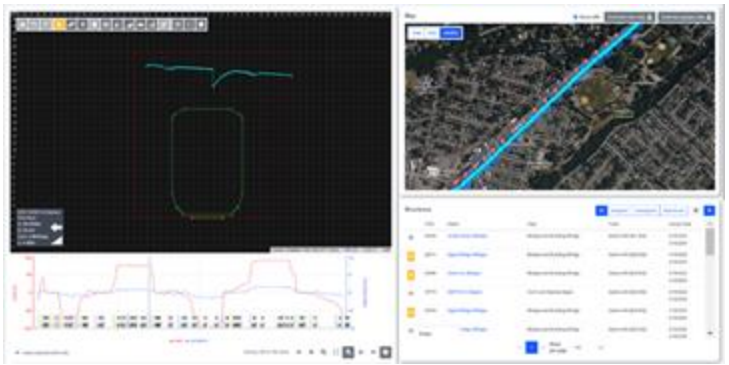




Classified point cloud



Data Visualization



Example clearance survey uploaded on Cordel's web platform

Values and Challenges

- Accelerated results
- Reducing storage size of data significantly by filtering and converting 3D cross-sections into 2D slices
- Identifying and adding missing structures to the structure dataset
- Raising defects followed by pushing notifications once infringements are identified

- Accuracy spectrum
- Environmental factors
- Skill sets requirements
- Data integration

Benchmarking Case Study

Colin Johnson

Project Overview

D/GAUGE

Benchmarking: SAR Railway

- Mixed Traffic Railroad
- 4,000km linear miles
- AAR ‘Operating’ Railway
- Metric and European Practices

Fitment of LiDAR

- Fitment to the existing Fleets
- Fit-and-Forget system

Clearance Survey Outputs

Structure Clearance

- Rail Positions
- Track Geometry
- Structure Points

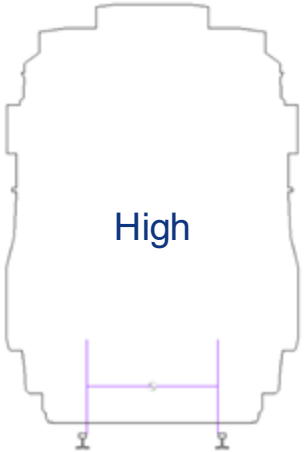
Passing Clearance

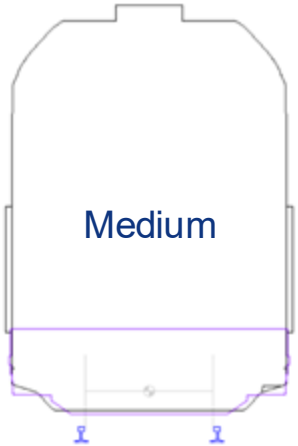
- Rail positions (2 tracks)
- Track geometry

Stepping Distances

- Rail Positions
- Stepping Attribute

Rolling Stock

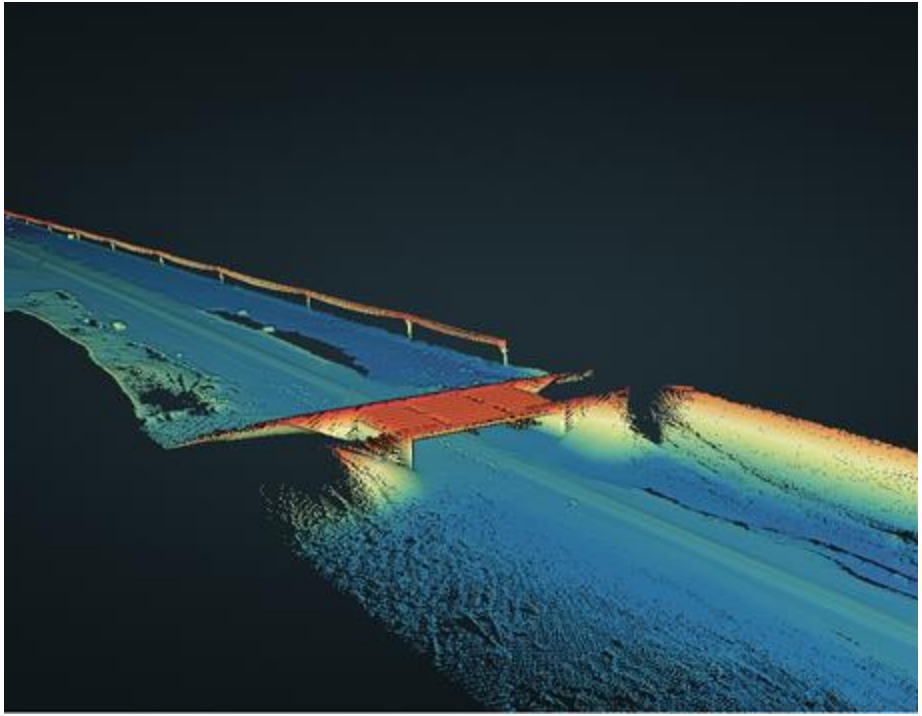




D/GAUGE

Clearance Survey

- Network Model and Asset Register
- 3D Point Cloud:
  - Manual Measurements
  - Track Levels
- HD Video:
  - Remote Inspection
  - Aids for Engineering
- Re-Survey Capability
  - Permanent LiDAR Installation available in Future



Clearance Outputs

Route Section	Signal 138.4km
Line Code	SARL2
Start Distance (km)	138.406
End Distance (km)	138.409

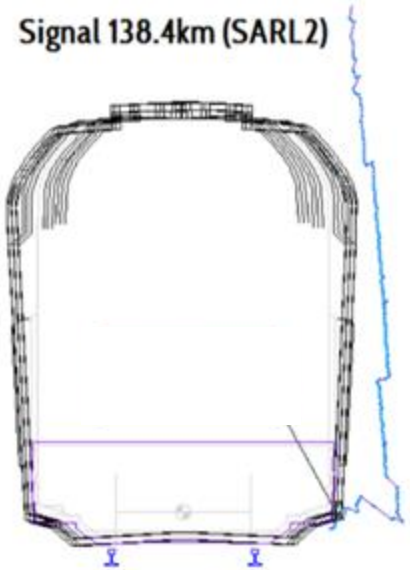
Gauging Commentary:

Foul clearance in lower sector can be seen to the bottom of the signal.

After video review, this has been identified as vegetation.

We recommend that SAR review the signal in the lower sector of this area to confirm if there is a genuine structure below the vegetation.

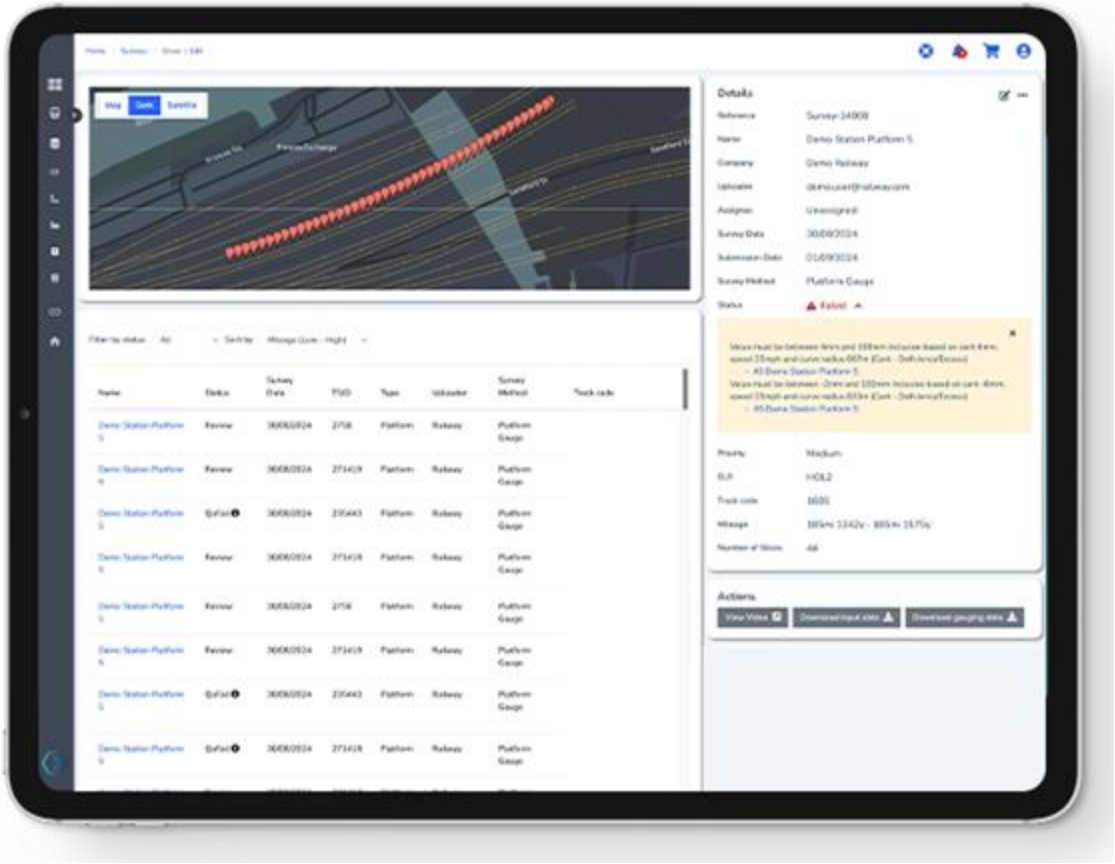
The signal gives sufficient clearance in the upper sector.



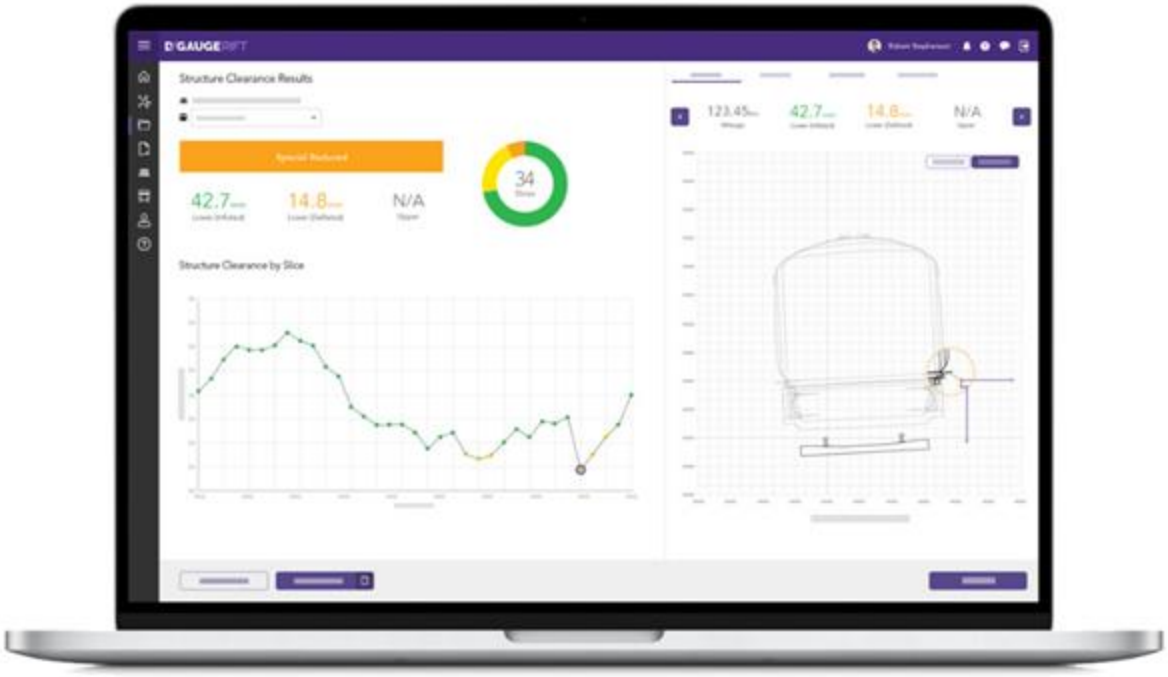
Summary of SAR Railway

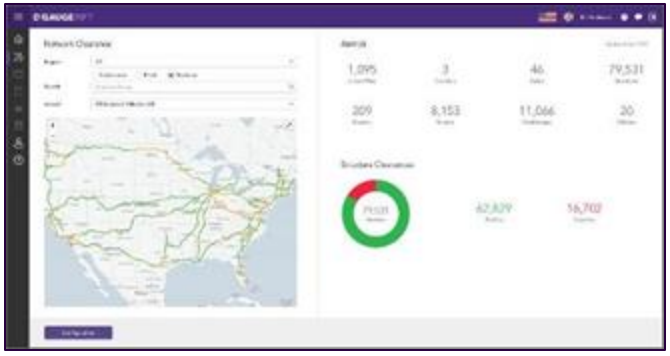
- 1,750km benchmarked in under 3 months.
- No delays to ongoing vehicle procurement.
- Areas of concern identified and mitigated.
- Data and software tools to support future clearance exercises (H&W).

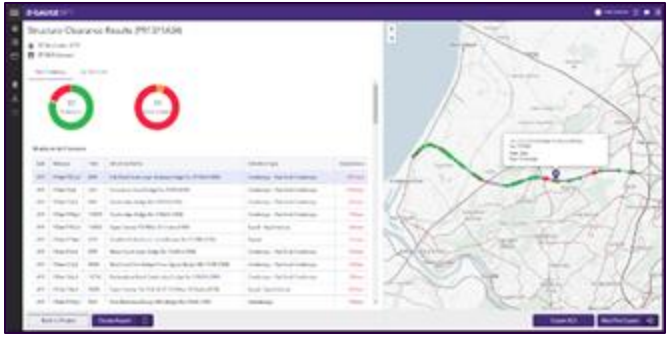
Software : LiDAR Analysis



Software : Clearance Analysis

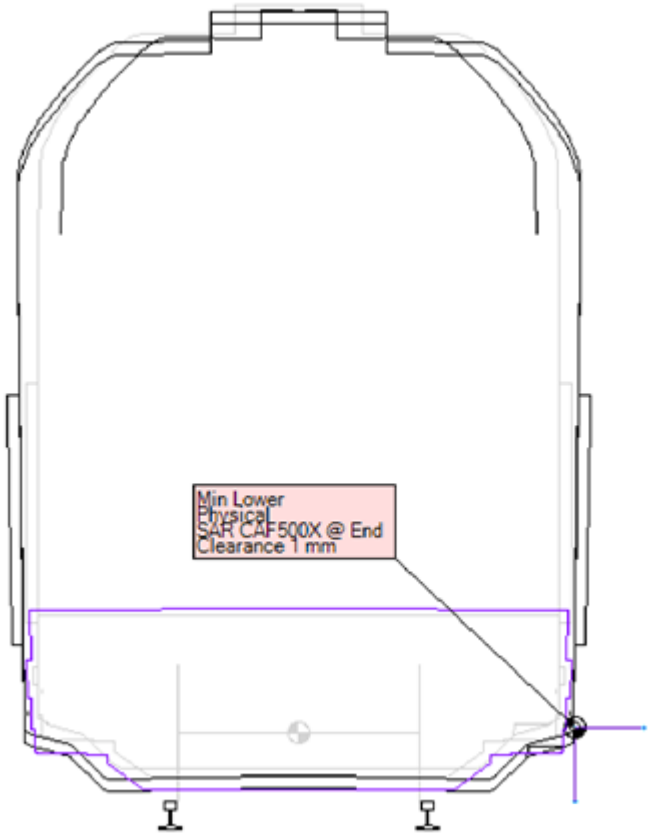




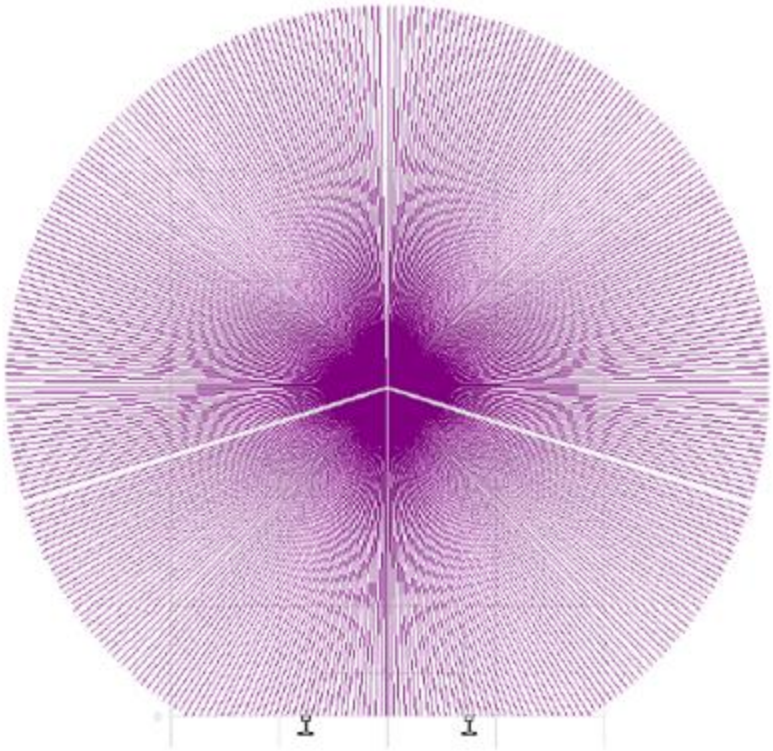


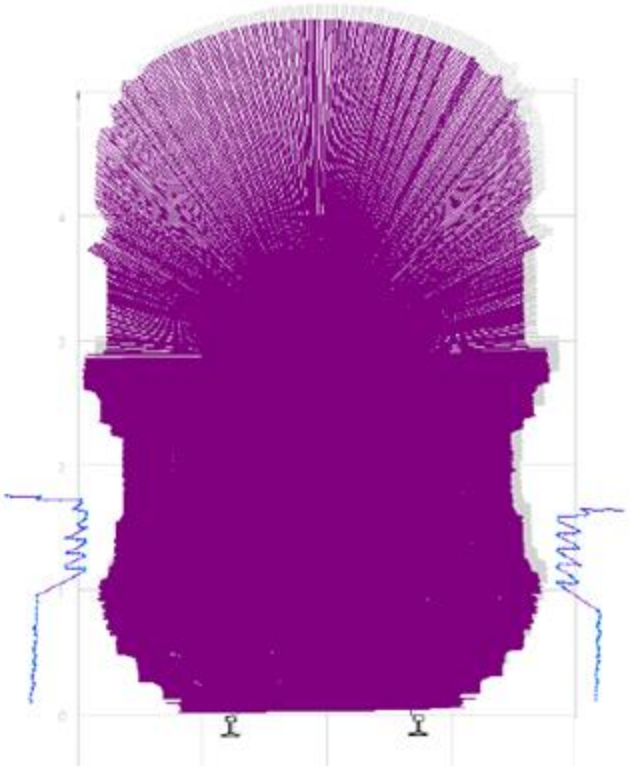
The Possibilities:

- Assessment of Existing Vehicles:
  - Existing Passenger
  - Existing Freight
  - Future Maximum Envelopes
- Assessment of Future Passenger Stock:
  - Required for Vehicle testing
- Assessment of Infrastructure Mods

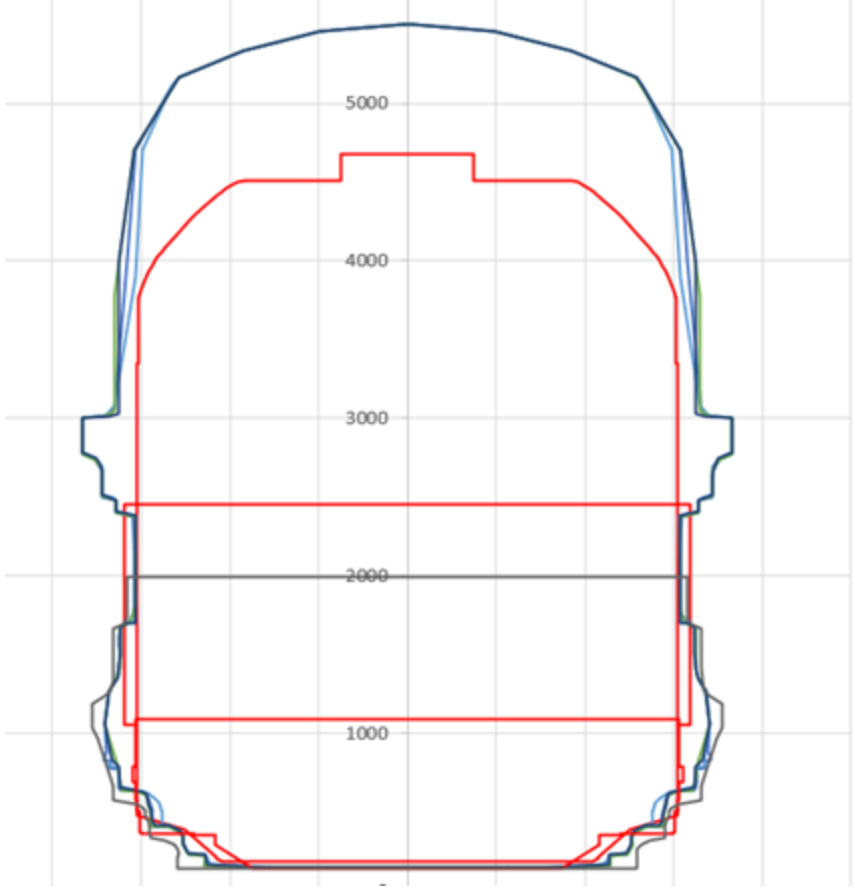


Max Build Envelope - Process





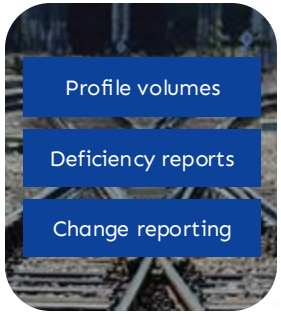
Max Build Envelope - Output



Other Opportunities

Clearances

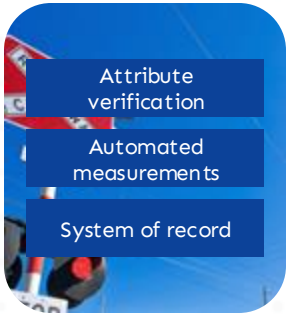
Ballast



Vegetation

Electrification

Level Crossings



Wayside Assets

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