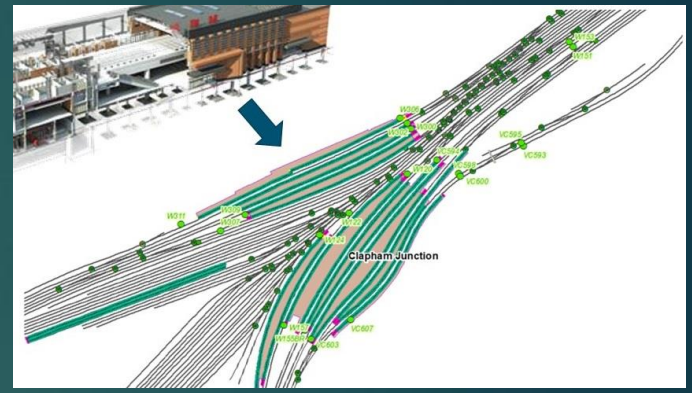
"THE JOURNEY FROM BIM TO A NATIONAL NETWORK MODEL FOR RAIL"

MAKING BIM REAL



Network Rail's journey to develop a national infrastructure and capability model to underpin digital transformation and *the application of BIM on major projects in Wales and Western with a particular focus on the challenges around geospatial grids from successes to lessons to be learnt and how all of this will play in the future into the digital network model and future digital twin implementation*

5th July 2023 - 5:15pm – 6:15pm GMT

Hosted by BIM4Rail and COMIT Projects

David White, Chair BIM4Rail, HS2 Head Strategic Planning & Asset Management
Stuart Young, COMIT Projects

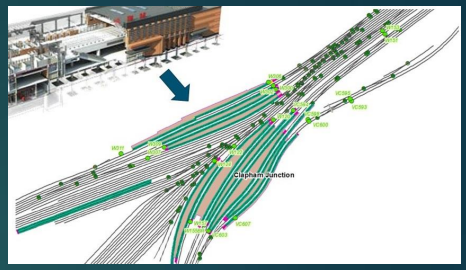
Facilitated & Supported by:

BIM4 rail

MAKING BIM REAL

"THE JOURNEY FROM BIM TO A NATIONAL NETWORK MODEL FOR RAIL"

Meet the team: Presenters &Panelists



Peter Burnett
Lead Architect: AXIOM
Network Model
Network Rail System Operator
Presenter &Panelist

John Nolan MSc MCILIP
Digital Engineering &
Construction - Information
Management – BIM
Network Rail Western Wales
Presenter &Panelist

Chris Myers
Business and Data Architect
Digital Rail Advisory Lead
Associate Director Arup
Panelist

David White
Chair BIM4Rail,
HS2 Head Strategic
Planning &
Asset Management
Panelist

Peter's talk will cover Network Rail's journey to develop a national infrastructure and capability model to underpin digital transformation.

….John will cover the application of BIM on major projects in Wales and Western with a particular focus on the challenges around geospatial grids from successes to lessons to be learnt and how all of this will play in the future into the digital network model and future digital twin implementation

Facilitated &
Supported by:

COMIT

BIM4rail

MAKING BIM REAL

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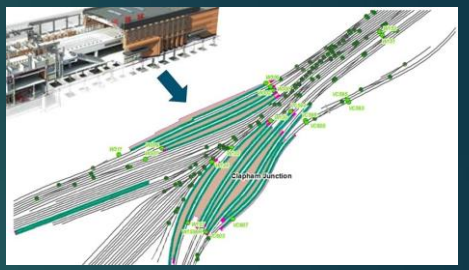
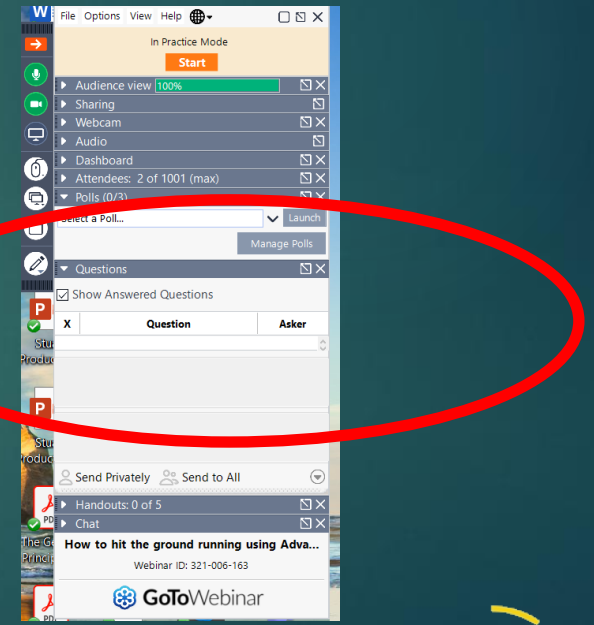


Questions?

https://www.linkedin.com/groups/8548306

https://www.bim4rail.org/



COMIT

BIM4Rail Webinar

From BIM to a National Network Model for Rail

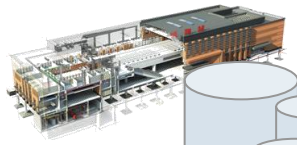
Peter Burnett

5th July 2023

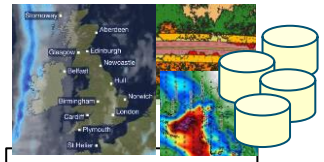
Agenda

1. **Introduction**
2. **The data landscape: As-Is and To-Be**
3. **High level strategy**
4. **Examples of current work**
   - Line Block Demonstrator
   - National Gradiant Data
   - BIM > National Network Model
5. **Digital Twin?**

Data Landscape Today



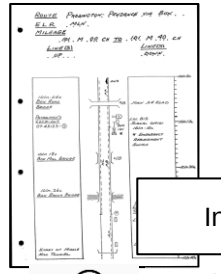
Design Data



Environmental Data

Train Movements

ITED



Industry

Hand-Drawn Sectional Appendix

Capacity Planning

Maintenance of 'Operational Geography (e.g. Tiplocs)

Timetable

Timetable Planning System

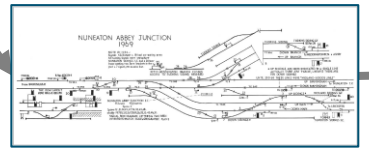
RailSY

PPS

Operations View of Track Layout & Signal Assets

Survey Data

Signalling Diagrams & Scheme Plans



ETCS

Traffic Management

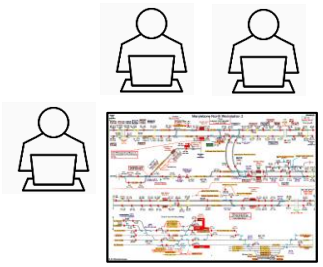
CDAS

Handback of Asset Attribution

Maintenance of Line Speed

INM

Maintenance of Track Model



Multiple hand-drawn, inaccurate, uncontrolled schematics

Simulation

Hitachi

Trenolabs

Analysis

Resonate

Decision Support Tools

TRAIL

VISION

Maintenance of Asset Attribution and Asset Location

Asset Registers

Capture of Temporal Data (Possessions, Line Blocks, ESR/TSR etc)

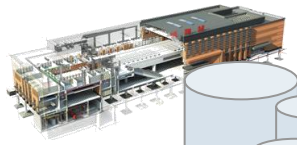
PPS

GZAM

XLS

NHD

Data Landscape Today



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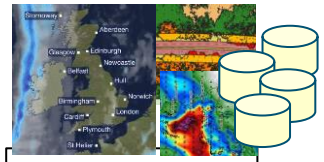


Environmental Data

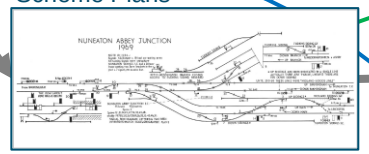
Train Movements

ITED

Geospatial Language

Survey Data

Signalling Diagrams & Scheme Plans

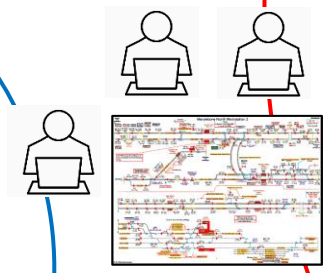


Handback of Asset Attribution

Maintenance of Line Speed

INM

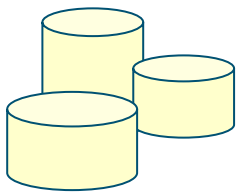
Maintenance of Track Model



Multiple hand-drawn, inaccurate, uncontrolled schematics

Engineering Language

Maintenance of Asset Attribution and Asset Location



Asset Registers

Capture of Temporal Data (Possessions, Line Blocks, ESR/TSR etc)

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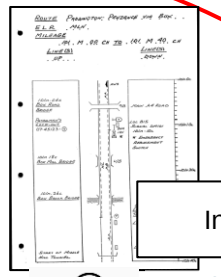

Industry

Hand-Drawn Sectional Appendix

Operations View of Track Layout & Signal Assets

Operations Language

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Traffic Management

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Simulation

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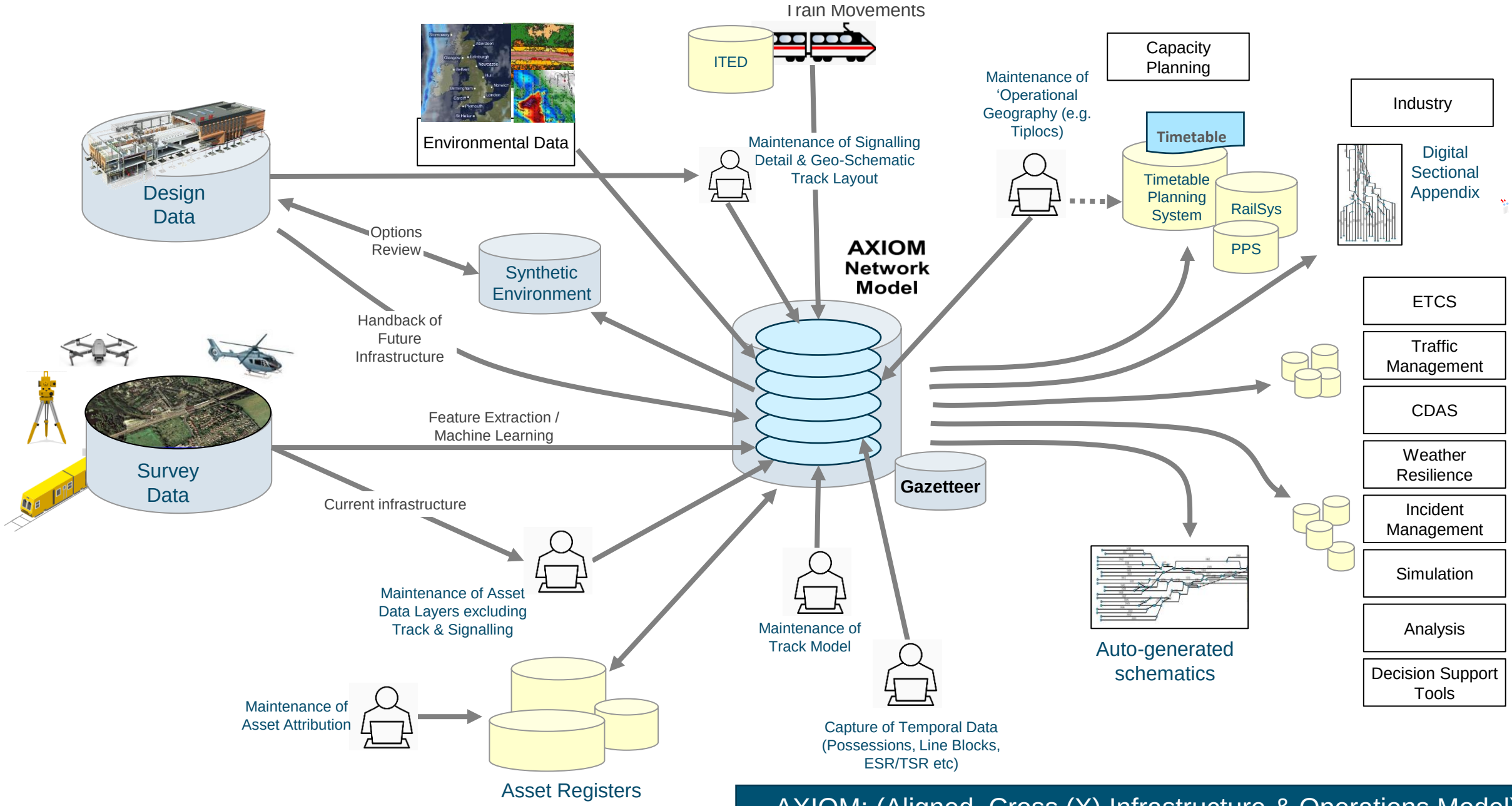
VISION

Strategy: Future Data Landscape

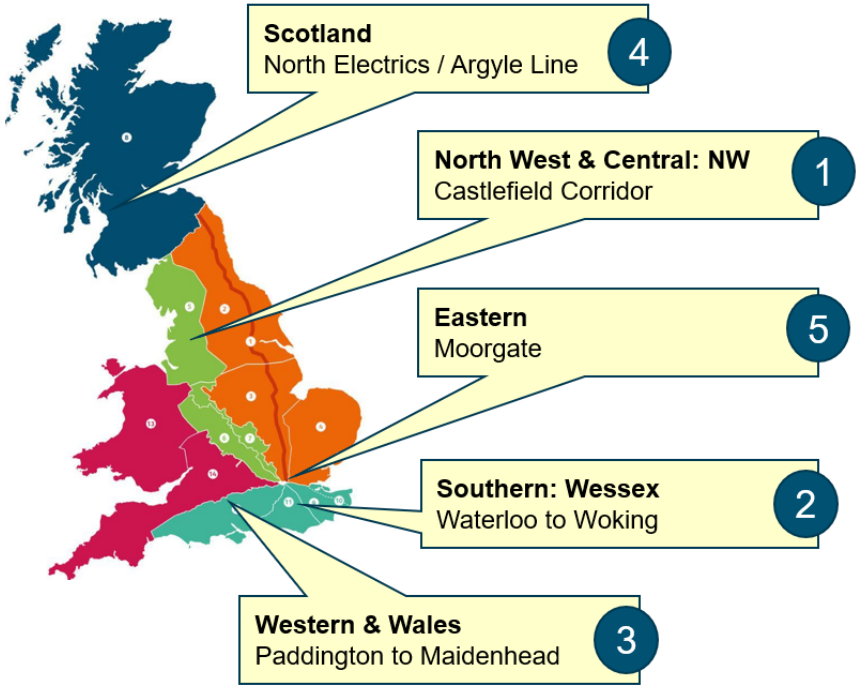


AXIOM: (Aligned, Cross (X) Infrastructure & Operations Model)

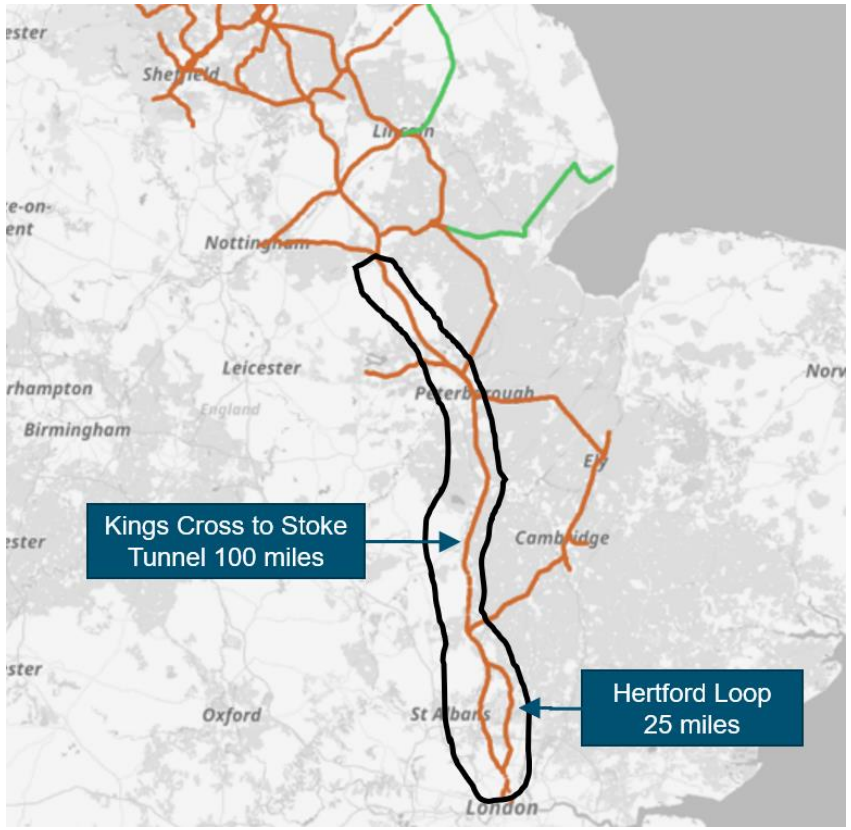
AXIOM: Where we are now?

Initial Pilot

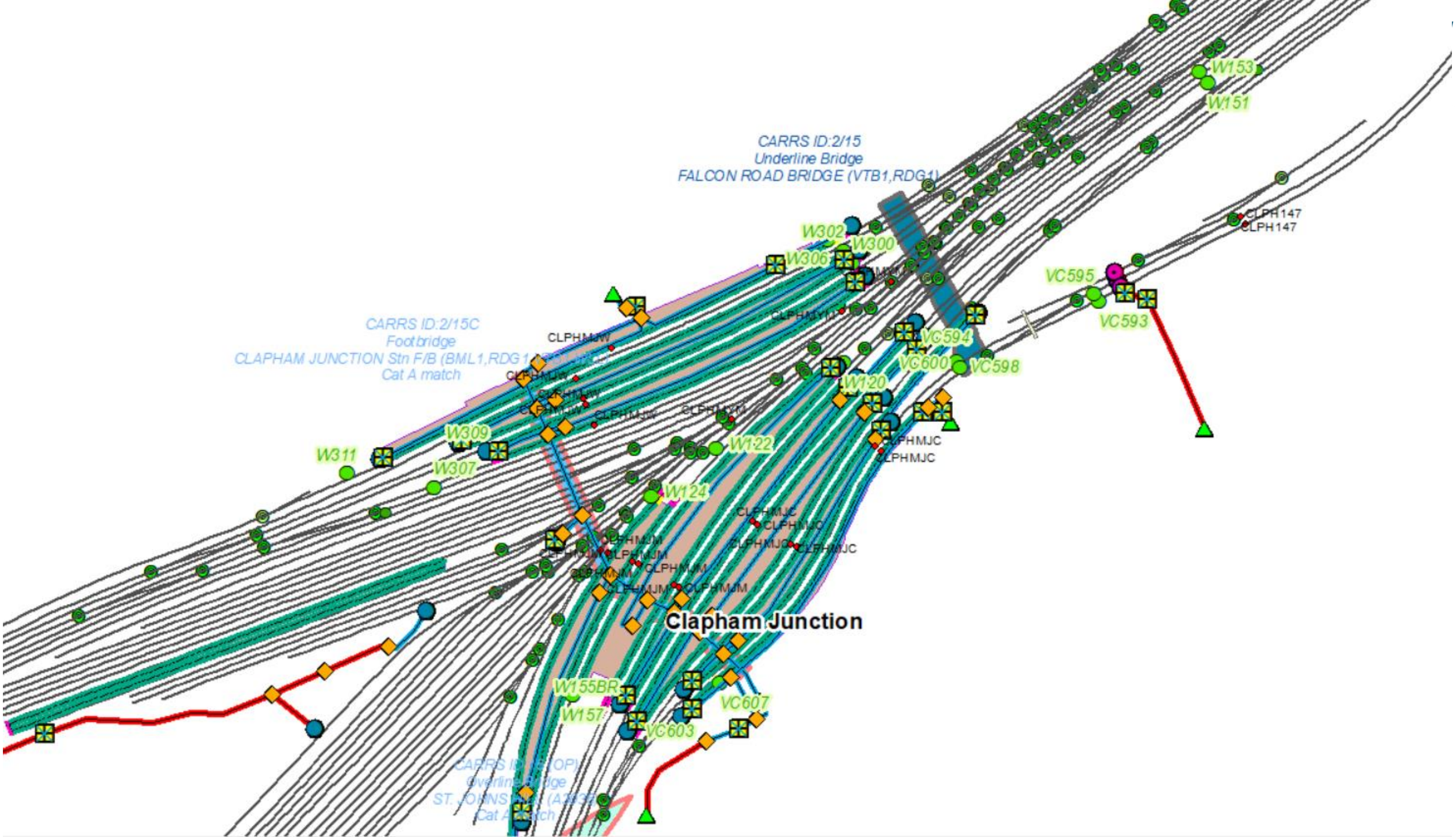
AXIOM Pilot Project



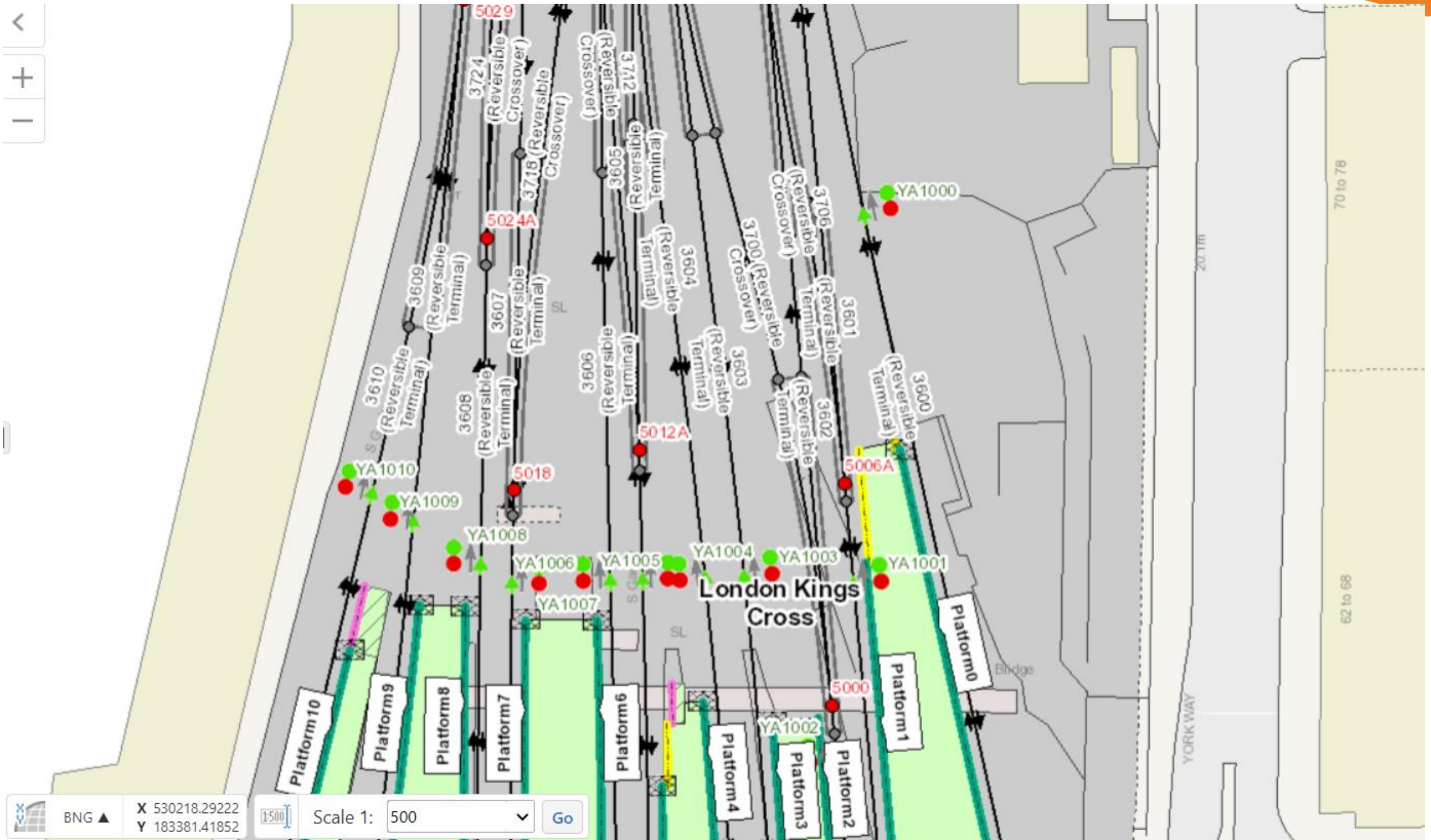
East Coast Mainline Trial



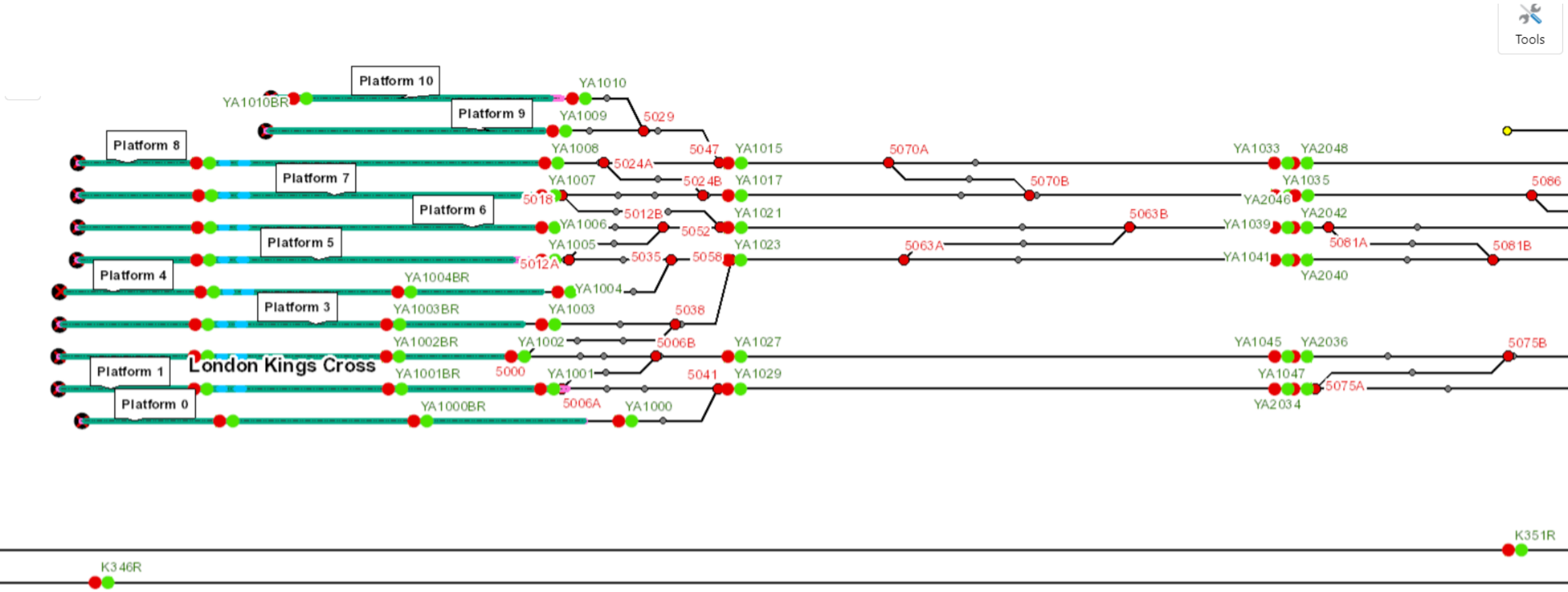
Development of Delivery Roadmap


CARRS ID:2/15
Underline Bridge
FALCON ROAD BRIDGE (VTB1,RDG1)
CARRS ID:2/15C
Footbridge
CLAPHAM JUNCTION Stn F/B (BML1,RDG1
Cat A match
W153
W151
W302
W300
W306
W309
W311
W307
W122
W120
W124
W155BR
W157
VC595
VC593
VC594
VC600
VC598
VC607
VC603
CLPH147
CLPHMJW
CLPHMJM
CLPHMJC
Clapham Junction

East Coast AXIOM Trial – Track, Platforms, S&C, Signals.



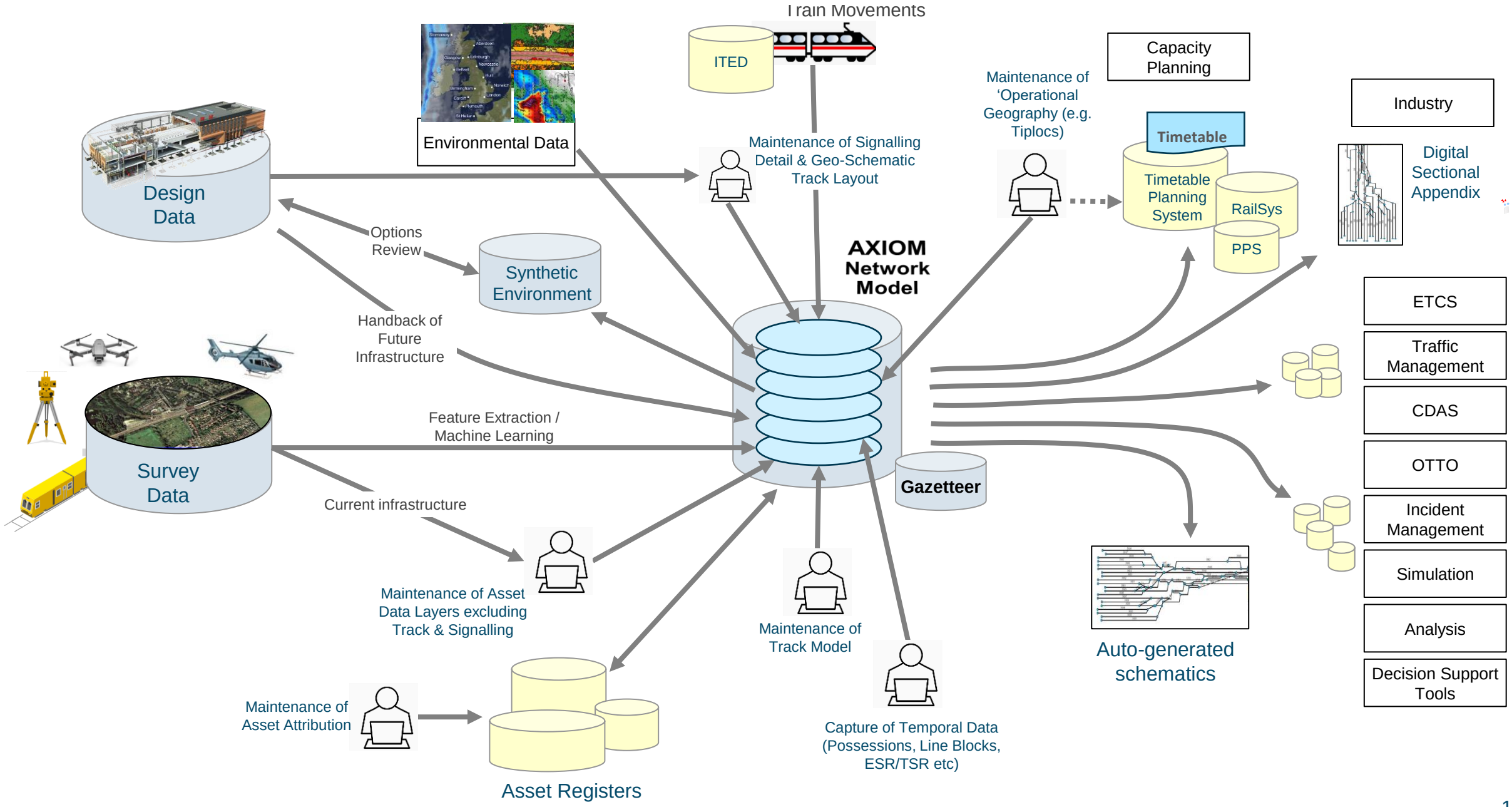
East Coast AXIOM Trial – Automatically Generated Schematic.



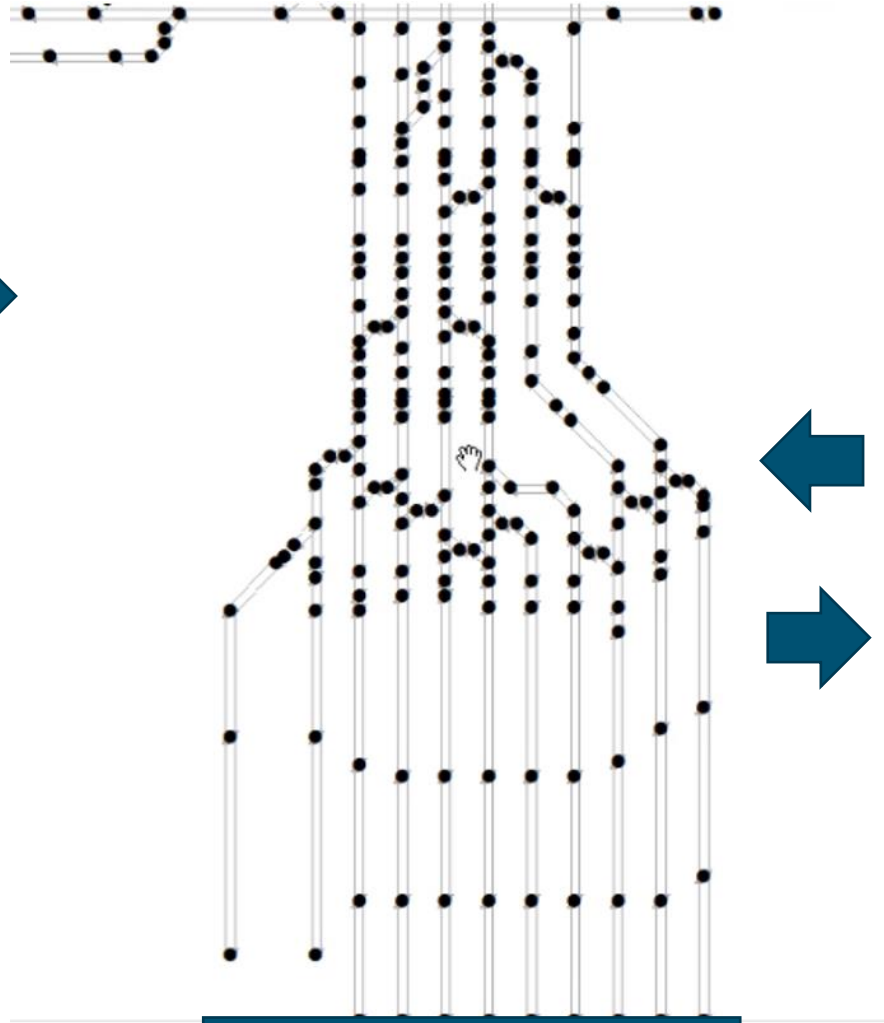
AXIOM

the cross-alignment bit

Strategy: Future Data Landscape



AXIOM Approach – Alignment of Geospatial Infrastructure Data and Operations Detail



Ellipse etc

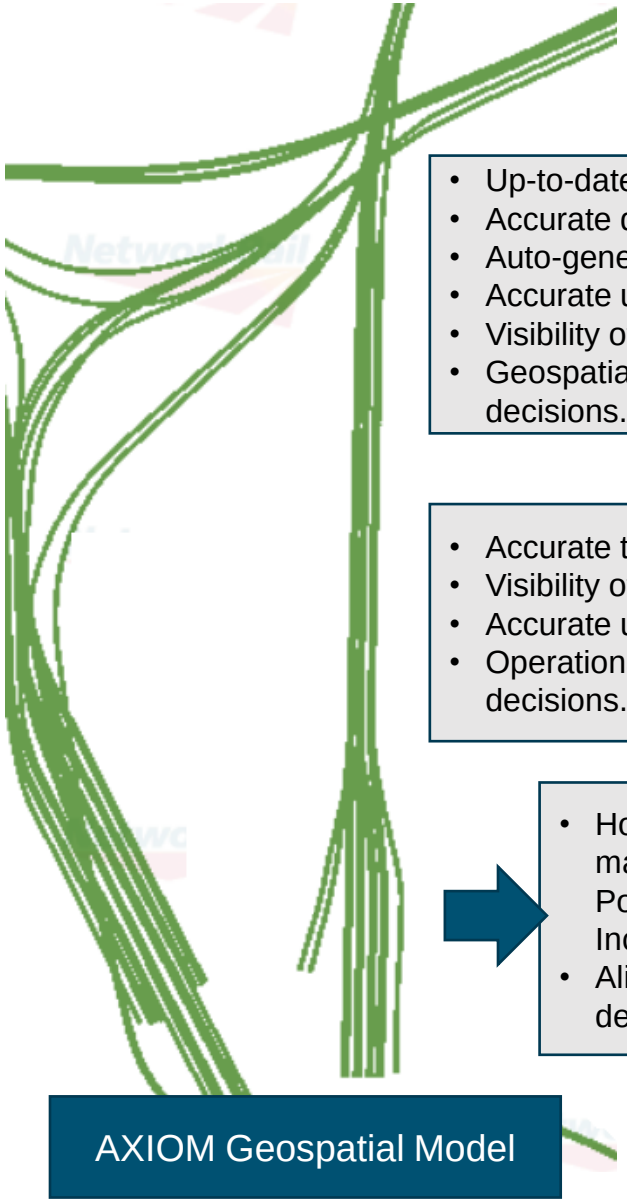
Operations Systems

AXIOM Geospatial Model

AXIOM Staging Area

AXIOM

AXIOM Approach – Alignment of Geospatial Infrastructure Data and Operations Detail



- Up-to-date infrastructure detail.
- Accurate distances between signals.
- Auto-generated gradient data.
- Accurate usable platform extents.
- Visibility of proposed infrastructure
- Geospatial detail to support operations decisions..

- Accurate track direction
- Visibility of real-time train information.
- Accurate utilisation based on actual traffic.
- Operational impact of asset management decisions.

- Holistic understanding and management of: Access, Possessions, Line Blocks, Incidents etc.
- Alignment of legacy train detection with train GPS data.

Ellipse etc

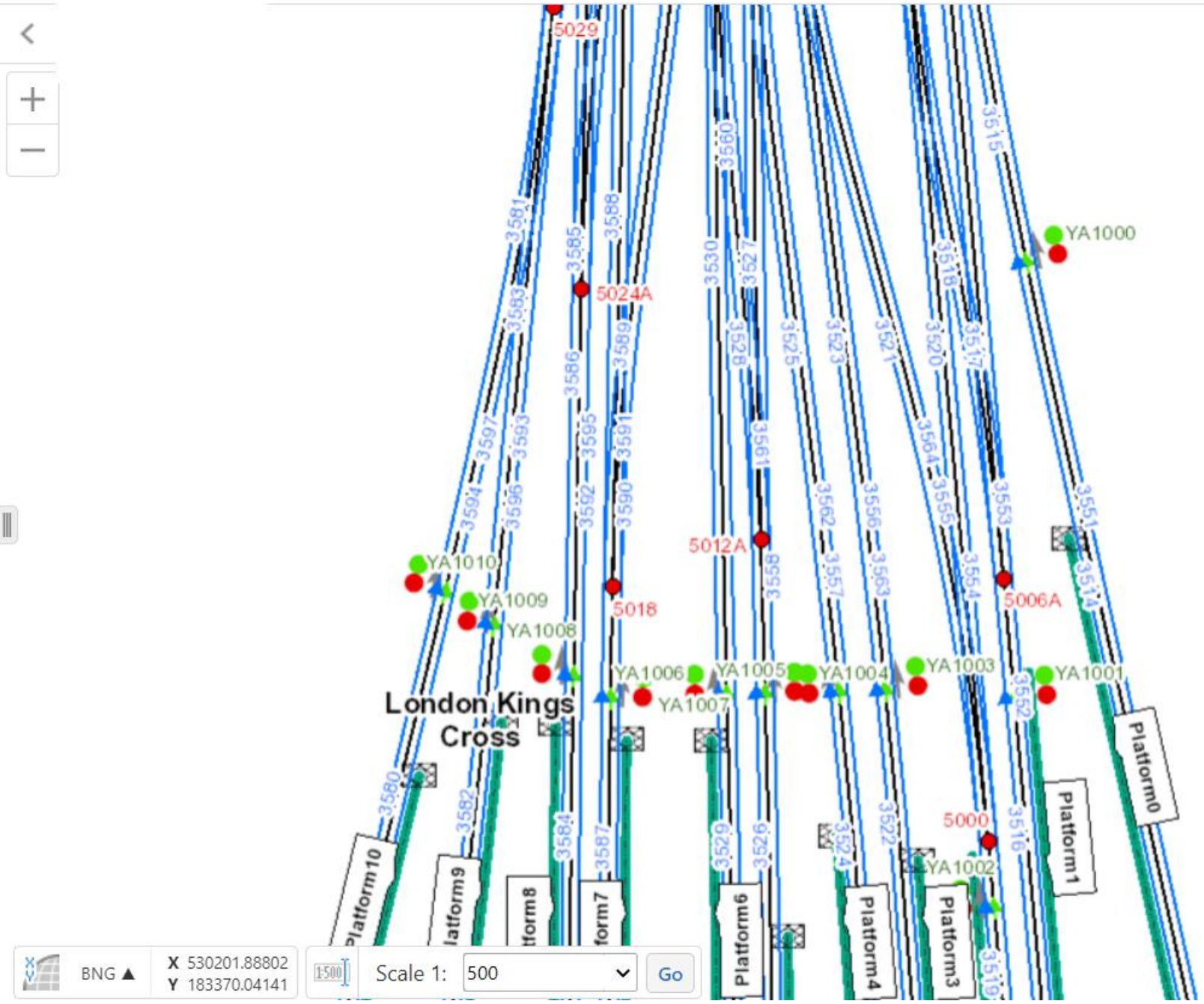
Operations Systems

AXIOM Geospatial Model

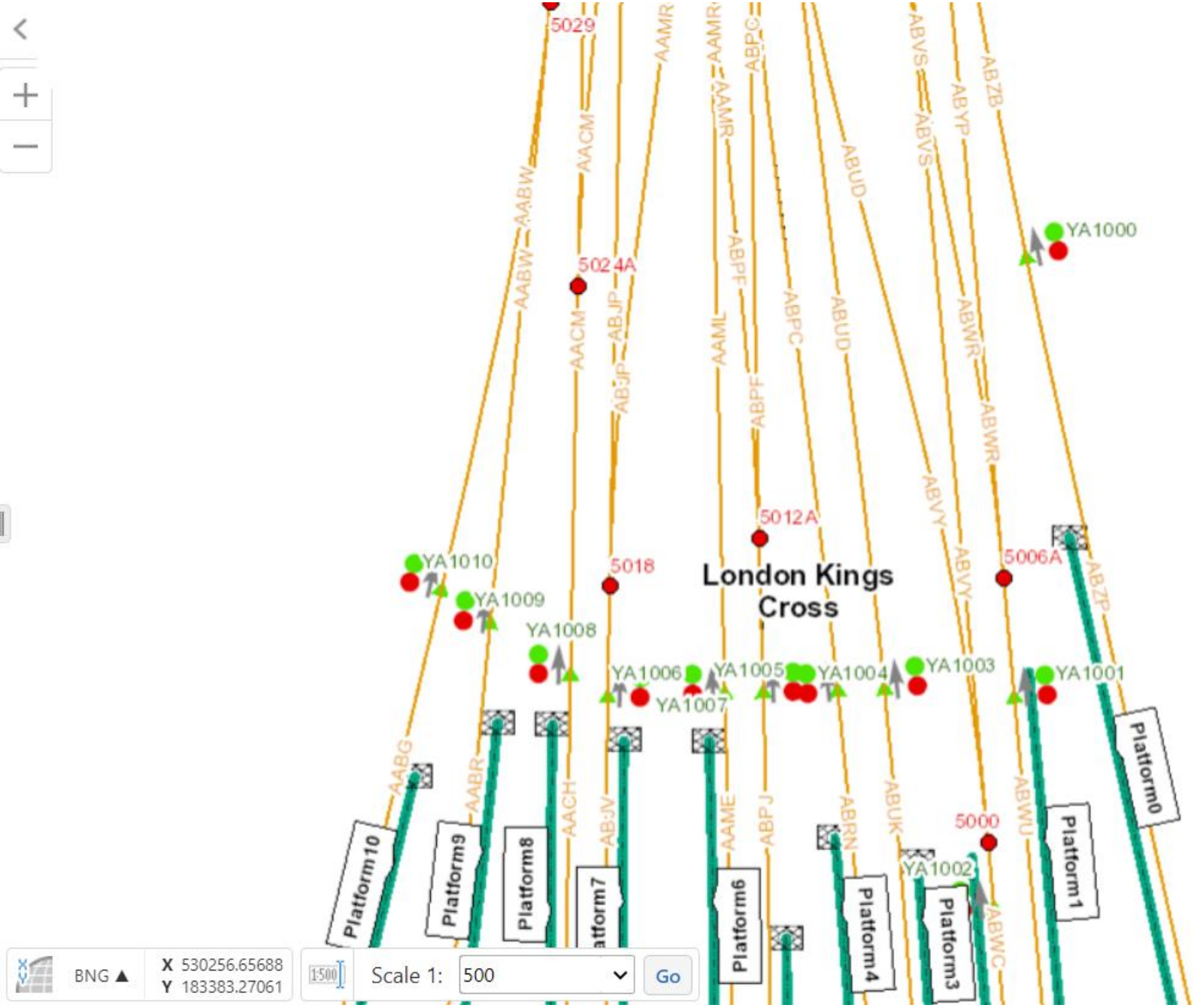
AXIOM Staging Area

AXIOM

East Coast AXIOM Trial – Track, Platforms, S&C, Signals. Signal Blocks

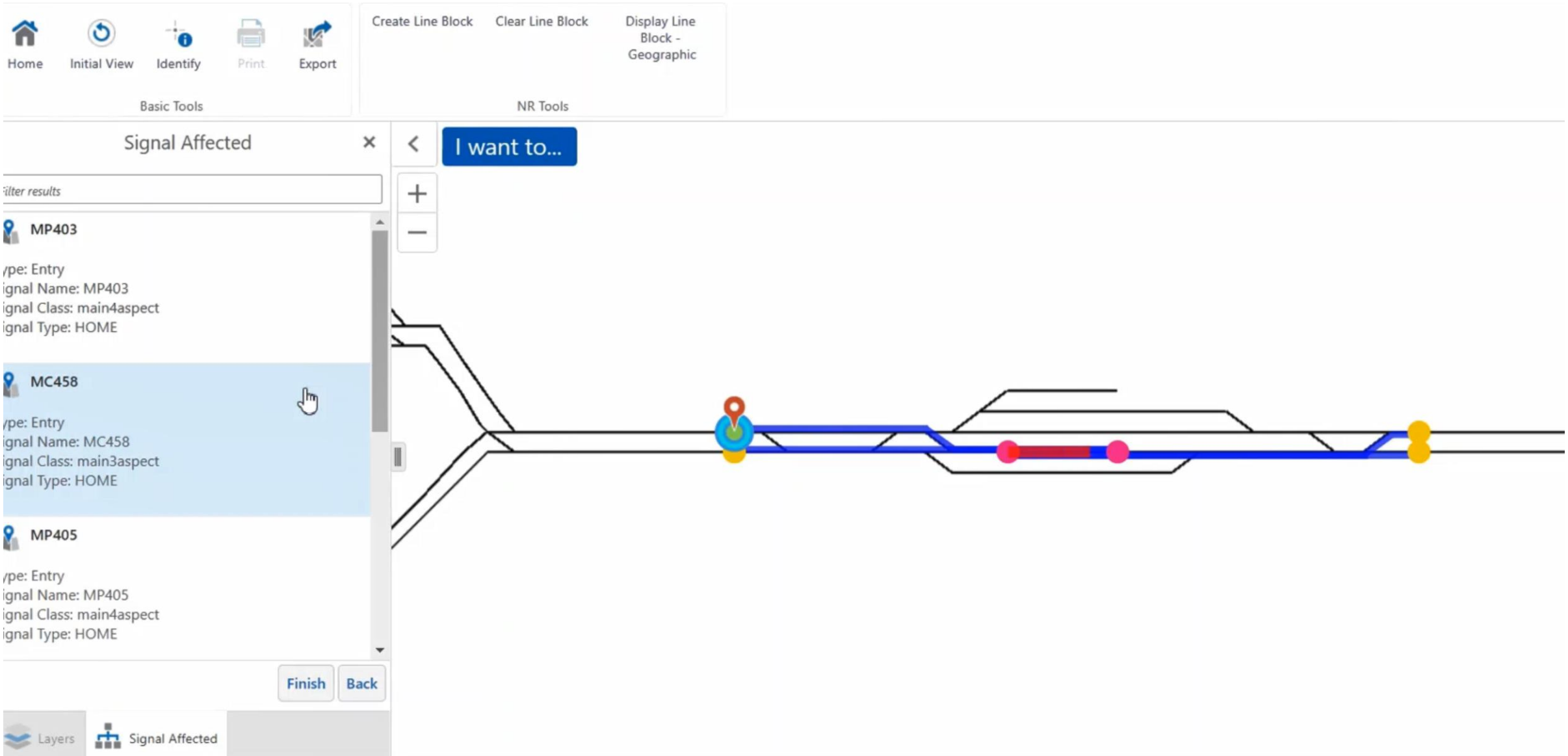


East Coast AXIOM Trial – Track, Platforms, S&C, Signals, Track Circuits.



Demonstrator of aligned model

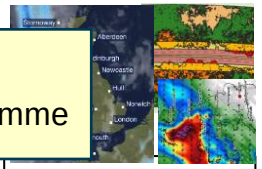
Demonstrator of Proof-of-Concept: Line Block Request



Other Initiatives

Examples of AXIOM Initiatives

Infrastructure Data Interoperability
Pilot with Trans-Pennine Route Upgrade Programme



Environmental Data

Train Movements

ITED

Sectional Appendix Replacement PoC

Capacity Planning

Industry

Maintenance of 'Operational Geography (e.g. Tiplocs)

Timetable

Timetable Planning System

RailSys

PPS

Digital Sectional Appendix

Maintenance of Signalling Detail & Geo-Schematic Track Layout

Design Data

Options Review

Synthetic Environment

AXIOM Network Model

Handback of Future Infrastructure

State of the Railway Compiler

ETCS

Traffic Management

CDAS

Incident Management

Simulation

Analysis

Decision Support Tools

Operations Data Interoperability PoC
- Data Exchange Format

Feature Extraction / Machine Learning

Survey Data

Current infrastructure

Automate generation of gradient data from LiDAR

Gazetteer

Auto-generated schematics

Maintenance of Asset Data Layers excluding Track & Signalling

Maintenance of Track Model

Maintenance of Asset Attribution

Asset Registers

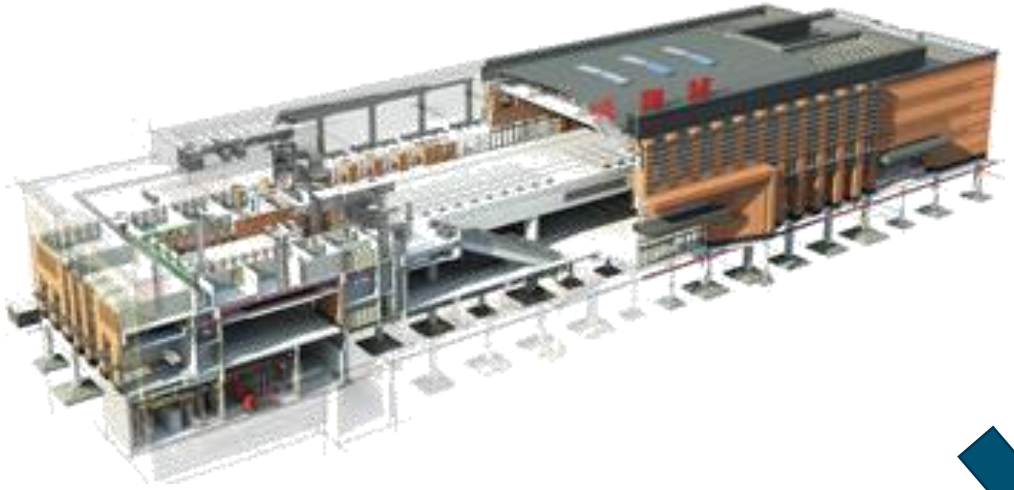
Capture of Temporal Data (Possessions, Line Blocks, ESR/TSR etc)

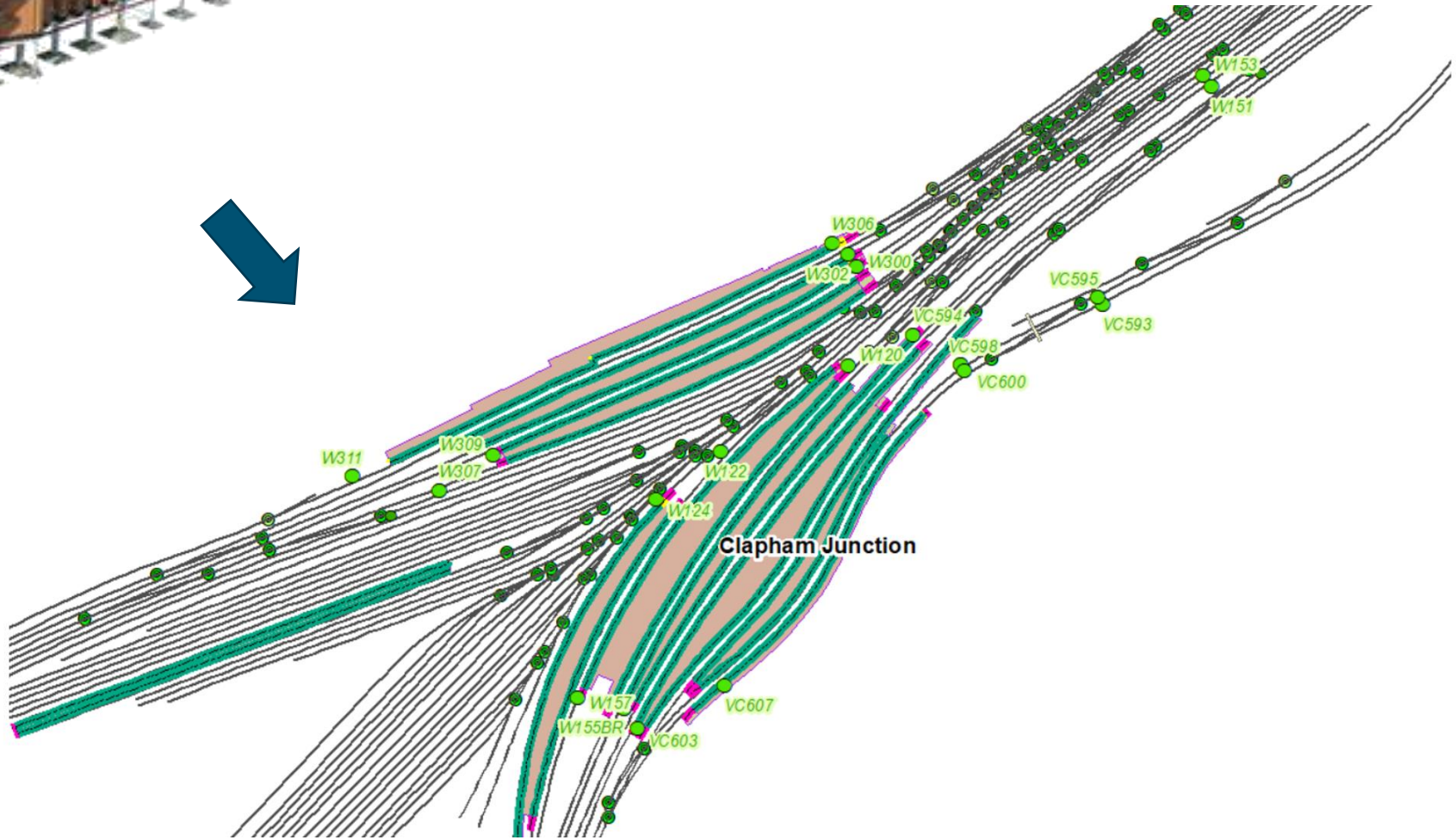
Auto-Generation of Track Gradient from LiDAR Data

Key Business Drivers: Runaway Risk, ETCS, Timetable Planning

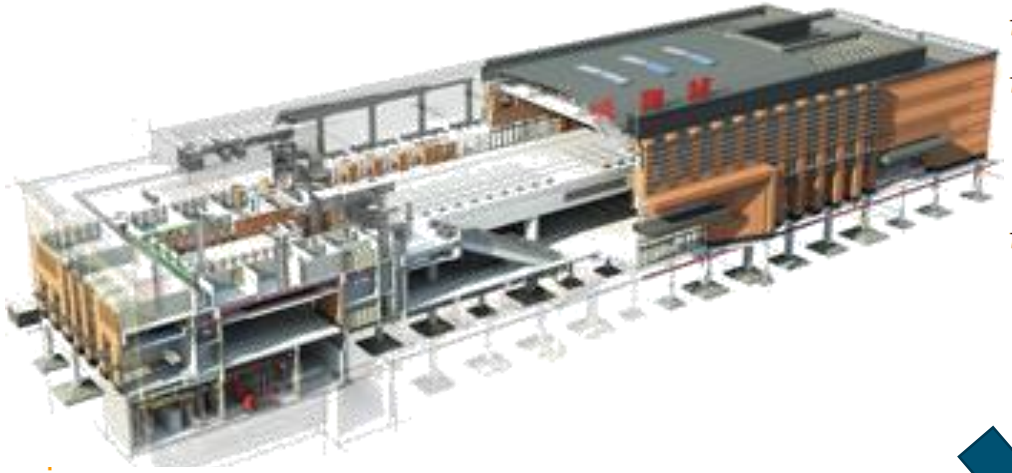
Simplified View: Decision Support Tool for Runaway Risk

Infrastructure Data Interoperability: Proof-of-Concept





Infrastructure Data Interoperability: Proof-of-Concept



9.6.5 Attribute 4 - Status

Denotes the design status of the CAD data. A single character status code shall be used as specified in Table 8.

Status Code	Element Status
E	Existing (to remain)
M	Modified
P	Proposed
R	Remove, Recover or Demolish
T	Temporary Works
Z	Miscellaneous

Table 8 – Status Descriptors

7.7 Reference files

7.7.1 Prior to final submission non-displayed reference files shall be detached in all design, drawing and sheet models.

7.7.2 Logical names and descriptions shall be assigned in the Reference Manager dialog box.

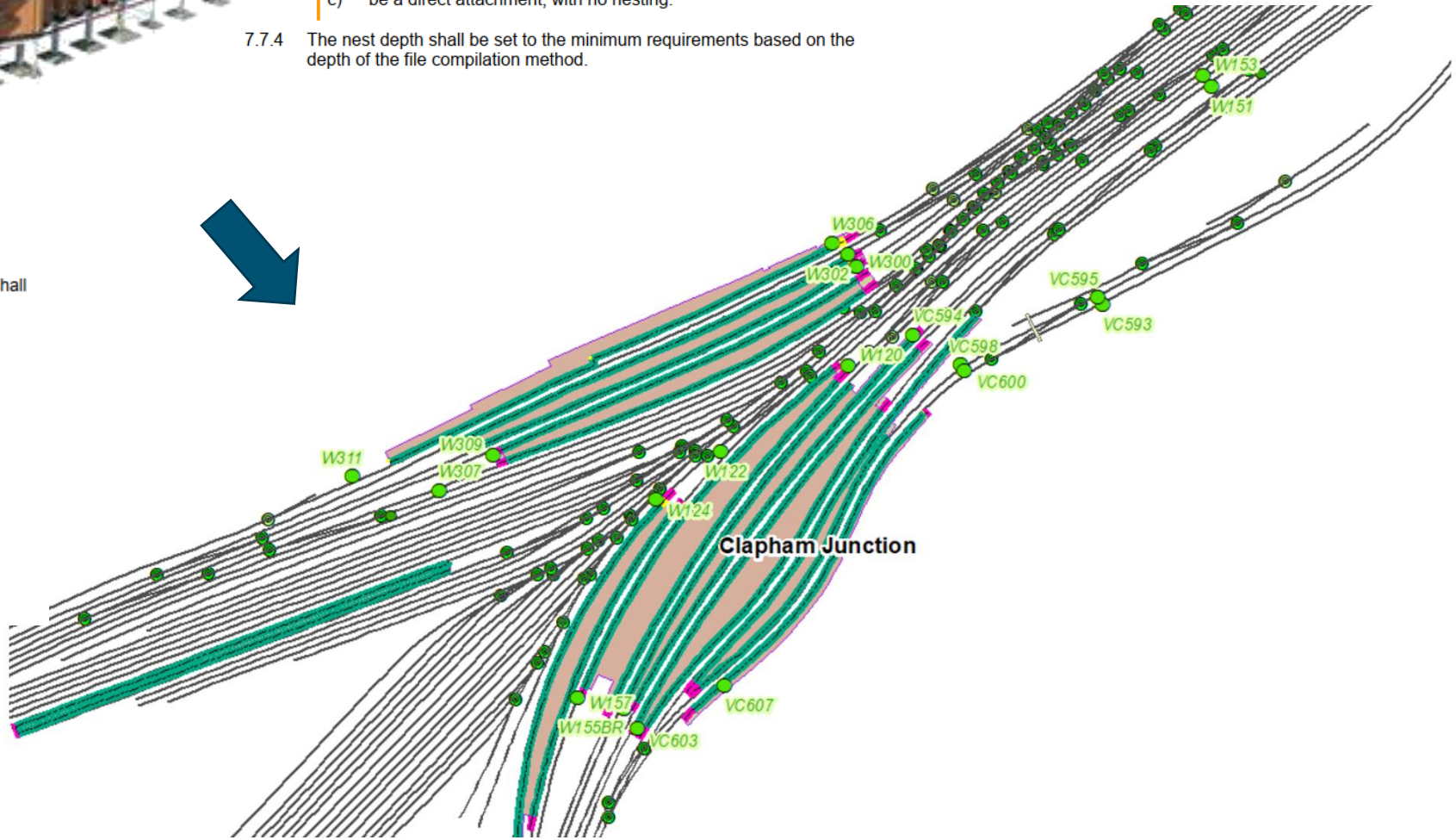
7.7.3 In the design model reference files shall:

a) be attached true to the co-ordinate location;

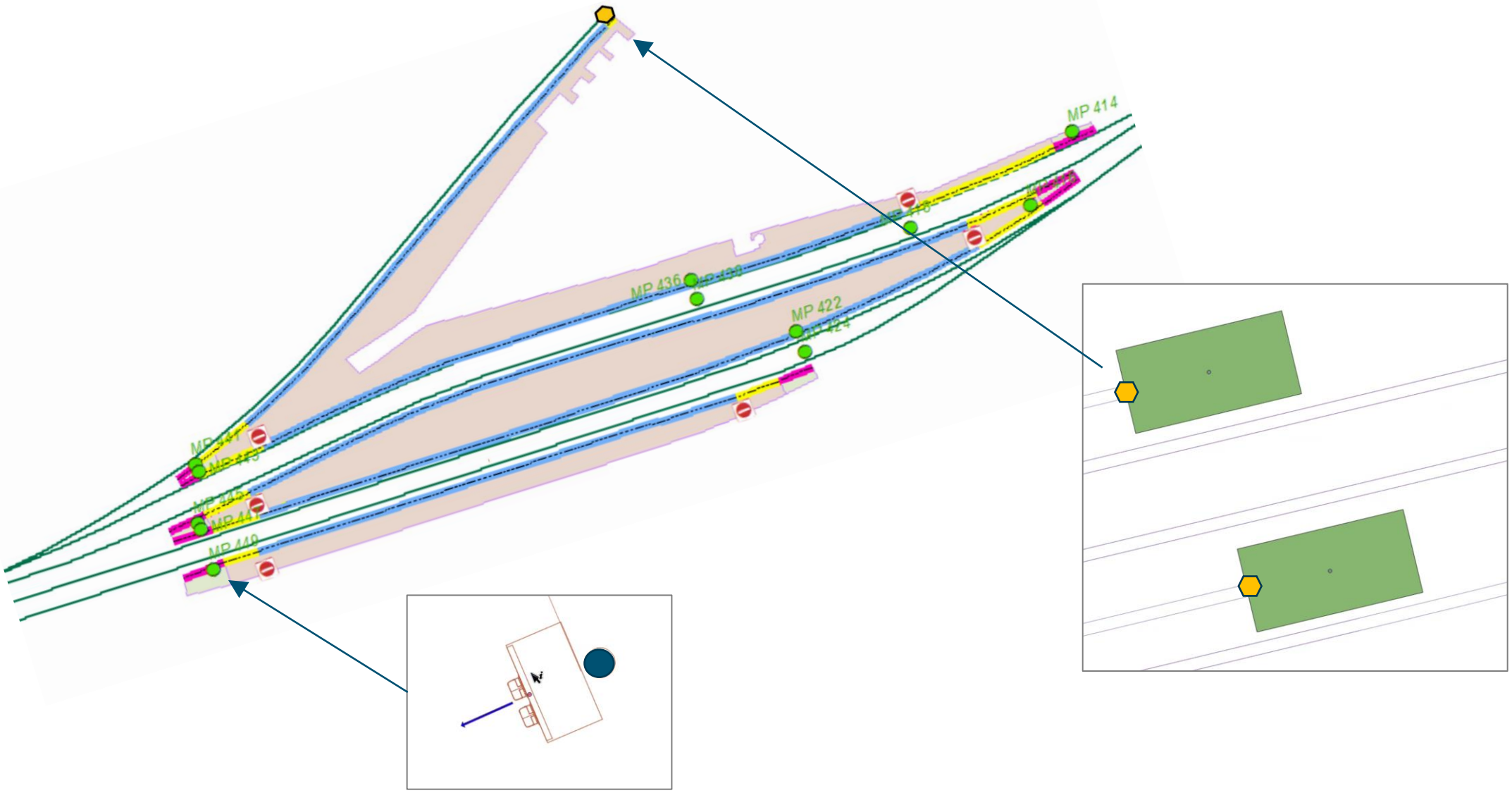
b) not be rotated or scaled; and

c) be a direct attachment, with no nesting.

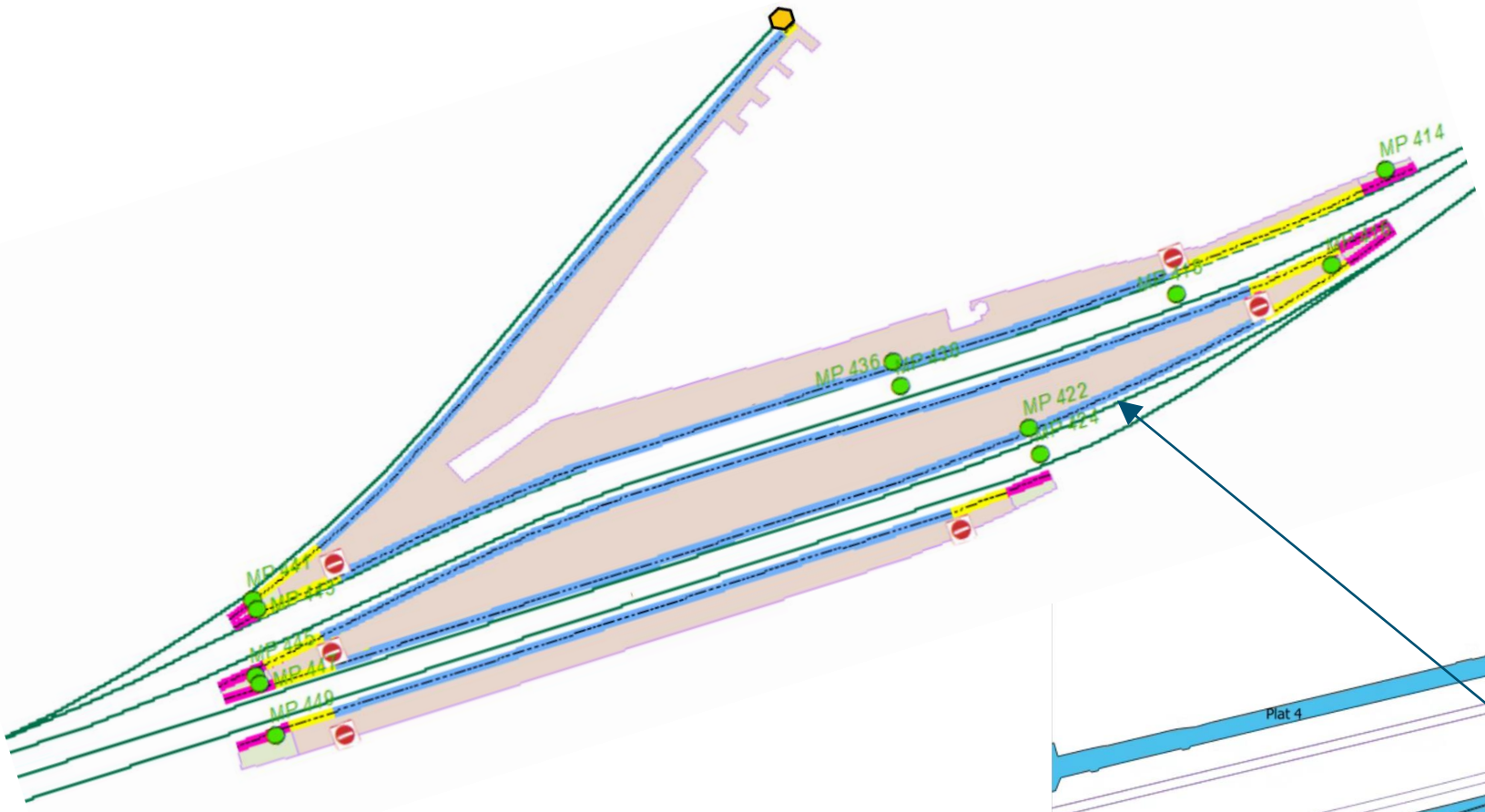
7.7.4 The nest depth shall be set to the minimum requirements based on the depth of the file compilation method.

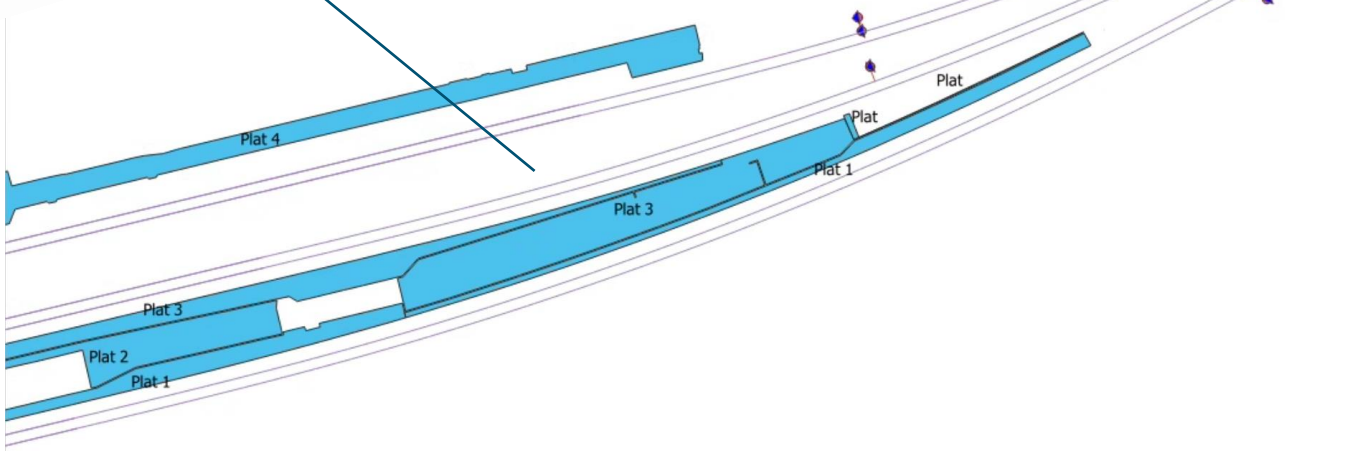


Infrastructure Data Interoperability: Proof-of-Concept

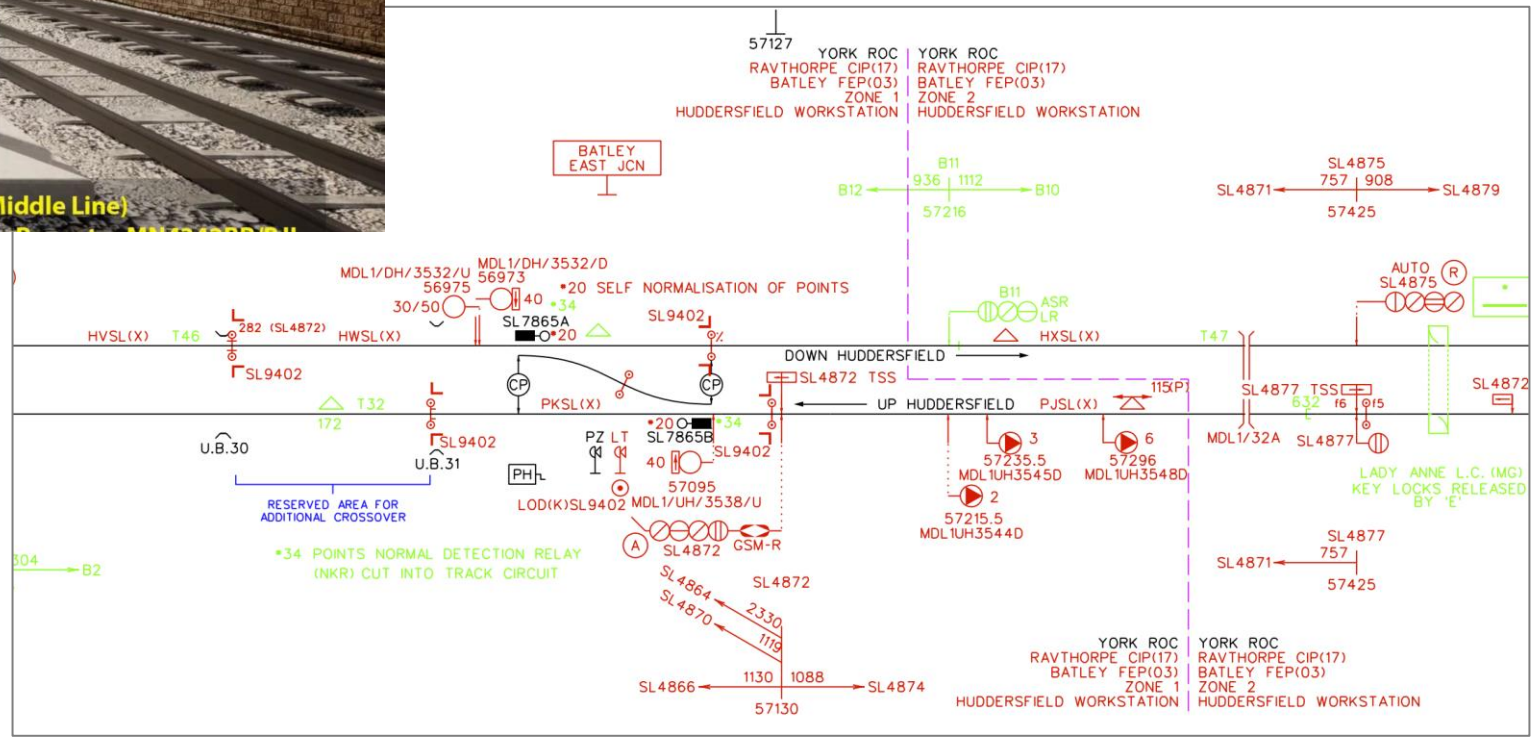


Infrastructure Data Interoperability: Proof-of-Concept





Infrastructure Data Interoperability: Proof-of-Concept



A Digital Twin….?

Digital Twin?

- *Wiki*: a **digital representation of an intended or actual real-world** physical product, system, or process that serves as the effectively indistinguishable digital counterpart of it for practical purposes, such as simulation, integration, testing, monitoring, and maintenance. One of the main characteristics of digital twin technology is its **connectivity between the physical component and its digital counterpart**. The basis of digital twins is based on this connection, without it, digital twin technology would not exist

- *Gartner:* a **digital representation of a real-world entity** or system. The implementation of a digital twin is an encapsulated software object or model that **mirrors** a unique physical object, process, organization, person or other abstraction. Data from multiple digital twins can be aggregated for a composite view across a number of real-world entities…, such as a power plant or a city, and their related processes.

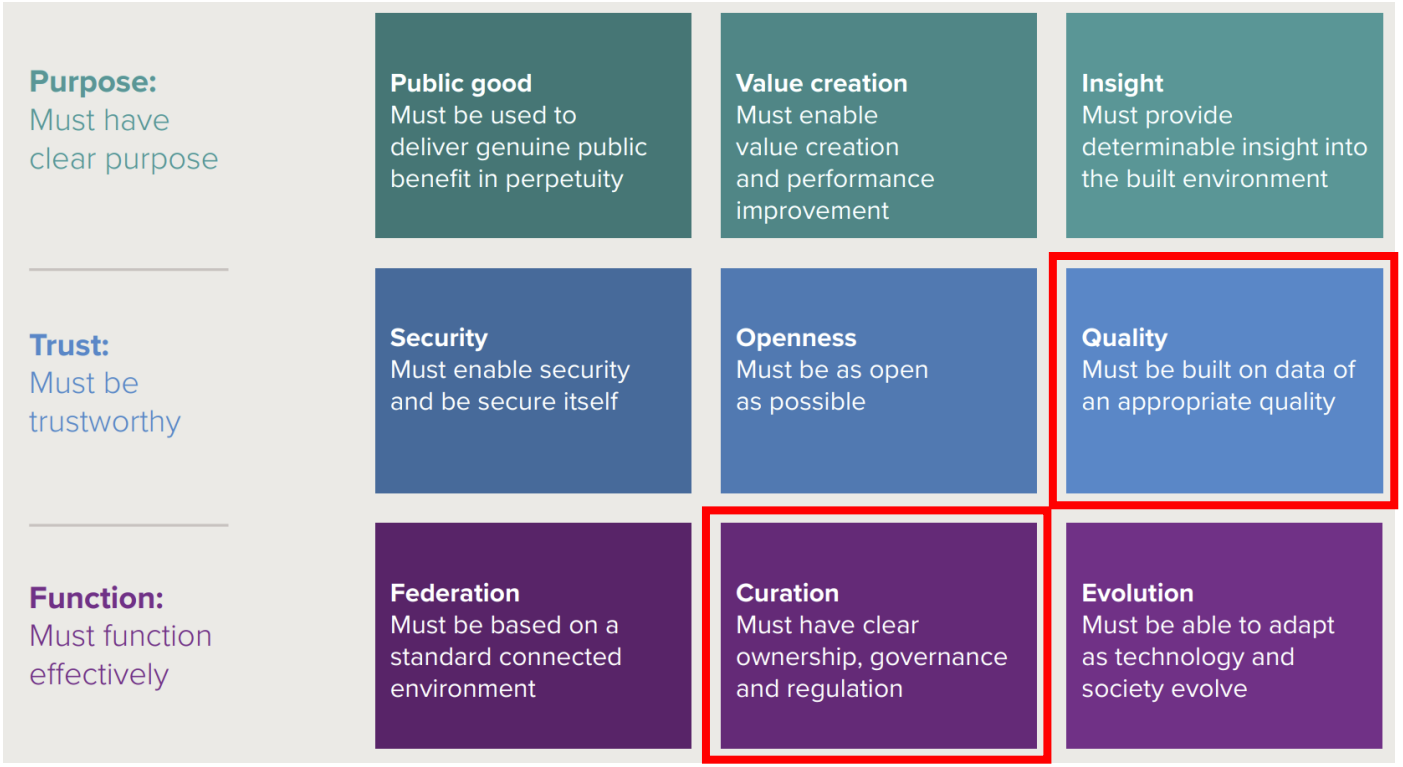
- *Centre for Digital Build Britain*:
    1. a **dynamic** model of an asset, with input of current performance data from the physical twin via **live** data flows from sensors; feedback into the physical twin via real-time control.
    2. a **static** strategic planning model of a system, with input of long-term condition data from the physical twin via corporate systems; feedback into the physical twin via the capital investment process
    3. a **realistic digital representations of physical things**….. it unlocks value by enabling improved insights that support better decisions, leading to better outcomes in the physical world

Digital Twin?

- A successful Digital Twin has a critical dependency on data quality, availability, accessibility, compatibility.
- Historically, much of the ‘Digital Twin’ work within Network Rail has been driven by Capital Delivery initiatives, delivering **BIM models** in a Common Data Environment for a relatively small geographic area. This has led to proposals from supply chain to extend these BIM models to deliver a fully integrated, near-real-time Digital Twin.
- Such an approach may work for an asset of limited size (e.g. a major station or a single route) but for 20,000 miles of complex infrastructure, is a business case for supporting use-cases at a **national level** realistic?
- However, we can **deliver significant value** (in terms of safety, efficiency and effectiveness) without a full Digital Twin.
- In the short term we are therefore taking a pragmatic approach, focusing on the fundamental building blocks:
    - A trusted, common **national network model (AXIOM)** to support transformation of safety, asset management and operations capabilities;
    - **Data Consistency and integration** across and between organisational units
    - Clearly defined and accepted, **sponsorship**, data **governance** and data **standards**; widely upheld.
    - **Rationalisation** of disparate legacy solutions.
    - **Collaboration** with the Supply Chain.
- Where BIM models exist, these can be utilized to build and/or enhance the network model.
- If at some point in the future, a business case can be proven for a full, integrated, national Digital Twin then the network model foundations can be extended to achieve this.

Digital Twin?

The Gemini Principles:



The Centre for Digital Build Britain. https://www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples

Gartner recommendation on Digital Twins:

'Seek simplicity. Avoid building a Digital Twin if business objectives can be met by basics'

Project delivery challenges around geospatial grids from successes to lessons to be learnt

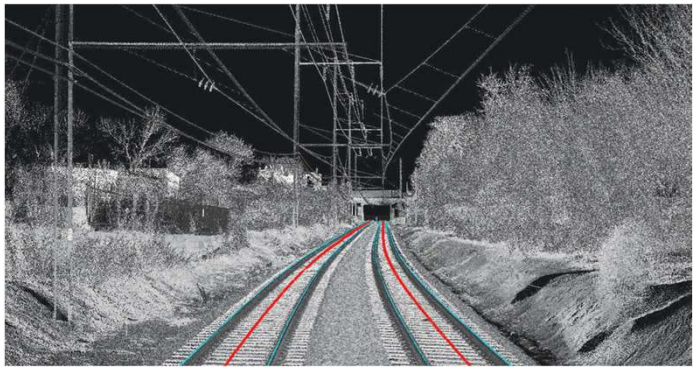
John Nolan

Wales and Western

Geospatial - Modern Data Capture

Modern, accurate, locational data capture methods come in a number of forms, which is why the standard recognises all of the following:

- Aerial imagery;
- Calibrated recording vehicles;
- Point Cloud surveys;
- Appropriately calibrated GNSS devices;
- Land surveys.
- Drones
- New Measurement Train (NMT) / Track Recording Unit (TRU)
- RILA (Rail Infrastructure aLignment Acquisition)
- Tail Lamp Camera (TLC)
- AIVR – Train based video surveys



What is SnakeGrid

SnakeGrid is a geospatial coordinate reference system that provides a method for accurately representing curved or irregularly shaped areas on a flat surface. It is specifically designed for applications that involve mapping or surveying linear rail areas – Also offshore oil and gas.

SnakeGrid uses a non-linear grid pattern that follows the shape of the area being mapped, rather than using a regular grid of latitude and longitude lines. This allows for a more precise representation of the area and minimizes distortion that can occur with traditional grid systems

What is OS Grid

The OS Grid (Ordnance Survey Grid) is a coordinate reference system. It is developed and maintained by the Ordnance Survey, the national mapping agency of Great Britain.

The OS Grid divides the UK into a grid network using eastings (horizontal) and northings (vertical) coordinates. It provides a systematic way to reference locations on maps and to perform accurate measurements and calculations.

The OS Grid is based on the Transverse Mercator projection, which projects the curved surface of the Earth onto a flat map. The projection is tailored specifically for the UK, allowing for minimal distortion in the region.

Do not use OS grid for track

What is a Local Grid

Do not use local grids

Issues when different survey grids are used

Incompatibility of data: When surveys or data collection methods use different grids or structures, the data obtained may not be directly comparable or integrable. It becomes difficult to merge or analyse the data cohesively, hindering a comprehensive understanding of the overall situation or risk landscape.

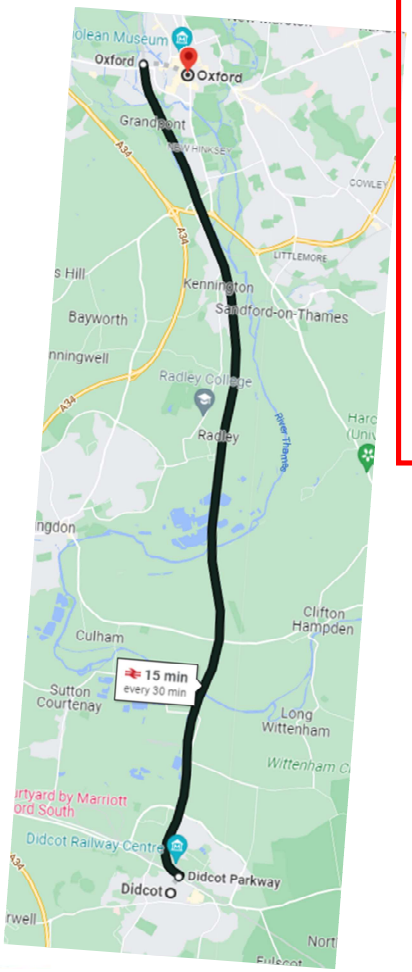
Data loss or inconsistency: Integration issues can result in missing or inconsistent data points, as different surveys may collect information in varying formats or categories. This can introduce gaps or errors in the dataset, making it challenging to draw accurate conclusions or identify trends.

Time and effort: Integrating data from disparate sources that do not follow the same survey grid requires additional time and effort to reconcile and align the information. This can lead to delays in analysing the data and making informed decisions, impacting the effectiveness of risk management or safety measures.

Increased complexity: Dealing with multiple survey grids or structures adds complexity to data integration processes. It may require developing custom mapping or transformation methods to align the data, which can introduce additional layers of complexity and increase the risk of errors.

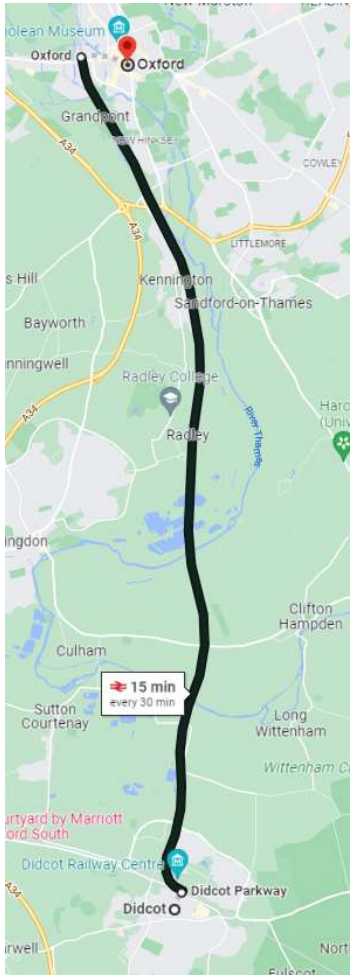
Reduced data granularity: Different survey grids may have varying levels of granularity in terms of the data captured. When integrating such data, there may be a loss of detail or specificity, which can limit the insights gained and potentially overlook critical risk factors or safety issues.

Oxford - Problem



DIDBAN 15 – Snakegrid

Oxford Local Grid



OSGB36 – No accuracy for track

ATHJV
A Halcrow – Tata Steel Joint Venture

Memo

To [redacted]
From
Reference Oxford OS Transformation (W1002B-TTS-MEM-ESU-012001 P02)
Date 12 December 2014
CC [redacted]

With reference to the query regarding the Transformation from the Ordnance Survey grid to the Site Grid on the Oxford Corridor project, I can confirm the following information:-

"The tiles were transformed using the coordinates of two widely spaced control stations. The OS data was first moved using the coordinates of station S6245 and then rotated and scaled around this point to match the coordinates of station S7179. The transformation was checked using the coordinates of the intermediate stations which were all found to be in agreement within 10mm.

Coordinates used
S6245 (OS 451054.613mE 205034.197mN) (Project 50738.037mE 72606.182mN)
S7279 (OS 448415.869mE 221107.005mN) (Project 48258.383mE 88710.386mN)"

In summary:

Translate

From (OS) 451054.613mE, 205034.197mN
To (Project) 050738.037mE, 072606.182mN

Delta E = -400316.576, Delta N = -132428.015

Rotation & Scale factor
Origin 50738.037mE, 72606.182mN
Rotation 0.569925 (decimal degrees - clockwise)
Scale factor 1.000369221160

Other Examples

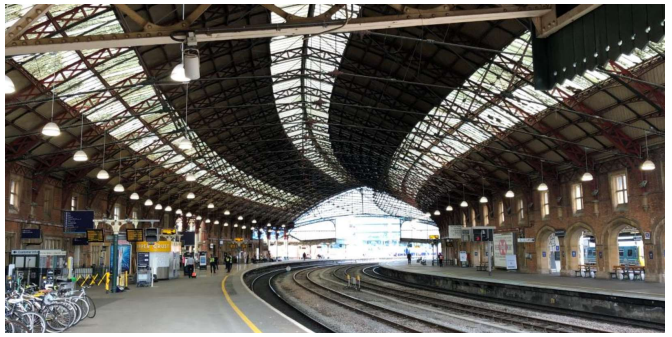
Box tunnel

1.83-mile (2.95 km) tunnel was the world's longest railway tunnel when it was completed in 1841

2019 Track lowering in lieu of Overhead line electrification – Track was designed in OSGB as GWEP contract was for OLE in OSGB. This caused major confusion as track had no scale factor

Bristol Temple Meads Station

3D model was delivered by one supplier in RBEPP12 SnakeGrid. The same supplier redelivered it in OSGB at a later date.



Filton 4 track

One designer moved the compliant survey to 0,0,0 in their model and rotated / adjusted it. LOC suite was designed on top of the proposed new track.

Contractual Solution

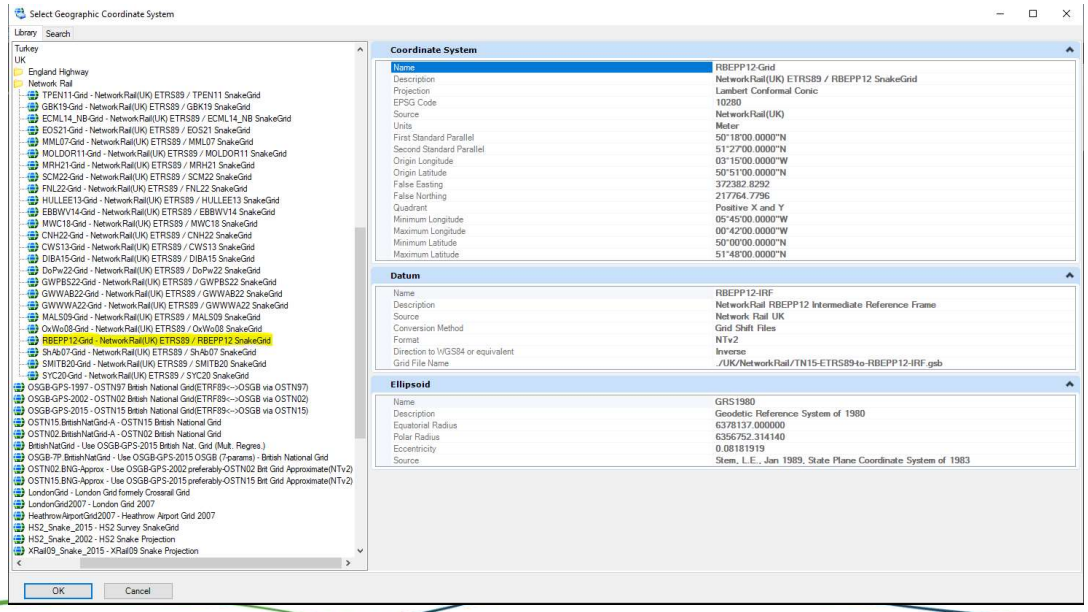
Source of Requirement	Module Requirement	Acceptance criterion	Rationale/Supporting information
Survey	The Contractor shall create a Project Survey Technical Work scope for every survey required for Design and As Built purposes. The Contractor shall maintain a Survey Tracker outlining the principles of survey data capture and management and a list of planned and available survey data to be used on the project. UAV surveys including methodology are to be agreed with the project team prior to commission. SI & GI Environmental and Ecological Data are to be georeferenced with Easting and Northing coordinates and submitted to NR BIM team to be included in NR GIS. The Contractor survey tracker will be submitted to NR BIM manager revised for very survey submission.	Production of Survey Technical Work scope accepted by the Employer and management of Survey Strategy Tracker by Design Team and DPE as up to date and suitable for project needs during this stage of works. List of survey requirements needed for future stages and consideration given to early provision where advantageous to programme and confidence in works and design options. Details and confirmation of this requirement to be included in the BEP and accepted by the Employer	Wales and Western Survey Strategy Exchange Information Requirements NR/L2/TRK/3100

Technical Solution

The **National Transformation version 2 (NTv2) is a standard for performing datum transformations on geodetic coordinates**. It is represented by a Grid Shift Binary (GSB) format file which stores a matrix of shifts to be applied to input latitude/longitude coordinates in one reference frame for conversion to another. The NTv2 format is used for a significant number of national mapping systems (including Canada and Great Britain) and is recognised by the majority of geospatially-enabled software systems. In Network Rail Track primarily uses Snakegrid

This means this will be operational in design software e.g. Bentley Apps, AutoCAD , OLE tools , Bentley Rail track and GIS for handback to Integrated Network Model (INM)

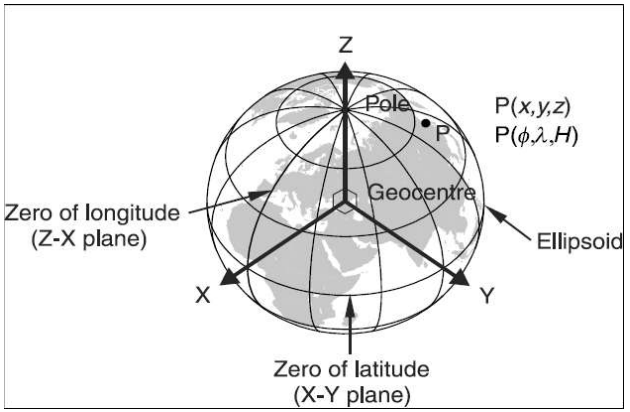
Files are converted from one grid to another in a few seconds with a single button



What makes up the Project Twin

Geometrical Data

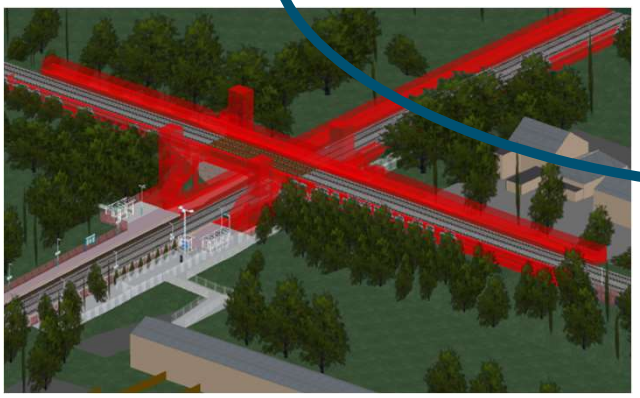
- Track
- Signals
- Signs
- Stations
- Utilities
- Buried Services
- Civils
- Lineside Infrastructure
- Neighbourhood buildings
- Vegetation
- Drainage
- Digital Terrain Model
- Ballast – Generic
- Mileposts
- Chainage
- Project Designs
- Survey Data



- All the above are based on a project Grid

Benefits for getting the basics right

The concept 2D to be developed to 3D for 10 different concepts would have added significant cost to the project to get all concepts to same level to prepare for option section.



With the introduction of BIM concepts, early optioneering was made possible. Stakeholder were able to quickly see if a solution would be acceptable. This reduced the development of options to just 4.

The option above became the Clients preferred option.

"We initially had about 10 models that were presented to the stakeholders. Some of the models were presenting some prejudged favourites which when the stakeholders saw the impact on the station made a definitive rejection. Which in turn influenced the whole of the future development: Shotton Station Project Manager – Development Group

"3D Modelling helped to vividly illustrate what our plans were, ensuring that the public understood exactly what we were proposing, which shaped public sentiment and in turn strengthened our argument with local stakeholders. This was in stark contrast to section one, where fear of the unknown coloured the perception of our plans and thus created scepticism within the community and local politicians" : SWRRP Comms Manager

3D Model Benefits for Live Railway

Signal Sighting – Swindon Speed Signs

Using BIM	Using a Contractor	Internal process before BIM
Committee of 8-10 people including representative for TOC's and FOC's from different parts of the Country (average band 2 salary (£45 per hour)) – 2-3 hours TEAMS meeting Staff - £900 (based on 8 people)	Cost of locomotive for video signal sighting - £ 10,000 Cost of sign signal change using a company to undertake video signal sighting @£ 5000 per change - £25,000 1 day site visit - Staff time - £2520 (based on 4 people) Travel costs – 4 people £50 per person per day £200	Committee of 8-10 people including representative for TOC's and FOC's from different parts of the Country (average band 2 salary) 2 days including site visits and overnight stays Staff time - £5040 (based on 8 people) Overnight Costs based on 3 people @ £250 pp - £1500 Travel costs – 5 people £50 per person per day £500
BIM Team costs - 1 day x 1 person £350	Planning/Possessions - £1800 Look Out/COSS/SSWOP – 4 people @ £550 per day = £2200	Planning/Possessions - £1800 Look Out/COSS/SSWOP – 4 people @ £550 per day = £4400
£1250	£39,920	**£13,240**

3D Model Benefits for early AIP – Outline Design

Are drawing needed for every stage of development?

Oxford Station – New Entrance (Grip Stage 3)

Using BIM	Using Consultants
Internal staff costs - £20,000	Quote from consultant for detailed drawing £650,000 – please note this is the baseline quote and does not include any changes to the design which would have been requested.
Designs suitable for planning permission process	Level of detail not required for planning permission
Quick turn around for any changes requested (approx 1 week)	Up to 6 weeks for any changes requested
Other Benefits: Used for Threat and Terrorism training Will benefit SPEED Can be used by other teams such as Maintenance for planned works (reducing site visits)	Do not own the drawings
£20,000	***£650,000***

The Future - Atlas

Background Data :

- Satellite Imagery
- NR Route Data
- 3D City models

Data Provided :

• Forward facing LIDAR -	762 GB	
• Forward Facing Video	-	9.9GB
• Thermal Video	-	19.2GB
• Drone Video	-	138MB
• Drone LIDAR	-	11.7GB

Using algorithms geopositioned video feeds and different point cloud and surveys were mapped to he correct ELR and Track ID