Electrifying Scotland in the 21st Century

Presentation to IMechE Railway Division – Scottish Centre

19th January 2017

Brian Sweeney
BEng(Hons) MSc CEng MIET
Senior Project Engineer, Electrification
Network Rail, IPSNE

Some Recent Headlines…

Costs soar on another two Scots rail projects

Cost of Great Western mainline electrification project triples to £2.8bn

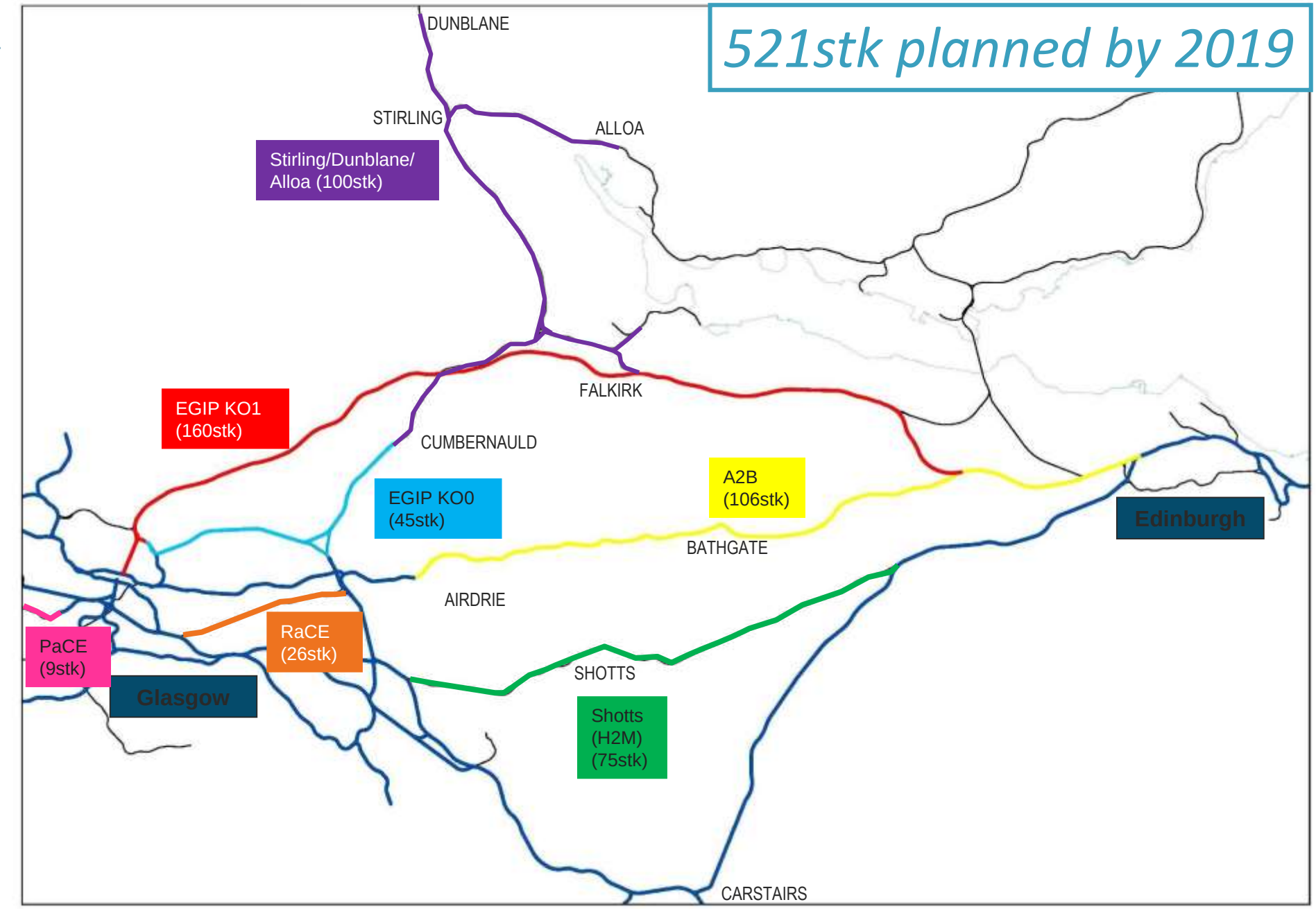
Electrification of Midland Mainline 'paused' by Network Rail

Edinburgh-Glasgow electrification facing seven-month delay

Rocketing rail electrification costs unacceptable, say MPs

Overview

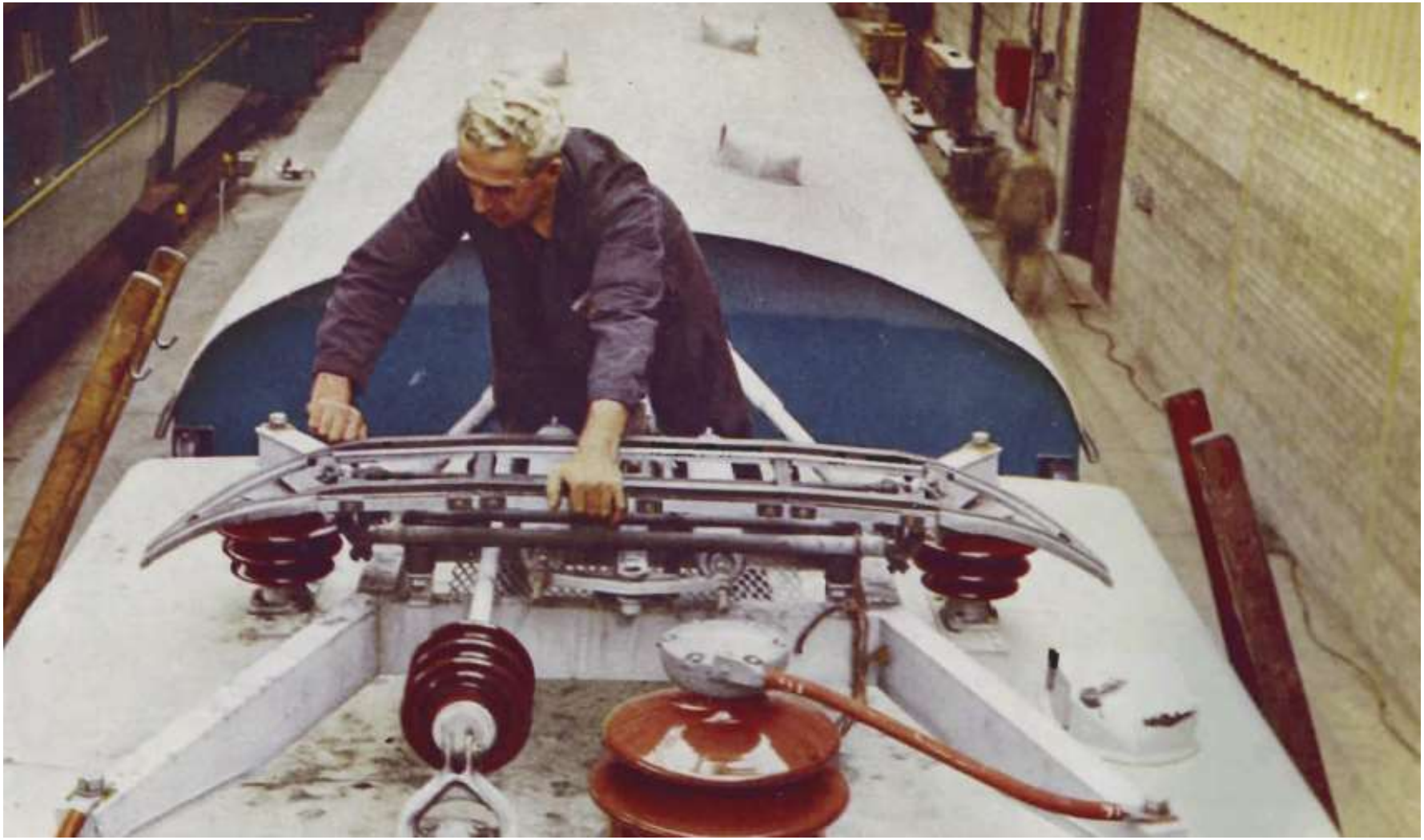
- Scottish CP4 & CP5 electrification portfolio
- 1960s vs 2010s – What has changed?
- “New EU Standards”
  - Railway Interoperability Regulations
  - Common Safety Method for Risk Evaluation & Assessment
- Electrical clearances from bridges and station platforms
  - What is “reasonably practicable”?
- Role of the ORR as National Safety authority under RIR
- Compliance with UK Legislation
  - Managing “Reasonable and Foreseeable” risks?
  - Isolation and Earthing
  - Working Practices
- Summary & Conclusions


521stk planned by 2019
DUNBLANE
STIRLING
ALLOA
Stirling/Dunblane/
Alloa (100stk)
FALKIRK
EGIP KO1
(160stk)
CUMBERNAULD
EGIP KO0
(45stk)
A2B
(106stk)
Edinburgh
BATHGATE
AIRDRIE
RaCE
(26stk)
PaCE
(9stk)
Glasgow
SHOTTS
Shotts
(H2M)
(75stk)
CARSTAIRS

Glasgow Electric

New Pantograph

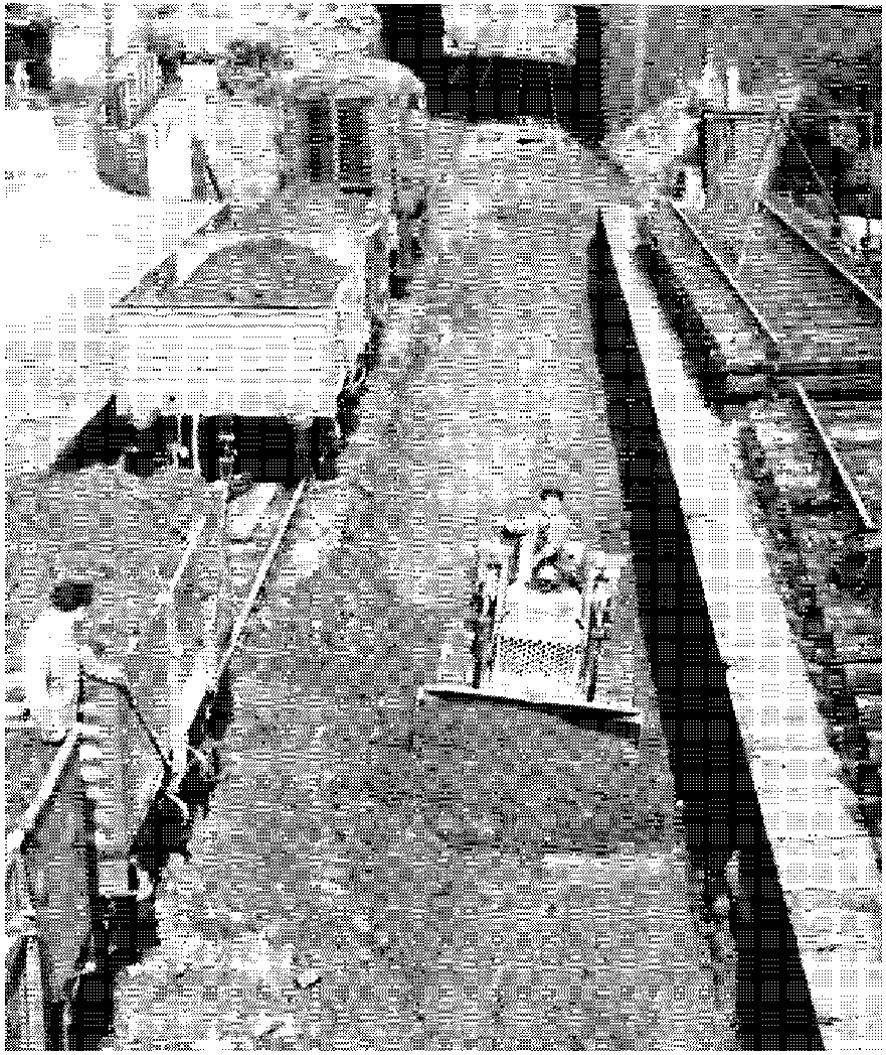
Old Pantograph



Augured Foundations

High-output piling methodology

Track Lowering



Statistics

A MASSIVE JOB IN THE MINIMUM TIME

In less than 4 years — ahead of schedule and within budget we have seen what the Re-birth of a Railway means:

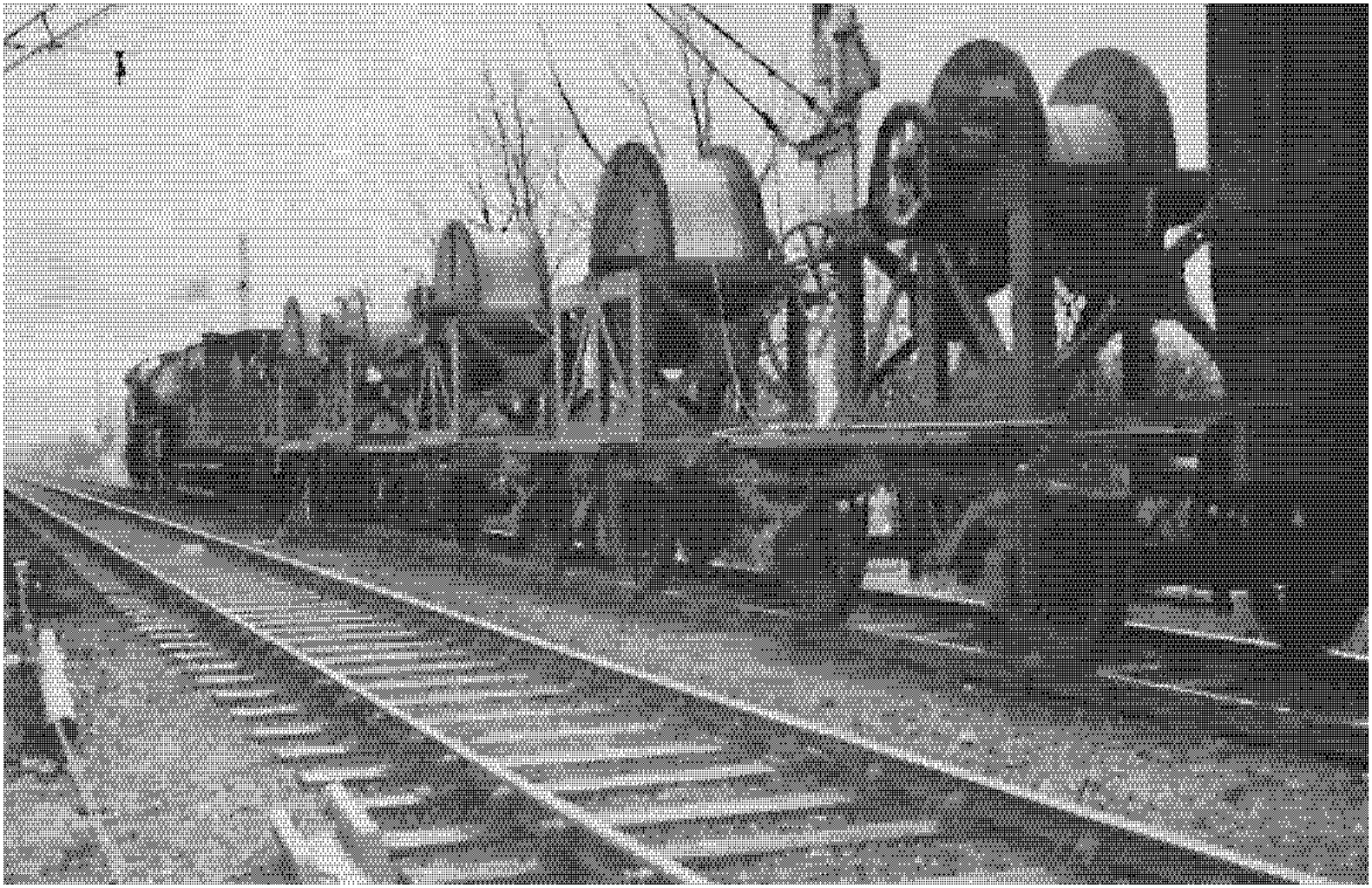
32,000 foundations dug for electrification masts	81 miles of signal cable
96 miles of overhead wiring, over	190 lineside electric signals
41 miles of route miles of track rebuilt	14,000 sq. metres of platform resurfacing
81 miles of lineside cable troughing	75 bridges altered
53 miles of telecommunication cables	13 stations upgraded

Ample evidence of the commitment of ScotRail and Strathclyde to provide the most efficient travel service possible.

EGIP KO1

- 138 single track kilometres of new electrification between Glasgow Queen Street and Newbridge Junction
- 2936 mast foundations
- 2370 new overhead line structures
- 60 overline structures to be cleared to allow electrification
- 70 parapets to be increased to 1.8m to allow for electrification
- 11 station platforms extended for up to 8 car sets

1960s Wiring Train



2010s Wiring Train

Installation & Maintenance – 1970s…

25kV Switchgear

Electrical Protection Settings

The track feeder circuit-breakers are all equipped with "distance impedance" protective relays so designed that in normal circumstances the total time to clear a fault by cutting off power from both ends of the section varies from 0·26 seconds to 0·76 seconds depending upon its position, or infrequently up to 1·26 seconds.

Should the fault be of exceptionally high resistance, a thermal relay takes control and causes the breaker nearest to the fault to open within times varying from 12 seconds to several minutes, according to the magnitude of the fault current.

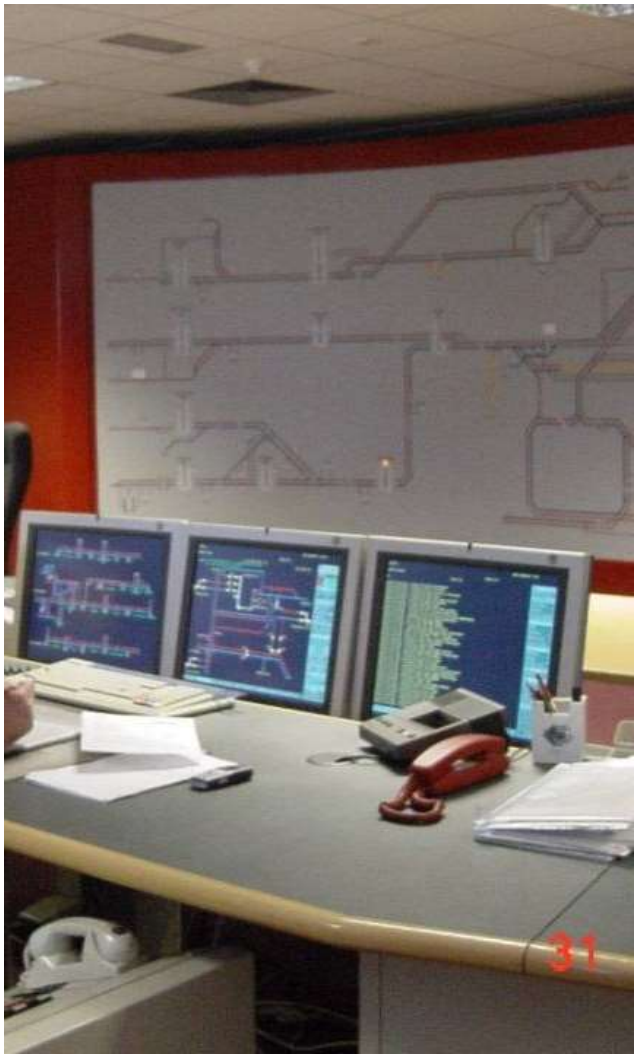
Should a circuit-breaker or its "distance impedance" relay fail to function, the back-up protection comes into play and the next breaker further back opens.

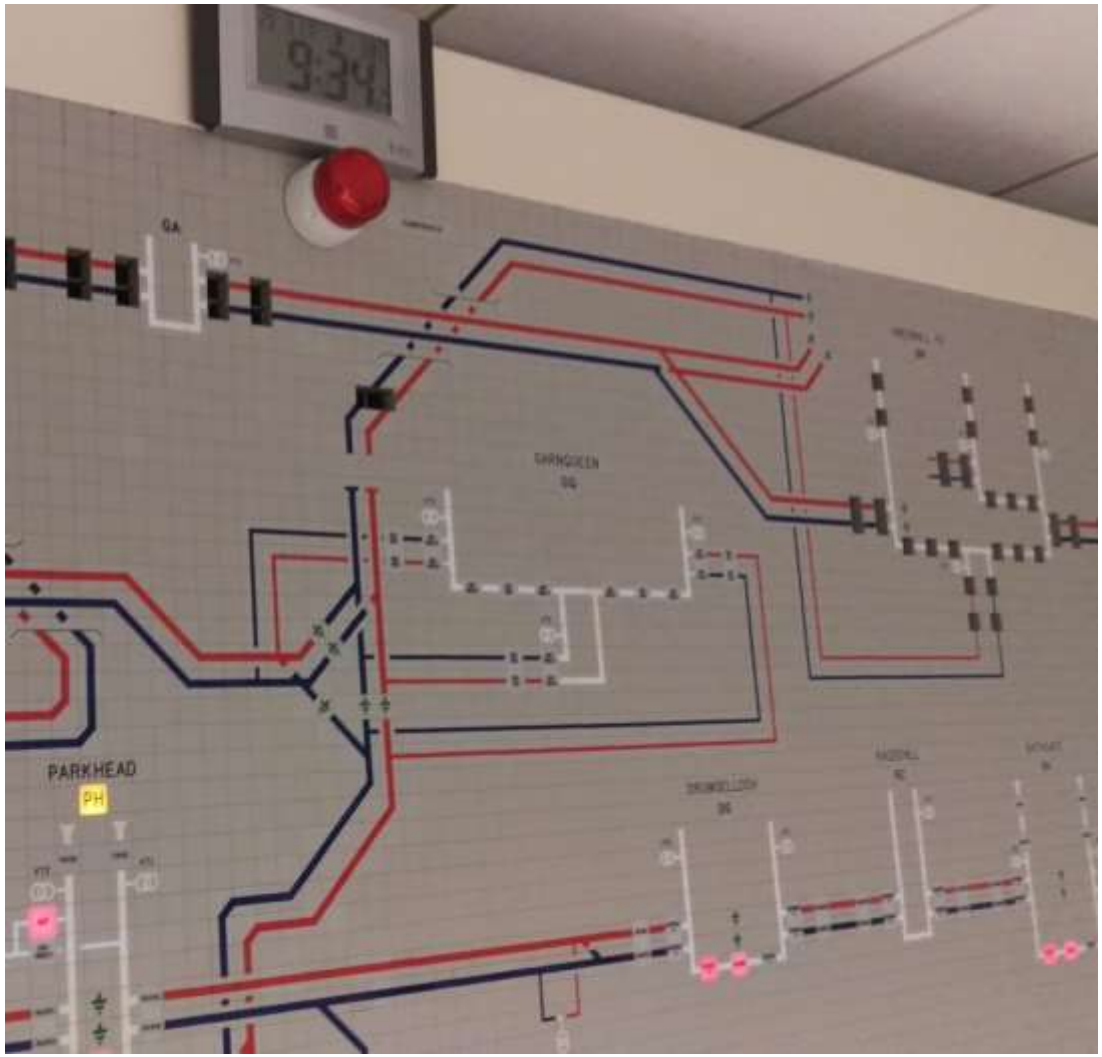
- Modern protection operating times:
  - Zone 1: 30ms + 50ms breaker operating time = 80ms
  - Zone 2: 150ms + 50ms breaker operating time = 200ms
  - Zone 3: 400ms + 50ms breaker operating time = 450ms

- Blink your eyes… that took you 200ms!!

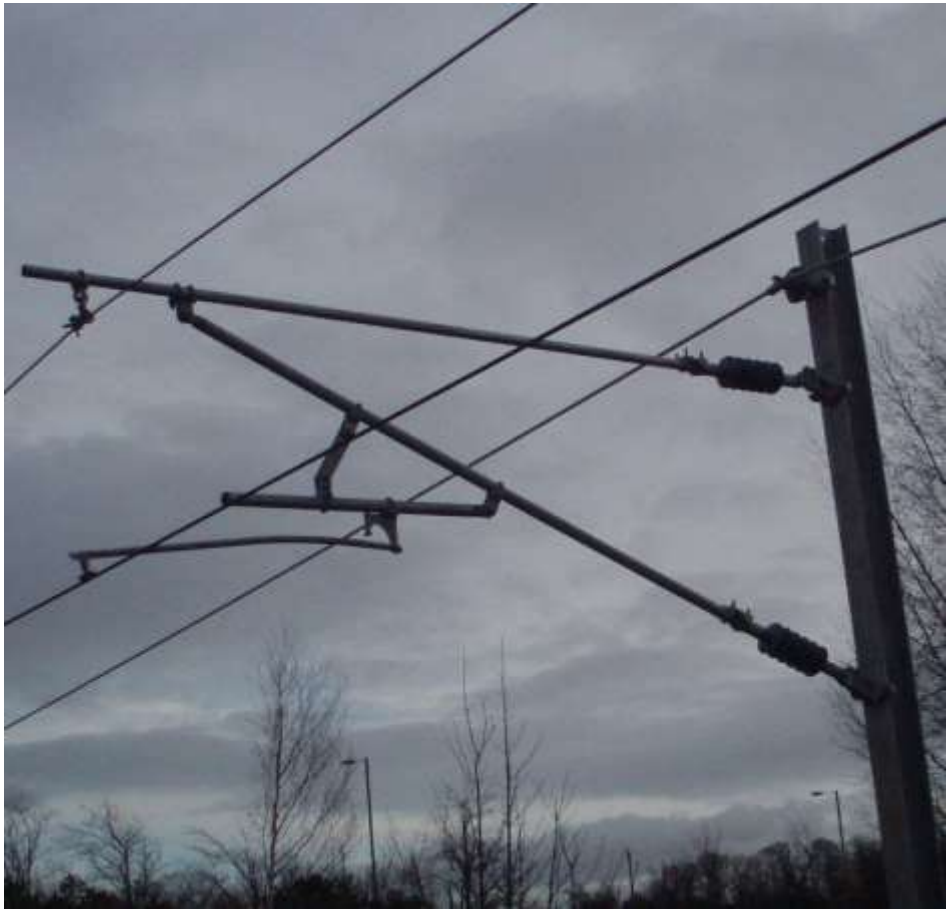
Cathcart Electrical Control – 1960s

Cathcart Electrical Control – 2010s





Mark 3 vs Series 2



A Green Mast…

Wires in the right place?…

Edinburgh Evening News

Blunder sees cables installed too low on Glasgow to Edinburgh rail line

The electrifications of the line between Edinburgh and Glasgow was meant to be completed by December this year. Picture: Jane Barlow

Published: 09:43

Updated: 22:44

Sunday 04 September 2016

ELECTRIC cables installed as part of an ongoing £742 million upgrade to the main Glasgow to Edinburgh rail line are too low – and must be replaced, it has emerged.

73 comments

Group 1: Livid and ill-informed…

AnotherView Like (18) Dislike (1)

8:20 AM on 05/09/2016

Congratulations Network Rail. Another shambles to be added to the ever growing list of your costly failures.

Call me cynical Like (54) Dislike (4)

2:06 PM on 04/09/2016

Absolutely staggering incompetence from those responsible for this.

OnTheBall Like (9) Dislike (1)

9:33 AM on 05/09/2016

Have electric trains just been invented? No, things like this can only happen in the UK. I am getting more and more convinced of this every day.

Group 2: Creative Solutions…

Paisley Baker Like (1) Dislike (4)

11:13 PM on 05/09/2016

Methinks the whole set up was a waste of money and the gantries are now an eyesore from Glasgow to Edinburgh. Can anyone explain to me why diesel electric trains had to be replaced anyway ?

TheyCallMePibo Like (10) Dislike (1)

1:19 PM on 05/09/2016

Could you not lower the trains a bit?

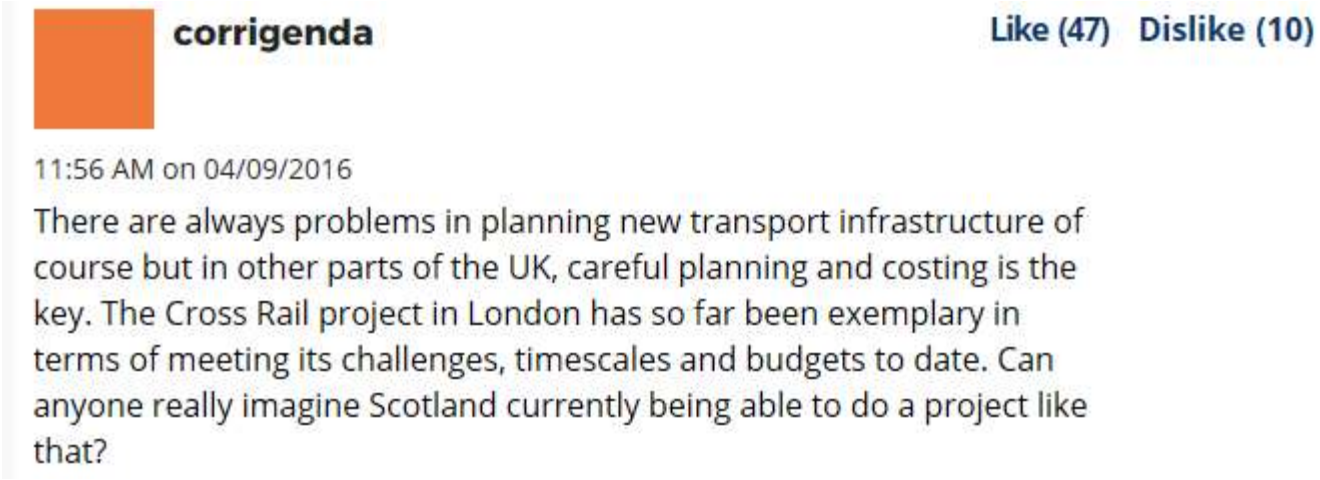
2 replies

WJohn Like (14) Dislike (3)

6:34 AM on 05/09/2016

They could just put smaller wheels on the trains.
And change "Mind the gap" signs to "Mind the step."

Then the Crossrail PR department got involved…



corrigenda

Like (47) Dislike (10)

11:56 AM on 04/09/2016

There are always problems in planning new transport infrastructure of course but in other parts of the UK, careful planning and costing is the key. The Cross Rail project in London has so far been exemplary in terms of meeting its challenges, timescales and budgets to date. Can anyone really imagine Scotland currently being able to do a project like that?

The truth almost gets its boots on…

we are The Fall

Like (17) Dislike (1)

12:26 PM on 05/09/2016

As with most of The Hoot'sman's transport output, this article is complete utter rubbish.

The catenary wires were hung at the correct height. There was no bungling by the contractors.

What HAS happened is that new standards have been set by the EU to do with clearances between wires and bridges and also minimum distances from platforms etc. to any live wires or supporting equipment.

Perhaps if Britain had engaged with the EU at the appropriate time then perhaps we could have negotiated exemptions, given that the already restricted UK loading gauge is comepletely different to the more generous continental loading gauge.

But no, we stand apart and don't engage with the legislative process and leave it to idiots like Farage and hi cohorts to screw it up for all of us.

New “Standards set by the EU”?

- The Railways (Interoperability) Regulations 2011 (RIR) came into force on 16 January 2012 and implement the EC Directive 2008/57/EC on the interoperability of the UK rail system. They apply to new, major, upgraded or renewed infrastructure and rolling stock.

- Generally the Directive aims to:
  - Ensure common Technical Specifications for Interoperability (TSI's) are applied across Europe's railways;
  - Establish a common European verification and authorisation process for placing new, upgraded or renewed infrastructure or rolling stock in service; and
  - Provide a process for putting certain rail components knows as interoperability constituents onto the rail market

- A new incarnation of ROGS / ROTS / “Headquarters Inspection”

Technical Specifications for Interoperability

- **Rolling Stock TSIs**
  - Locomotives and passenger rolling stock - LOC & PAS TSI
  - Noise - NOI TSI
  - Wagons - WAG TSI
- **Fixed installations TSIs**
  - Infrastructure - INF TSI
  - Energy - ENE TSI
- **Common TSIs**
  - Control command and signalling - CCS TSI
  - Persons with reduced mobility - PRM TSI
  - Safety in railway tunnels - SRT TSI
- **Functional TSIs**
  - Operation and traffic management - OPE TSI
  - Telematics applications for freight service - TAF TSI
  - Telematics applications for passenger service - TAP TSI

New Electrification Scheme - Energy TSI

- Energy System should be constructed using “Interoperable Constituents” and be verified as such by a Nominated or Designated Body (NoBo/Debo)

- Energy TSI also references EuroNorms as “Approved Codes of Practice”
  - (BS)EN50119 for system voltage levels
  - (BS)EN50367 for interaction between pantograph and overhead line
  - (BS)EN50122-1 for electrical safety provisions

- Each member state can produce a “Notified National Technical Rule” (NNTR) that addresses open points of the TSI in the specific member state
  - Railway Group Standard GL/RT1210 on clearances is a NNTR

- Network Rail have specified additional performance conditions for the Series 2 system as part of product acceptance:
  - Series 2 (11/11) accepted for 46m spaced pantographs @ 85mph
  - Series 2 (12/14) not yet accepted for 54m spaced pantographs @ 100mph

Series 2 - 11/11 vs 12/14

Two Interoperable Constituents…

Common Safety Method (CSM REA)

- CSM aims to harmonise processes for risk evaluation and assessment and the evidence and documentation produced during these processes.

- By applying a common process, it will be easier for an assessment undertaken in one EU Member State to be accepted in another with the minimum of further work.

- If the change has an impact on safety the proposer must decide on whether it is significant or not by using CSM criteria.
  - If the change is significant the proposer must apply the risk management process.
  - If the change is not significant, the proposer must keep a record of how it arrived at its decision.

- An assessment body must carry out an independent assessment of how the risk management process is applied and the results from the risk management process

Authorisation for passenger service

- Assessment Body (AsBo) reviews the project technical file and produces a Safety Assessment Report (SAR) which may be supportive or non-supportive
- Network Rail makes a “declaration of control of risk” based on the recommendations of the SAR, although can ignore a non-supportive SAR
- Network Rail can enter a new system into service for testing or driver training under it’s infrastructure manager safety case
- The “National Safety Authority” of each member state must then authorise the technical file and subsequent placing into revenue earning service of any new piece of railway
- The ORR (Office of Rail and Road) are the National Safety Authority for the UK

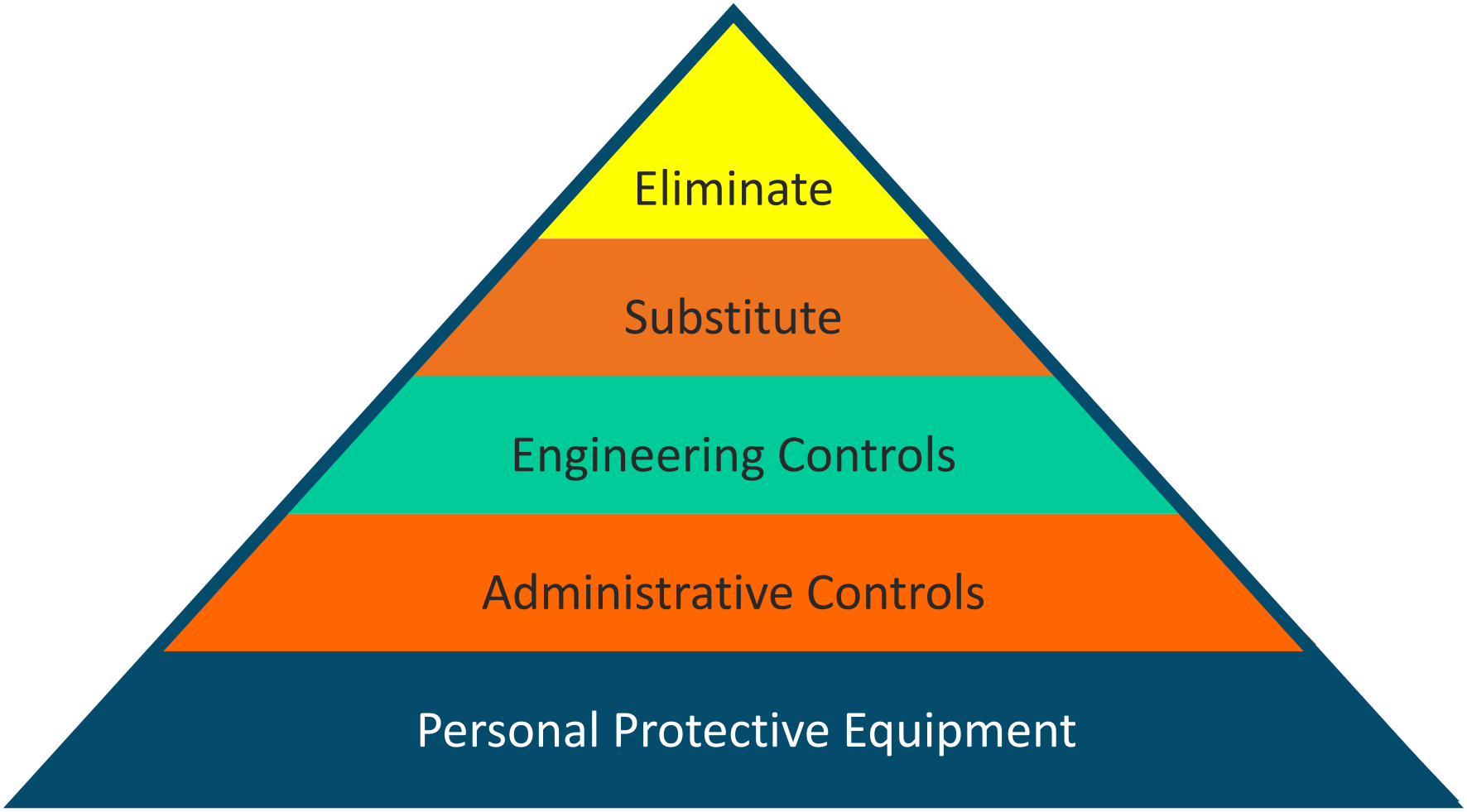
What does CSM mean in practice?

- Electrification projects are “Significant”
- Risk Management Process:
  - Define system
  - Identify Hazards (HAZID / HAZOP)
  - Analyse
  - Mitigate
  - Demonstrate
- This is an iterative process until the right answer is identified
- HAZID with Subject Matter Experts can determine a risk is broadly acceptable and does not warrant further analysis
- Three ways to control risk:
  - Apply Code of Practice (meet it)
  - Reference System (CSM) (show equality & assess delta)
  - Explicit Risk Estimation (prove ALARP)
- There is a difference between a **standard** and a **code of practice**:
  - Must be generally available
  - Must have been shown to be suitable i.e. have pedigree.
  - Must be applicable to hazard(s) concerned

As an example…

- The hazard is the new Overhead Electrification System, live at 25kV
- The main risk is electrocution as a result of person(s) making inadvertent or malicious contact
- The risk is managed by applying the provisions of the Energy TSI
- Energy TSI makes reference to Code of Practice (BS)EN50122-1 which has three main categories of protective measures:
  - Protection by clearance
  - Protection by obstacle
  - Earthing & Bonding
- GL/RT1210 is the UK Notified National Technical Rule for EN50122-1, therefore following the Group Standard meets the requirements of CSM

Hierarchy of Risk Controls



Words and phrases that are banned for the rest of this presentation…

- Standards
- Compliance
- Derogation
- Deviation

Bridges

Permissible Electrical Clearance

Old GE/RT8025 (RGS)	
Enhanced	≥ 600mm
Normal	≥ 270mm
Reduced	≥ 200mm
Sp. Reduced	≥ 150mm

New GL/RT1210 (NNTR)	
≥ 600mm	Reinforced
≥ 370mm	Basic
≥ 270mm	Functional
< 270mm	Reduced

- Both standards desire achievement of 600mm clearance at bridges
- “Normal” or “Basic” clearances may be adopted without a specific risk assessment, however this is required for lower categories
- Old RGS allowed the Risk assessment to be approved by Route Asset Manager (Reduced) or Professional Head E&P (Special Reduced)
- New NNTR requires demonstration of not reasonably practicable combined with supporting CSM Risk Assessment

EGIP KO1 Structure Clearances

Basic or Reinforced Clearance	Functional Clearance	Reduced Clearance
45	**17**	**4**
Two late additions:	*Site specific*	Winchburgh Tunnel
OB34 Park Farm	*risk assessments*	Falkirk High Tunnel
OB20 Niddry Castle	*for each structure*	Queen Street Tunnel
		OB22 Winchburgh Aqueduct

Winchburgh Aqueduct

Perth Road, Dunblane

Electrical Clearances and GL/RT1210

- Risk assessments should not be used as the tool to say we are doing nothing!
- Even simple interventions can make a difference:
  - Removal of toe holds
  - Provision of chevaux de frise
- EGIP have employed the Great Western Risktec model as a supporting tool to calculate a Safety benefit which can assist in demonstrating ALARP decisions
- A cost and grossly disproportional cost is calculated based on the risks at each structure and all potential interventions
- Risktec is a tool that can help you reach an informed decision but cannot make the decision for you!

Risktec Output

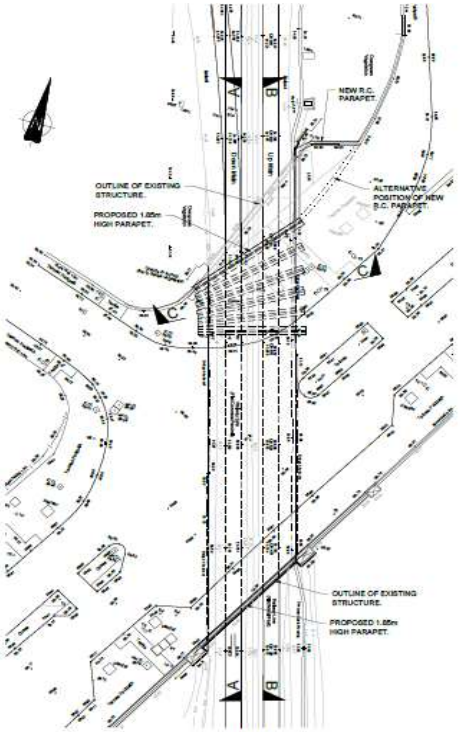
RESULTS

Structure							Risk of Proposed Design in FWI per year for asset analysed									Total safety cost per year (risk (FWI x VpF)) for proposed design	Trespass Breakdown		ation vs Structure Breakdo	
ID	ELR	Miles	Chains	OLS Name	Does the OLS restrict the wire height at a station for any of the options considered this OLS?	Is the overbridge over the platform?	Fault 12KA	Option Description	Total Risk to Staff	Total Risk MOP (Non-trespass)	Total Risk MOP (Trespass)	Total Risk to Passengers at station	Total train accident risk (strike object with possible derailme	Non-Trespass	Trespass	Total	Total	Percentag e Risk from Non-Trespass	Percentag e Risk from Trespass	Percentage Risk at Station	Percentage Risk on Structure
1	SCM3	105	58	OB03 Perth Road	Yes	No	No	Reconstruct to provide functional	8.57E-06	8.73E-06	5.93E-04	1.00E-05	5.0E-07	3.25E-05	5.88E-04	6.32E-04	£	2,416.57	5%	95%	83%	17%
2	SCM3	105	58	OB03 Perth Road	Yes	No	No	reconstruct to provide Elastic	8.90E-06	8.74E-06	6.07E-04	1.41E-05	5.0E-07	3.29E-05	6.07E-04	6.40E-04	£	2,450.07	5%	95%	83%	17%
3	SCM3	105	58	OB03 Perth Road	Yes	No	No	Reconstruct to provide reinforced Insulation	7.73E-06	8.74E-06	5.23E-04	1.40E-05	5.0E-07	2.22E-05	5.23E-04	5.46E-04	£	2,066.72	4%	96%	1000%	0%
4	SCM3	105	58	OB03 Perth Road	No	No	No	Demolish structure	1.54E-06	8.74E-06	5.55E-06	0.00E+00	5.0E-07	3.55E-06	5.55E-06	1.29E-07	£	0.50	26%	74%	0%	1000%
5	SCM3	105	58	OB03 Perth Road	Yes	No	No	Increase wire height to increase clearance to	9.28E-06	8.74E-06	6.20E-04	1.44E-05	5.0E-07	3.34E-05	6.20E-04	6.53E-04	£	2,500.90	5%	95%	84%	16%
6	SCM3	105	58	OB03 Perth Road	Yes	No	No	Change Environmental Factors: Move access point	8.58E-06	8.74E-06	5.93E-04	1.38E-05	5.0E-07	3.25E-05	5.88E-04	6.32E-04	£	2,416.65	5%	95%	83%	17%
7	SCM3	105	58	OB03 Perth Road	Yes	No	No	Track Lower to provide functional Insulation	9.25E-06	8.74E-06	6.18E-04	1.43E-05	5.0E-07	3.33E-05	6.18E-04	6.51E-04	£	2,493.86	5%	95%	84%	16%
8	SCM3	105	58	OB03 Perth Road	No	No	No	Reconstruct to provide basic insulation without restricting wire	1.54E-06	8.74E-06	5.55E-06	0.00E+00	5.0E-07	1.03E-05	5.55E-06	1.07E-04	£	400.92	10%	90%	0%	1000%

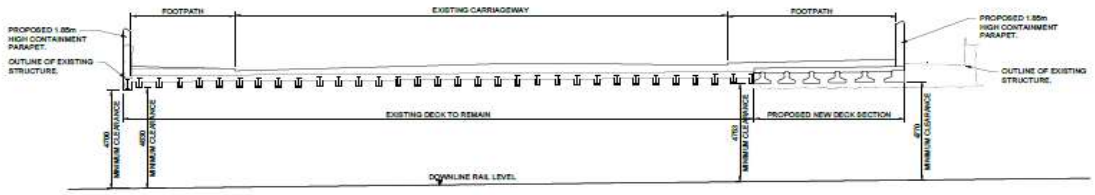
Scoring Matrix

Option	Technical Viability	Disruptive Possessions	Service Diversions	Road Traffic Impacts	Station Platform Impacts	Temporary Bridges	Carriageway Tie- Ins	Programme Duration	Overall Cost	Whole Life Costings	Planning Implications	Technical Risk	Total
Track Lower	2	1	5	5	1	5	5	3	3	1	1	3	**31**
Bridge Deck Jacking	1	3	1	2	5	3	2	2	3	2	2	1	**24**
Bridge Deck Replacement	5	2	1	3	5	3	4	1	3	5	2	4	**32**
Partial Bridge Deck Replacement	5	3	2	4	5	4	4	3	5	3	3	5	**38**

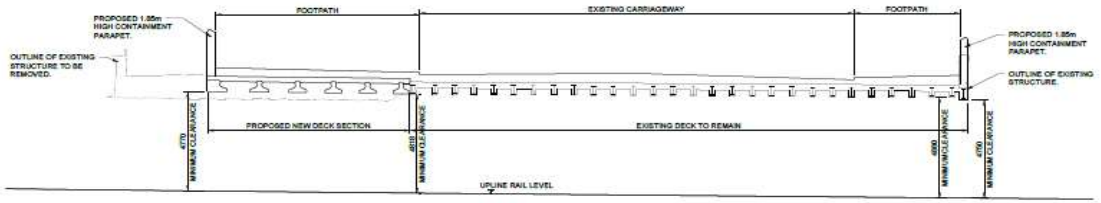
Single Option Detail



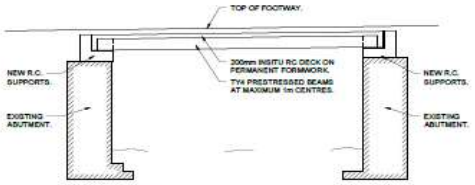
PLAN



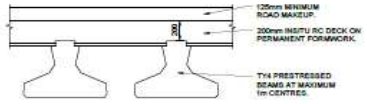
PROPOSED ELEVATION ON A-A



PROPOSED ELEVATION ON B-B



PROPOSED SECTION ON C-C



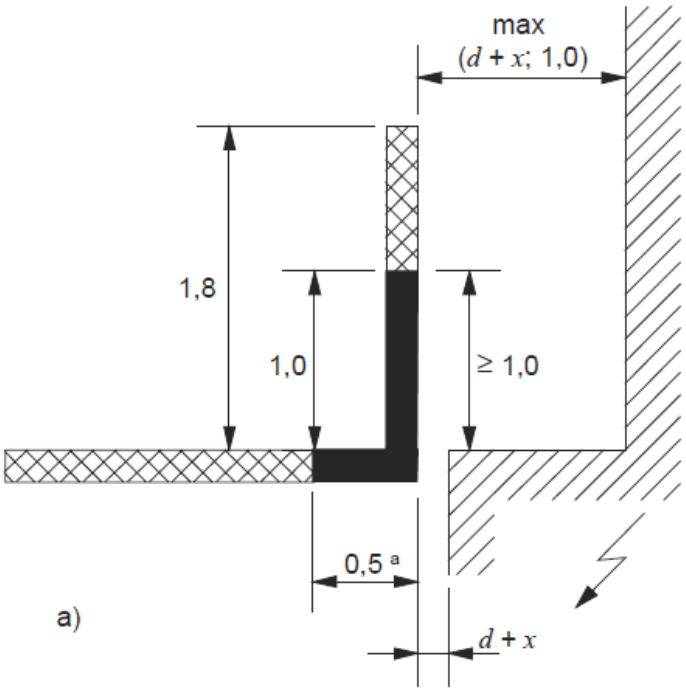
PROPOSED TYPICAL DECK CROSS SECTION

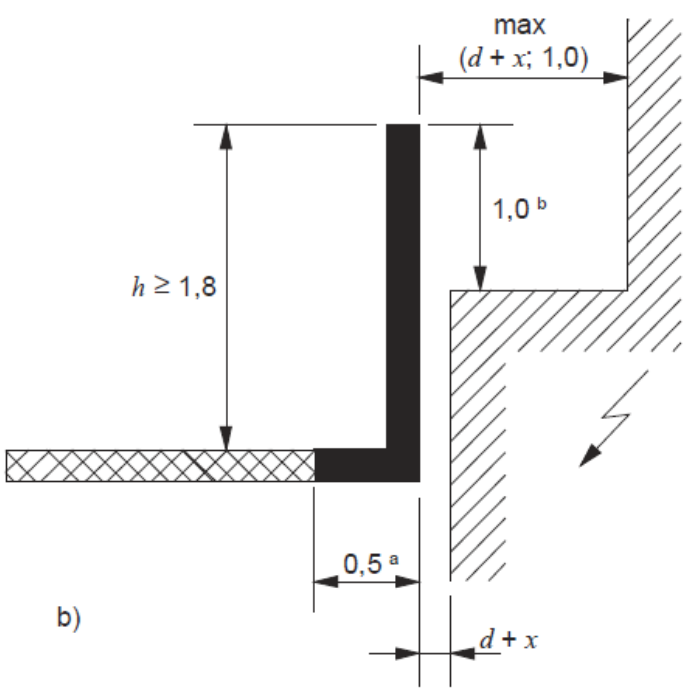
Kerse Road, Stirling

1.5m vs 1.8m Parapets?

“Vertical Obstacles” as per EN50122-1

Dimensions in metres





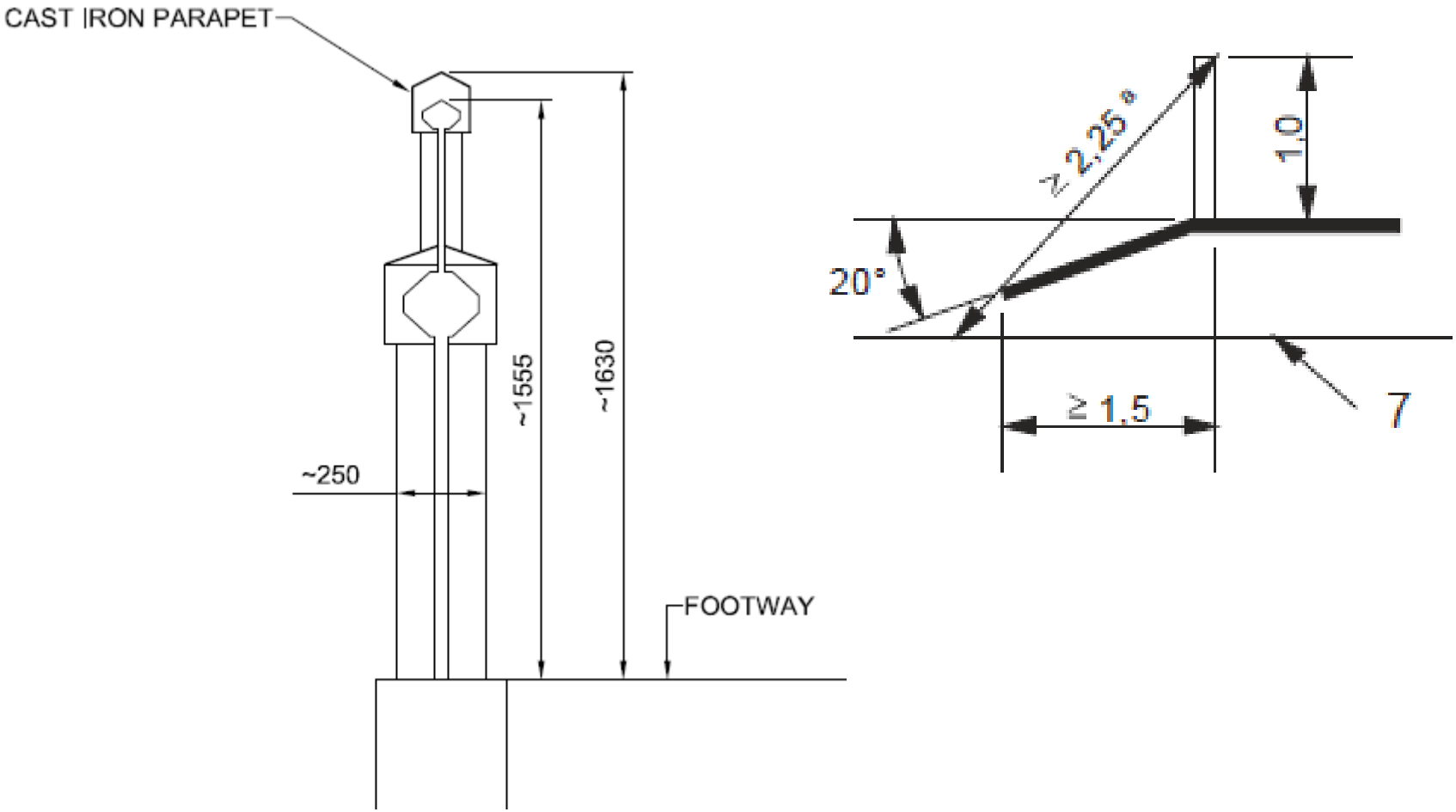
NR/BS/LI/331 Issue 2

The height of new/renewed vehicle parapets above adjoining paved surface over the railway shall not be less than the following:

1800mm	for bridges over an automatic/driverless railway
1800mm	for bridges frequently used by equestrian traffic
1800mm	for bridges where there is a high risk of trespass or vandalism or suicide
1800mm	for parts of bridges over OLE where electrification 'protection by safety clearance' requirements are not achieved (see 10.10)
*1800mm	for other overline bridges and upgraded parapets that span over the railway where pedestrians, animals, pedal cycles and vehicles drawn by animals are not excluded by Order (* see note 1 below)
1500mm	for other bridges (e.g. motorway bridges and bridges not over the railway where the above higher risk categories don't apply)

Cathedral Street OB130

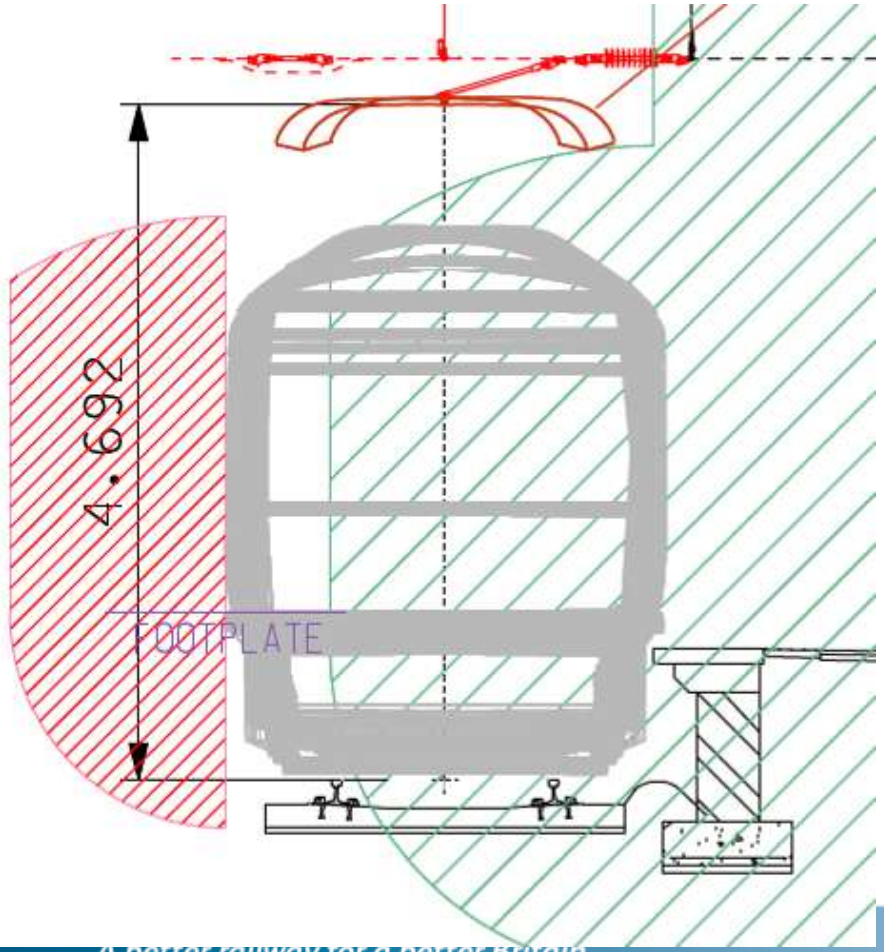
Cathedral Street OB130



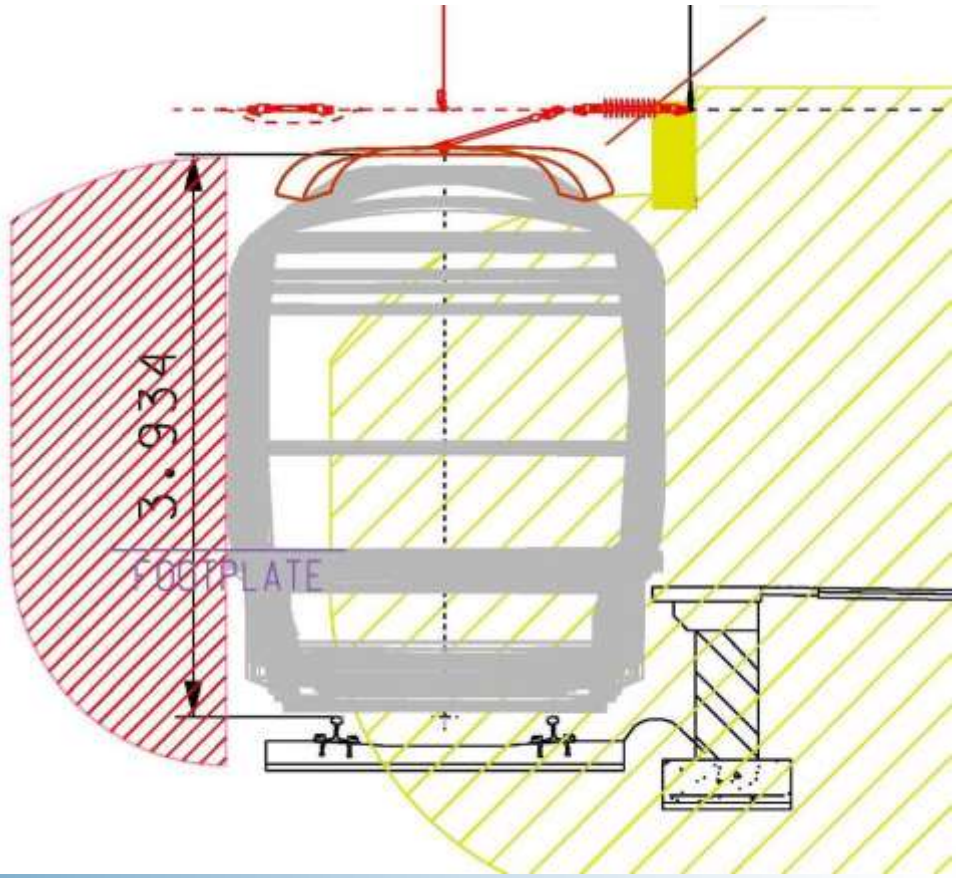
Stations

Station Wire Heights and EN50122-1…

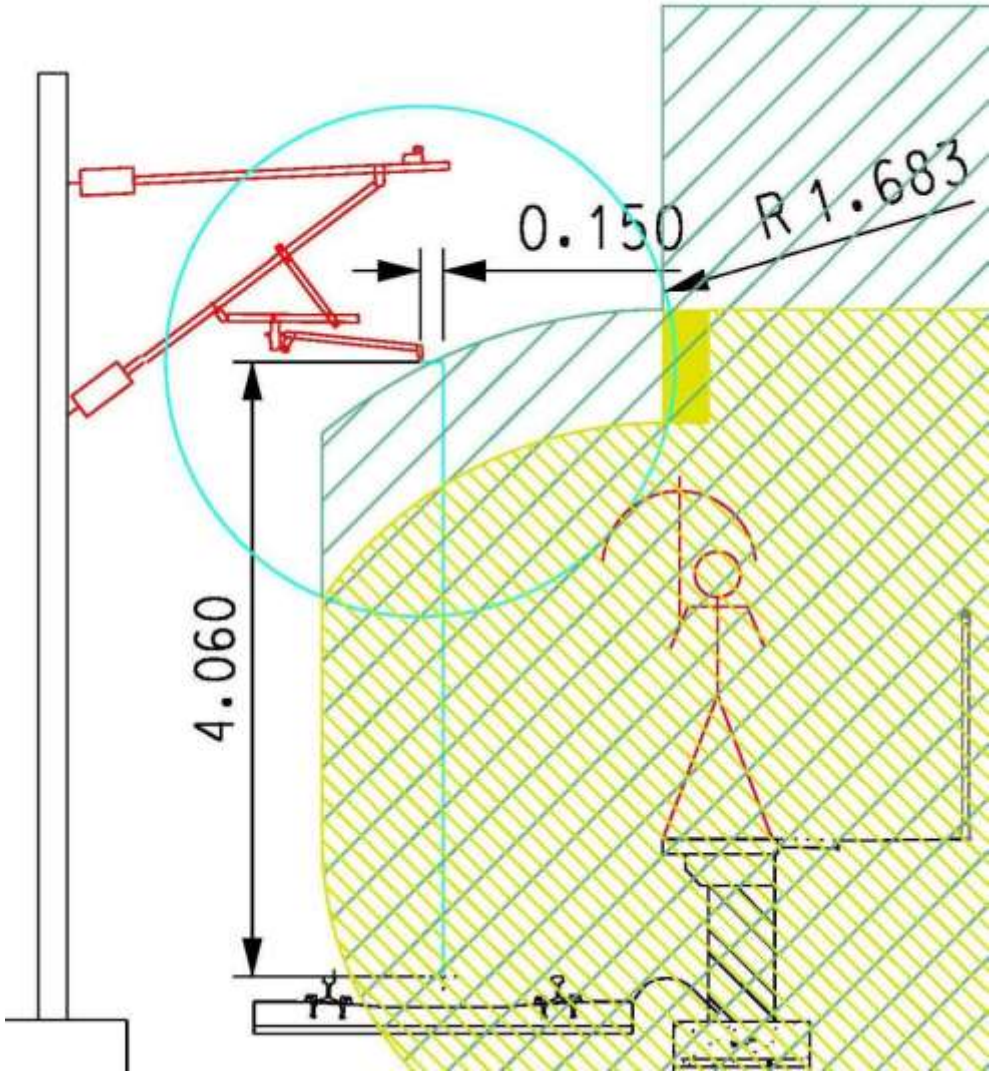
EU Standard Case (3.5m)



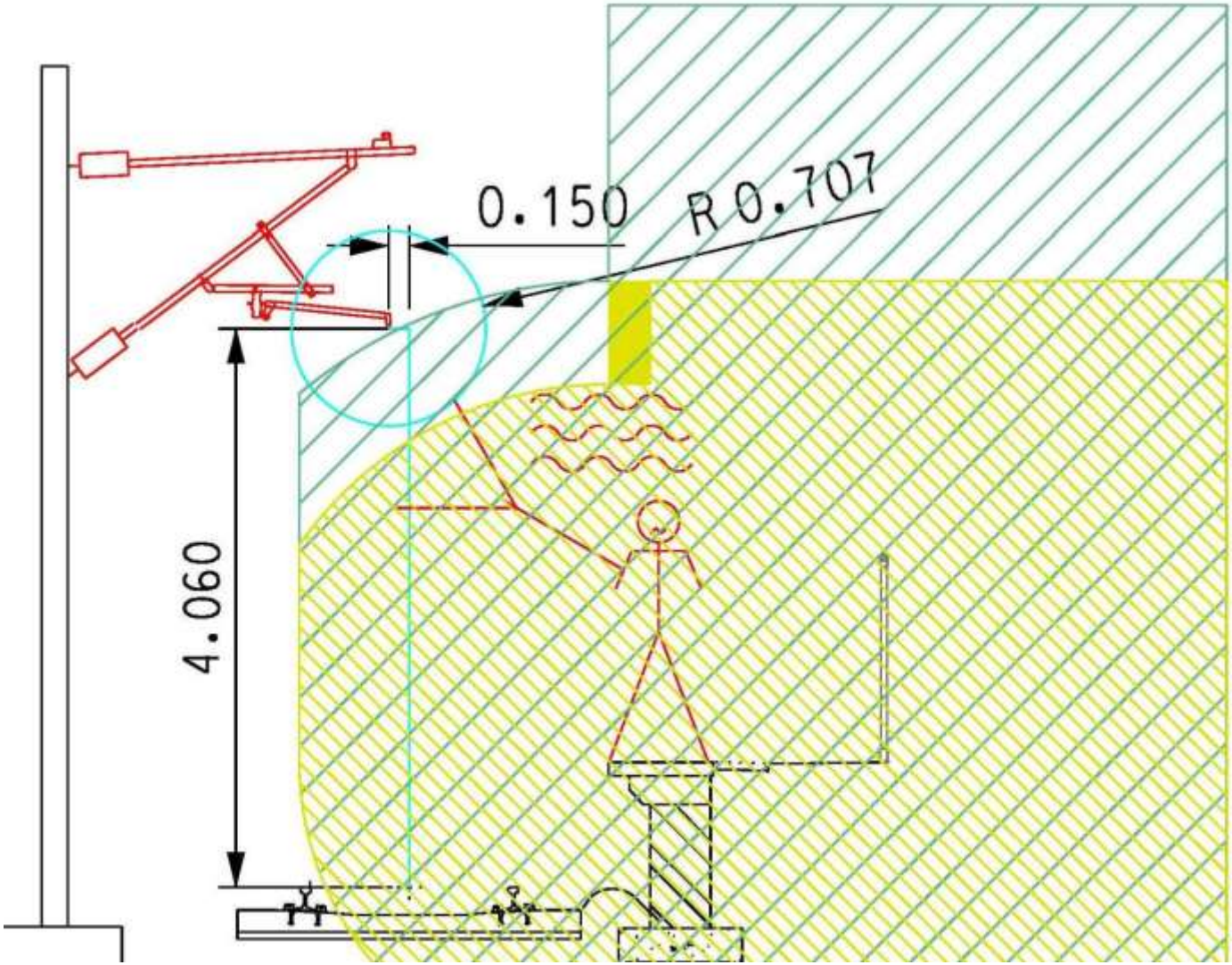
UK Special Case (2.75m)



Man with umbrella…



Add some Scottish weather…



RSSB Energy Committee Meeting…

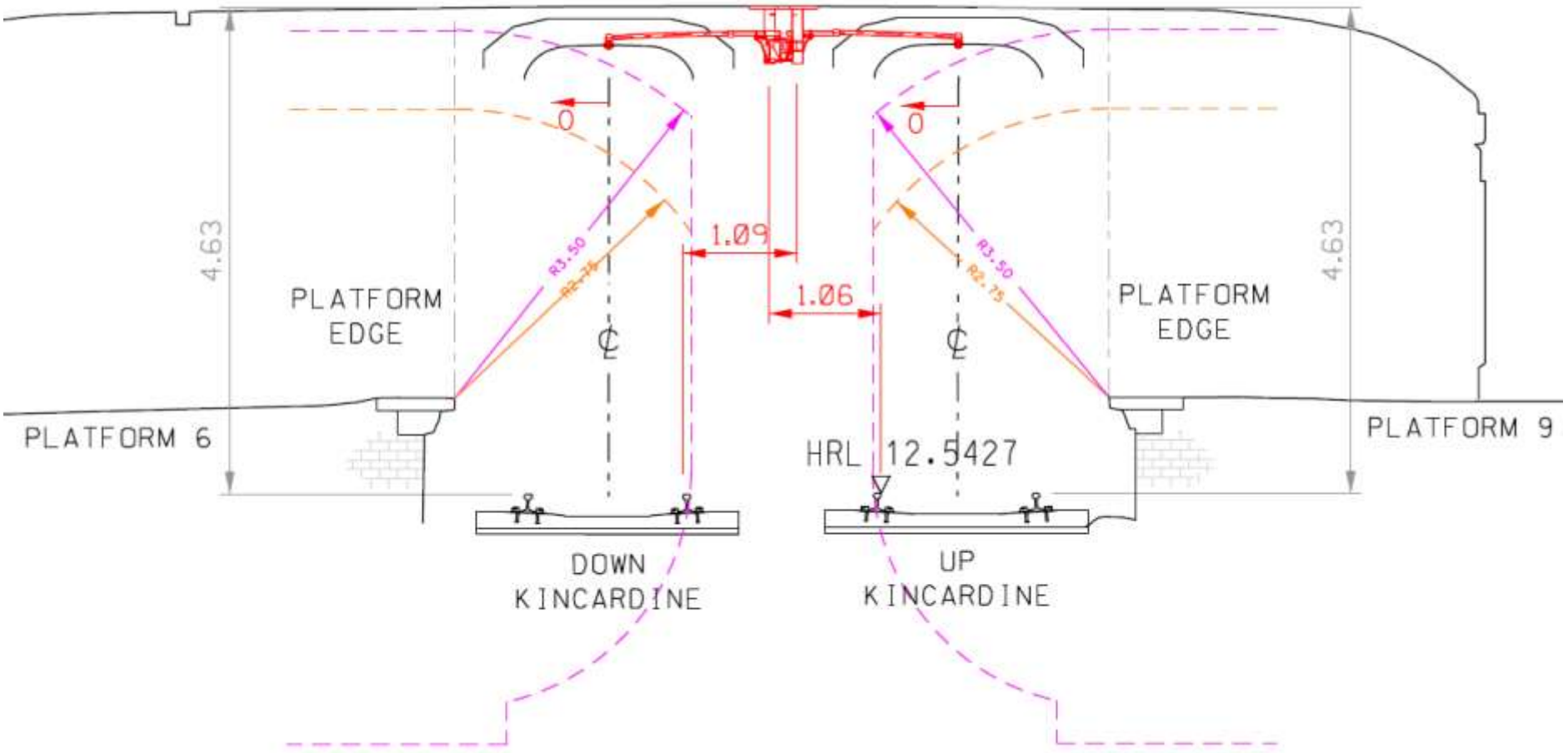
GL/RT1210

Protective provisions against direct contact – protection by clearance

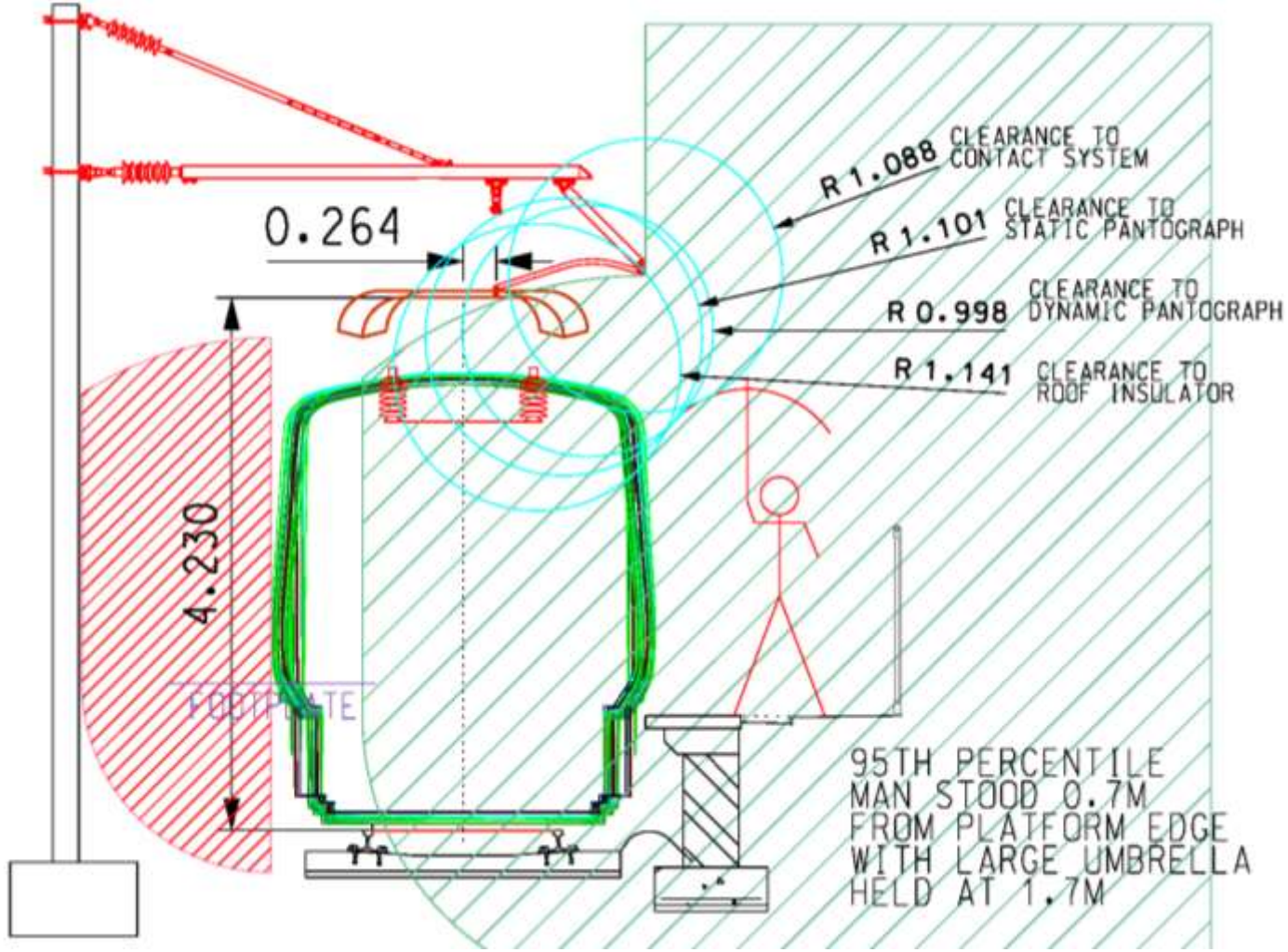
2.2.2.1 Exposed live parts of the energy subsystem, including a pantograph head (complying with 3.1.6.1 and in contact with the contact line), shall comply, at all locations, except where 2.2.2.2 applies, with the clearance requirements set out in EN 50122-1:2011+A1:2011 clause 5.2.1, using the public area dimensions in Figure 4. The United Kingdom special national condition relating to clause 5.2.1, as set out in EN 50122-1:2011+A1:2011 Annex G, shall not be used.

2.2.2.2 It is permissible, where existing physical features of a particular site constrain the gauge (for example, overline bridges and tunnels) and it is not reasonably practicable to modify them or the public platform area, for a pantograph head, conforming to 3.1.6.1, which is in contact with the contact line, to encroach into the area defined in EN 50122-1:2011+A1:2011 clause 5.2, Figure 4 (public area), provided that reinforced insulation in accordance with 2.1.8.1 c) is maintained between persons, including any foreseeable objects they may be carrying, and the nearest part of the pantograph head, where justified by a risk assessment complying with the Common Safety Method for Risk Evaluation and Assessment (CSM RA) and the application of appropriate safety measures. Requirements for other live parts of the train-mounted equipment are set out in GL/RT2111 clause 3.16.1.

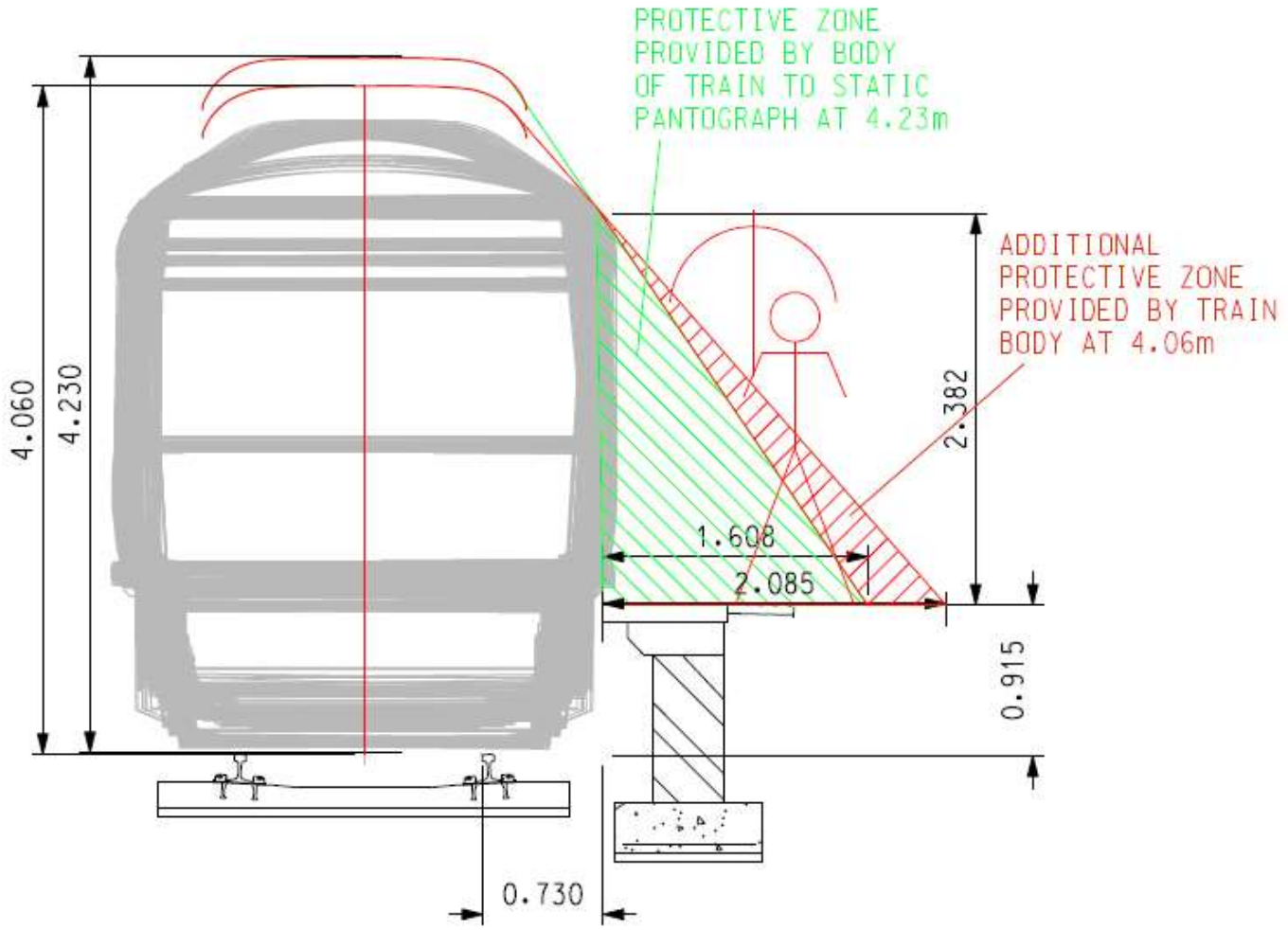
3.5m clearance?



GL/RT1210 risk assessment



Train body as an obstacle?



All Foreseeable Objects?

EAW(1989) Reg 7 – Live Conductors

Regulation 7
All conductors in a system which may give rise to danger shall either– *(a) be suitably covered with insulating material and as necessary protected so as to prevent, so far as is reasonably practicable, danger; or* *(b) have such precautions taken in respect of them (including, where appropriate, their being suitably placed) as will prevent, so far as is reasonably practicable, danger.*

- The live contact wire cannot be insulated as per 7(a) therefore it requires to be placed out of reach
- Manage the risk via CSM by applying Code of Practice (BS)EN50122-1, caveated by UK NNTR GL/RT1210
- Need to achieve a minimum 3.5m from platform edge to live equipment

Extract from ORR Guidance Note

10. ORR notes that no other industry uses a dimension as low as 3.5m to achieve compliance with EaWR for 25kV systems, so its use already takes into account the constraints of UK rail infrastructure. As such, the scope for further compromise of this already significantly reduced clearance distance without accompanying mitigations is extremely limited.

11. Where the risk being considered is of death to members of the public then the judgement on what is reasonably practicable moves towards what is technically achievable (in other words, because the "quantum of risk" is at a very high level then the level of "time, trouble and effort" that is proportionate to control it will inevitably also be high). Where entirely new electrified infrastructure is being considered, then the duty to design out risk - rather than mitigate –is strengthened considerably[4].

Extract from ORR policy statement…

12. Costs of redesigning features and retrospective modifications due to lack of rigour in the duty holder's original design should not be used to inform any cost-benefit analysis. ORR's strategy document on safety by design[5] explains this in more detail and quotes RSSB's guidance: "It is not acceptable to argue that a measure is not necessary to ensure safety SFAIRP on the basis of excessive cost if that measure could and should have been identified at an earlier point in the project when its implementation would have been required".

13. Duty holders should aim to maximise clearances wherever possible, beginning at the design stage of the project. 3.5m is a minimum, and not a design target.

14. Duty holders should consider all practicable options to achieve the required clearance distance, including platform position, track lowering, track alignment and altering structures where they are the limiting factor. Where duty holders' internal company standards, for example around track gradient, pose an obstacle to achieving legal compliance then the onus should be on adhering to the law and considering any necessary revisions or variations to the standard(s) in question.

The Law

Health & Safety at Work Act 1974

- Workplace (Welfare)
- Manual Handling
- Display Screen Equipment
- PUWER
- LOLER
- CoSHH
- PPE
- Asbestos
- Mgmt of H&S at Work Regs 1999
- Electricity at Work Regs. 1989

BS7671
IEE Wiring Regulations

"Requirements for Electrical Installations"

Electrical Risks - Frequency

		National frequency (events/year)	Risk cont. (FWI/year)
HEN-31A	Workforce electric shock (OHLE) (direct contact)	1.05	0.474476
HEN-31B	Workforce electric shock (OHLE) (indirect contact)	0.6242424	0.219537
HEN-28B	Workforce observes electrical arcing (OHLE)	1.25	0.02655
HEN-50	MOP (non-trespasser) observes electrical arcing	0.1428571	0.003607
HEN-51	MOP (non-trespasser) electric shock (OHLE)	0.2857143	0.147203
HEN-37	MOP (adult trespasser) electric shock (OHLE)	2.029	0.8888346
HEN-41	MOP (child trespasser) electric shock (OHLE)	0.7538	0.1241105
HEN-08	Passenger observes electrical arcing at a station	0.2391524	0.006038
HEN-09	Passenger electric shock at a station (OHLE)	0.0588235	0.011068

Croy

Croy

Croy – 26 Options for Evaluation

- Close access stairs from the existing footbridge to platforms.
- Review stop car markers to see if 'normal' pantograph stopping positions can be moved away from lowest wire height area.
- Review stopping positions with regard to station access and waiting positions of passengers to move away from pantograph location.
- Barriers at Platform Edge
- Areas in the immediate vicinity of the bridge are to remain closed to the public thus reducing risk from flash burns, arc eye and molten metal.
- Provide a height restricting goal post at barrier entrance to platform(s)
- Make use of lightning flash symbols around the station on the platform surface.
- Dot the platform between edge of platform and yellow line with lightning flashes.
- Project to consider introduction of red line to lie behind yellow line to signify a danger in addition to moving trains.

Croy – 26 Options for Evaluation (2)

- Consider extending tactile surface further back to yellow/red line to bring discomfort when standing closer to platform edge.
- Consider CCTV PTZ video tracking function to trigger announcements of infringements.
- Consider PA announcements specifically warning of the dangers from OLE of when not standing behind the line.
- Project to make full use of community liaison person and send out timely warning to local community about the implementation of OLE
- Project to make full use of community liaison person and visit all local schools, youth clubs and child recreation sites to inform the dangers of OLE,
- Project to make full use of community liaison person to implement local TV and Radio announcements - Twitter, leaflets, social media.
- Platform widening
- Repositioning of CIS away from hazard
- Signage - way marking of entrance and exit

Croy – 26 Options for Evaluation (3)

- Make the platform shelters open sided in order to aid passenger flow and locate them closer to the new footbridge where the wire height is larger. These should also be pushed closer to the new footbridge back away from the platform edge.
- Platform extension away from bridge / risk area
- "Manned ticket gates / Station staff and train crew- staff (when present) to monitor behaviour on platform / entrance- additional staff to monitor behaviour on platform / entrance"
- Selective door opening
- Automate announcement when passing into station (possibly at ticketing barriers when present) triggered by laser interference by objects.
- Station canopies to encourage people to stand back from platform edge (also to reduce the use of umbrellas and possibly restrict the height of objects carried).
- Run different type of rolling stock on this route

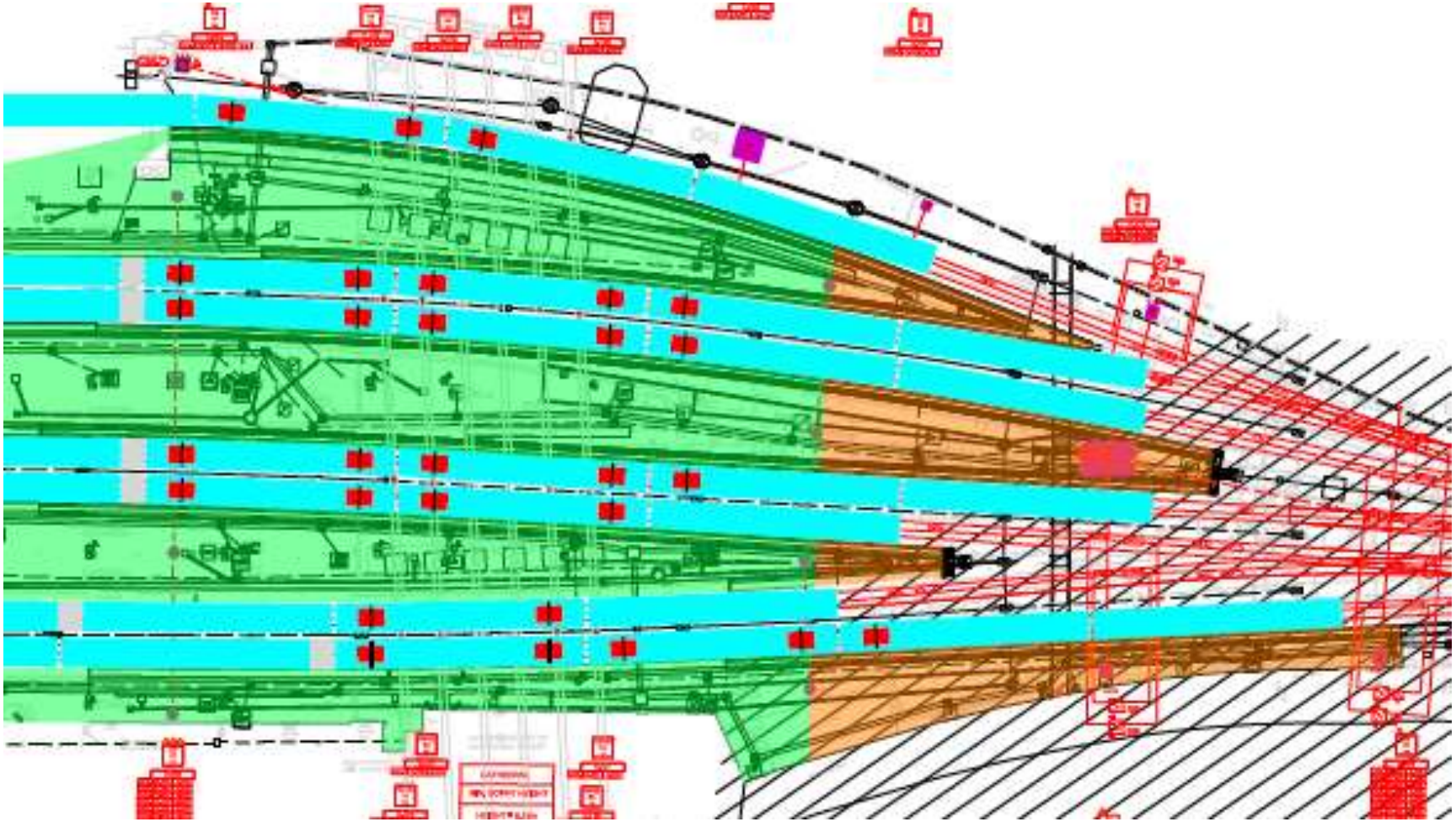
Croy

Johnstone

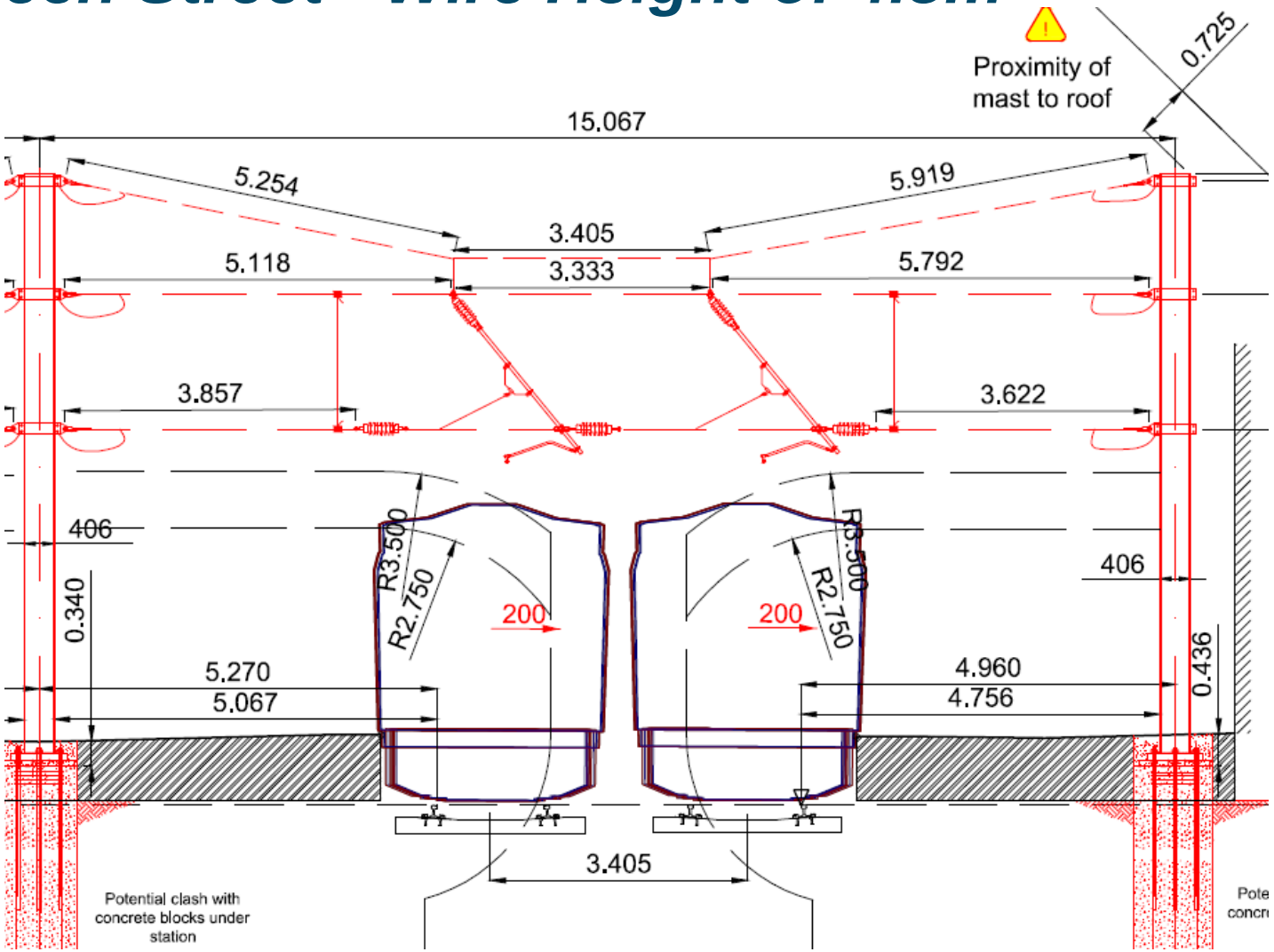
Queen Street

Queen St Station – Listed Building

Queen St Station – Listed Building



Queen Street - Wire Height of 4.5m



Cleland

Cleland

Cleland

Cleland

Legislation

Relevant Legislation for Electrification

- 1. Electricity at Work Regulations 1989
- 2. Railway Safety (Miscellaneous Provisions) Regulations 1997
- 3. Workplace (Health, Safety and Welfare) Regulations 1992
- 4. PUWER
- 5. Confined Spaces Regulations 1997
- 6. Manual Handling Operations Regulations 1992
- 7. Personal Protective Equipment Regulations 1992
- 8. Work at Height Regulations 2005
- 9. Supply of Machinery (Safety) Regulations 2008
- 10. Control of Asbestos Regulations 2006
- 11. Railways and Other Guided Transport Systems (Safety) Regulations 2006
- 12. Railway Interoperability Regulations 2011
- 13. Construction (Design and Management) Regulations 2015
- 14. Control of Substances Hazardous to Health Regulations 2002
- 15. Control of Lead at Work Regulations 2002

MoHSW 1999 Regulation 3

Risk assessment

3.—(1) Every employer shall make a suitable and sufficient assessment of—

(a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and

(b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking,

(3) Any assessment such as is referred to in paragraph (1) or (2) shall be reviewed by the employer or self-employed person who made it if—

(a) there is reason to suspect that it is no longer valid; or

(b) there has been a significant change in the matters to which it relates; and where as a result of any such review changes to an assessment are required, the employer or self-employed person concerned shall make them.

Reasonable and Foreseeable Risks

Reasonable & Foreseeable Risk No.1?

Network Rail Scotland Route

Time: 18:15 on 19/08/16

Police Scotland advise that they have report that a young male aged approx 13 years may have been electrocuted after coming in contact with the OLE. Injured party reported to be clear of the OLE and lying on the ground. Emergency Services en route.

Boundary Measures

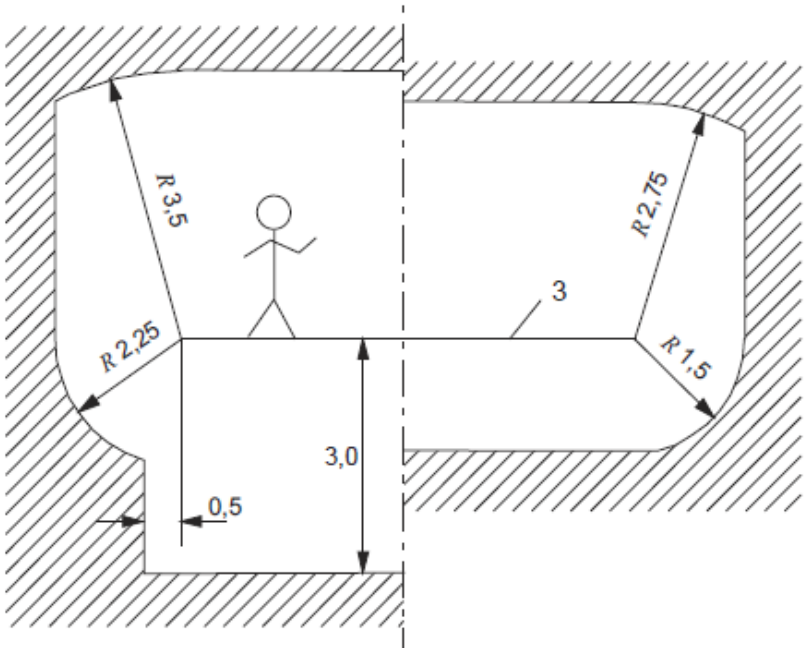
- Network Rail has a duty to “Prevent Danger” as per Electricity at Work and Management of Health & Safety at Work Regulations

- This includes tackling the “Reasonable and Foreseeable” risks around public trespassing onto the railway network and compromising Electrical clearances

- Boundary assessments need to consider:
  - Areas of known trespass and vandalism
  - Areas where trains may be stopped for long periods
  - Areas where electrical clearances may be compromised as a result of trespass

Public area or restricted area?

- Track fencing standard NR/L2/TRK/5100 only considers third rail – no mention of OLE
- When can an area reasonably be considered as a “restricted area”?
- Dimensions from (BS)EN50122-1 shown opposite



3.9.4
public area
area to which the public has unrestricted access

3.9.5
restricted area
area for which access is only permitted for authorized persons

OB110 – Wester Cleddens Road

OB114 – Kirkintilloch Road

Cowlairs Incline

Demolished OB121 Gourlay Street

Demolished OB121 Gourlay Street

Boundary Wall - Linlithgow

Boundary Wall - Linlithgow

Boundary Wall - Linlithgow

…Raised to 1.8m

Boundary Wall - Linlithgow

Boundary Wall - Linlithgow

Boundary Wall - Linlithgow

EG/46/20 (which will be moved!)

Reasonable & Foreseeable Risk No.2?

Network Rail Scotland Route

Time: 19:18 on 28/06/16

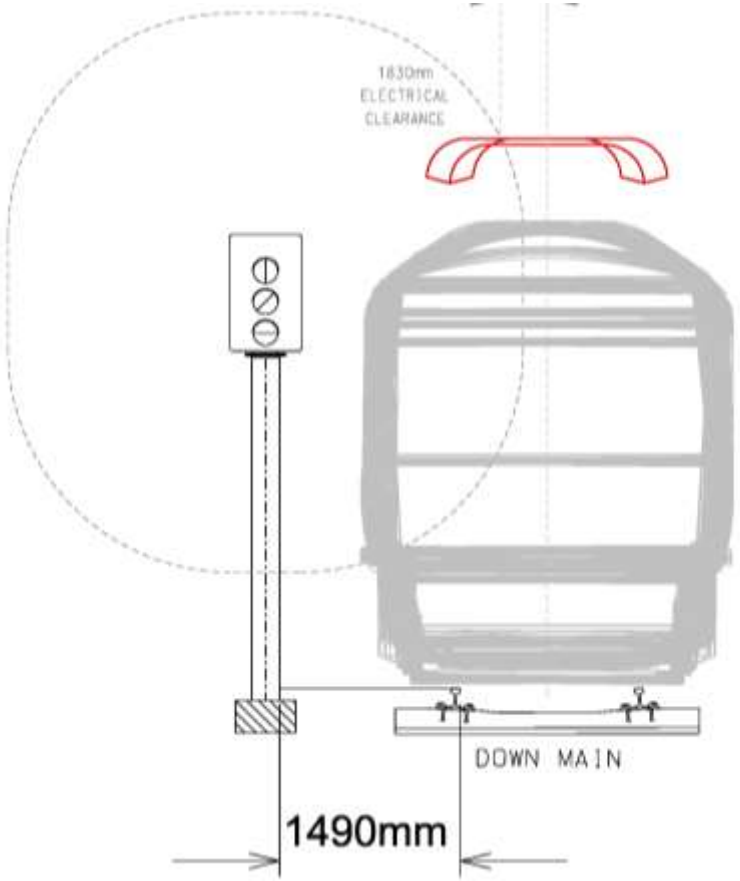
SSM Motherwell SC advised 2L01 [1803 Larkhall - Milngavie] driver reported 3 juveniles climbing the signal ladder for M206R signal, located between Blantyre and Earnock Sidings. BTPolice were advised, as was the Motherwell MOM [BB] to undertake a fencing check in the area.

Next driver 2C14 [1738 Milngavie - Cumbernauld] warned the juveniles the Police were enroute and all 3 were observed as running away off the railway.

TDA:332443, delays currently 6 trains delayed 28 minutes. Medium risk incident.

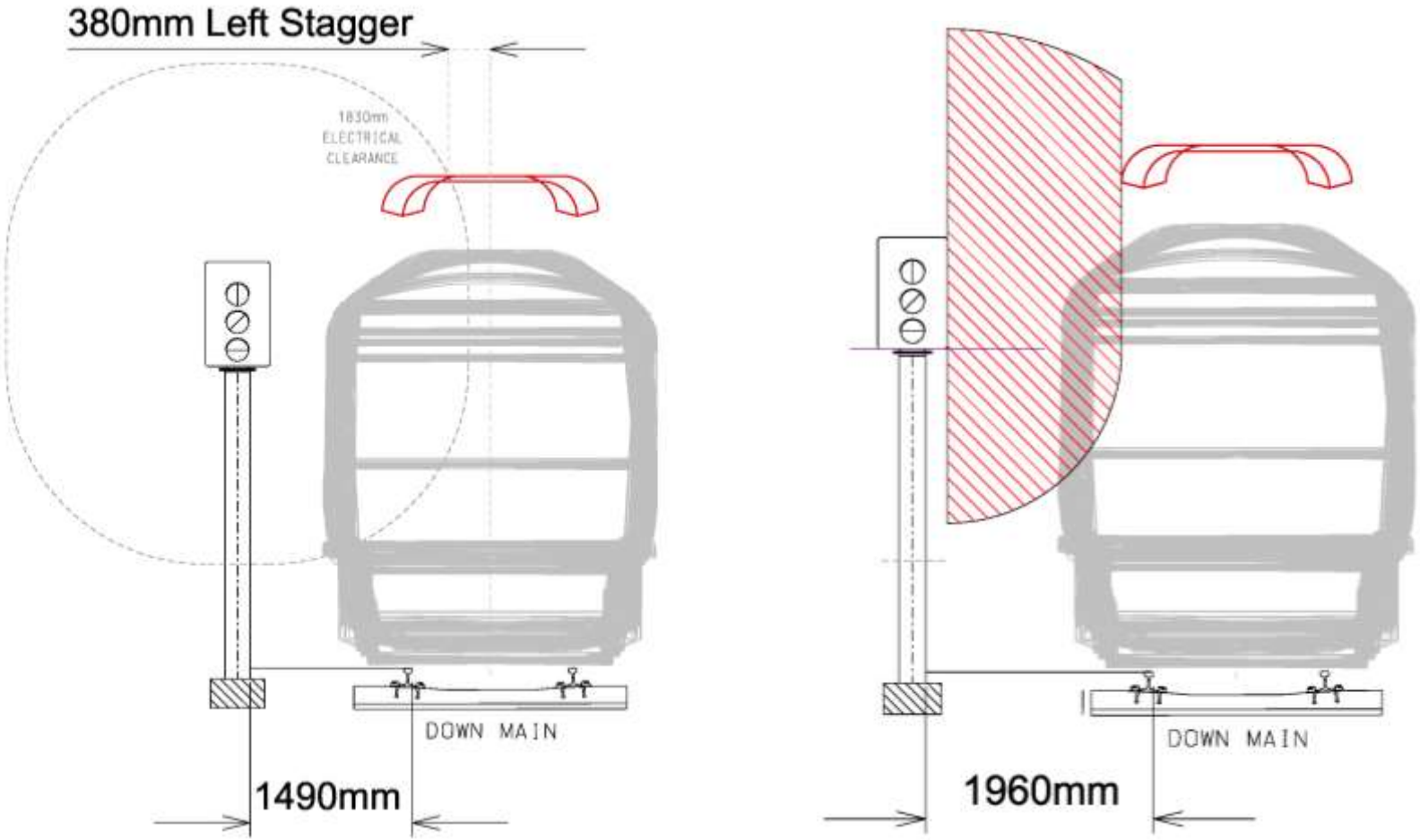
Signal Screening – 1960s

NR/SP/ELP/27204



- EGIP KO1 had intended to screen all signals in accordance with NR/SP/ELP/27204
- Initial scope was for screening of 21 signals
- ORR have written to the project stating that they do not believe NR/SP/ELP/27204 can be considered an approved code of practice under CSM that adequately manages the risks in accordance with relevant legislation

NR/SP/ELP/27204 vs (BS)EN50122-1



Application of (BS)EN50122-1 to signals

- Remedial works now required to 142 signals on EGIP KO1
- Two options:
  - Non-restricted area with 1.8m solid barriers as per bridge parapets

    or
  - Establish a “restricted area accessible only to skilled persons” with either 1.5m clearance to live parts or 1200mm² mesh screen

Restricted Area – Ladder guards

Application of (BS)EN50122-1 to signals

- Ladder guards on all signals manage the reasonable and foreseeable trespass risk, but also to create a “restricted area accessible only to skilled persons”
- Screens fitted where practicable, Cowlairs as an example
- “No access without line blockage” removes pantograph from the equation - 81 signals
- “No access without isolation” for 9 gantries pending parapet upgrade

Signal Gantries

Authorisation

RaCE Authorisation Conditions

Ref	Condition
(1)	Voltage monitoring of the subsystem to demonstrate compliance with NR/L2/ELP/27010 must be undertaken and evidenced.
(2)	VI and Vt testing of the subsystem must be undertaken and evidenced
(3)	Only class 314, 318, 320, 334 and 380 are permitted to operate over the route until further compatibility assessments have been undertaken to confirm compatibility with all stock intended to operate over the subsystem
(4)	Dynamic behaviour of the subsystem must be demonstrated in accordance with CR ENE TSI clause 6.2.4.5

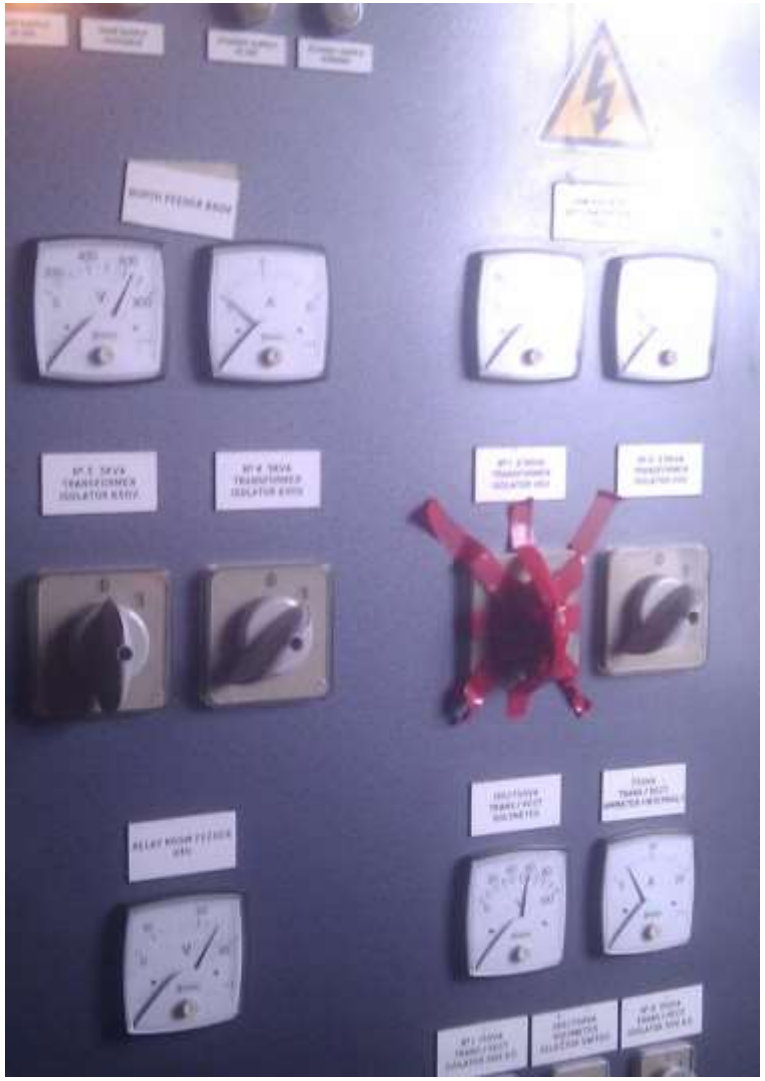
RaCE Authorisation Conditions

Ref	Condition
(5)	Assessment of the Series 2 overhead line equipment to provide certification as an Interoperable Constituent.
(6)	The subsystem must be re-assessed and brought into compliance with the certified series 2 Interoperable Constituent
(7)	Implement formal maintenance instructions supported by training for the operation and maintenance of the Return Screening Conductor
(8)	The project must complete the installation of the return conductor arrangement at Rutherglen
(9)	Implement formal maintenance instructions supported by training for all staff required to maintain the Series 2 overhead line equipment in this subsystem
(10)	As-built information is to be produced and evidenced

RaCE Authorisation Conditions

(11)	The operations and maintenance strategy is to be updated to include the controls required to manage reduced clearances at structures
(12)	Electrical isolations of the 25kV overhead line installed as part of this subsystem must comply with Regulation 12 and Regulation 13 of the Electricity at Work Regulations 1989

Isolation & Lock off



MLE Motor Switch with Castell Key

Secure Key Boxes

Working Practices

Electrical Isolations – Accident rate

- A serious incident takes place, on average, every 15 months across Network Rail Infrastructure
- Majority of incidents are a result of staff straying outside isolation limits and touching something they believe is isolated
- By 2019, the amount of 25kV AC electrified railway in the UK to increase by 35% therefore it is highly likely that the safety level may reduce without intervention rather than be maintained or improved
- New electrification schemes need to be “safe by design” in accordance with CDM:
  - PAN83 – Elimination of Residual Electrical Hazards
  - POL83 – Electrical Safety Principles for New Electrification

WORKING




Dead or Alive?

EAW(1989) Reg 14 – Live Working

Regulation 14
No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless– *(a) it is unreasonable in all the circumstances for it to be dead; and* *(b) it is reasonable in all the circumstances for him to be at work on or near it while it is live; and* *(c) suitable precautions (including where necessary the provision of suitable protec-tive equipment) are taken to prevent injury.*

- Is there a need for the system to be live?
- Two conditions to satisfy:
  - Reasonable to be live
  - Unreasonable to be dead
- A case can be made for rapid response / faulting, however for planned maintenance activities…?

Electrical Isolations – Time Taken

	Activity	Avg. Duration
1	Last train transits clear of possession/BTET area	6.5 mins
2	Signaller protects possession area and grants signal protection to PICOP	6.5 mins
3	PICOP arranges physical protection and grants possession	10.5 mins
4	ES demarcates worksite, allowing other staff to enter	4 mins
5	Signaller protects isolation area and grants signal protection to Electrical Control Operator (ECO)	27 mins
6	Electrical Controller de-energises OLE and grants Form B to Nominated Person	5.5 mins
7	Nominated Person earths OLE, briefs and issues Form C to workers	23.5 mins
8	Working Opportunity Begins	

Total Average Time = 83.5 mins

Future Isolations – The Intention

	Activity	Avg. Duration
1	Last train transits clear of possession/BTET area	6.5 mins
2	Isolation limits are aligned with possession limits Signaller issues BTET to ECO before protecting possession area and grants signal protection to PICOP	6.5 mins
3	PICOP arranges physical protection and grants possession while Electrical Controller de-energises OLE and grants Form B to Nominated Person who locks off CMEs CMEs are located lineside in a position of safety	10.5 mins
4	ES demarcates worksite, allowing other staff to enter	4 mins
5	Nominated Person applies any local earths to the OLE, briefs and issues Form C to workers	23.5 mins
6	Working Opportunity Begins	

Total Time = 51 mins

Which scenario is safer?...

Scenario A	Scenario B
▸ 3 hour access window available	▸ 3 hour access window available
▸ It takes 80 minutes to apply Form C Permit to Work & possession	▸ It takes 30 minutes to take possession and apply Limitation of Access Controls
▸ It takes 60 minutes to hand back possession and permit	▸ It takes 30 minutes to hand back possession and LOAC
▸ 40 minute working opportunity is useless therefore decision taken to carry out risk assessment and work adjacent to live equipment	▸ 2 hour working window now available
▸ Work does not require contact with OLE, but involves RRVs with height restrictors	▸ Work does not require contact with OLE, but involves RRVs with height restrictors
	▸ **Which scenario is safer?!?**

States of OLE

Live	Switched Off	Confirmed Switch off	Circuit Main Earths Applied & Secured	Manually Earthed
System Energised	ECO open Circuit Breakers	Live line test undertaken	CME activated by ECO then checked and locked by Nominated Person	Local Earth applied 0.4 or 3.2km
25kV Live & Dangerous	Assumed 25kV as not proven	Voltage not <60V but not 25kV	"Charged but not live"	Voltage confirmed "Dead"
No permits, work only if reasonable under EAWR 14	Emergency instruction "Approach but not touch"	~~*EAWR 8&13 protection against inadvertent energisation is absent*~~	"Limitation of Access" controls deployed for a specific, low-risk, task that does not involve work on or near the OLE	Permit to Work on equipment issued to competent person

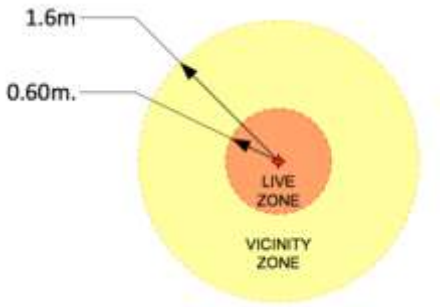
Least Preferred Working Method

Most Preferred Working Method

Conductor states

State	Definition		To be treated as
Live	The item in question is at a voltage as a result of being connected to the normal source of electricity supply.		Live
Charged, but not Live	An item that is not Live but has acquired a charge by means such as static or induction charging, or has retained or regained a charge due to capacitance effects even though it may be disconnected from the rest of the system.		Live
Dead	A conductor that is neither Live nor Charged and danger is prevented while work is carried out.		Dead

Live Zone and Vicinity Zone

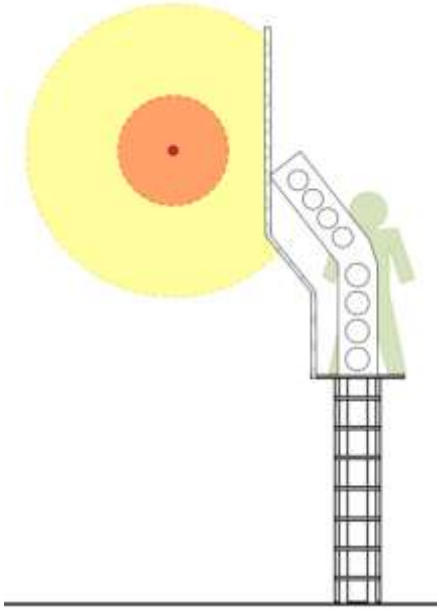


Live Zone: The space around **Live** parts in which the insulation level to prevent electrical danger is not assured when reaching into or entering it without protective measures. (BS EN 50110 2013)

Vicinity Zone: The limited space outside the **Live Zone,** where specific precautions are taken to avoid encroaching into the **Live Zone**. (BS EN 50110 2013)

Conductor zones	25 kV a.c.
Live Zone (D_L)	600 mm
Vicinity Zone (D_V)	1600 mm

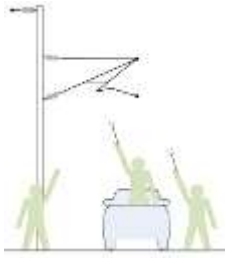
Dimensions are given in air and relative to the nearest **Live** part and derived from BS EN standards.



The extent of the **Vicinity Zone** can be modified through the use of **Barriers**. Where a barrier is used for this purpose, specific requirements apply in relation to permitted clearances and mesh size. (BS EN 50122:2011)

Categories of work

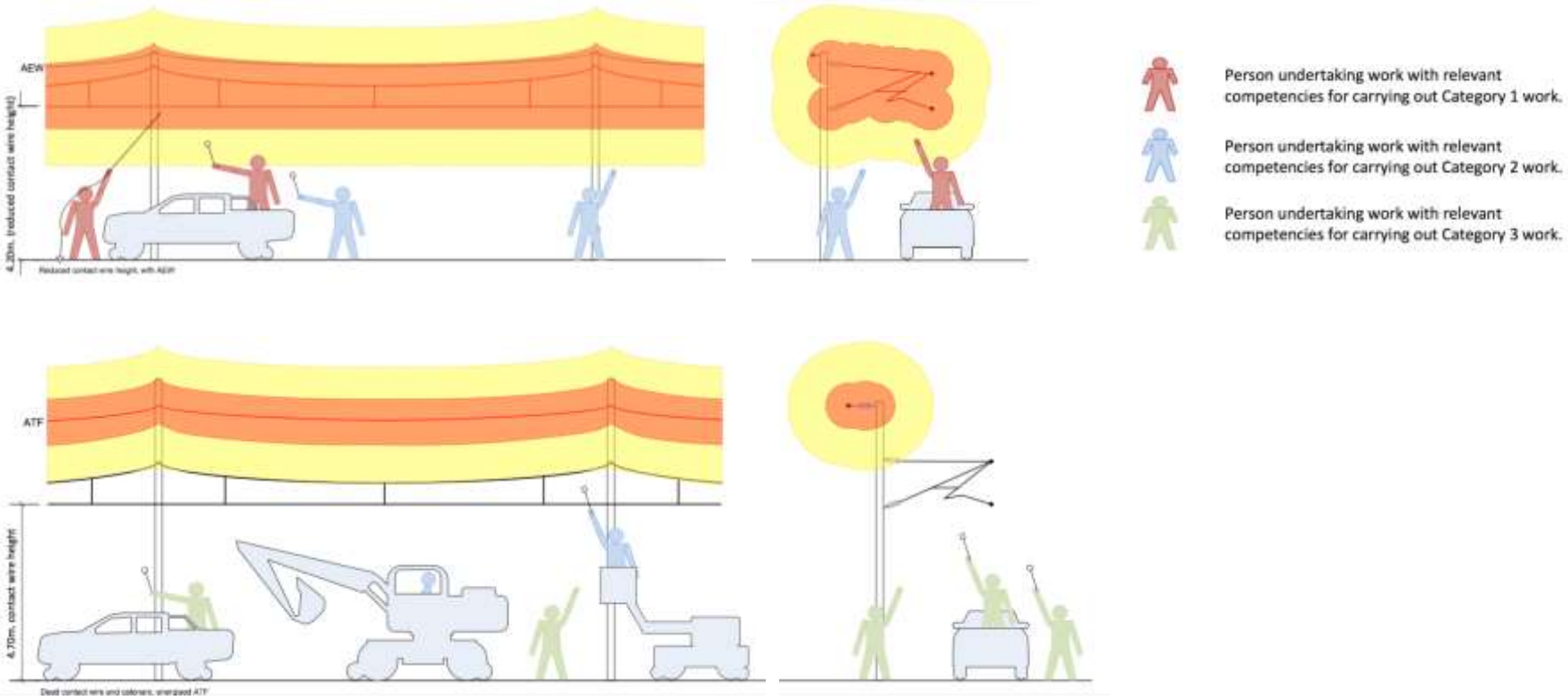
All work on Network Rail traction power systems shall be subject to a risk assessment to determine the appropriate category of work. The category is defined after the application of any proposed safety measures.

Category 3 (Dead working)	Work that does not require or present the risk of parts of the body or tools, equipment and devices entering the Vicinity Zone.		• SSOW • Permit*
Category 2 (Working Near Live or Charged Parts)	Work that does not require, but presents the risk of, parts of the body or tools, equipment and devices entering the Vicinity Zone.		• SSOW • Permit* • Limitation of Access Certificate
Category 1 (Working in the Vicinity Zone of Live or Charged Parts, or Live Working)	Work that does require parts of the body or tools, equipment and devices to enter the Vicinity Zone. This shall include activities requiring tools and equipment to enter the Live Zone, such as testing and the application of earths.		• SSOW • Permit* • Limitation of Access Certificate

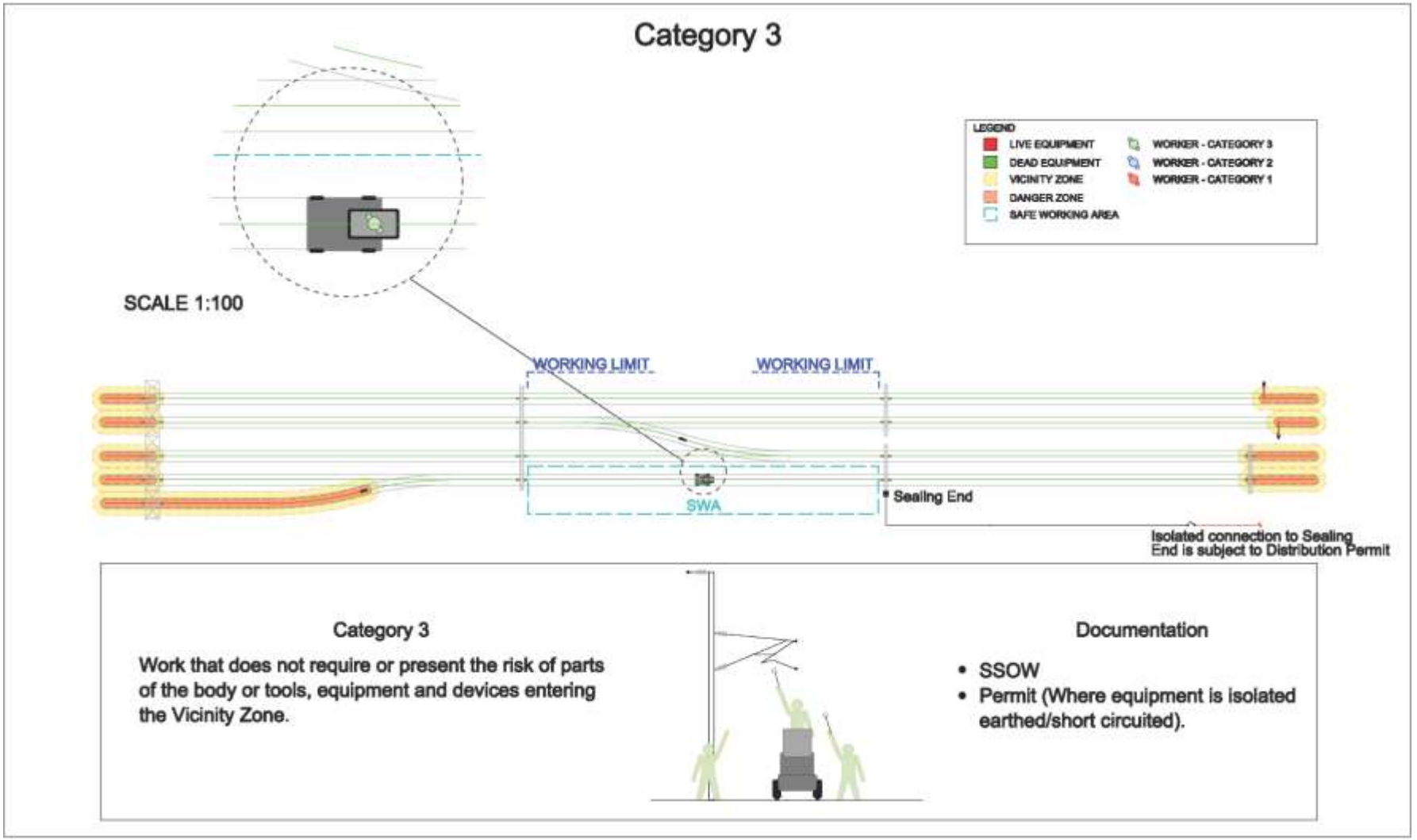
* Where equipment is isolated earthed/short circuited

Categories of work

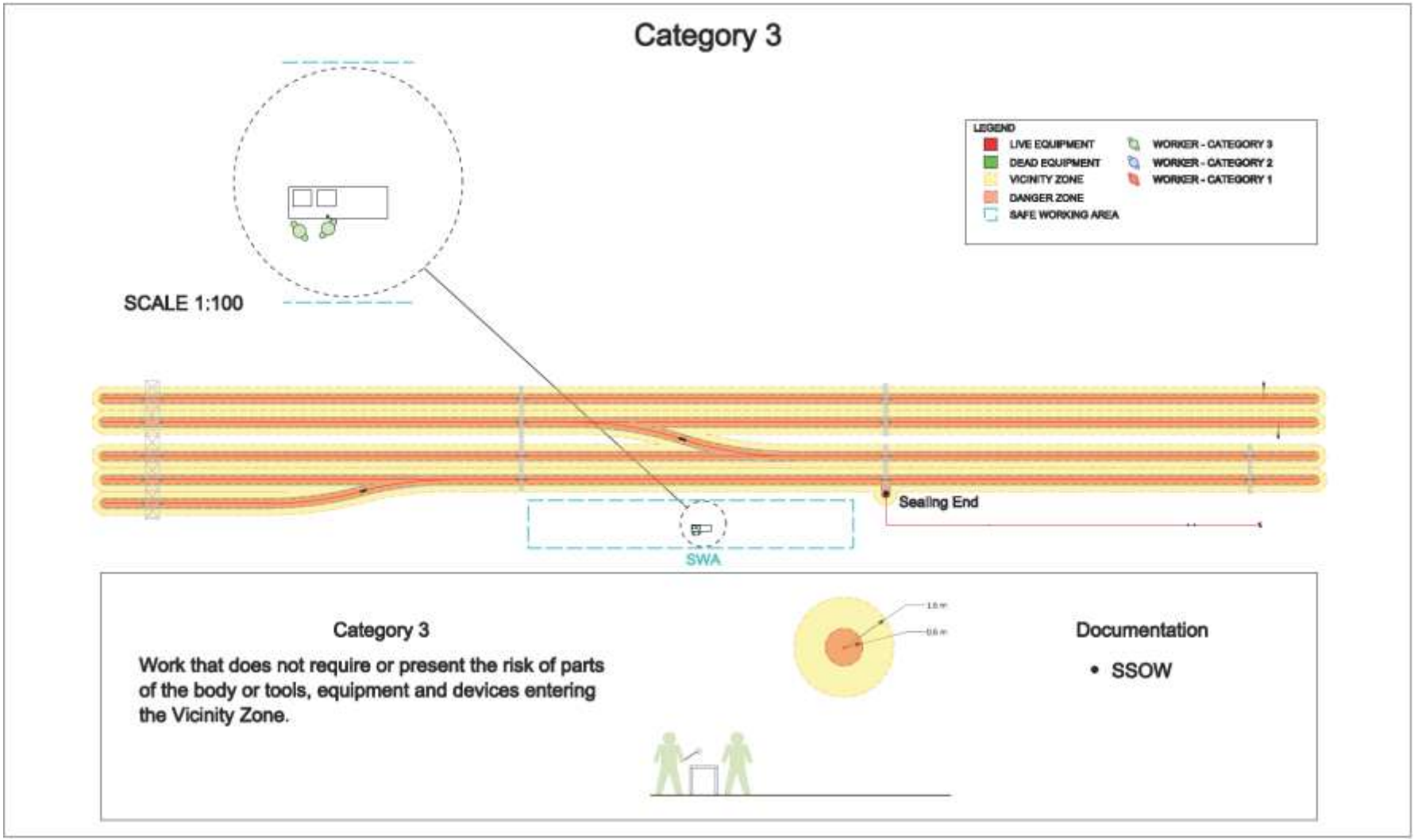
The following simplified sketches illustrate the categories of work for 25 kV a.c. electrification traction power systems:



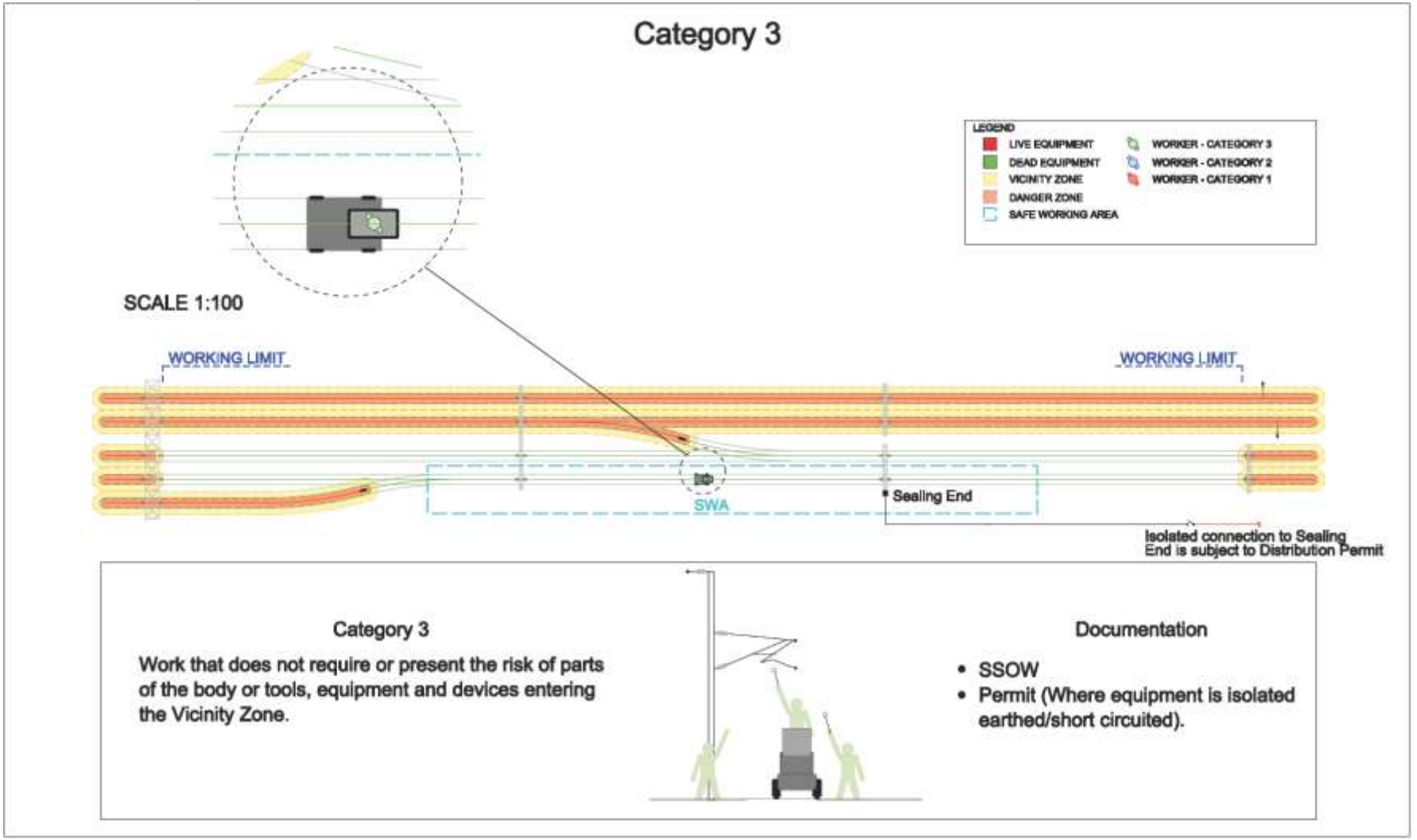
Category 3 work – example 1 (the ‘gold standard’)



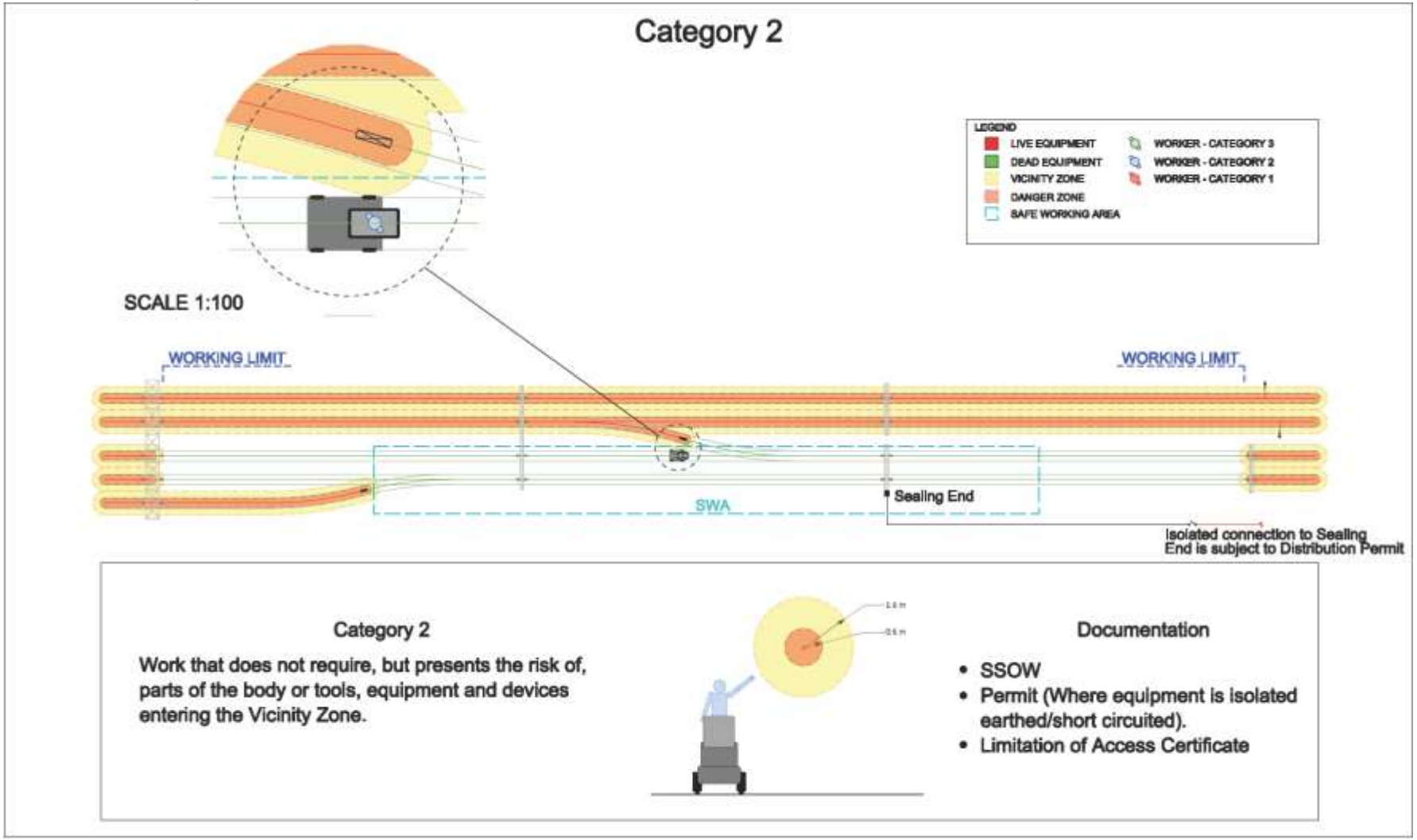
Category 3 work – example



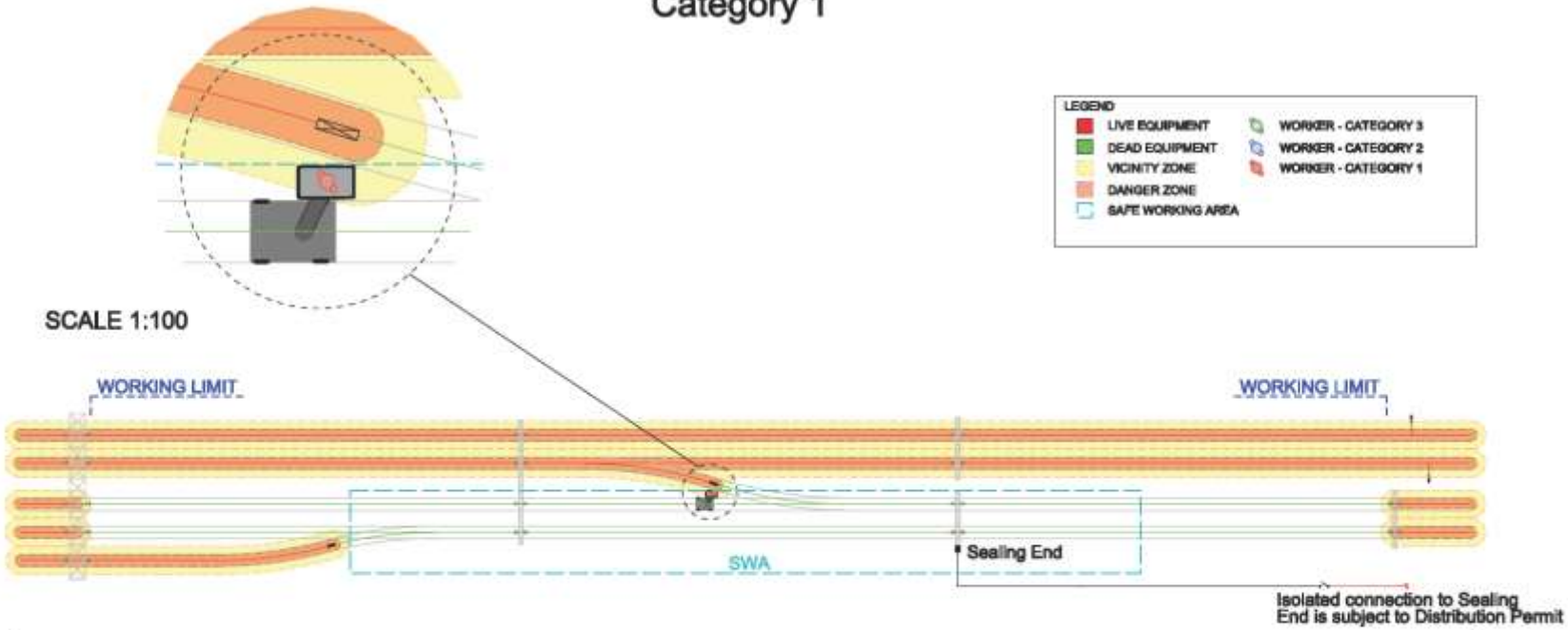
Category 3 work – example



Category 2 work – example

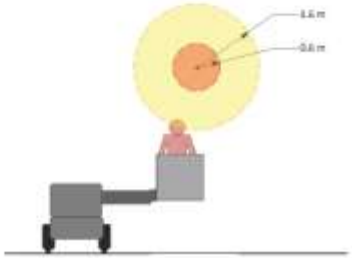


Category 1 work – example (least preferred)



Category 1

Work that does require parts of the body or tools, equipment and devices to enter the Vicinity Zone. This shall include activities requiring tools and equipment to enter the Live Zone, such as testing and the application of earths.



Documentation

- SSOW
- Permit (Where equipment is isolated earthed/short circuited).
- Limitation of Access Certificate

So, to conclude…

Summary

- 1960s vs 2010s – What has changed?
  - Nothing and Everything!
- “New EU Standards”
  - Railway Interoperability Regulations
  - Common Safety Method for Risk Evaluation & Assessment
- Electrical clearances from bridges and station platforms
  - Need to determine, at GRIP 3, what is “reasonably practicable”
  - The wires on EGIP are, for the most part, in the right place…
- Role of the ORR as National Safety Authority under RIR
  - Regulator wishes to see compliance with UK Legislation!
  - Complying with standards does not mean you comply with the law!
  - The role of the Professional Engineer is to manage risk!

    - recognise and understand the intent behind standards and codes, and understand when their limits are being approached

Summary

- Managing “Reasonable and Foreseeable” risks
  - Consider the railway as a system!
  - Electrification schemes are no longer just about putting wires up
- Isolation and Earthing
  - Design the system to eliminate residual hazards and optimise maintenance (both of which are CDM anyway!)
  - Overview of new Green Book Version 5
- Working Practices
  - If you can isolate, you should – it is safest!

- Also, I haven't mentioned wires for about 50 minutes now!!

Thank you!

Electrifying Scotland in the 21st Century

Presentation to IMechE Railway Division – Scottish Centre

19th January 2017

Brian Sweeney
BEng(Hons) MSc CEng MIET
Senior Project Engineer, Electrification
Network Rail, IPSNE