

A blue stylized graphic consisting of three parallel diagonal lines, positioned on the left side of the slide.

NW&C 25kV Future Electrification requirements Dean Chauke

A blue stylized graphic consisting of three parallel diagonal lines, positioned on the right side of the slide.

25kV Traction Power

How much Electrical Energy does it take to move different trains?

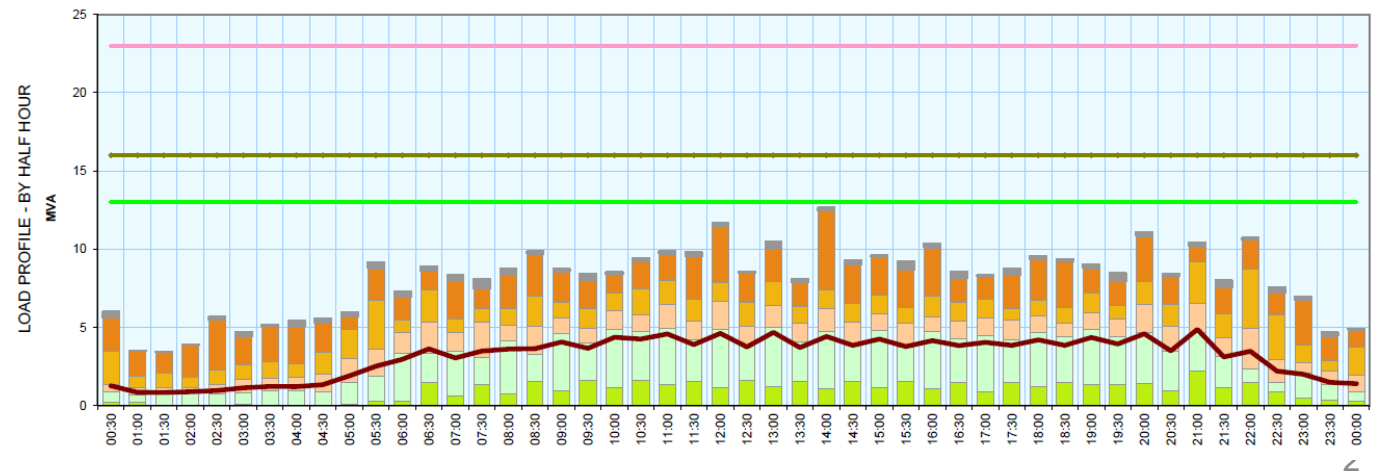
- | | | |
|--|-----------------------------|--|
| • Electric Multiple Unit: | 8 to 10 kWh/ <u>unit</u> km | e.g. 4 car Class 350 Northampton to Birmingham |
| • Class 390 Pendolino: | 25 kWh/train km | e.g. 11 Car Class 390 London to Glasgow |
| • Locomotive hauled passenger train: | 25 kWh/train km | e.g. Caledonian Sleeper |
| • Locomotive hauled 1500 tonne freight: | 40 kWh/train km | e.g. London Gateway to Daventry |
| • Locomotive hauled 2000+ tonne freight: | 55 kWh/train km | e.g. Crewe to Garston |

Peak electrical load is often outside of peak train service...e.g. Crewe

Electric freight paths are +/- 30 minutes

Freight paths are often not used daily

400m HS2 trains will be close to freight impact



25kV Traction Power is a bit like Communal Showers...



25kV Feeder Areas are Large

- Typically only 30 infeeds, spaced 30-60km apart (which are not electrically connected) feed all of NW&C (The Water Towers)
- 275kV and 400kV National Grid Supplies are “high pressure” and “fat pipes”; 132kV Distribution Connections are “low pressure” and “smaller pipes”
- These either feed Booster (“thin”) or Boosterless (“medium”) or Autotransformer (“fat”) rail electrification schemes
- If the plumbing diameter (of the grid and the rail network) and infeed pressure aren’t good enough you get poor performance affecting parts of the feeding area, or in a worst case, things can start tripping off or we run out of capacity

Today: NW&C has a mix of systems

Blue

- Autotransformer electrification from WC PSU programme
- Fat electrical pipes and high capacity (pressure) in feeds

Red

- Booster Transformer Classic Electrification
- Thin electrical pipes

Magenta

- Boosterless Classic Electrification
- A modern system where only medium piping is needed for the foreseeable future (unwise if electric freight or high levels of intercity service are planned)

Green

- Rail Return Classic Electrification
- Generally, legacy areas only



Avanti West Coast has announced that the first of its Hitachi Class 805 bi-mode trains has begun dynamic testing at Network Rail's Rail Innovation and Development Centre (RIDC).

Following the **completion of static tests**, this dynamic testing marks a major milestone in the operator's 350 million GBP project.



Stadler has started production of the Class 93 locomotive fleet for Rail Operations UK at its plant in Valencia, Spain.



Electrical Load is increasing on the existing infrastructure even without new electrification

- Class 80x Bi-modal passenger trains
- Class 730 longer trains around Birmingham and commuter routes to London Euston
- Class 93 4 axle bi/tri-modal freight locomotive
- Class 99 6 axle bi-modal freight locomotive

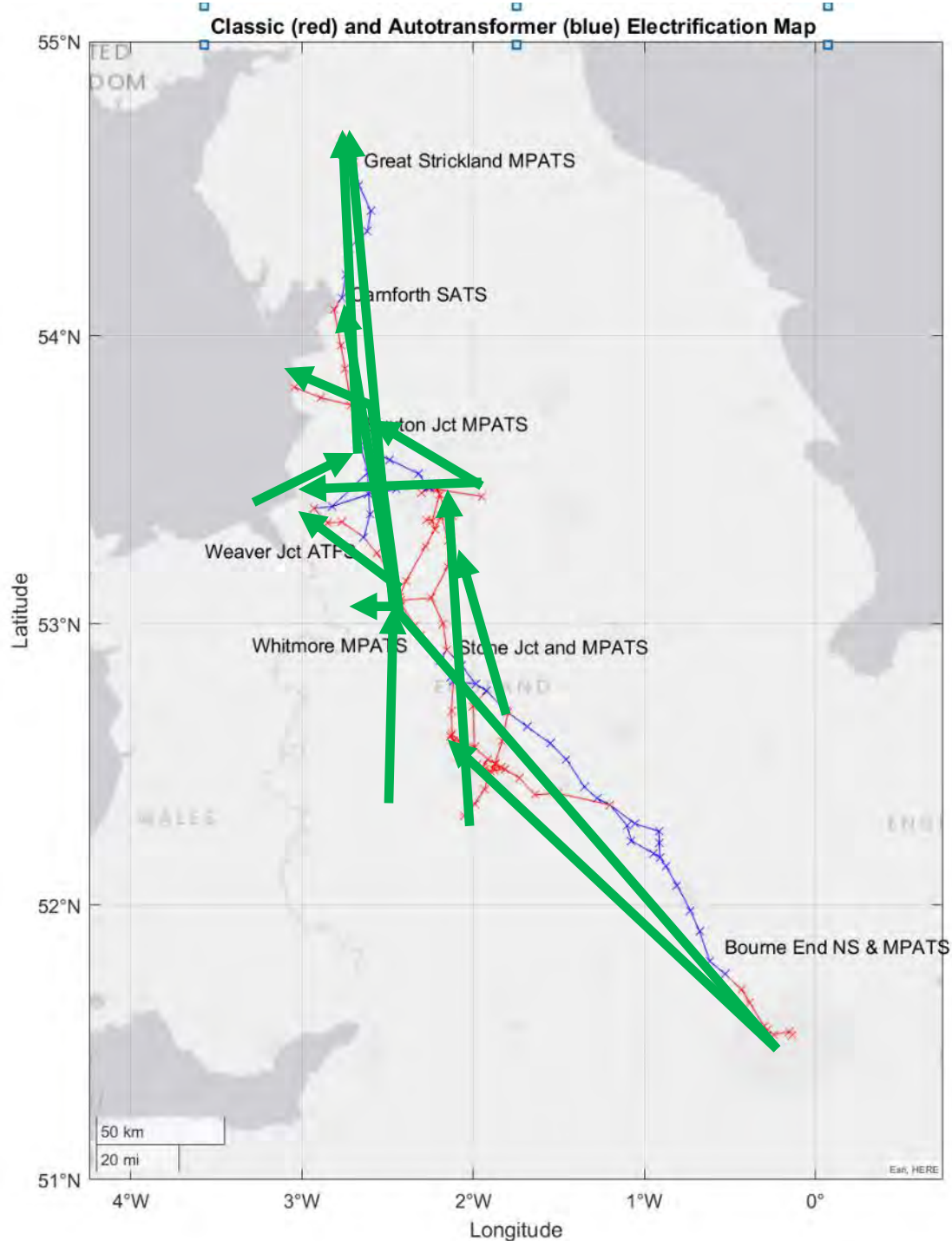
The first Class 730 train for Birmingham's Cross City Line is complete

The unit has gone to Europe for testing



GBRf orders Stadler bi-mode Class 99 locomotives





Service Electrification



- Dec '22
 - Open Access
 - Euston → Stirling Class 93 + 5 car
 - Avanti Voyager → Class 80x conversion
 - Euston → Chester Class 805, 5 car
 - Euston → Blackpool Class 807, 7 car
 - Euston → Liverpool Class 807, 7 car
 - Euston → Shrewsbury Class 805, 5 car
 - Euston → Shrewsbury Class 805, 5 car Peak
 - Class 730 Introductions, 3→6 car changes and new stations
- Transpennine
 - Liverpool x 2 TpH
 - Wigan x 1 TpH
 - Manchester Victoria / Airport / Piccadilly (not today)
- HS2 Phase 2A (202X)
 - HS2 Services arrive just South of Crewe
 - Additional Handsacre → Macclesfield
 - Additional Crewe → Lancaster
- Crosscountry
 - Voyager → Class 80x conversion
 - Exeter / Bristol → Manchester (Not today)
- HS2 Phase 2B (203X)
 - HS2 Services arrive at Golborne junction
 - Additional Golborne → Scotland
 - 400m trains?
 - Actually removes some load from Crewe to Euxton

First Come, First Served?

Whole Industry Strategic Plan (WISP)

- Flaw – Limited Decarbonisation of Freight

T1229 – Recommendations for low carbon freight traction mix and routes to deployment
 Flaw – No Decarbonisation of Passenger

What Actually Runs, the NW&C analysis is overly conservative?

- ~2/3 TPH electric freight at lighter load than we're measuring



Class 93 and 99s
 Only one unit needs to demonstrate compatibility, not a timetable

Timetable

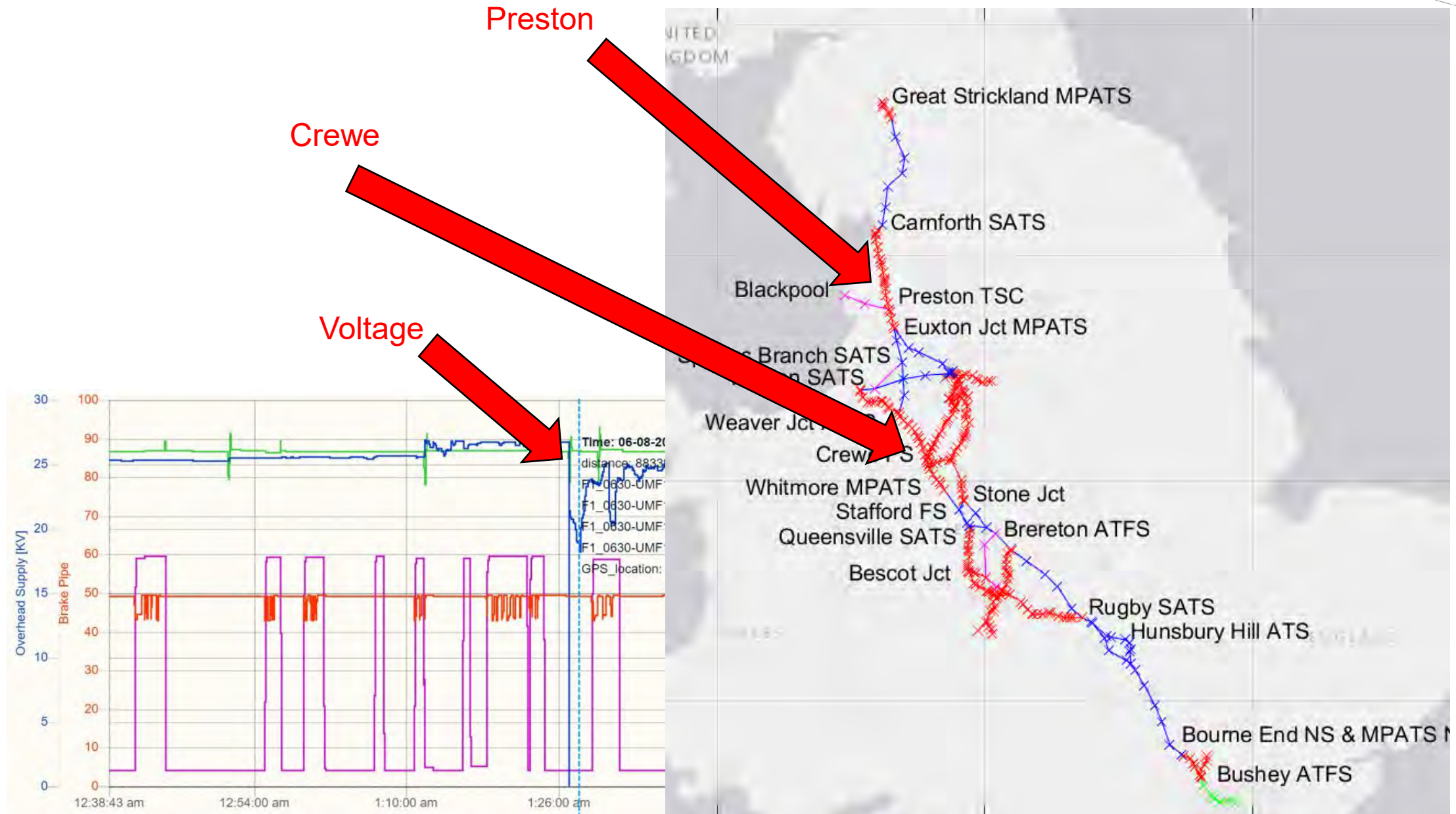
- Max 2 TPH *Electric* Freight currently

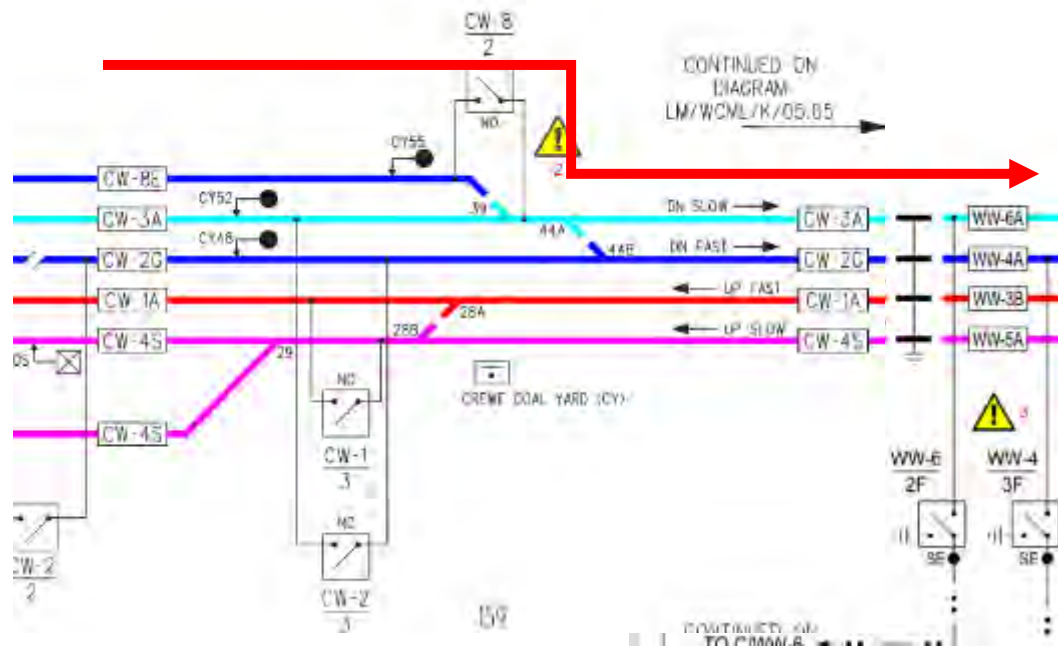
Weaver Junction Freight Rights
 • Up to 9TPH Freight Rights

Passengers in train journey 'from hell' as they are trapped in pitch black for HOURS and 'urinate on floor'

This Impacts on Our Customers

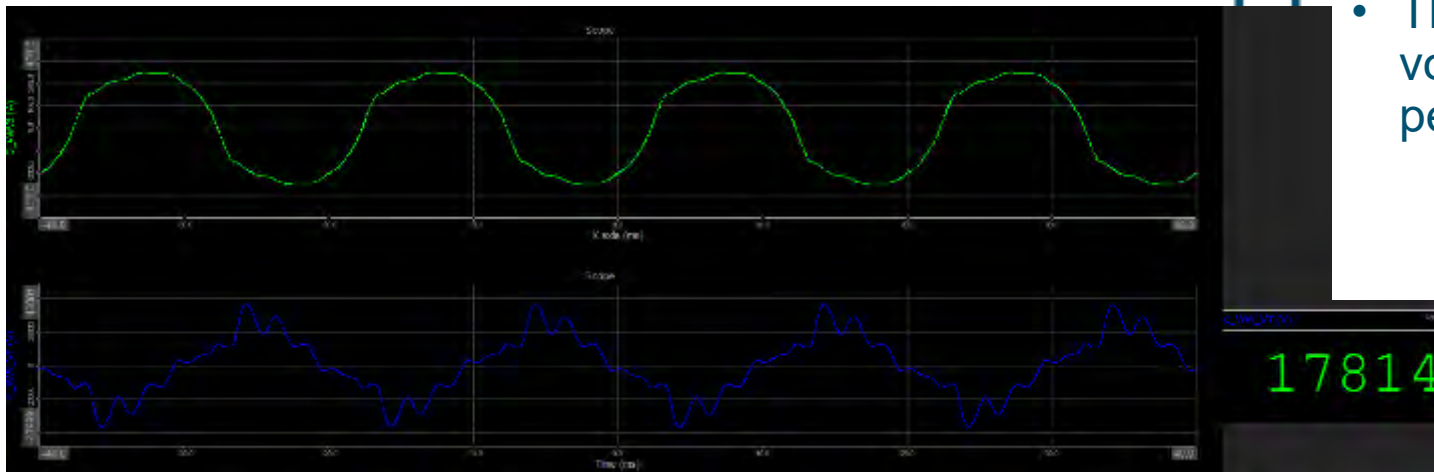
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Crewe Measured - Today

- Every time a double headed Class 90 heads North on the Down Slow, it leaves the Liverpool independent at ~10mph
- It has to accelerate hard up to and beyond the Neutral Section at the furthest point from the National Grid Feed
- Voltage is very marginally compliant, but heavily distorted at Crewe
- As voltages reduce, acceleration performance of other trains in section (and SRTs) will degrade
- Voltages that are this heavily dependent on freight paths could occur at any point in any hour as freight paths are +/- 30 minutes
- The on time timetable might well show **no** low voltages, but resilience gradually degrades to perturbation

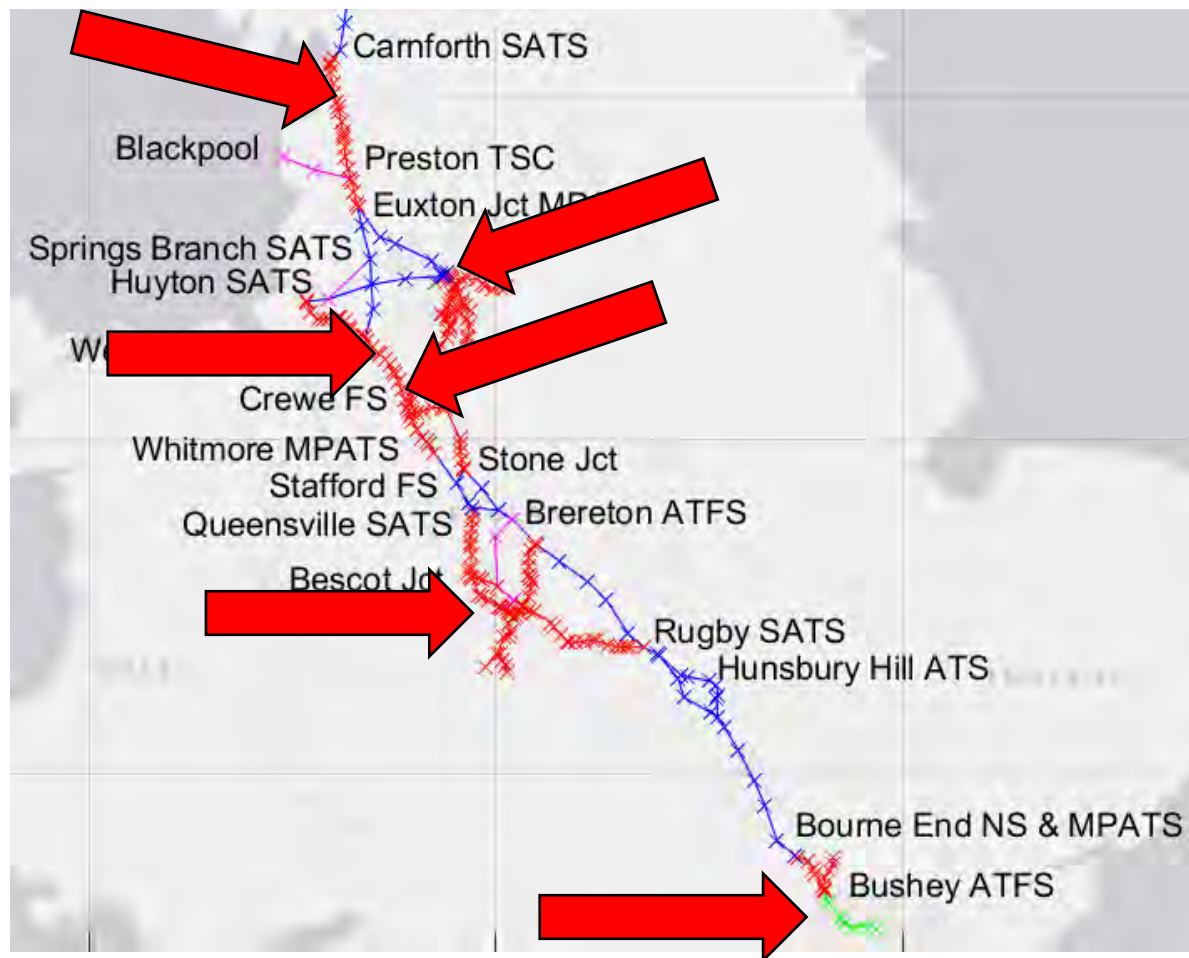


The System is Protected against Faults and Overload

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There are lots and lots of short outages (3-5 minutes)

- With the exception of Ardwick, which was originally a d.c. system, the trips are in the same areas of infrastructure that capacity challenges are
- In Acton Lane's case, at least three major (1-10,000 delay minutes) incidents have occurred where the back-up feeder has overloaded after the primary feeder tripped



Breaker	Total Trips	Site
A/AH-5	115	Acton Lane 25kV FS
AK/HM-14	107	Ardwick TSC
WD/WW-6	105	Winsford TSC
RU/PN-AF6	95	Rugby SATS
AK/HM-7	94	Ardwick TSC
AK/HM-13	90	Ardwick TSC
B/OC-5	81	Hest Bank MPTSC
B/OC-6	75	Hest Bank MPTSC
Total	9444	

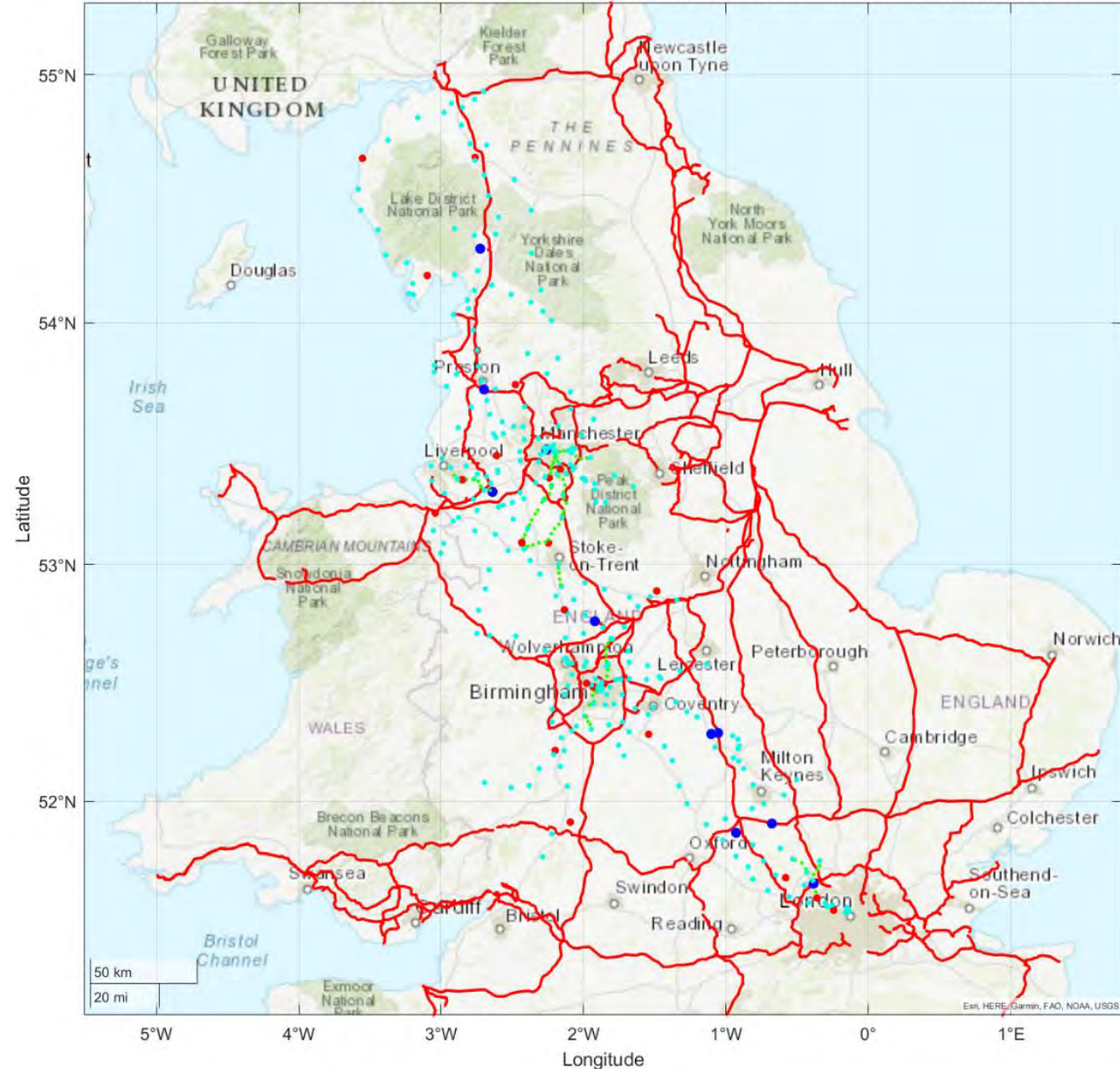
NW&C Long Term Trend / Strategy

Renew and Enhance 1959-1980s electrification (red) to:

- Auto-transformer (Blue) on WCML and busier routes
- Boosterless Classic (Pink) on lighter load routes
- Renew AWAC to Mk3D Contact System for better resilience north of Weaver Junction on WCML

- Red = National Grid Network
- Dots = Scatter plot of E&P locations
- The long term trend / strategy for the WCML has been:
 - “High pressure” (275 / 400kV National Grid) connections
 - High capacity in-feeds
 - Autotransformer (fat pipe) electrification

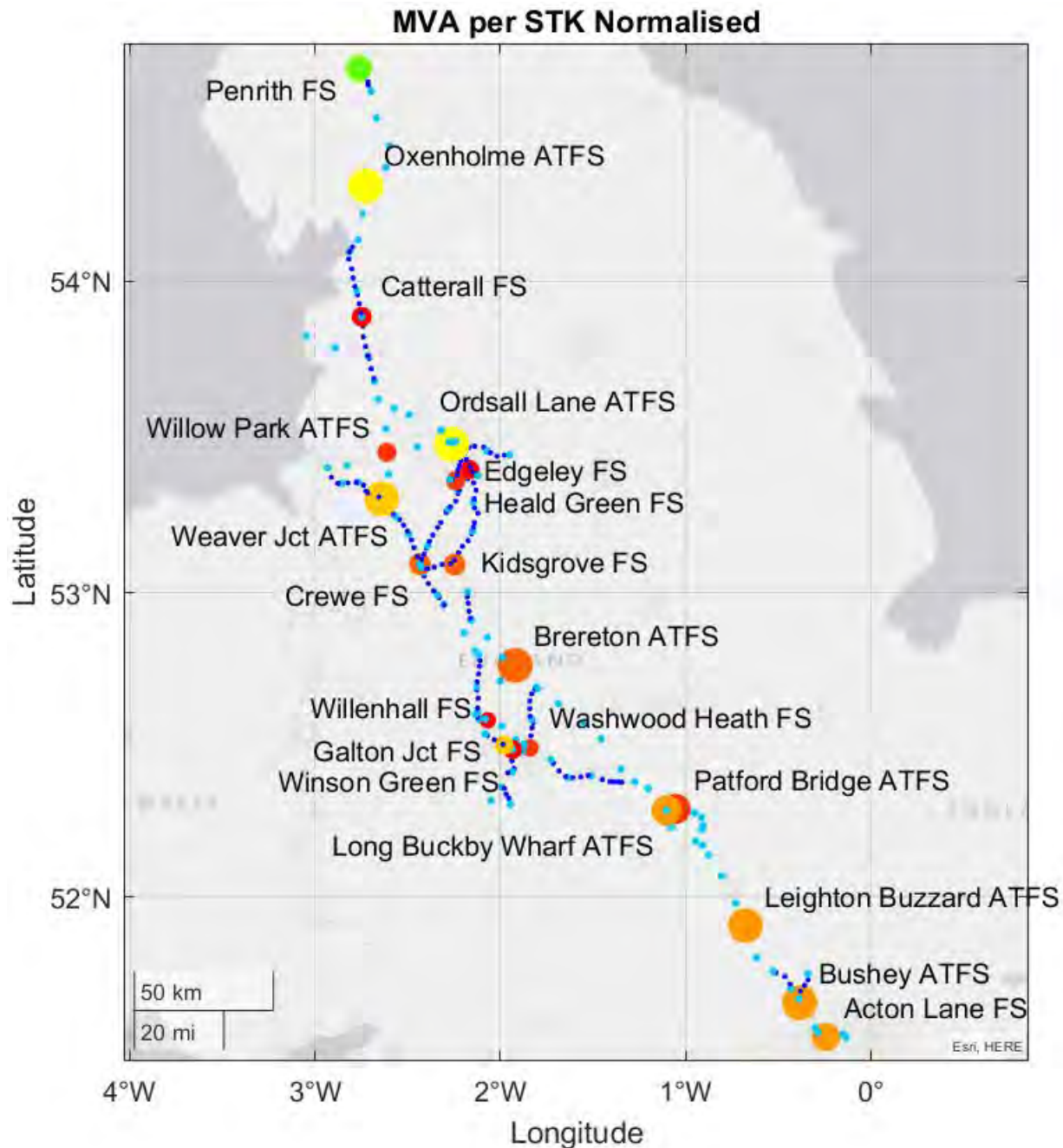
Scatter Plot of NW&C Electrification Assets overlaid onto National Grid 275kV and 400kV Tower locations



Autotransformer Feeder Stations (ATFSs)

MVA per Stk gives a high level indication of capacity available at NW&C supply points

The long-term strategy depends on National Grid 400 or 275kV to 25/25kV Autotransformer Feeder stations and associated along track interventions, in particular a new feeder to replace Catterall and a new feeder in the Birmingham area



Autotransformer Conversion

Autotransformer conversion requires additional along track conductors

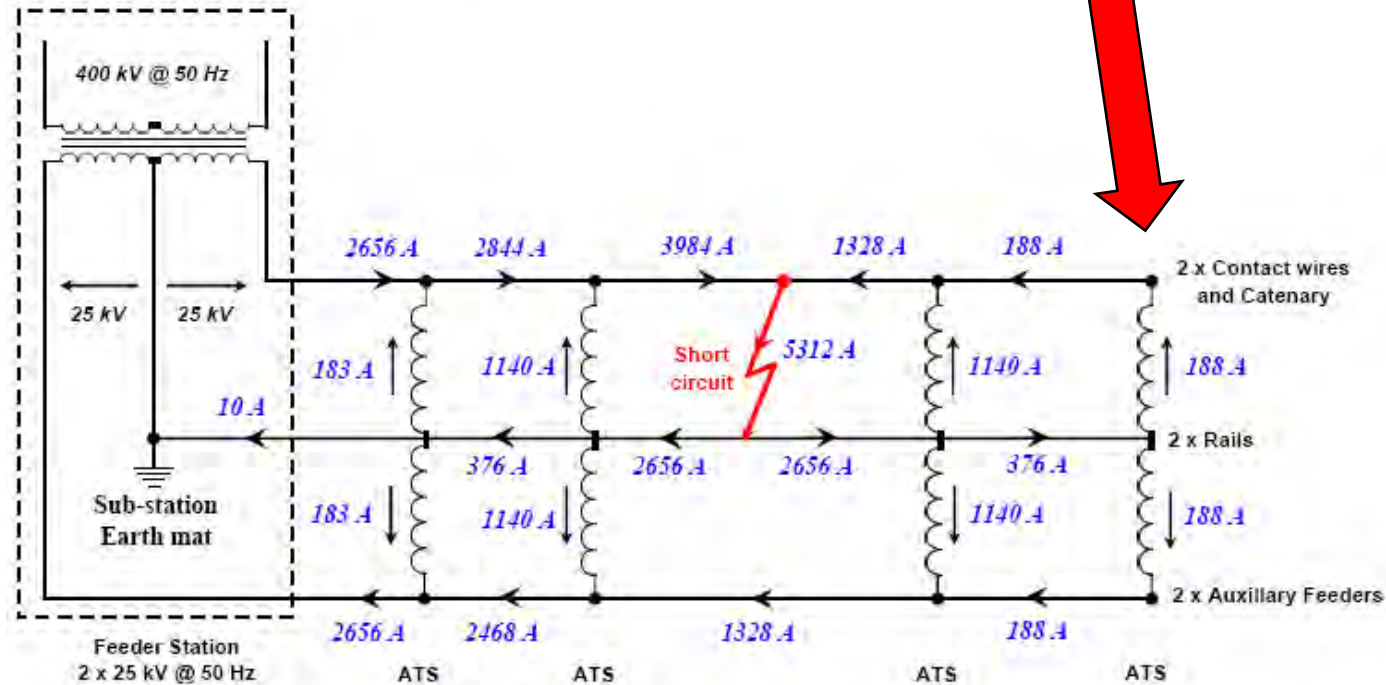
Additional mitigations to stop contact with live parts

Additional bonding and along track immunisation

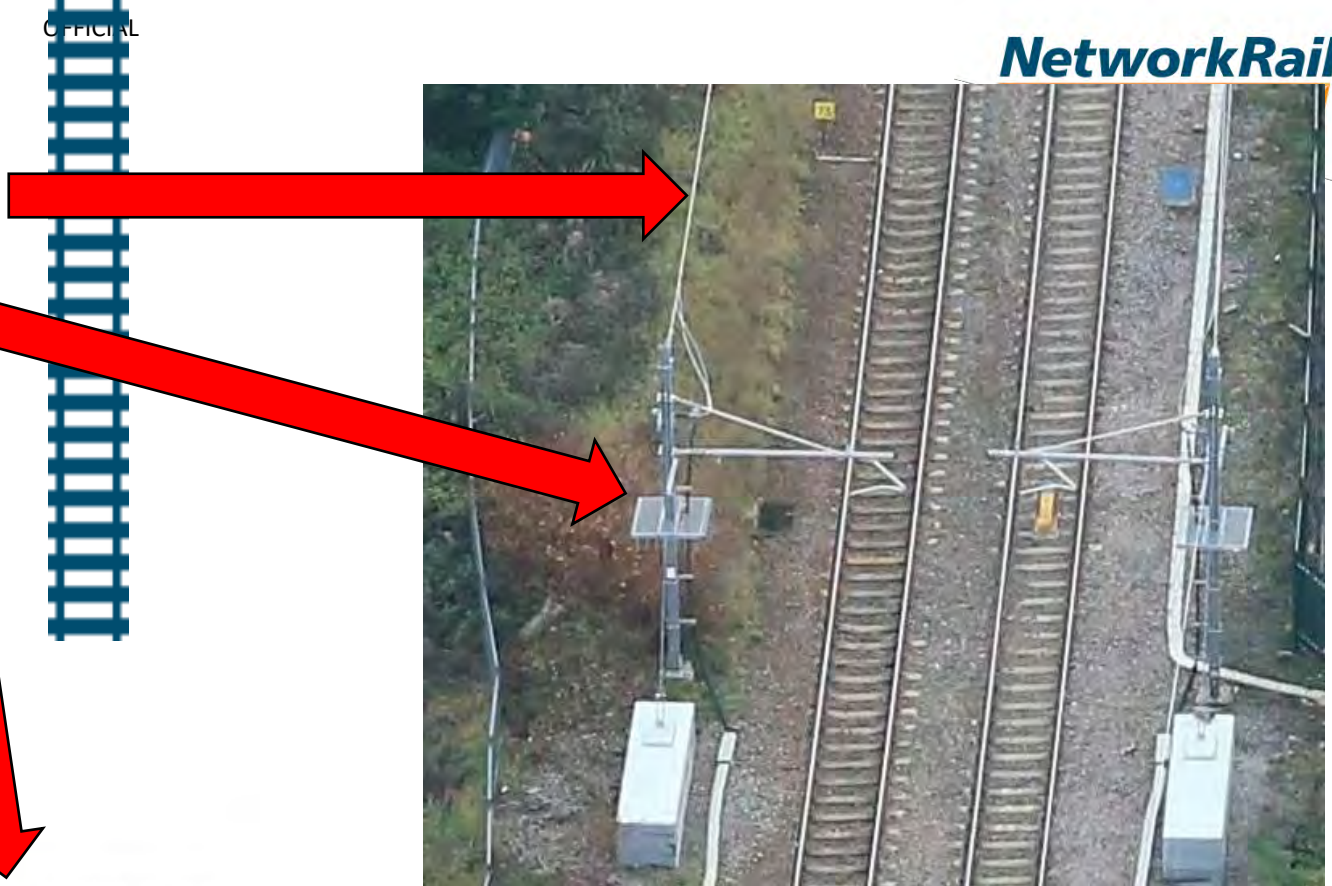
Autotransformers and new switchgear at substations

Removal of redundant assets like booster transformers

It is a substantial system change



Note: 2 Autotransformers per distribution site



Strategic Need



- Renew and Enhance 1959-1980s electrification (red) to:
 - Auto-transformer (Blue) on WCML and busier routes
 - Boosterless Classic (Pink) on lighter load routes
 - Renew AWAC to Mk3D Contact System for better resilience north of Weaver Junction on WCML
- Priorities to Support Passenger Services, Freight and Decarbonisation Agenda:
 - New Grid Supply at Penwortham and AT Conversion Penwortham to Euxton Junction
 - AT Bourne End to North Wembley
 - AT Conversion Weaver to Crewe
 - AT Conversion and Mk3D conversions Weaver Junction to Carnforth
 - AT Whitmore to Crewe
 - Renewal in modern form Grand Junction line Substations
 - Develop a capacity uplift at Washwood Heath
 - MK3D conversions Carnforth to Great Strickland
 - AT Conversion and Mk3D conversion of Great Strickland into Scotland
 - Develop a higher capacity supply at Crewe
 - Develop AT conversion from Rugby to Queensville via Birmingham

A stylized graphic of a rail track, consisting of two horizontal lines with vertical cross-ticks, rendered in a dark blue color.

Traction Power Annual Capacity and Capability Report

A stylized graphic of a rail track, consisting of two horizontal lines with vertical cross-ticks, rendered in a dark blue color.

NW&C 2022 Traction Power Capacity and Capability Overview

Version 12

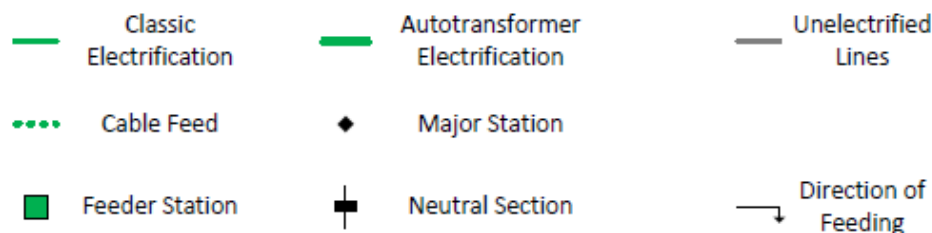
Date: Jan 2023 / Prepared by: Felix Murphy / Checker: Dom Banham-Hall

This Drawing forms part of a wider strategy.

More information can be gained by reading the NW&C Traction Power Strategy (link below) or contacting Felix Murphy [Senior Engineer, Power Systems NW&C] or Dom Banham-Hall [Principle Engineer, Power Systems NW&C]

<https://networkrail.sharepoint.com/:f/r/sites/NWCEPRegionalTeam/Shared%20Documents/Regional/Power%20Systems/Power%20Systems%20Strategy/NW%26C%20Strategy%20%26%20Capability%20Document?csf=1&web=1&e=Cn57vY>

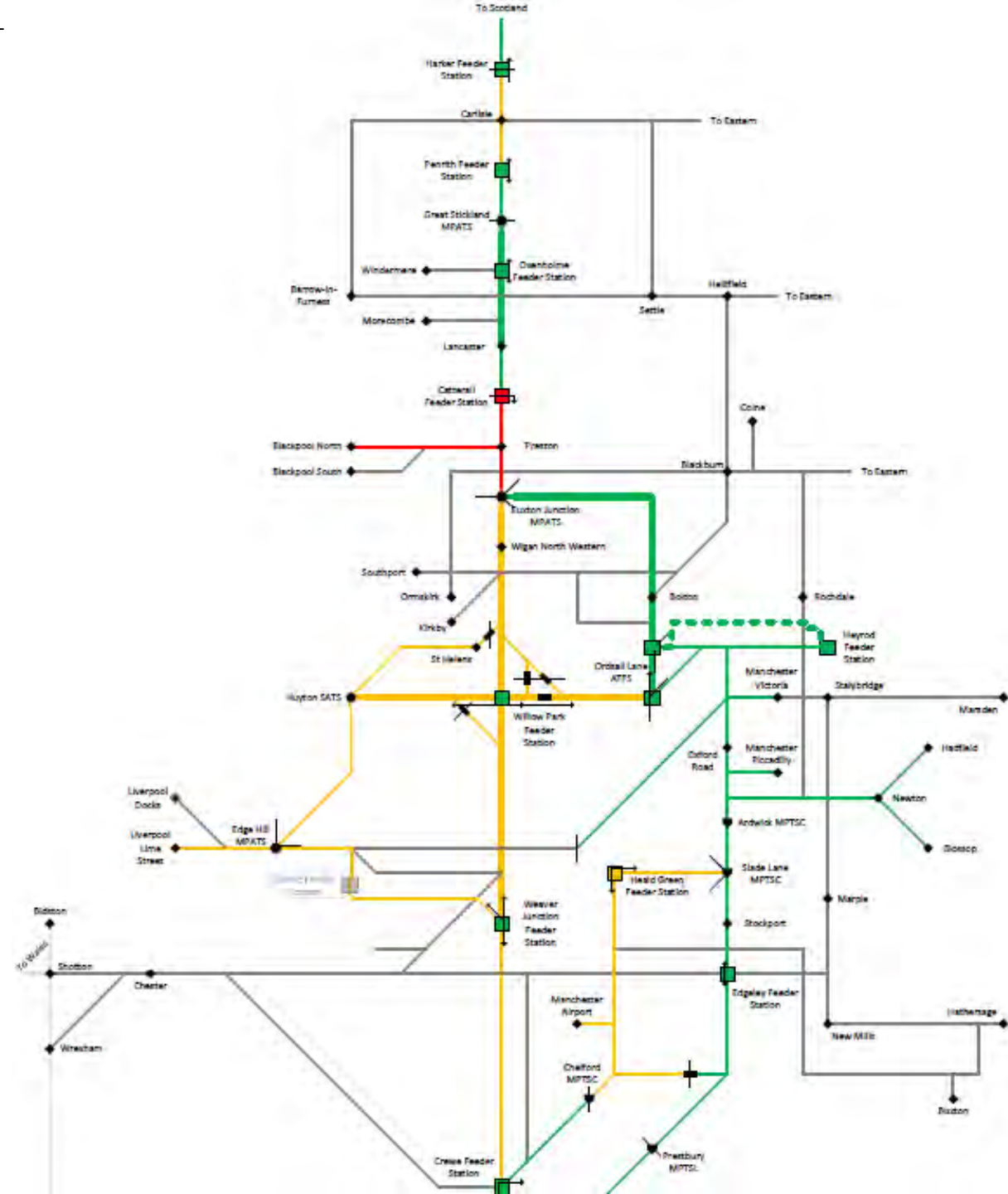
Key



What do the colours mean?

Explanation	Reality of service introduction
There are no issues on these routes or at these Feeder Stations	Normal assessment and verification is needed
There are concerns for the ability of Feeder Stations to continue their current output without intervention. There will likely be service affecting issues along the route	Introduction would likely be dependant on time of day, rolling stock, and frequency of service required
There are Safety concerns at this Feeder Station The Feeder Station is unable to accommodate more traffic without endangering people or reducing asset life considerably There is a high likelihood of service affecting issues along this route	Introduction would be limited to specific times of day, limitations on rolling stock, driver behaviour and routing of train. Introduction may be required to be shared amongst TOCs/FOCs

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NW&C 2022 Traction Power Capacity and Capability Overview

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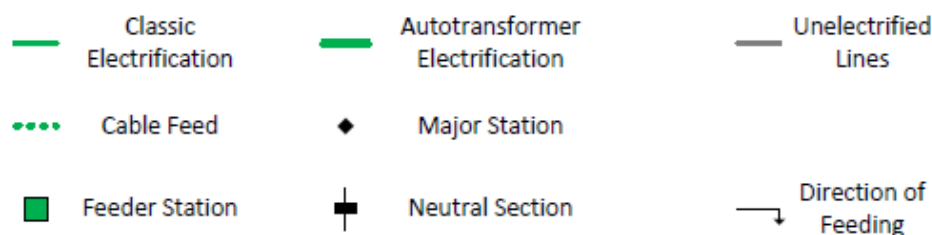
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