Enabling Efficient Electrification to help decarbonise the railway

Colin Lamb (Scotland Region) Richard Stainton (STE)

Climate Change Context

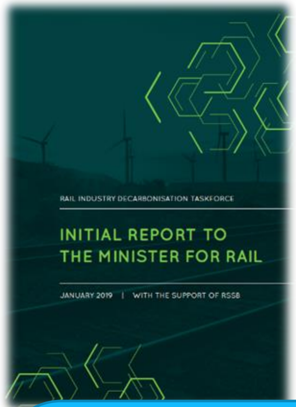
UK Climate Change Act 2008 passed into law binding UK to reducing emissions by 80% from 1990 levels by 2050.

Climate Change Act 2008

December 2015 Paris Agreement established seeking to limit global average temperature increase to well be below 2°C and to pursue efforts to limit this to 1.5°C

In Feb 2018, then minister for rail Jo Johnson MP challenges the industry to remove all diesel-only trains from the network by 2040

In response to the minister the rail industry convened the Decarbonisation Taskforce to explore decarbonisation in rail



In January 2019 the Decarbonisation Taskforce publishes its interim report noting that it is possible to remove diesel only passenger trains but this is harder for freight

May 2019 CCC recommends to the UK government that a revised UK target of Net-zero emissions by 2050 should be established

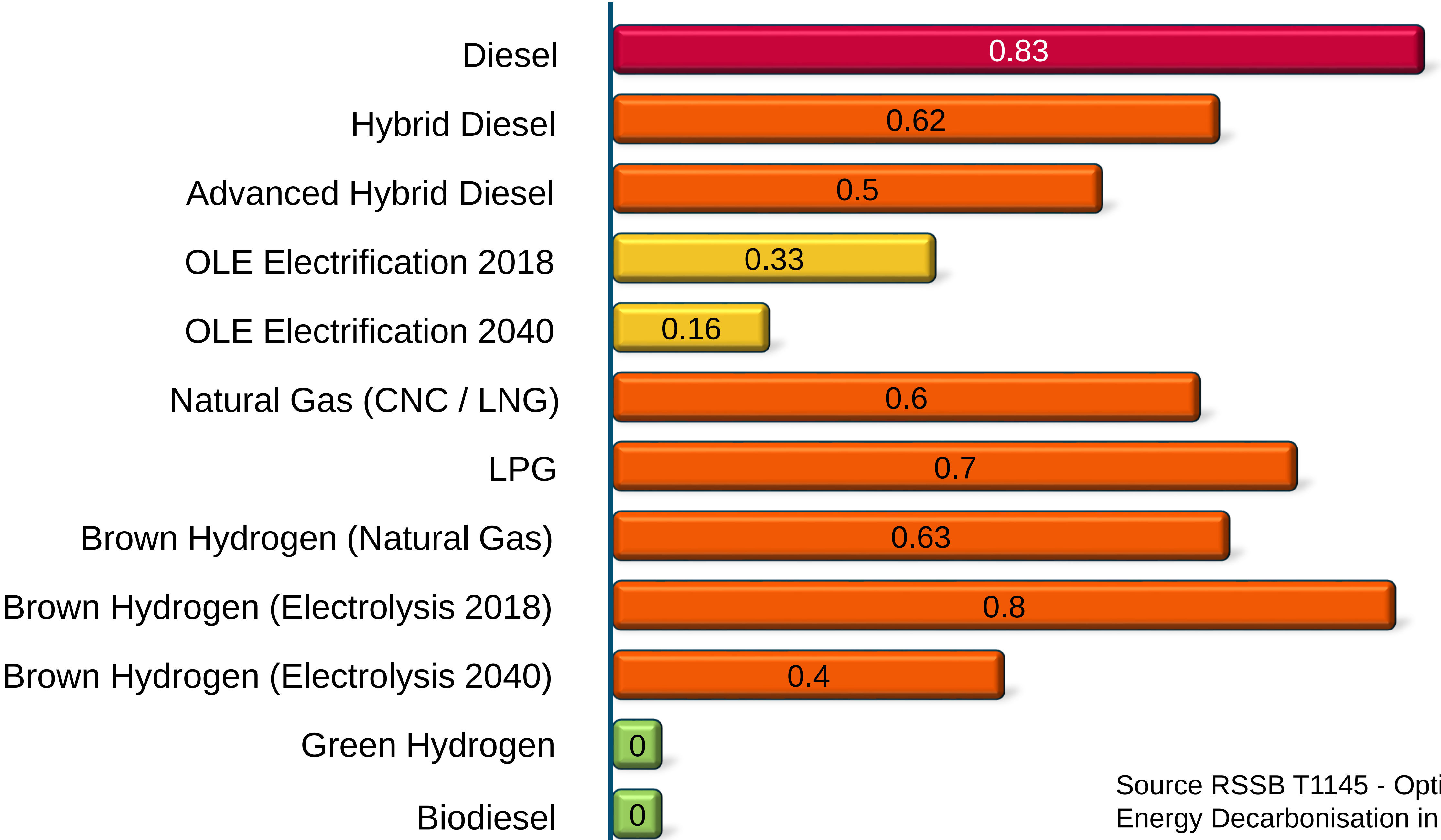
Climate Emergency declared by Scotland Government, Wales Assembly and UK Government.

In June 2019 the UK Government revised the 2008 Climate Change Act to commit to a target of net-zero greenhouse gas emissions by 2050.

In July 2019 the Decarbonisation Taskforce publishes its final report.

Scottish Government aim to decarbonise railway by 2035

Traction Emissions $kgCO_2e$ / kWhr



Source RSSB T1145 - Options for Traction Energy Decarbonisation in Rail

NetworkRail

THE SUNDAY TIMES

CLEAN AIR FOR ALL

Call to cut diesel trains over air pollution risk

Graeme Paton,
Transport Correspondent

July 1 2019, 5:00pm,
The Times

Transport

Scientists found a link between the number of diesel trains in and the concentration of nitrogen dioxide
ALAMY

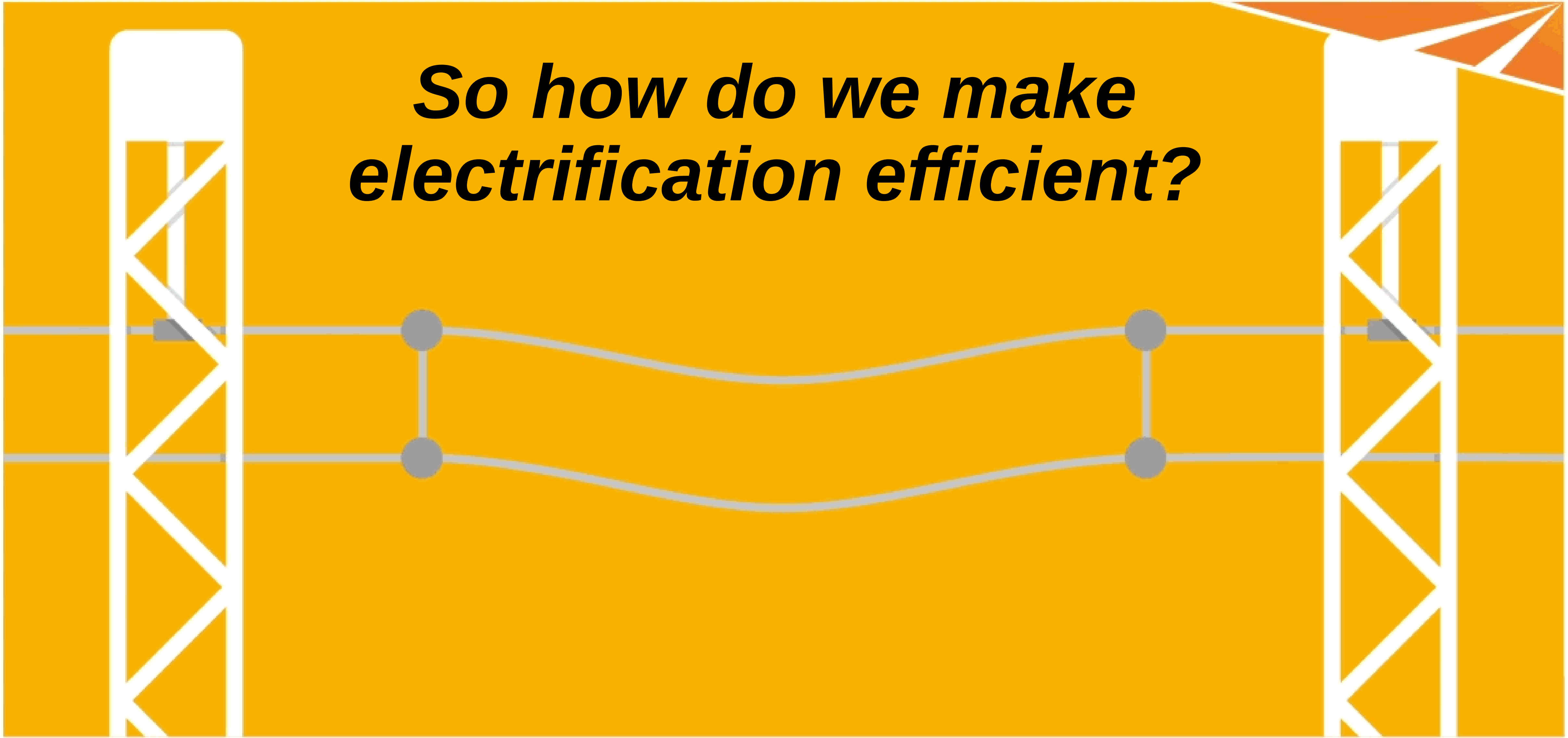
Transport for London

Ultra low emission
ULEZ
ZONE

At all times

Source RSSB T1122 – Research into air quality in enclosed stations

So how do we make electrification efficient?



Scotland electrification challenge and opportunities

- Continue electrification in CP6 onwards, following successful CP5 projects
- TS requirement in High Level Output Specification for CP6 – efficient electrification specification
- 3 September 2019 the First Minister in her Programme for Government (PfG) gave a commitment to decarbonise domestic railway services in Scotland by 2035
- Phase 1 electrification projects launched – CP6/CP7 delivery

- Task Group setup to outline a prioritised rolling programme, items to be considered are the interdependent workstreams:

City/towns emission targets

Rolling Stock Strategy

Renewal Projects

Gauging Strategy

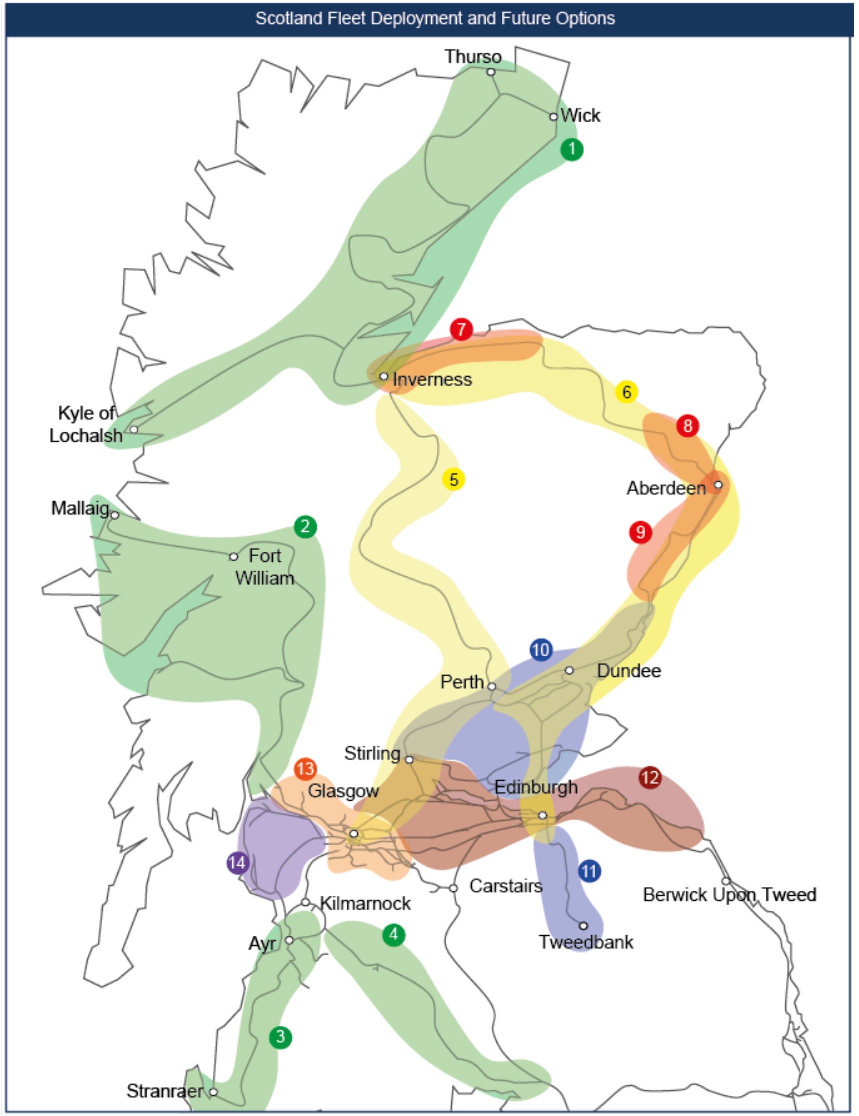
System Signalling Strategy

Traction Power Supply Strategy

Enhancement, pipeline projects

Production Levelling

Depots & Stabling Strategy



Scotland Fleet Deployment and Future Options

Ref	Current Fleet Deployment	Future Considerations
1 2 3 4	• Currently running Class 156/8s on rural lines • These will be life expired by the mid-2020's	• Scenic trains are likely to drive the next DMU procurements • The West Highland and Kyle lines are the drivers but all rural routes are likely to take the same stock • Capacity is also a key consideration on the West Highland, G&SW and Stranraer lines

5
6
	• Intercity HSTs will run until 2030 on
	  • Inverness to Glasgow and Edinburgh
	  • Aberdeen to Inverness
	  • Aberdeen to Glasgow and Edinburgh
		• For the future of these services journey times will be the most important consideration between Inverness and Aberdeen/Edinburgh/Glasgow
		• However both journey time and capacity will be key between Aberdeen and Edinburgh/Glasgow

7 8 9	• Currently running Class 158s on local services in the north-east • These will be life expired by the mid-2020's	
10 11	• Class 170s will be life expired by 2030	
12	• Class 385s are committed to Scotland until 2035-40	
13	• The 20m DMU fleet (Class 318/20s) will be life expired by the mid 2020s	• Additional capacity will be required on the North Electrics and Argyle Lines
14	• Class 380's currently run on the Ayrshire lines	• Growth can be managed by fleet cascade of 385s or a new fleet

Electrification Lessons Learnt (1)

Item	EGIP	SDA & Shotts
Contracting Strategy	Alliance between NR & suppliers, model not fully applied and unsuccessful.	Simpler strategy was implemented with multiple principle contractors – improved focus on their specialism.
Development stage of the programme	Key deliverables at early development stage need to be delivered. This would reduce risk and lead to improved quality, cost and programme certainty.	Key deliverables at early development stage need to be delivered. This would reduce risk and lead to improved quality, cost and programme certainty.
Clearance Works	Pre 2015, track lower and / or reconstruction at 60 overline structures then impacted by new standards, with further implications.	Risk assessments at certain locations where significant clearance challenge to demonstrate risk was ALARP.
Railway (Interoperability) regulations	Ongoing discussion with ORR, resulting in additional works.	Early Engagement with ORR at route and national level. NR Standards updated.
Electrical Station clearances per GLRT1210	Project team developed a risk model.	
Track Access	ROTR access was insufficient for construction works.	Shotts was re-planned to allow greater use of EROTR.
Access Locations	Sufficient road rail access points (RRAPs) essential to maximise construction periods.	
Construction Quality	Initial Alliance focus was on volumes, quality was impacted. Resulting in project entry into service with significant number of snags.	Improved focus on build quality. New NR Standards.

Electrification Lessons Learnt (2)

Item	EGIP	SDA & Shotts
Pile Refusals	Quality of ground investigations led to significant number of refusals. This impacted OLE construction and rework on OLE design.	Impact on construction quality of build, rework, • RaCE - 21% • EGIP - 11% • SDA - 2% • Shotts - 4% New NR Standard issued NR/L2/CIV/074
Lineside Power Supplies		Utilisation of existing signalling power supplies to power OLE switches. This avoided the need for new LV supplies.
Overhead Utilities diversions due to clearances to new OLE		Essential that this is planned at early stage. This leads to cost avoidance.
Construction time impacted due to existing lineside power cables		Consideration of renewals of cables in advance of civils works. Reduced the need for trial holes at each mast location. Potential access time of up to 2 hours due to power up / down requirements.
Use of temporary sidings to maximise access		Redundant sidings brought back into use to improve access for road rail vehicles.

Benchmark - Swiss OLE Renewal

Frauenfeld – Weinfelden

9 days instead of 600 nights

3 years of planning

13m CHF ≈ £10m

34 stk

https://vimeo.com/236053661

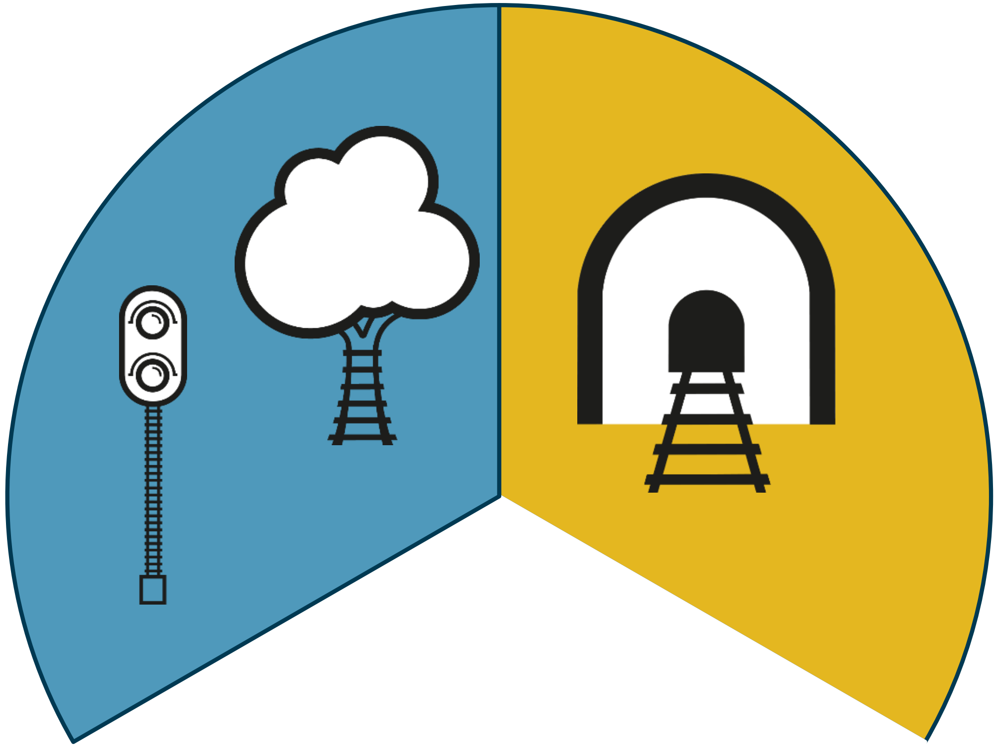

Schönholzer
726 FUNDAMENTE
623 MASTEN

Electrification Projects Cost Analysis

Electrification Projects Cost Analysis

Civils Works
- Tunnels
- Stations
- Bridges

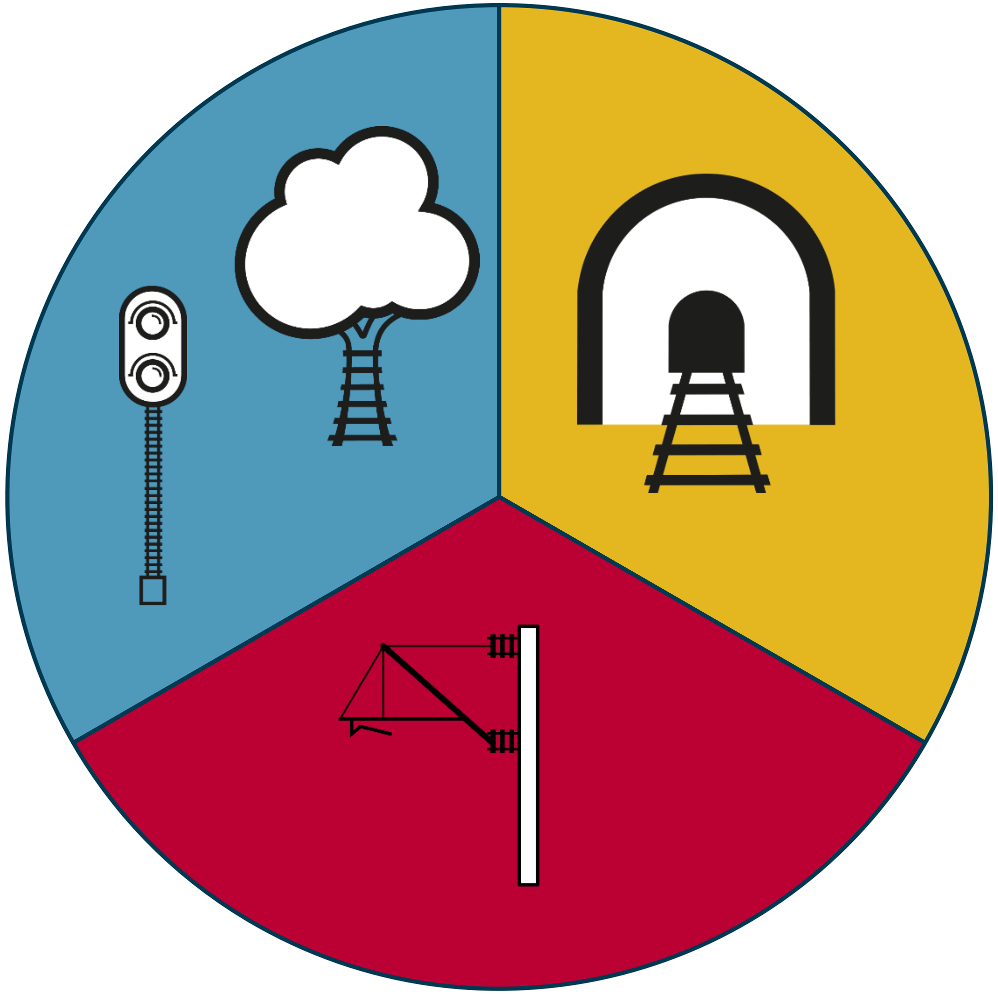
Electrification Projects Cost Analysis



Civils Works
- Tunnels
- Stations
- Bridges

Other
- Signalling
- Fencing
- De-vegetation
- Mobilisation
- TOC Compensation

Electrification Projects Cost Analysis

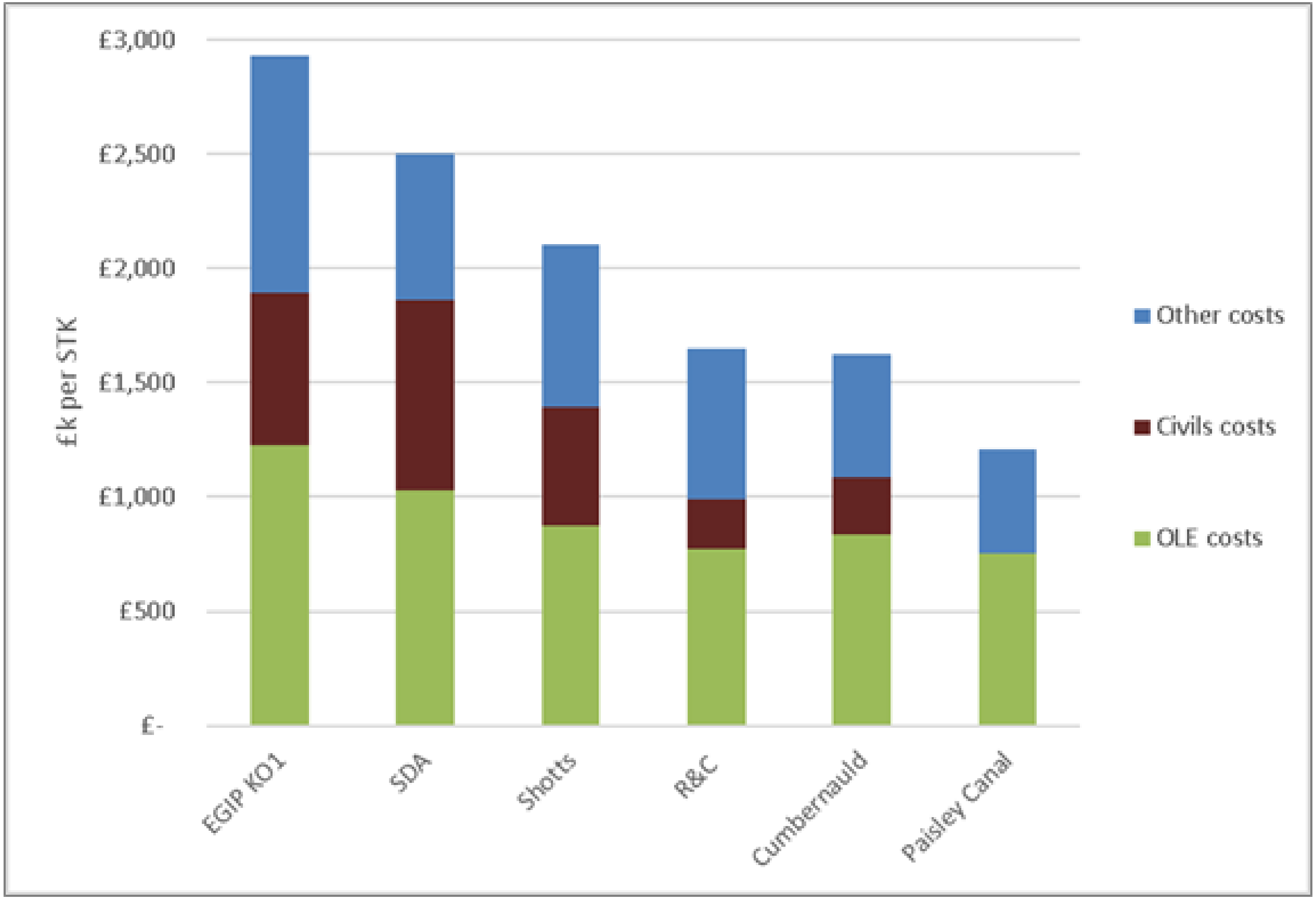


Civils Works
- Tunnels
- Stations
- Bridges

Other
- Signalling
- Fencing
- De-vegetation
- Mobilisation
- Operator Compensation

Electrification
- Foundations
- Masts
- Wiring
- Commissioning
- Traction Power

Electrification Projects Cost Analysis

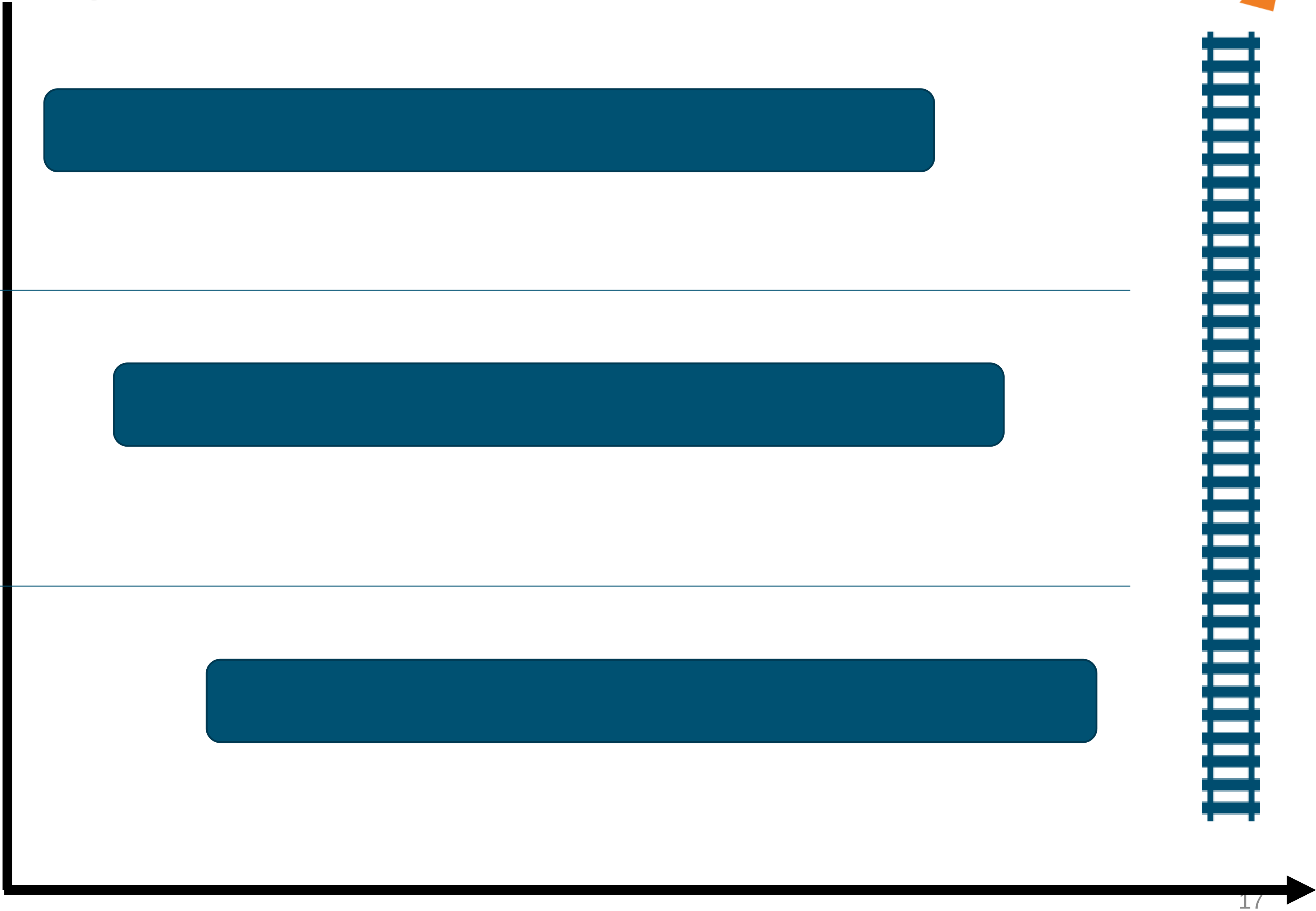


Typical UK Programme

Advanced Works
Track Layout
Ground & Structure Investigation
Traction Power
Signalling & Telecoms
Utilities Diversion

Route Clearance & Civils
Access Points
Structure Reconstruction
Stations Modifications
Mast Foundations

Overhead Line & Electrification
Finalise Design & BoQ
Install OLE Masts & Registrations
Install Wire Runs
Panning
Energise
Testing & Commissioning

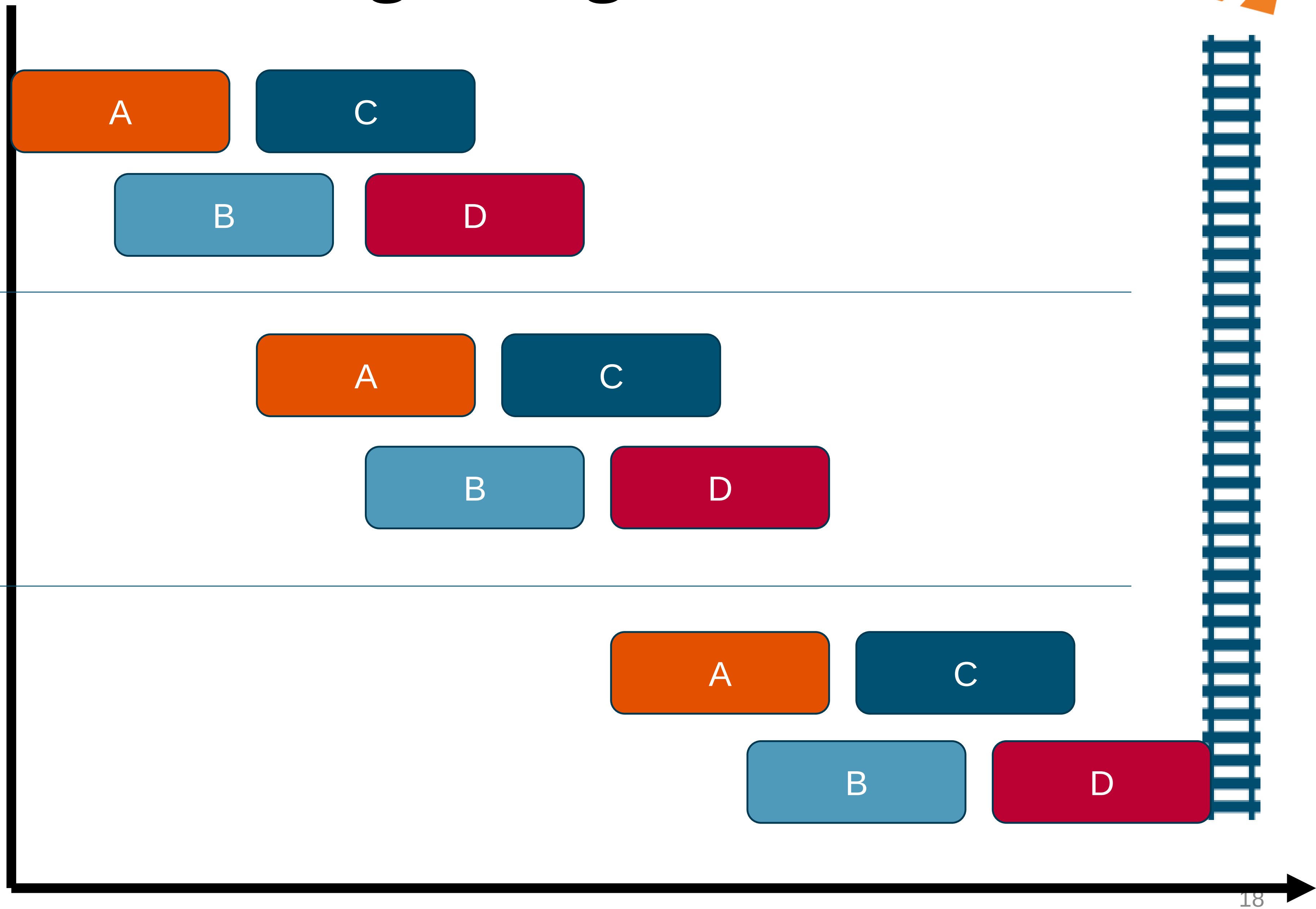


Opportunities – Rolling Programme

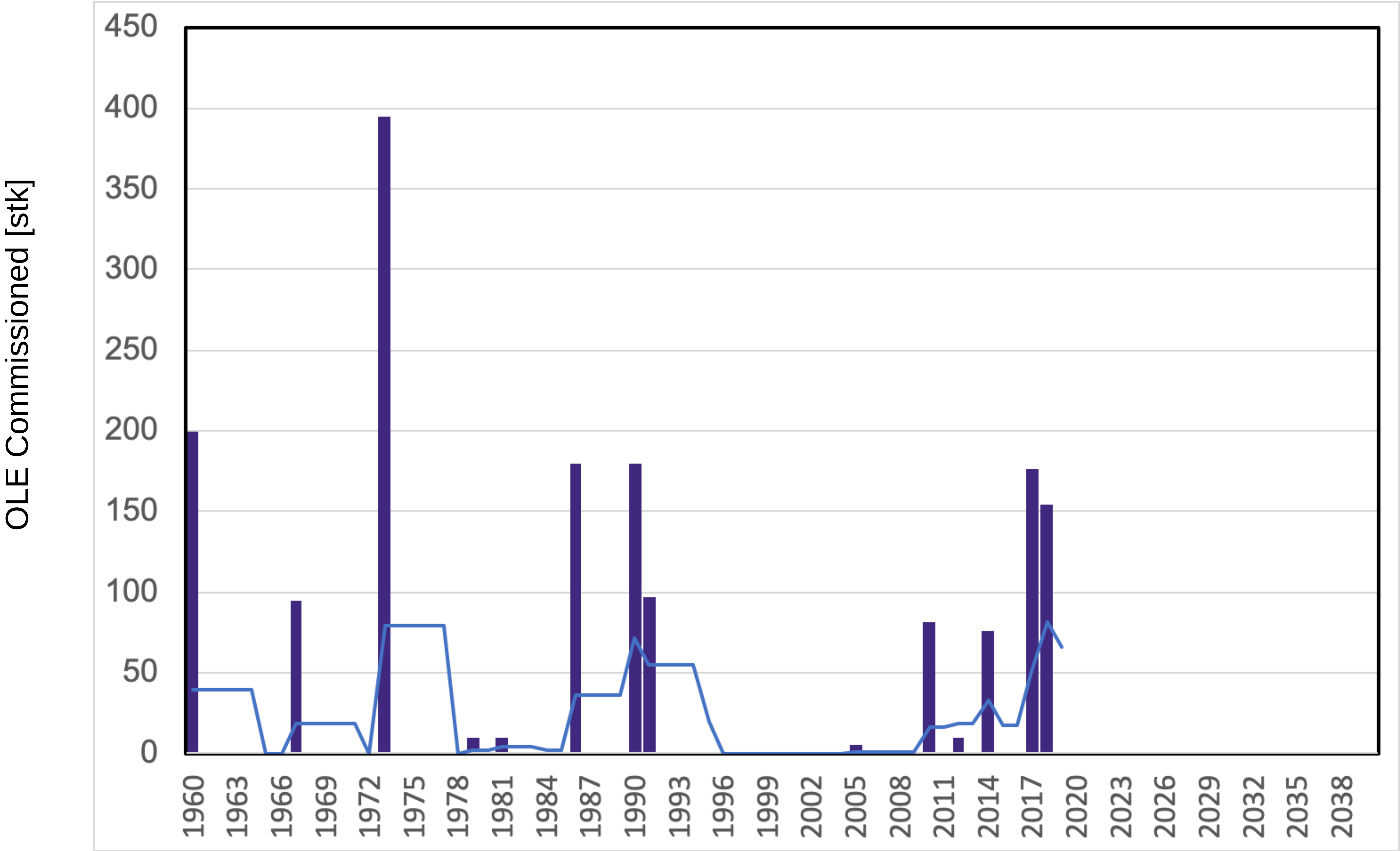
Advanced Works
Track Layout
Ground & Structure Investigation
Traction Power
Signalling & Telecoms
Utilities Diversion

Route Clearance & Civils
Access Points
Structure Reconstruction
Stations
Mast Foundations

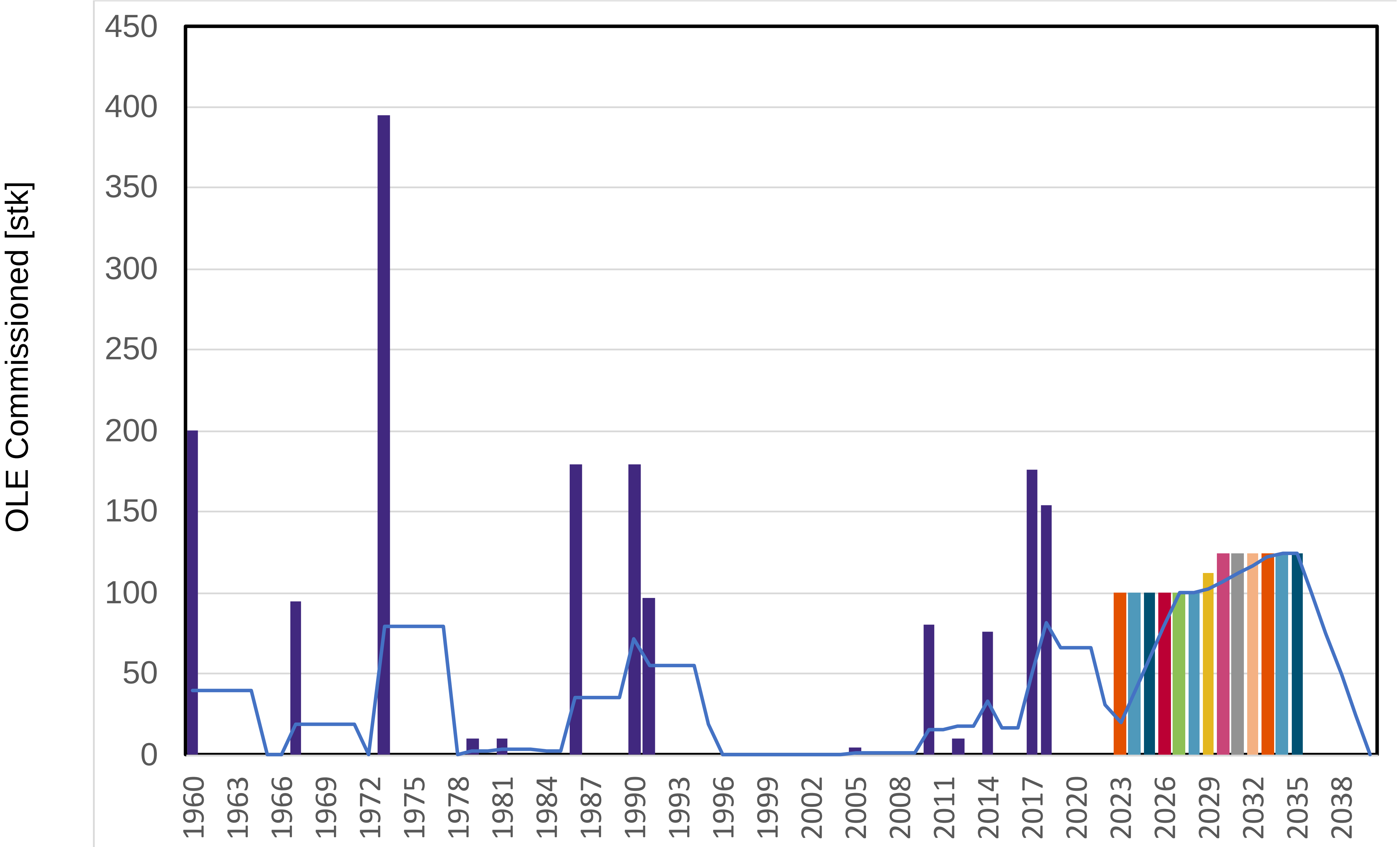
Overhead Line & Electrification
Finalise Design & BoQ
Install OLE Masts & Registrations
Install Wire Runs
Panning
Energise
Testing & Commissioning



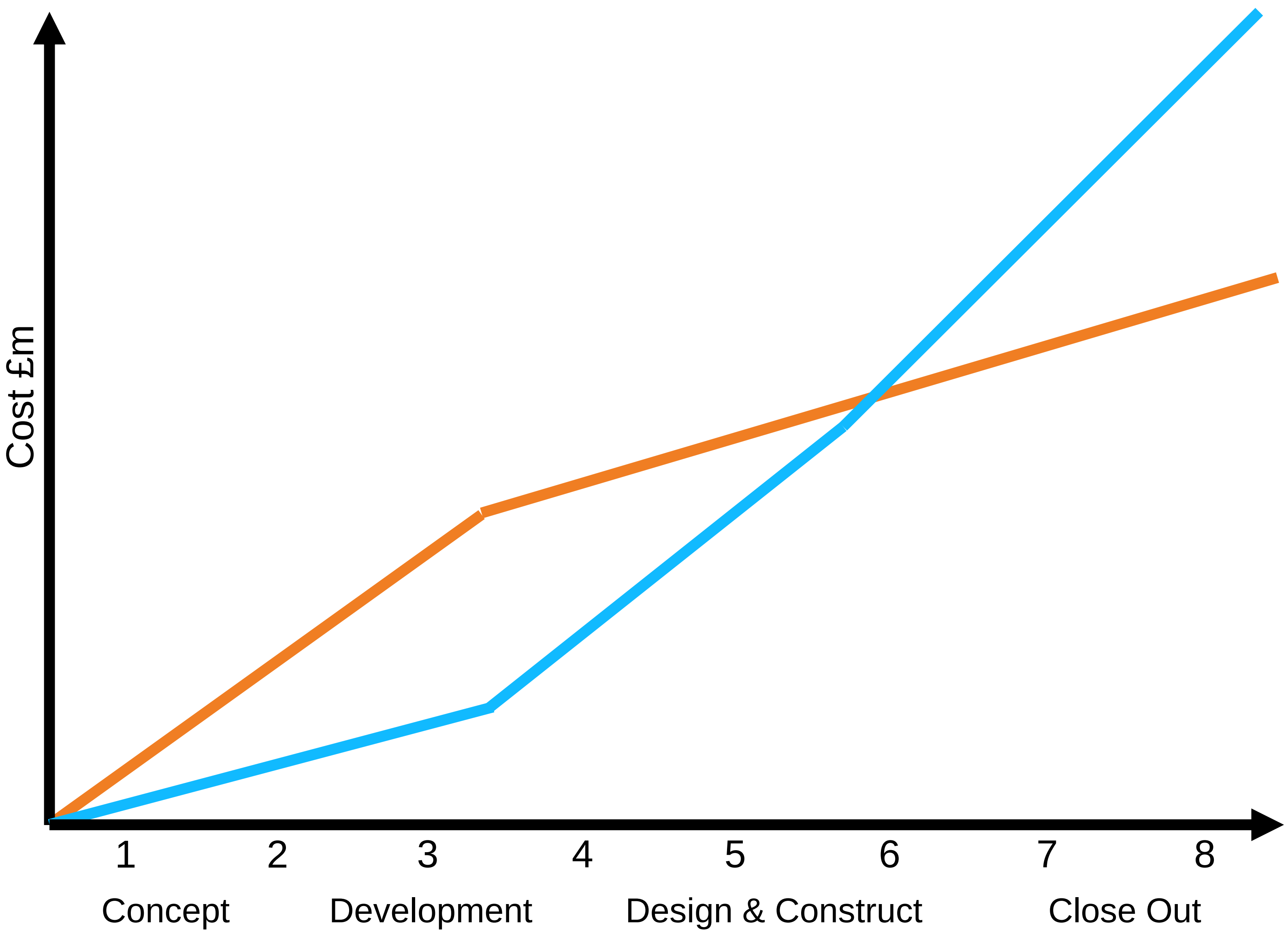
Electrification Commissioned in Scotland



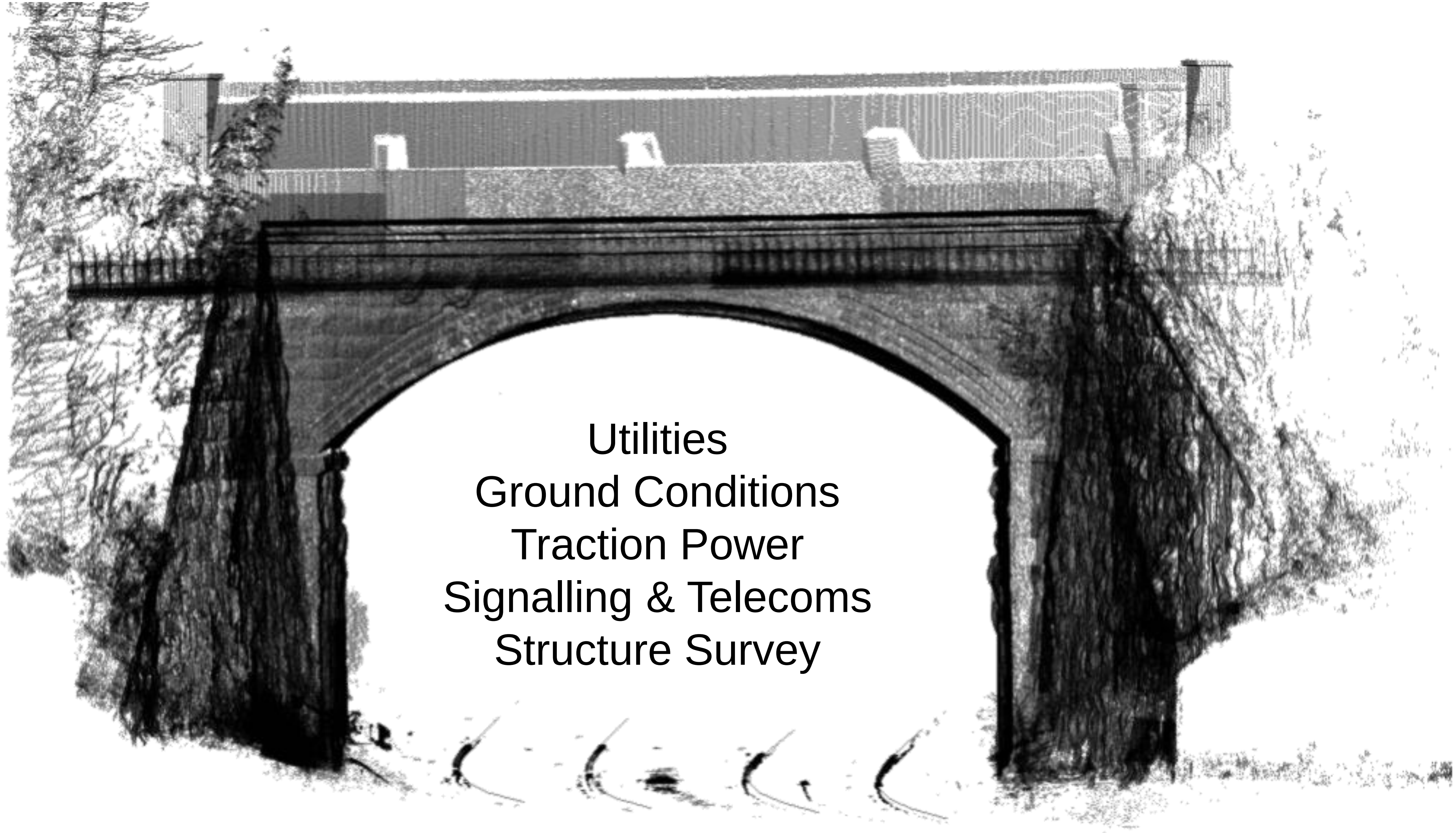
Opportunities – Rolling Programme



Opportunities – Managing Risk

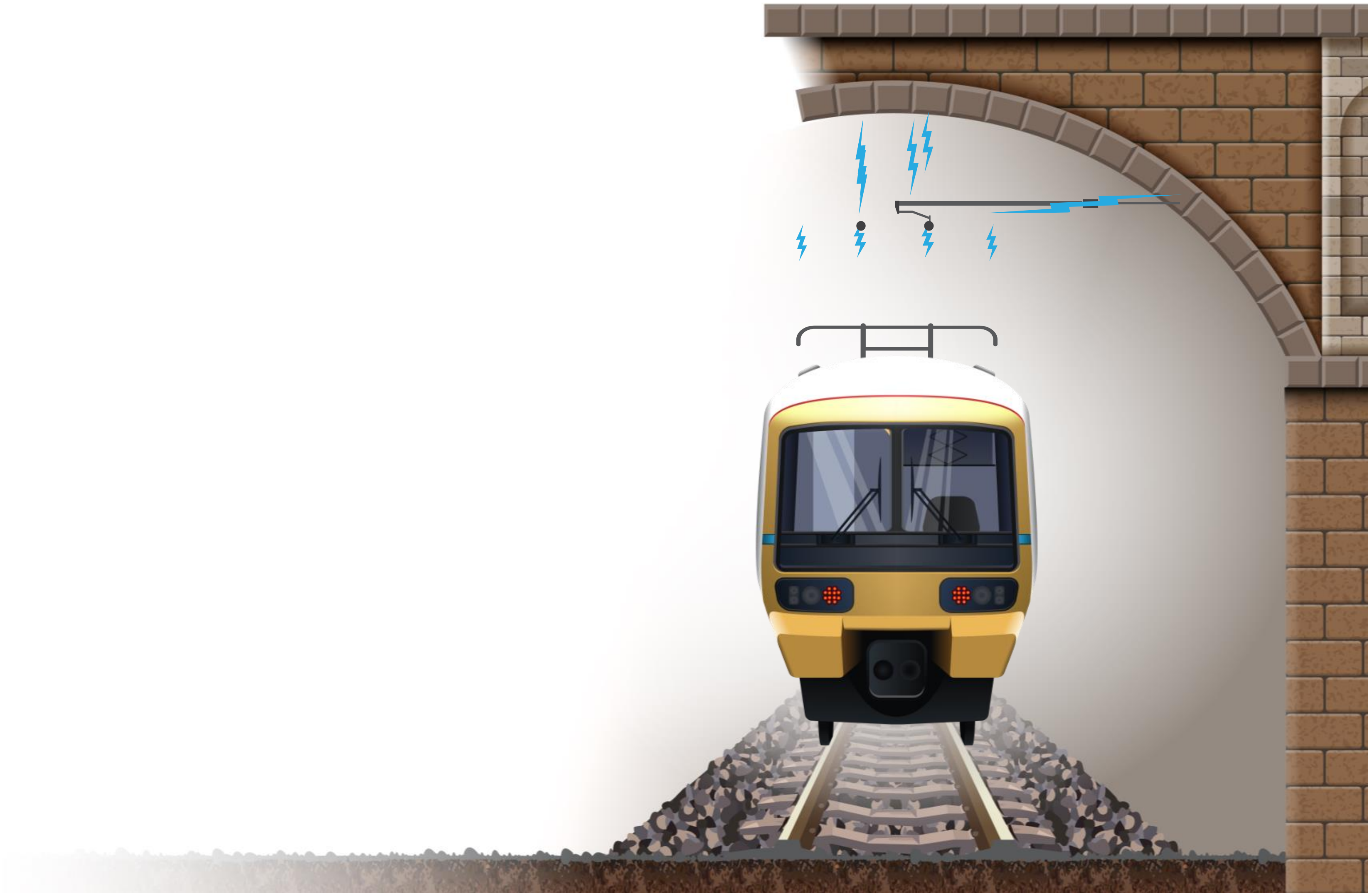


Opportunities – Managing Risk

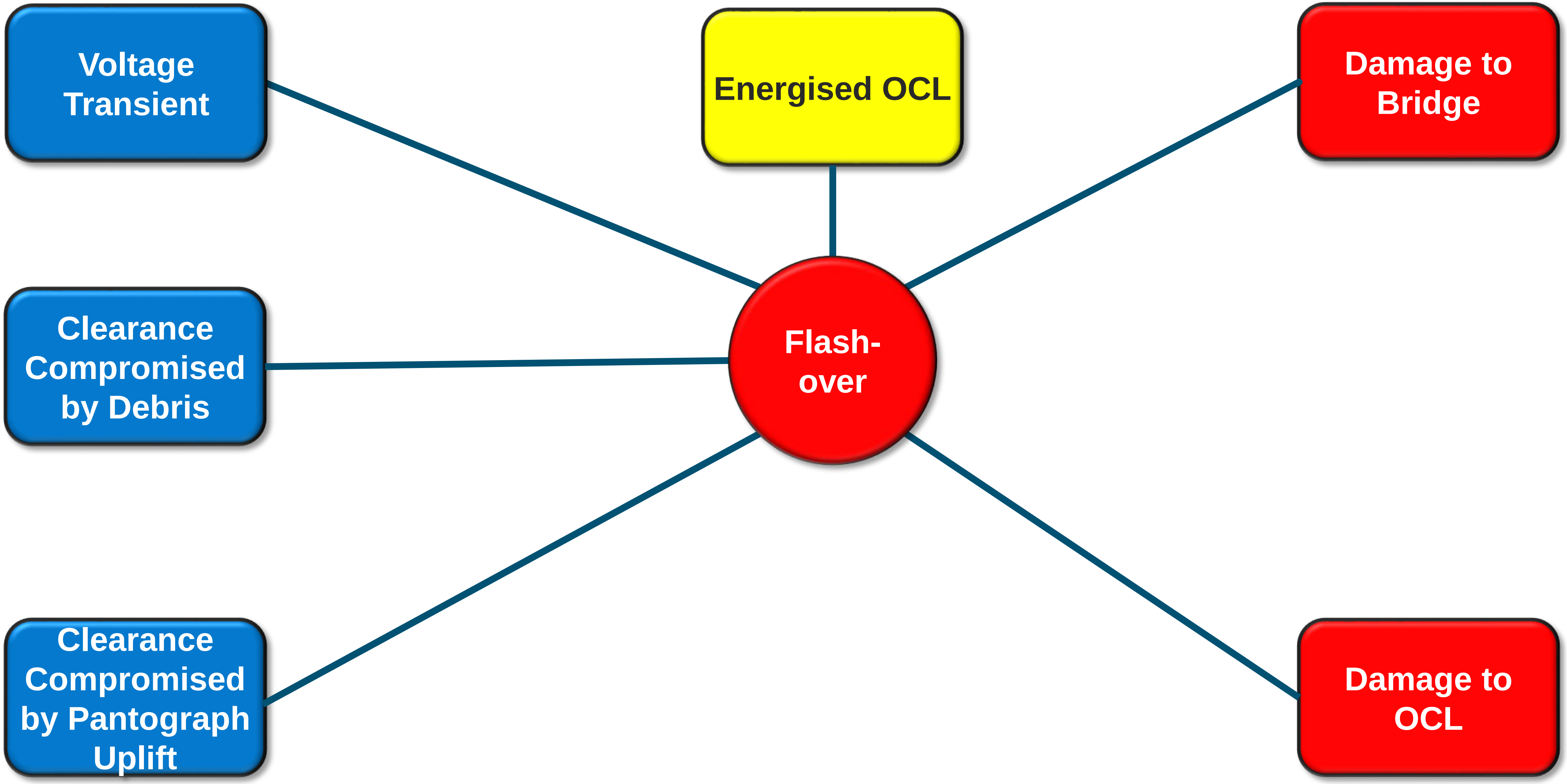


Utilities
Ground Conditions
Traction Power
Signalling & Telecoms
Structure Survey

Electrical clearances

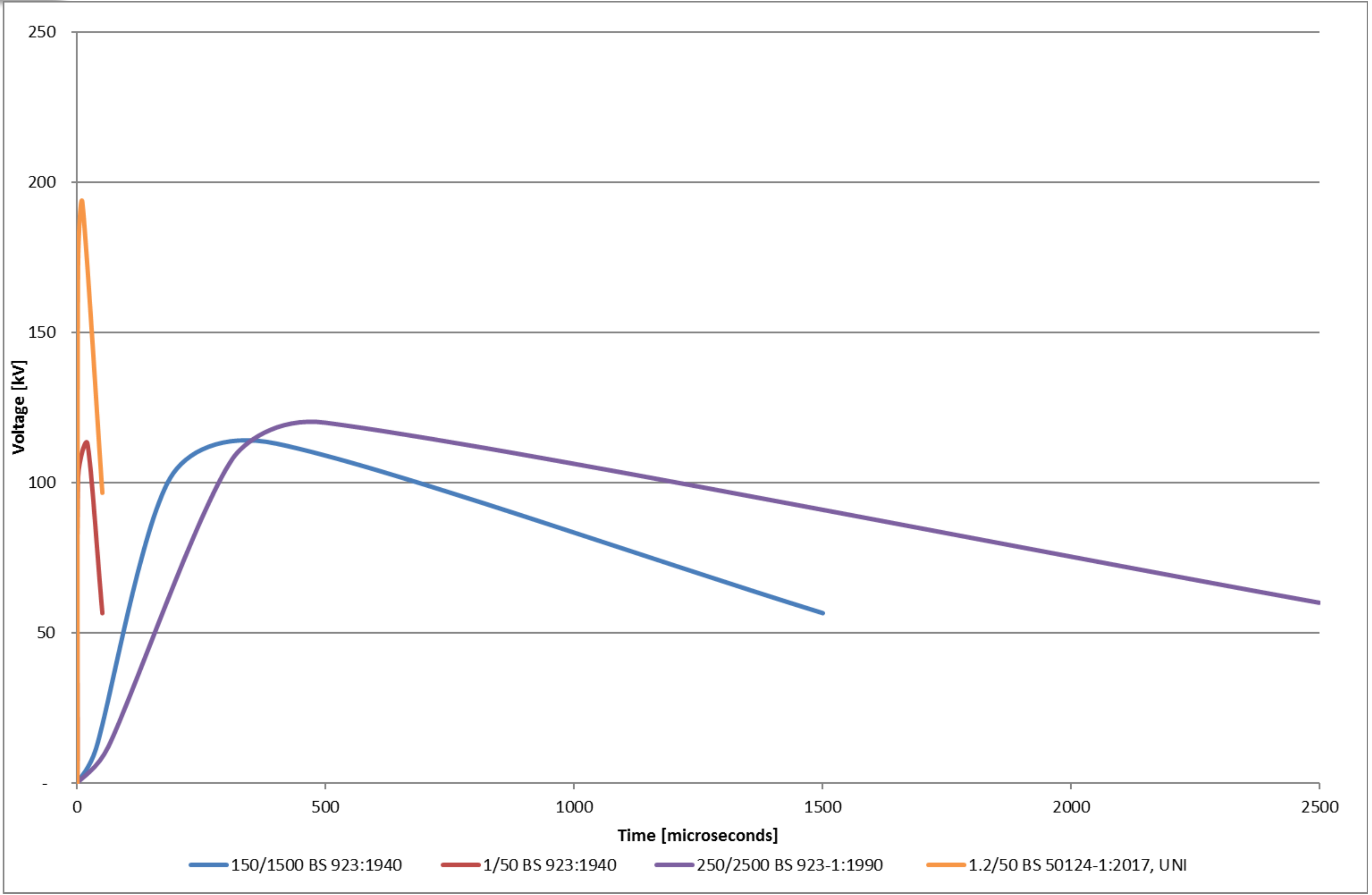


Hazard Analysis



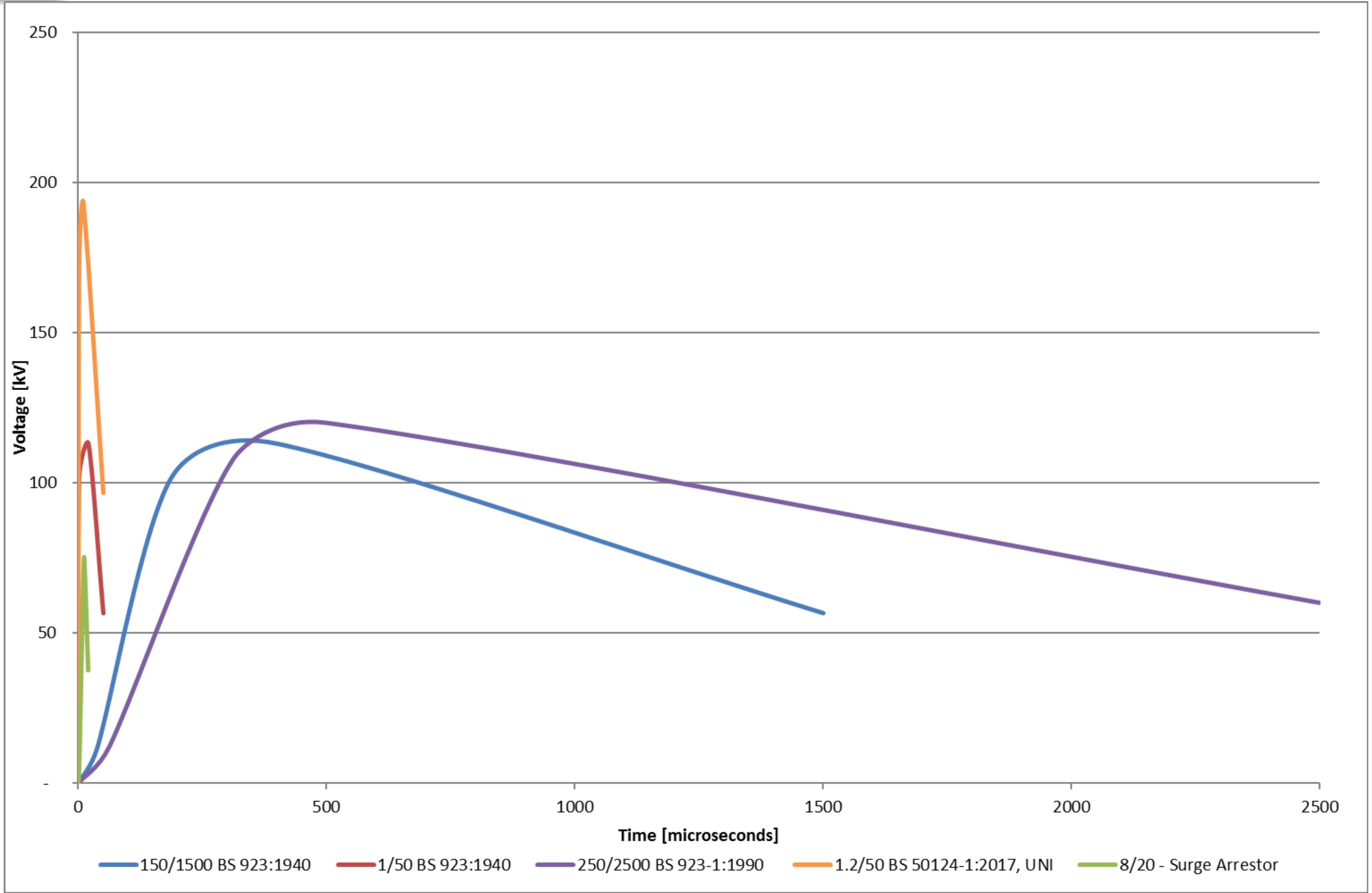
Voltage Transient

Transient Traces



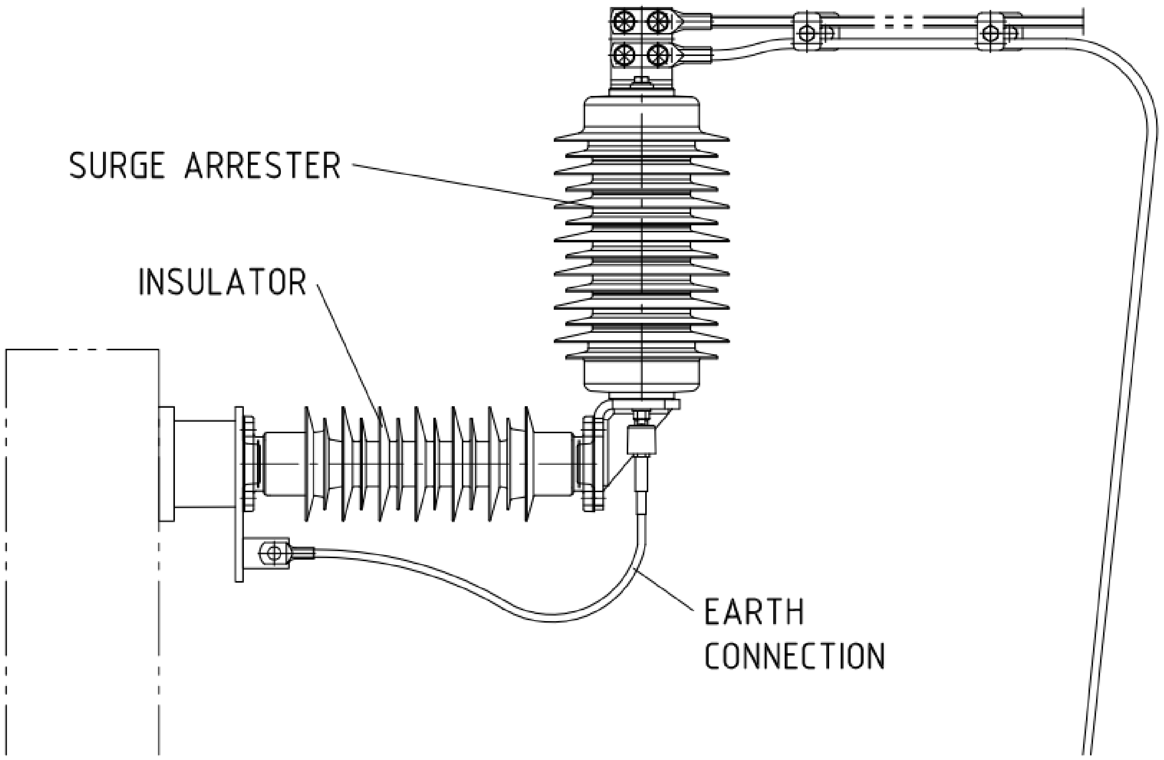
Voltage Transient

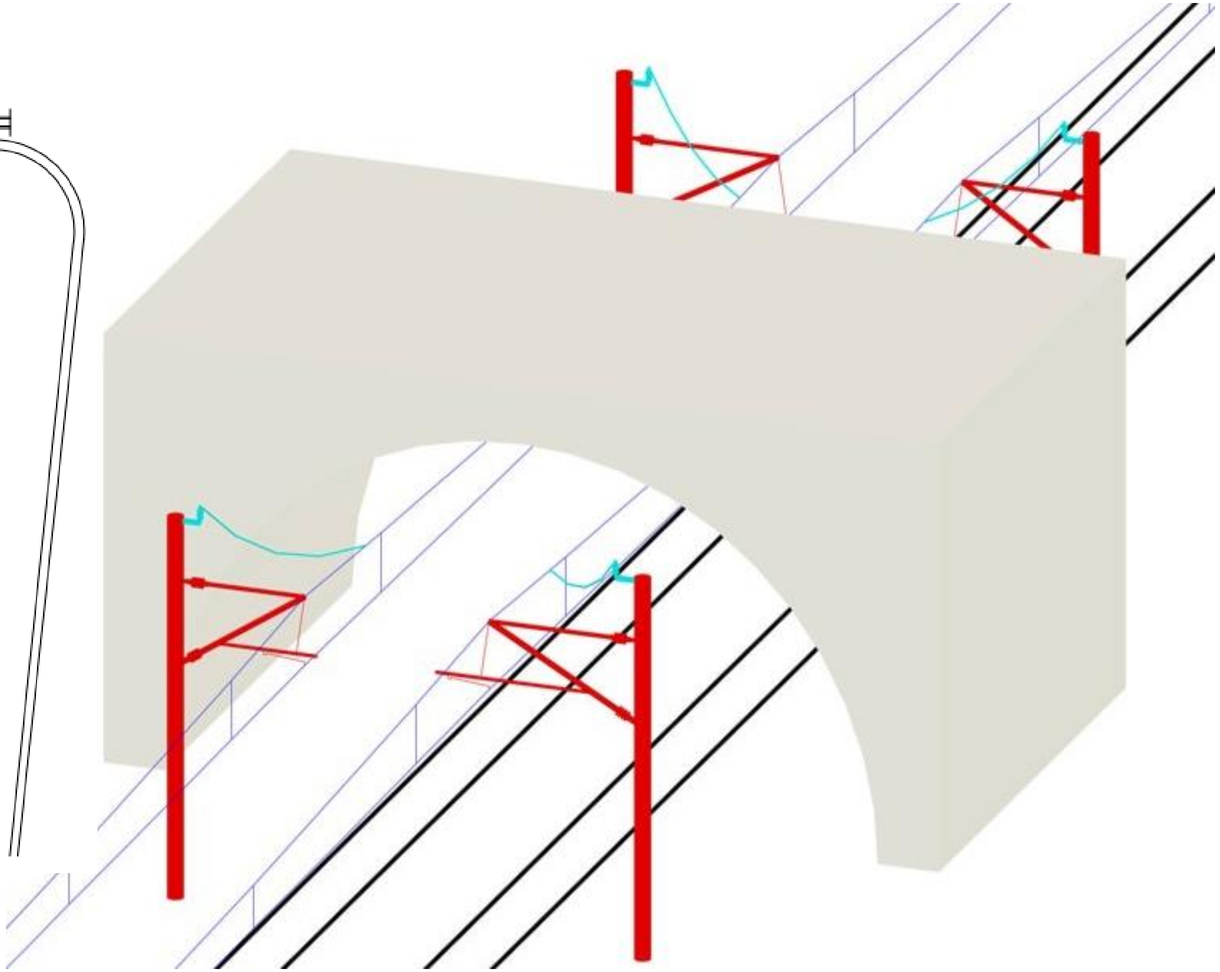
Transient Traces



Voltage Transient

Surge Arrestor

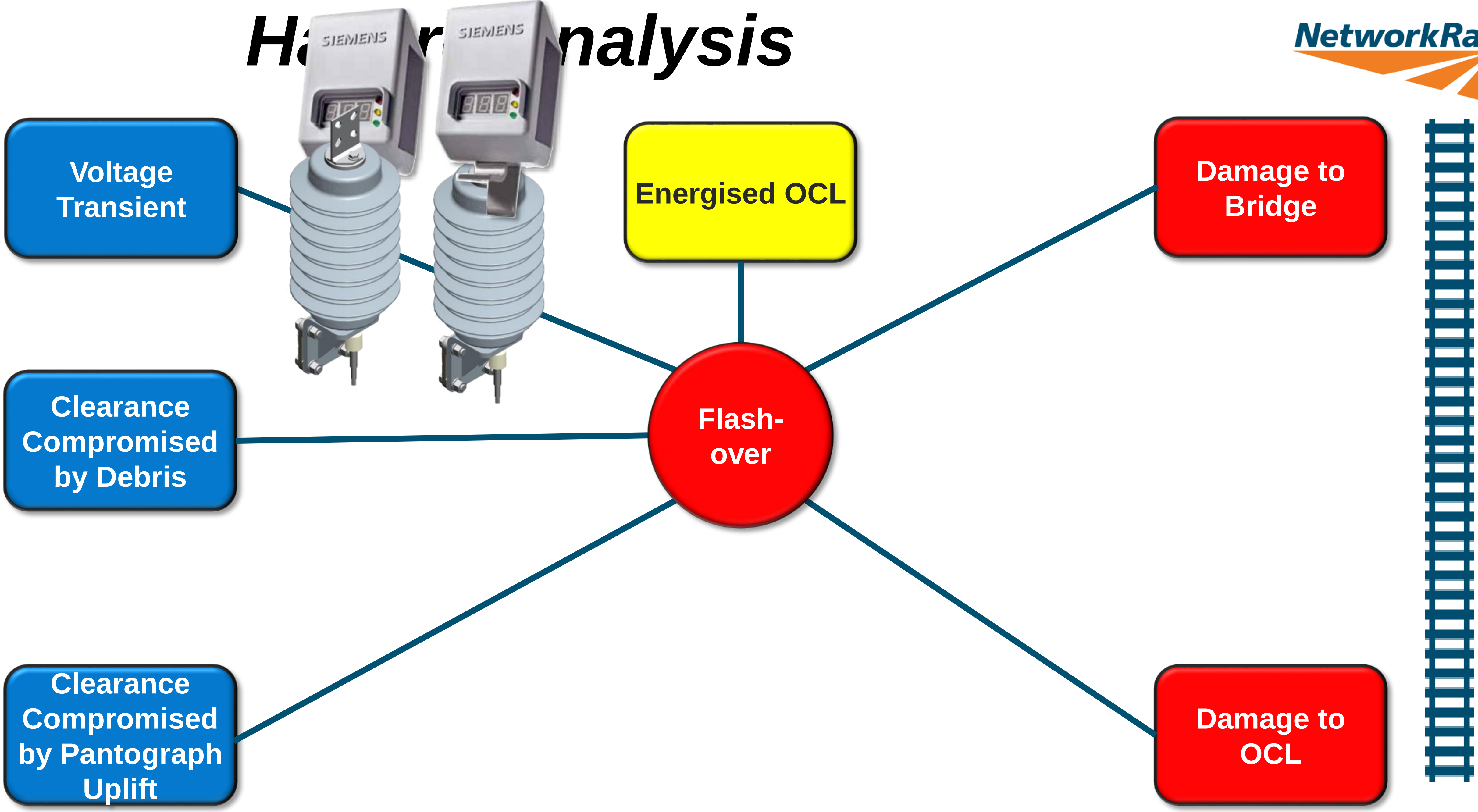




Impulse protection level:
U10kA - 8/20µs = 75 kV

Ha r nalysis

NetworkRail



Clearance Compromised by Pantograph Uplift

PTFE Contact Wire Cover (Kago)

NetworkRail

Clearance Compromised by Pantograph Uplift

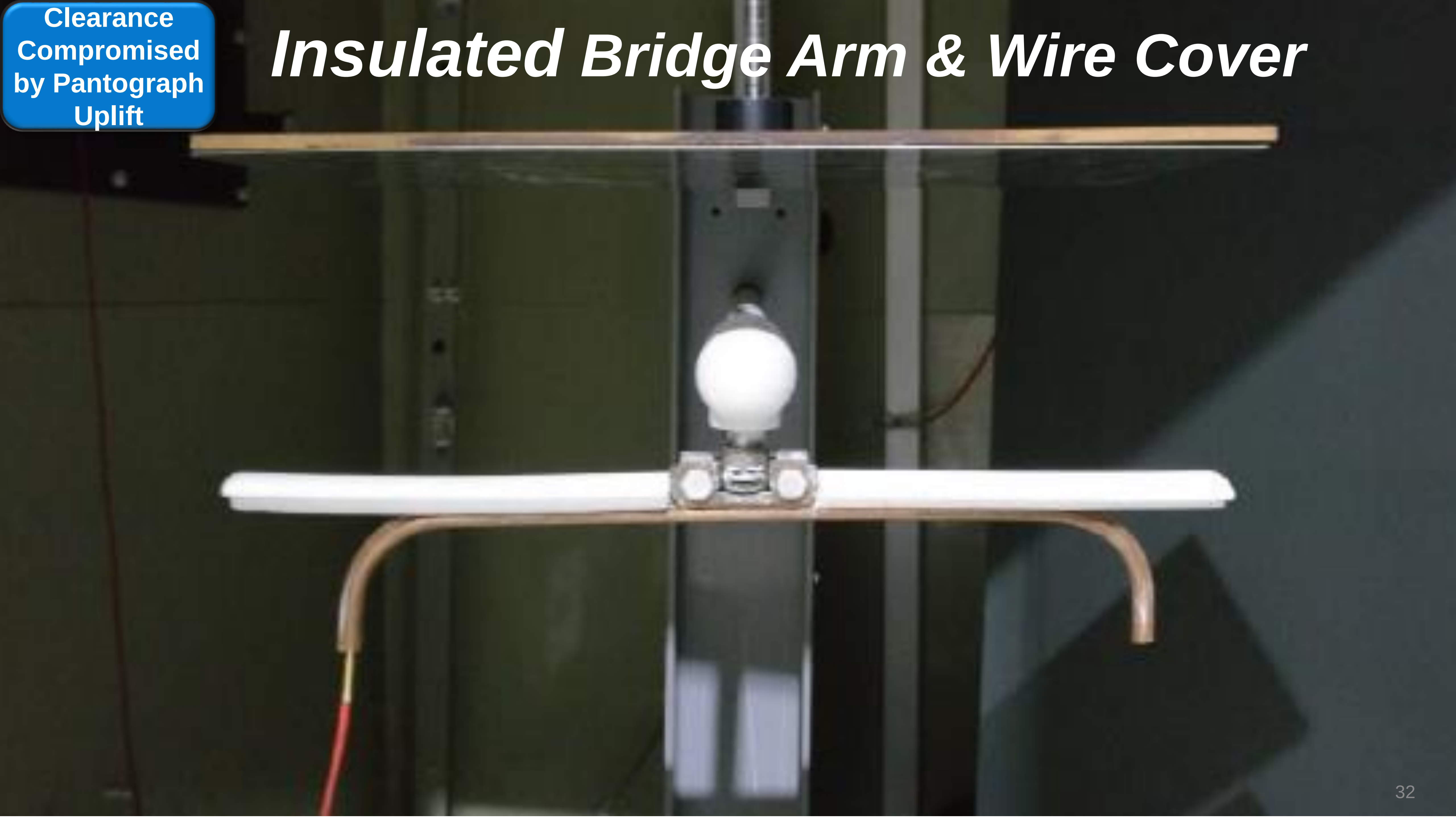
Polyurea Coating (GLS100R)

Thickness of Coating	Pass voltage	Fail Voltage
3mm	22kV	25kV
5mm	30kV	35kV
8mm	35kV	38kV

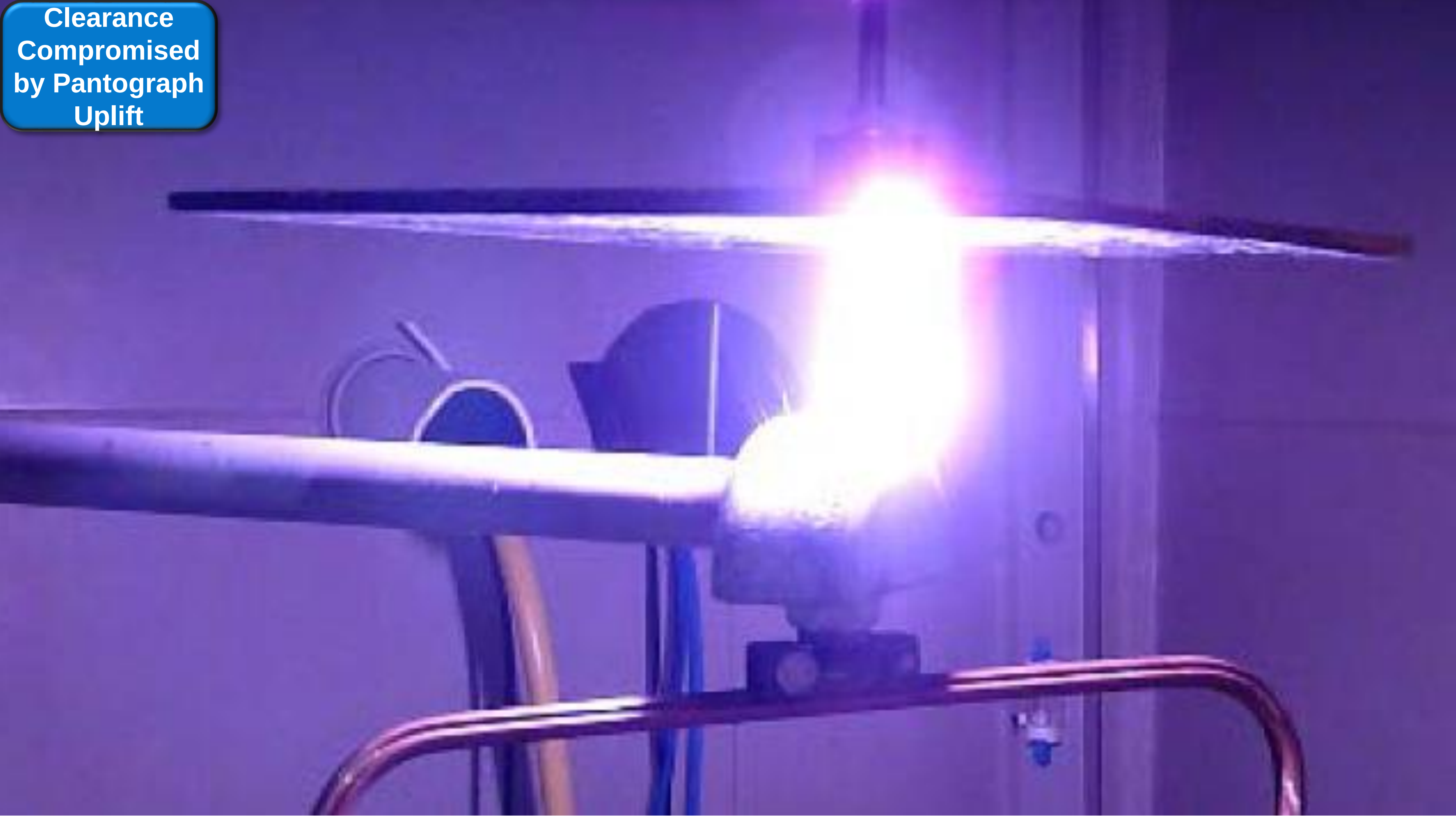
Electrical Stress Graded Bridge Arm

Clearance Compromised by Pantograph Uplift

Insulated Bridge Arm & Wire Cover



Clearance Compromised by Pantograph Uplift



Clearance Compromised by Pantograph Uplift

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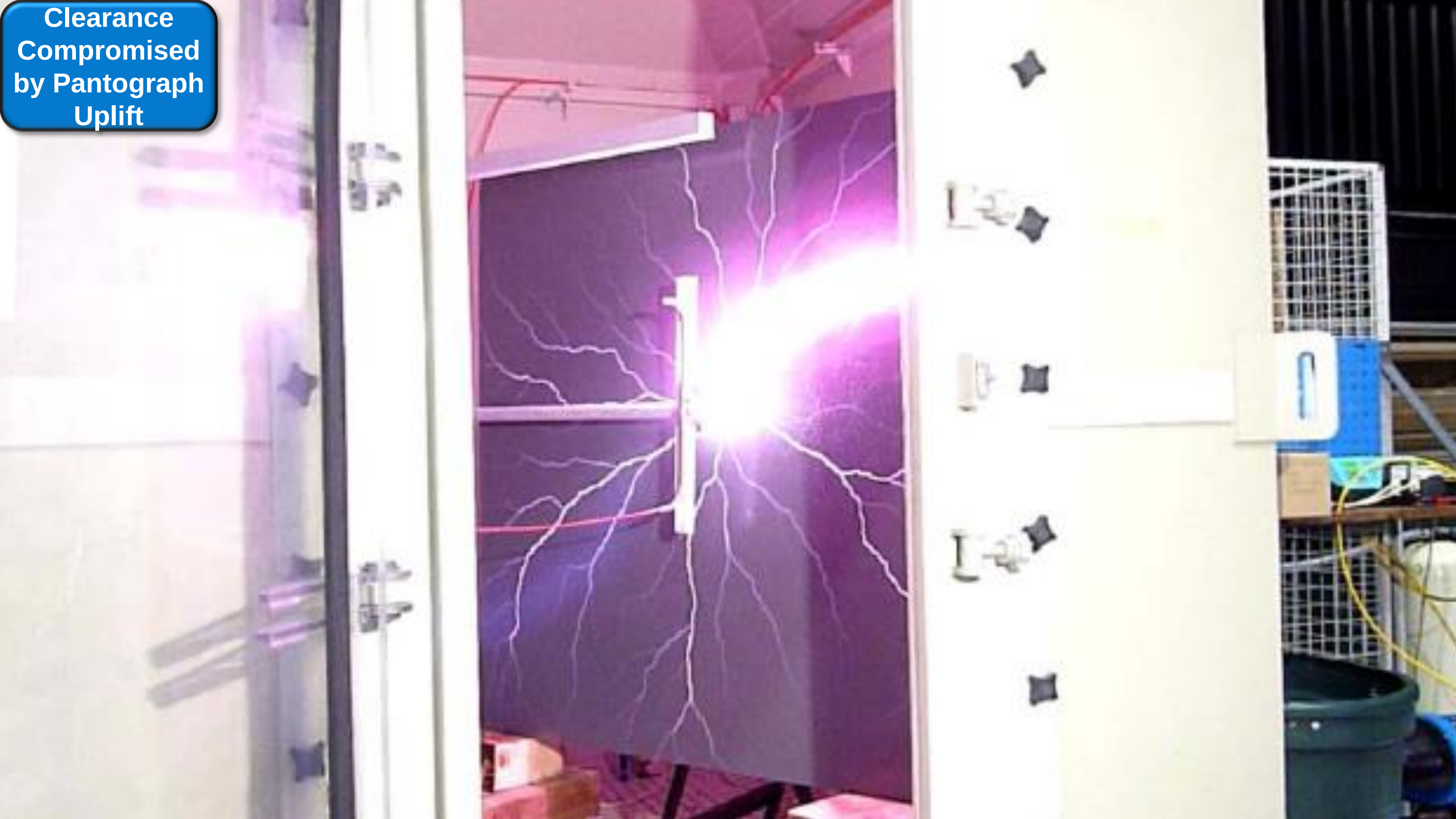


Clearance Compromised by Pantograph Uplift

Insulated Bridge Arm Results

NetworkRail

	Mitigation	Clearance															
		70 mm		60 mm		50 mm		40 mm		30 mm		20 mm		10 mm		0 mm	
		+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Dry	Contact Wire Only	×××	×××														
Dry	Surge Arrestor	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	×✓✓				
Dry	Surge Arrester and contact wire cover									✓✓✓	✓✓✓	✓✓✓	×××				
Dry	Surge Arrester, contact wire cover and insulated coating											✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Wet	Contact Wire Only																
Wet	Surge Arrestor			✓✓✓	✓✓✓	×××	✓✓✓	×××	✓✓✓	×××	×××						
Wet	Surge Arrester and contact wire cover					✓✓✓	✓✓✓	✓✓✓	✓✓✓	×××	✓××						
Wet	Surge Arrester, contact wire cover and insulated coating							✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓××	✓×✓	×××	×××

Key

× = Flashover
✓ = Pass

Failed with both impulse polarities

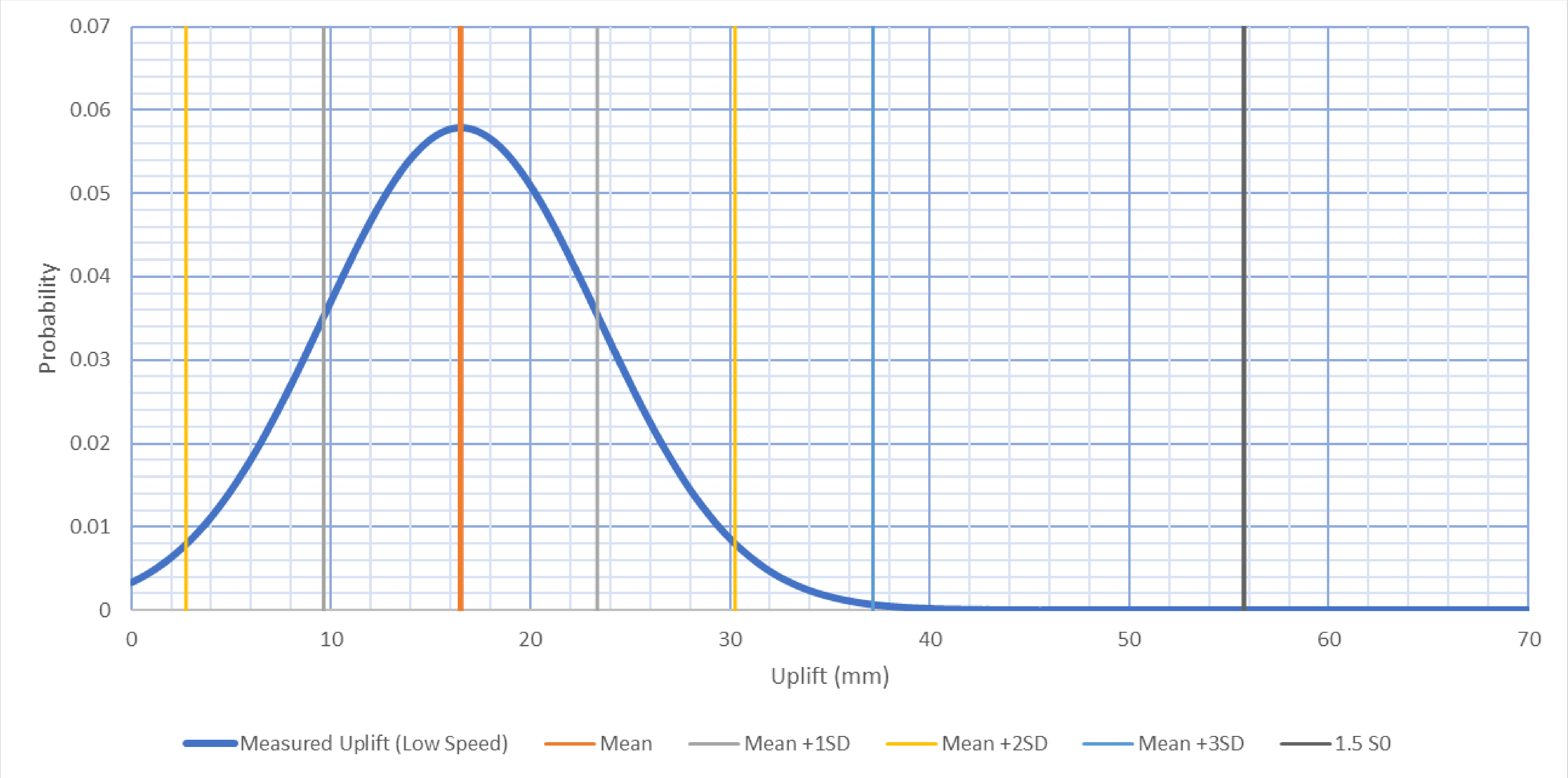
Passed with one impulse polarity

Passed with both impulse polarities

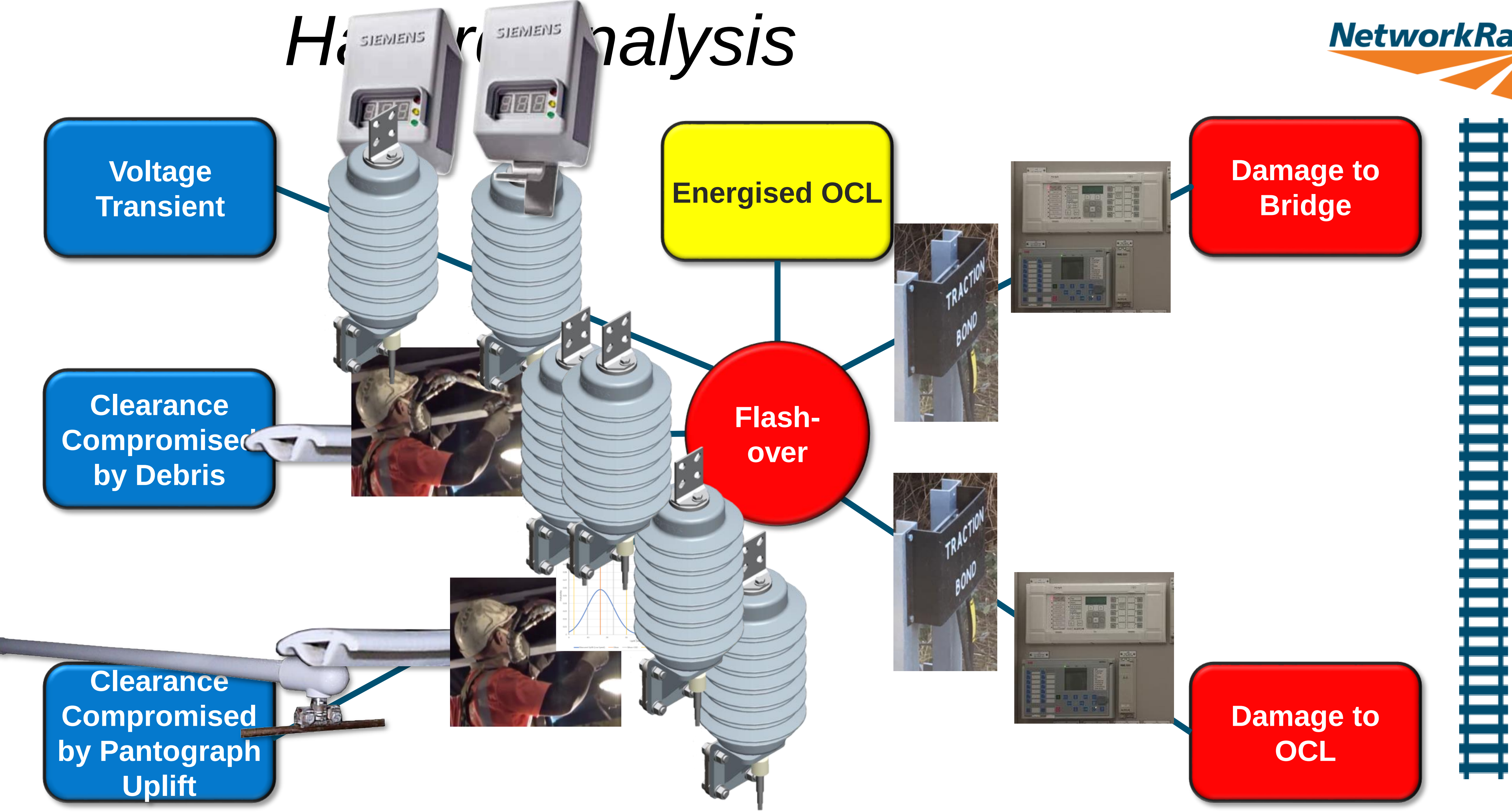
Clearance Compromised by Pantograph Uplift

Bridge Arm Uplift Measurements Low Speed (<100 kmph)

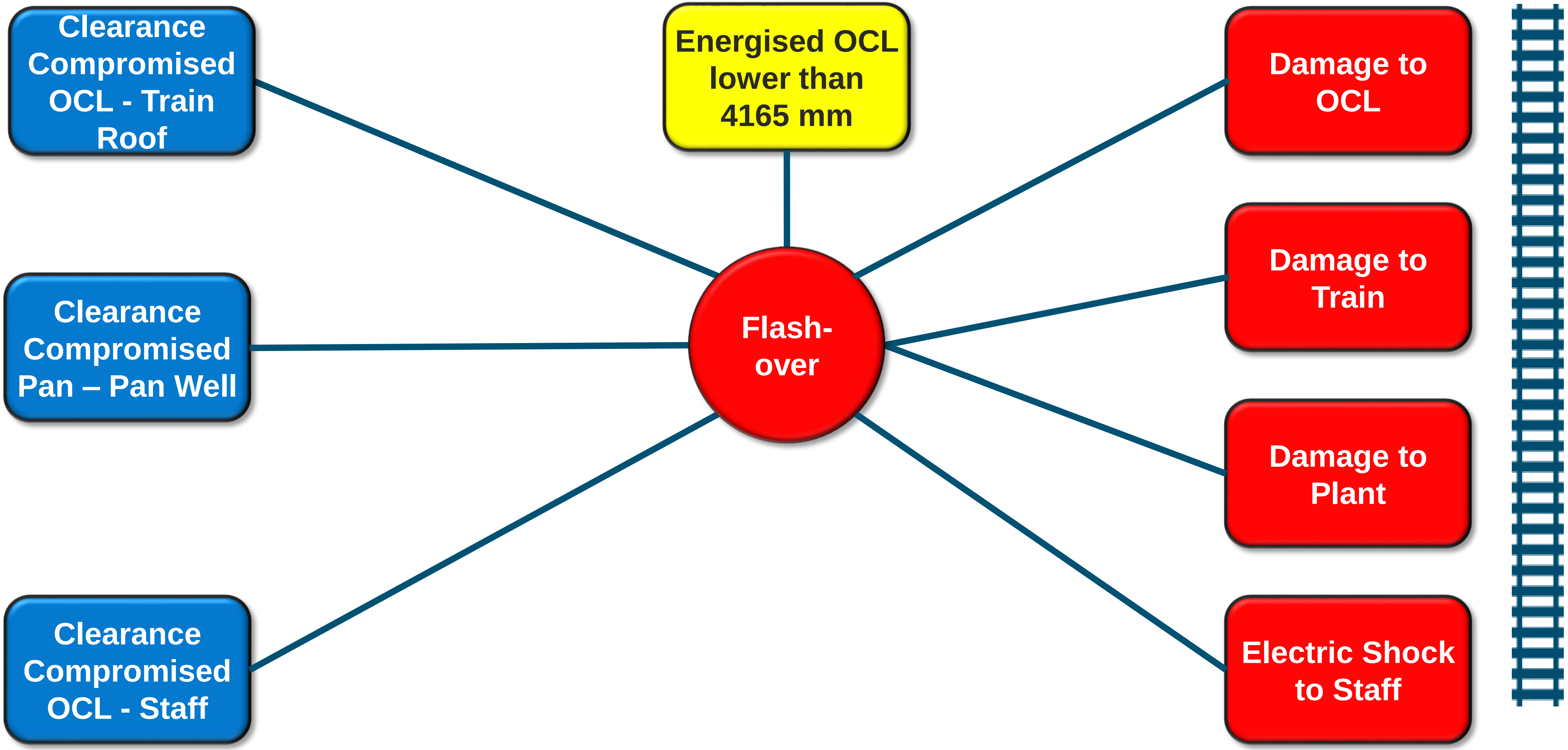
NetworkRail



Ha r nalysis


Voltage Transient
Clearance Compromised by Debris
Clearance Compromised by Pantograph Uplift
Energised OCL
Flash-over
Damage to Bridge
Damage to OCL
SIEMENS
SIEMENS
TRACTION BOND
TRACTION BOND

Hazard Analysis

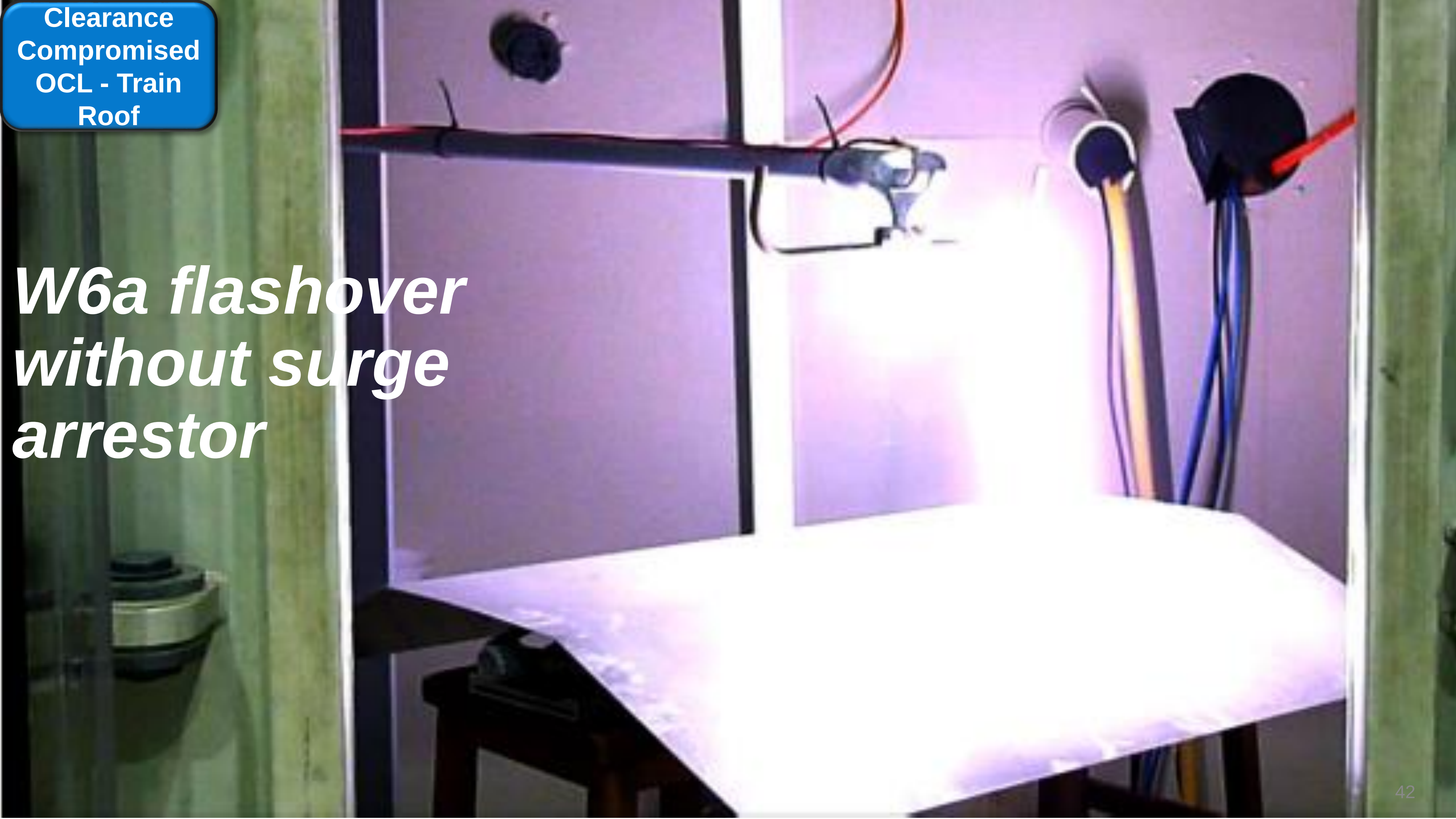


Clearance Compromised OCL - Train Roof

W6a plate in environmental chamber

Clearance Compromised OCL - Train Roof

W6a flashover without surge arrestor

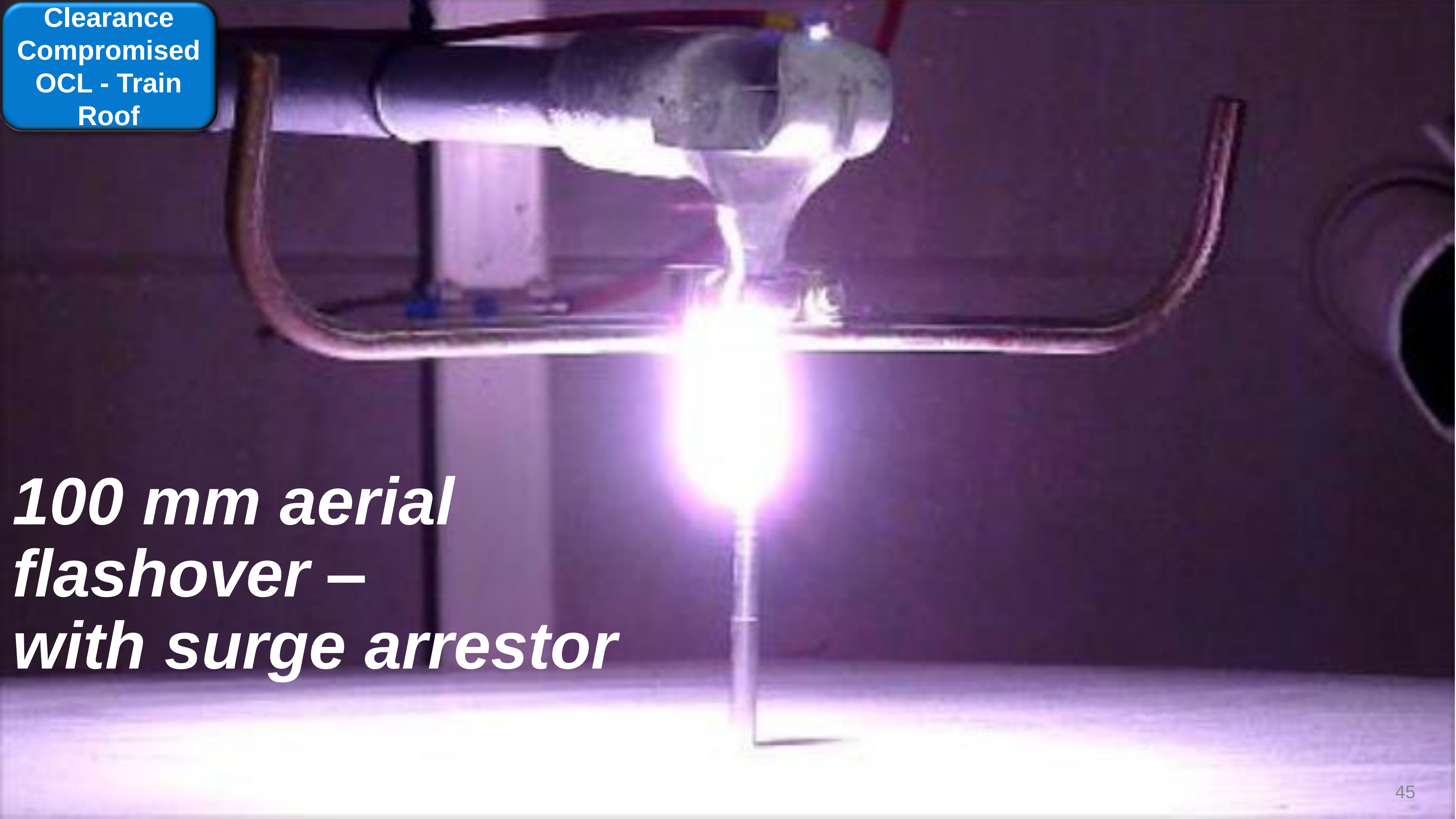


Clearance Compromised OCL - Train Roof

W6a flashover - with surge arrestor

Clearance Compromised OCL - Train Roof

100mm aerial flashover – without surge arrestor


Clearance Compromised OCL - Train Roof
100 mm aerial flashover –
with surge arrestor

Clearance Compromised OCL - Train Roof

Contact Wire to Train Roof - with surge arrestor

	Test with Surge Arrester	70 mm +	70 mm -	60 mm +	60 mm -	50 mm +	50 mm -	40 mm +	40 mm -	30 mm +	30 mm -	20 mm +	20 mm -	10 mm +	10 mm -	0 mm +	0 mm -
Dry	Shaped plate for W6a			✓✓✓		✓✓×	✓✓✓	×××	✓××		×××						
Dry	Shaped plate for W10			✓✓✓		✓✓×	✓✓✓	×××	×✓×	×××	×××						
Dry	Shaped plate for W12			✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓×	×××	×××						
Dry	Shaped plate with simulated aerial		✓✓✓	✓✓✓	×××	✓✓×	×××	×✓✓		×××							
Wet	Shaped plate for W6a					✓✓✓	✓✓✓	✓✓✓	✓×✓	×××	×××						
Wet	Shaped plate for W10			✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓×	×××	×××						
Wet	Shaped plate for W12			✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	×××	×××							
Wet	Shaped plate with simulated aerial		✓✓✓		✓✓×	✓✓✓	✓×✓	×✓✓	×××	×××	×××						

Key

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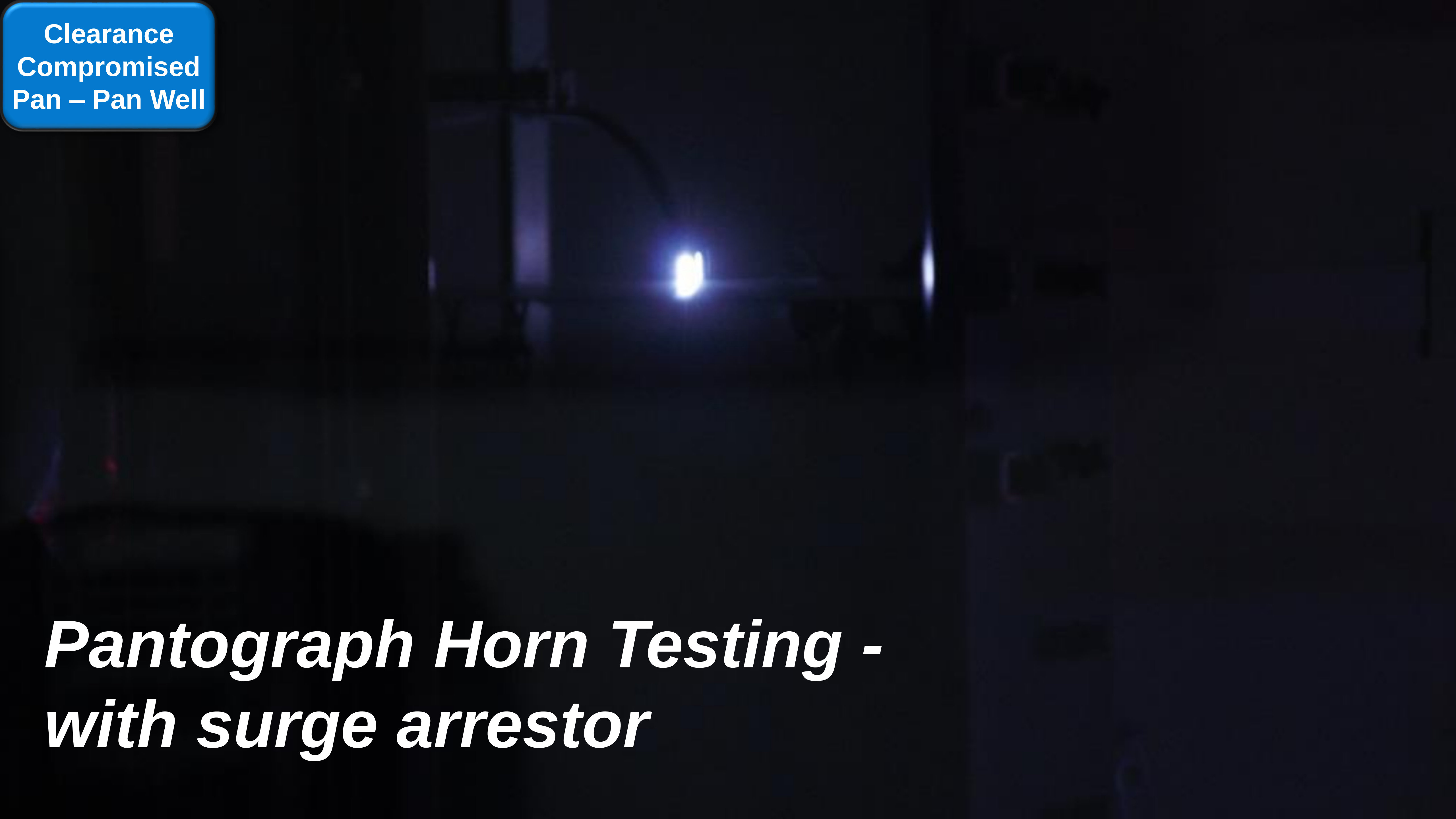
Failed with both impulse polarities

Passed with one impulse polarity

Passed with both impulse polarities

Clearance Compromised Pan – Pan Well

Pantograph Horn Testing - without surge arrestor


Clearance
Compromised
Pan – Pan Well
Pantograph Horn Testing -
with surge arrestor

Clearance Compromised Pan – Pan Well

Pantograph Horn to Train Roof with surge arrestor

NetworkRail

	Test with Surge Arrester	Clearance 80 mm +	80 mm -	70 mm +	70 mm -	60 mm +	60 mm -	50 mm +	50 mm -	40 mm +	40 mm -	30 mm +	30 mm -	20 mm +	20 mm -	10 mm +	10 mm -	0 mm +	0 mm -
Dry	Brecknell Willis HS-A Pan. Horn	✓✓✓	✓✓✓	✓✓✓		✓✓✓	✓✓✓	×××	✓✓✓	×××	✓✓✓		×××						
Dry	Brecknell Willis HS-P Pan. Horn (Mk2)	✓✓✓		×✓×		×××		×××	✓✓✓		✓✓✓		×××						
Dry	Brecknell Willis HS-P Pan. Horn (Mk2) Low Stress									✓✓✓	✓✓✓	✓✓✓	✓✓✓	×××	×××				
Dry	Falverley CX Insulated Pan. Horn																	✓✓✓	✓✓✓
Wet	Brecknell Willis HS-A Pan. Horn					✓✓✓		✓✓✓	✓✓✓	×✓×	✓✓✓	×××	×××						
Wet	Brecknell Willis HS-P Pan. Horn (Mk2)	✓✓✓		✓✓✓		×××			✓✓✓		✓✓✓		×××						
Wet	Brecknell Willis HS-P Pan. Horn (Mk2) Low Stress							✓✓✓		✓✓✓	✓✓✓	×✓✓	✓✓✓	××✓	×××	×××			
Wet	Falverley CX Insulated Pan. Horn																	✓✓✓	✓✓✓

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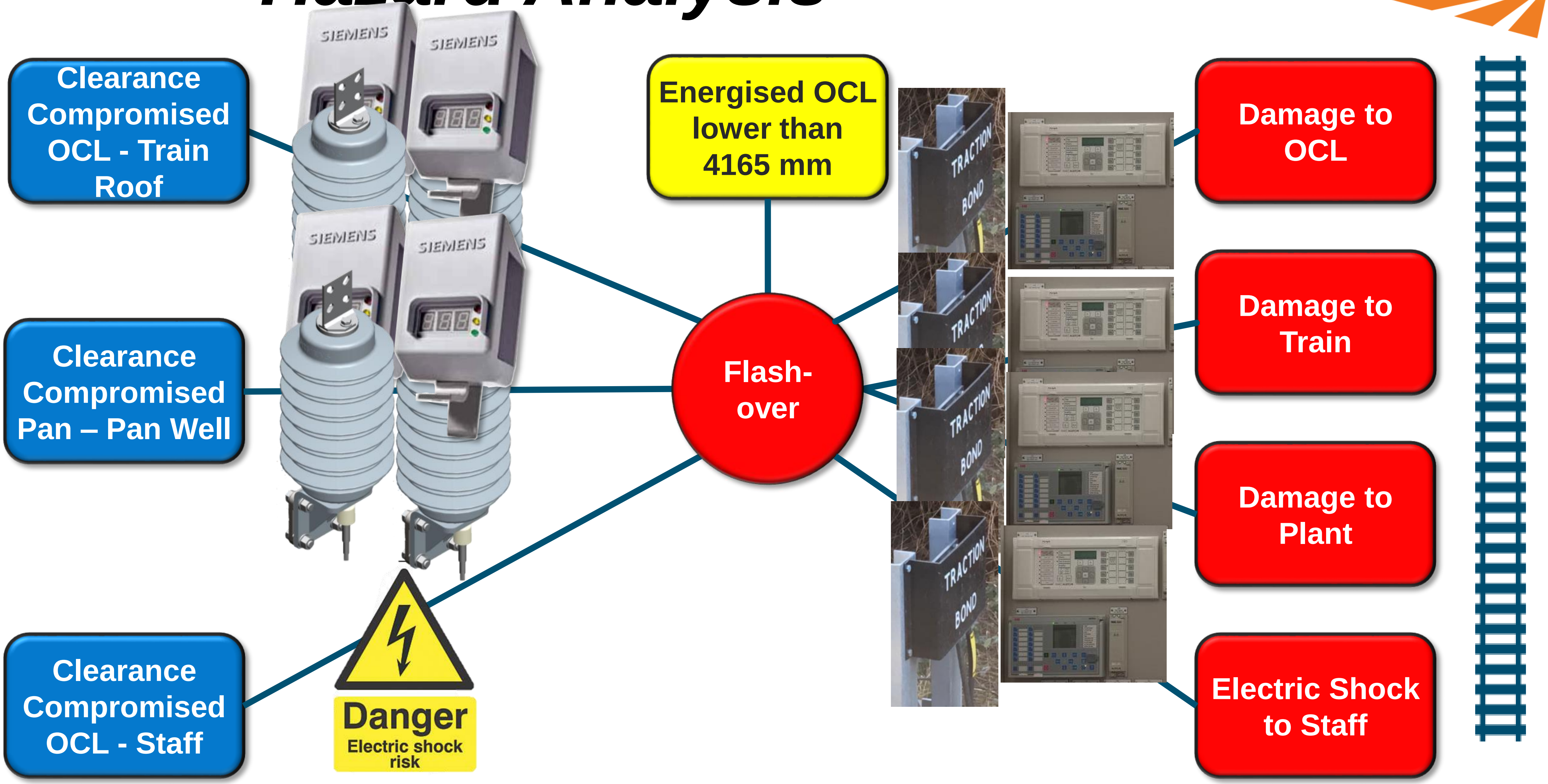
Hazard Analysis

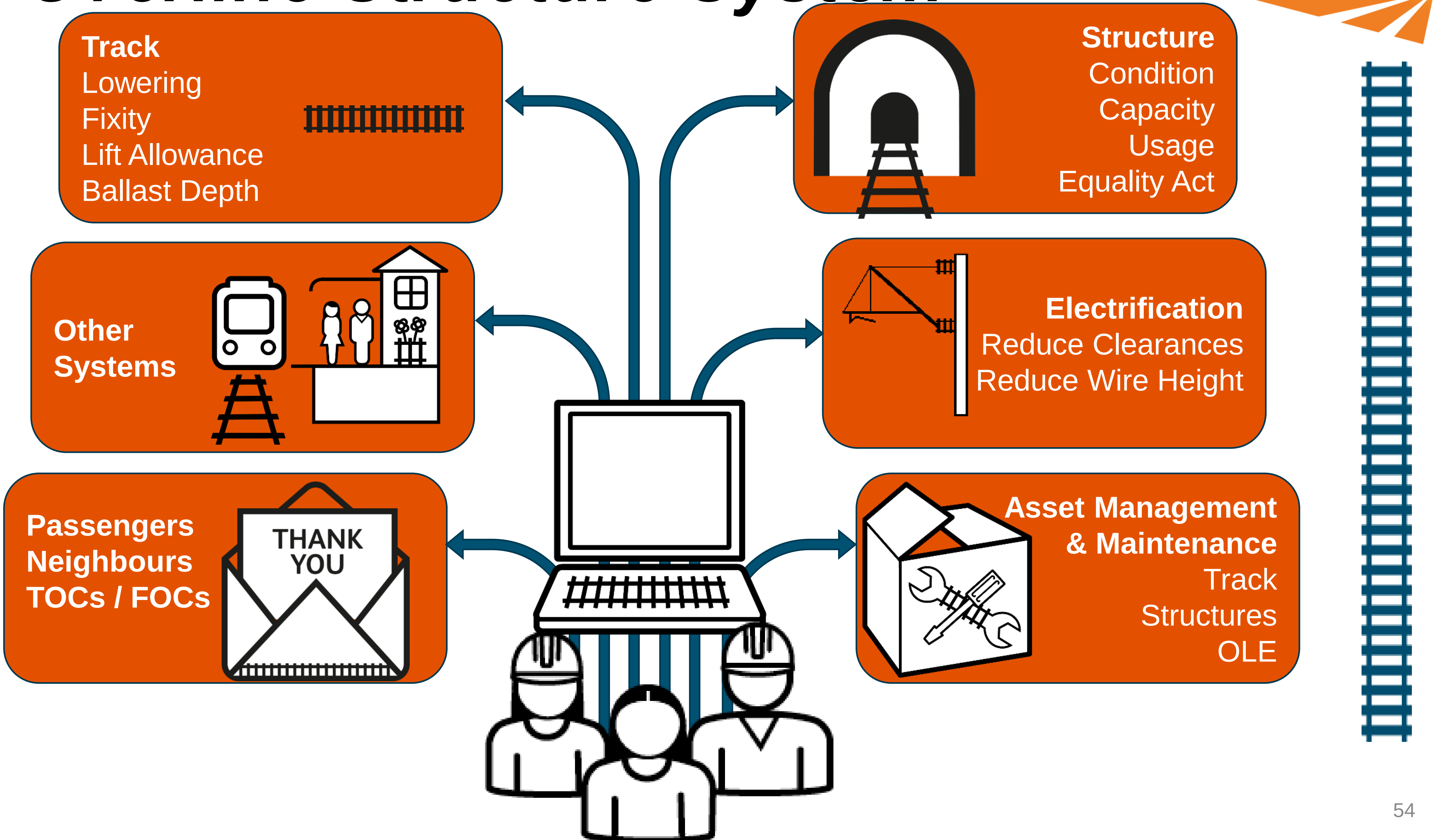


Opportunity – Clearances at Overline Structures

Opportunity – Clearances at Overline Structures

Opportunity – Clearances at Overline Structures

The Overline Structure System



Other Research & Development

Pilling and pile caps

Gradient

Uplift & Ice Loading

New Feeding Architectures

Neutral Sections

Insulated Pantograph Horns

Span Lengths

Reducing Bridge Parapets

More Electrical Clearances

Pilling and pile caps

Insulated Pantograph Horns

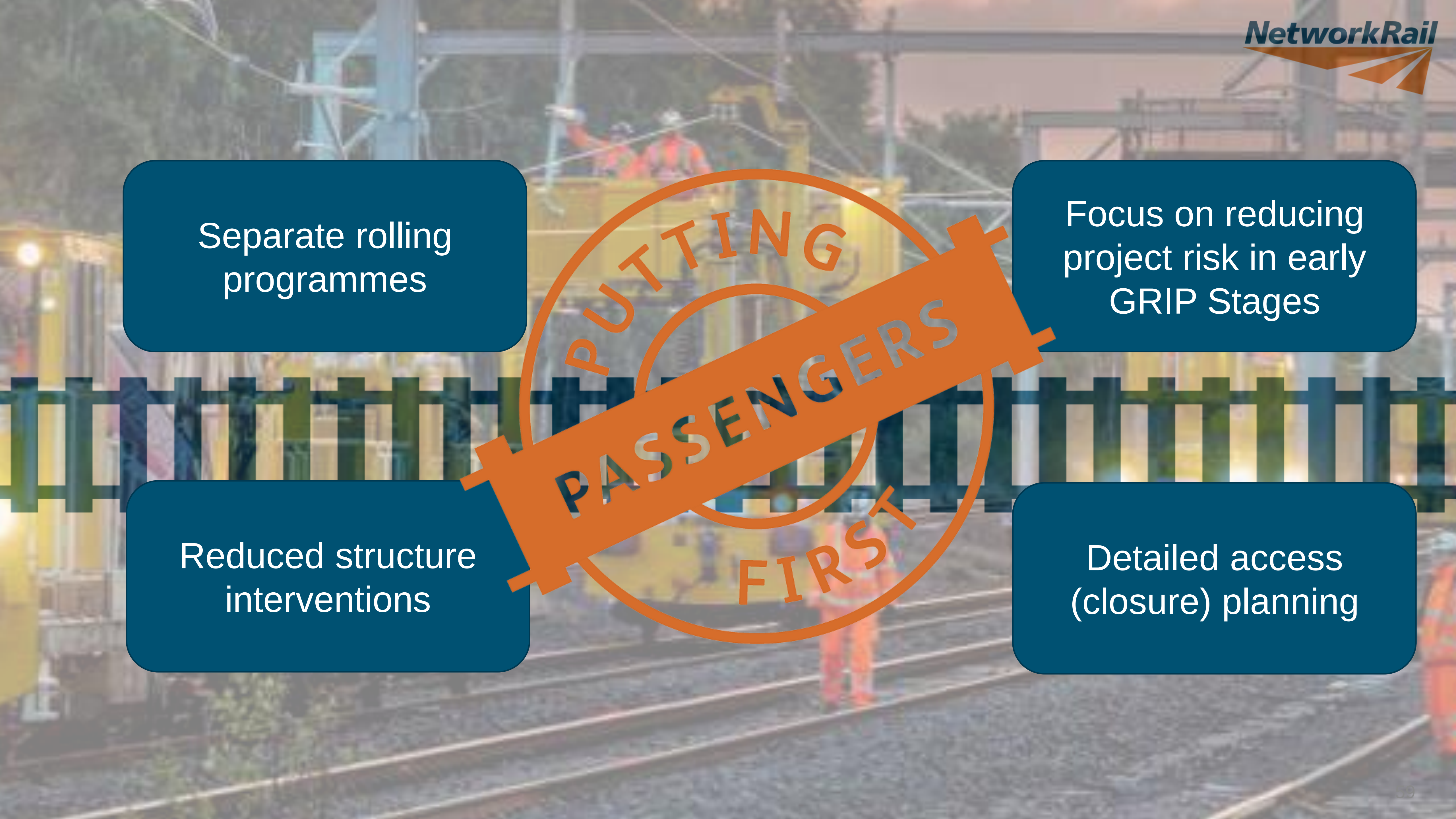
Opportunity – Access

- Traditionally construction is through ROTR
- Disadvantages of using ROTR
  - Limited construction time due to setup and handback requirements
  - EGIP 4 hour access time = circa 1 hour construction time
- Opportunity
  - Improved use of EROTR and blockades – increased construction efficiency, reduction in many cost drivers

Case studies

Shotts project - initially planned primary ROTR, plus EROTR. Project team review, project not able to be delivered in CP5. Agreed access EROTR six nights, plus blockages for critical interventions

EK / Barrhead project – estimated up to 11% saving of project overall cost based upon EROTR and blockades


NetworkRail
Separate rolling programmes
Focus on reducing project risk in early GRIP Stages
PUTTING PASSENGERS FIRST
Reduced structure interventions
Detailed access (closure) planning