



SCOTLAND'S RAILWAY
BETTER IN THE MAKING

MODERNISING CARSTAIRS JUNCTION

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Systems Engineer with Capital Delivery

Carstairs Project Signalling CRE & Signalling Project Engineer for Delivery

AMIRSE

PWI Presentation on Modernising Carstairs Junction

- Introduction
- History of previous projects
- Development of final layout
- Access Challenges
- Construction Challenges



Introduction



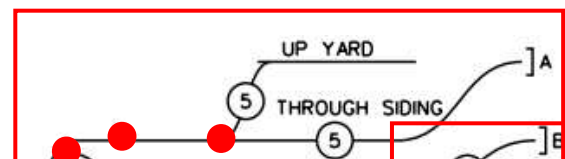
Carstairs Junction
WCML



Carstairs Station

A diagram of a 2-to-1 multiplexer. It has two inputs: 'c' and '15'. The output is '15'. A red dot is placed on the input line for 'c'.

-
- A diagram showing a horizontal curve. A red vertical line on the left indicates the start of the curve. A circular speed limit sign with the number '30' is positioned above the road. The text 'CARSTAIRS CURVE' is written below the road line.

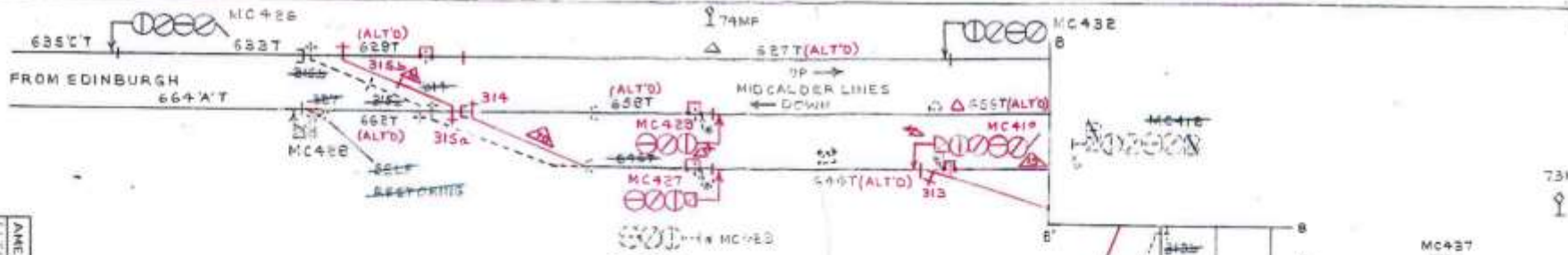


Previous Projects

1970's

WCML Electrification and colour light signalling

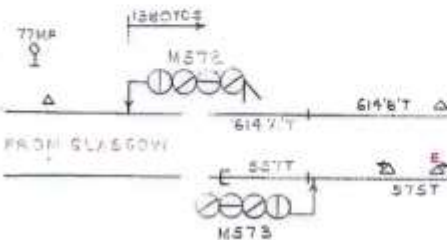
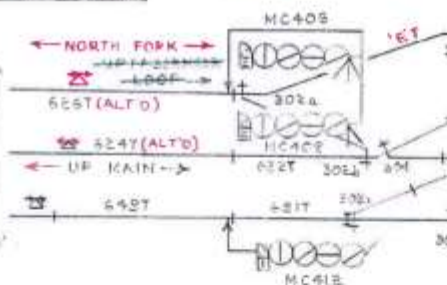




NOTES
PANEL ALTERATIONS RE:
MOTHERWELL S.C. & CARES
MINIMUM STANDAGE BET:
MC405 & MC425 TO BE

CHRSTHINS NORTH CURVE

1004 YDS
TO MC434



NEW WORK SHOWN RED
REMOVE WORK SHOWN GREEN
OR DOTTED

1991												1992													
JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR.	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV			
SCHEME PLAN APPROVED			PANEL DROPS																						
			END MAY. - RUST PANEL.																						
			100% + AUGMENTARY EST																						
PREPARE DESIGN DRAWINGS (R. ROOM) (36 WEEKS)												CHECK	ISSUE	R/R.		TESTING									
PREPARE LOCATION DRAWINGS								CHECK	ISSUE	SUPPLY LOCS.		INSTAL LOCS.		TESTING		LOC. CABLE BREAKING, RE.									
			PANEL ALTERATIONS																						
			T.C. BONDING																						
			MATERIAL LIST TO SITE																						
SITE(S)			SIGHT SIGNALS																						
			WT.		SITE																				
												ORDER MATERIAL & DELIVERY													
												INSTAL EXTERNAL EQUIP.													
												RELAY ROOM / MOTHERWELLS C INSTALLATION													

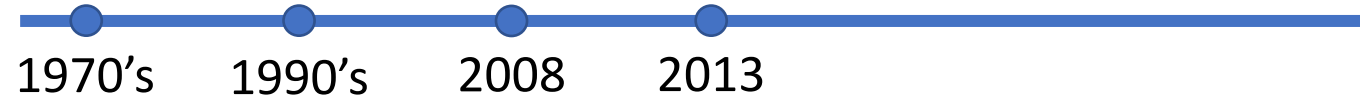
Previous Projects



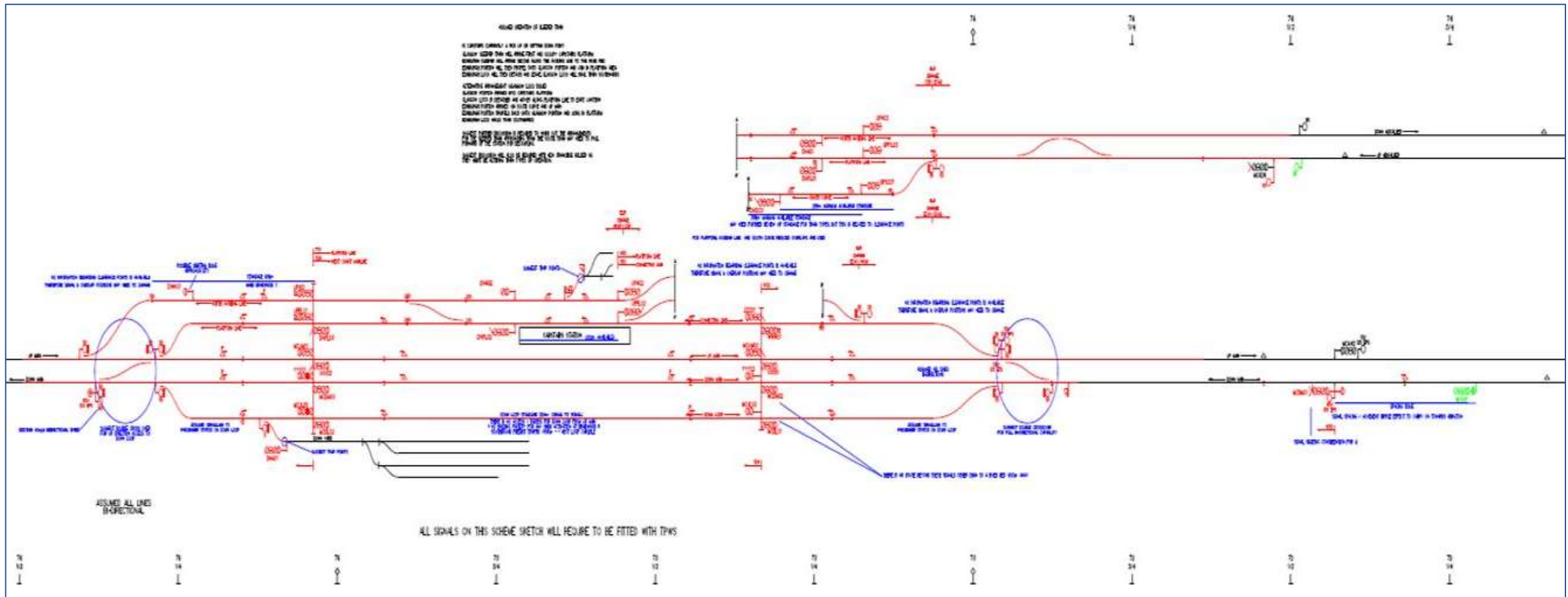
West Coast Route Modernisation – Carstairs Junction wasn't upgraded



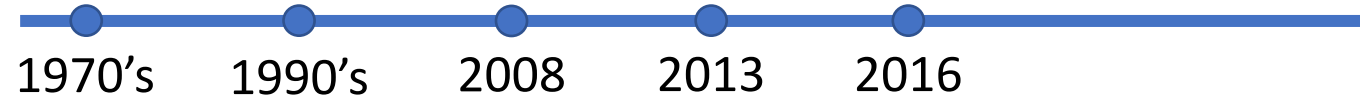
Previous Projects



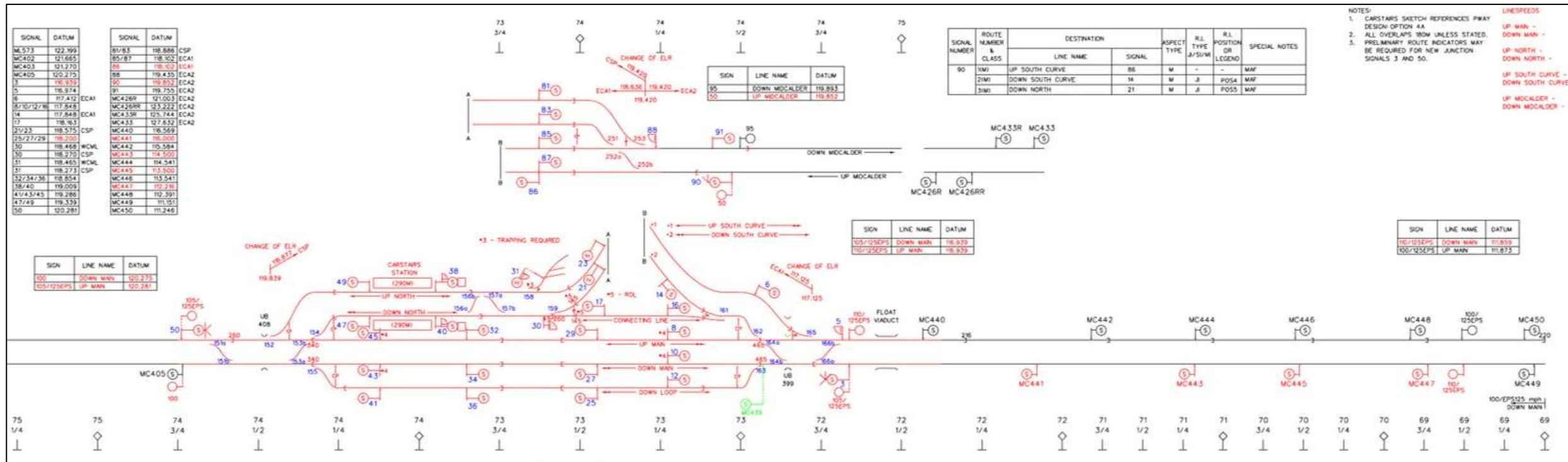
Carstairs track renewal project didn't go ahead



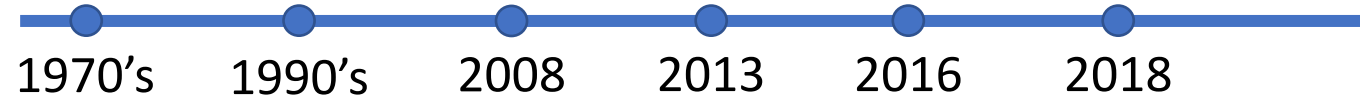
Previous Projects



£350M Carstairs Remodelling Project didn't get funding



Previous Projects



What's next?

- Plain lined points since 2015
- 50 mph TSR's on Up and Down WCML
- CRT issues
- Broken rails
- Dip in track reports
- 311/312 points - B Switches on timber sleepers with tight radius



Carstairs track renewals couldn't wait for another project

New Layout Restrictions



North Embankment

Station, Overbridge and Road

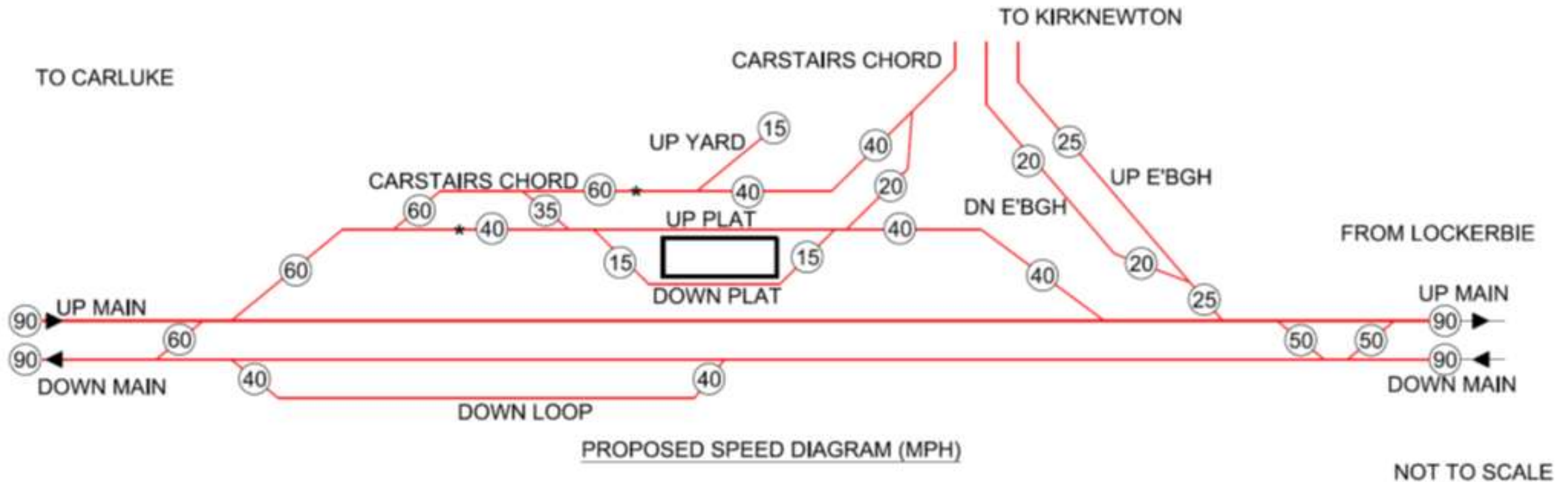
Strawfrank
Road Bridge

Track option for development

- WCML now avoiding Carstairs Station
- New Carstairs Chord Line from Up Loop
- New Down Loop moved North
- Single lead junctions
- 90mph linespeed on WCML
- 25mph – 20mph turnout to Edinburgh

Constraints

- Effective WCML linespeed decrease
- No EPS provision
- Restrictive layout at Station
- 25mph turnout means restrictive signalling controls
- Double crossover at South not required
- No facility for Caledonian Sleeper loco stabling



Early Stakeholder Engagement



Development of Initial Track Option

Down Loop with 775m standage

Double North Junction

New Engine Line (For Sleeper Loco)

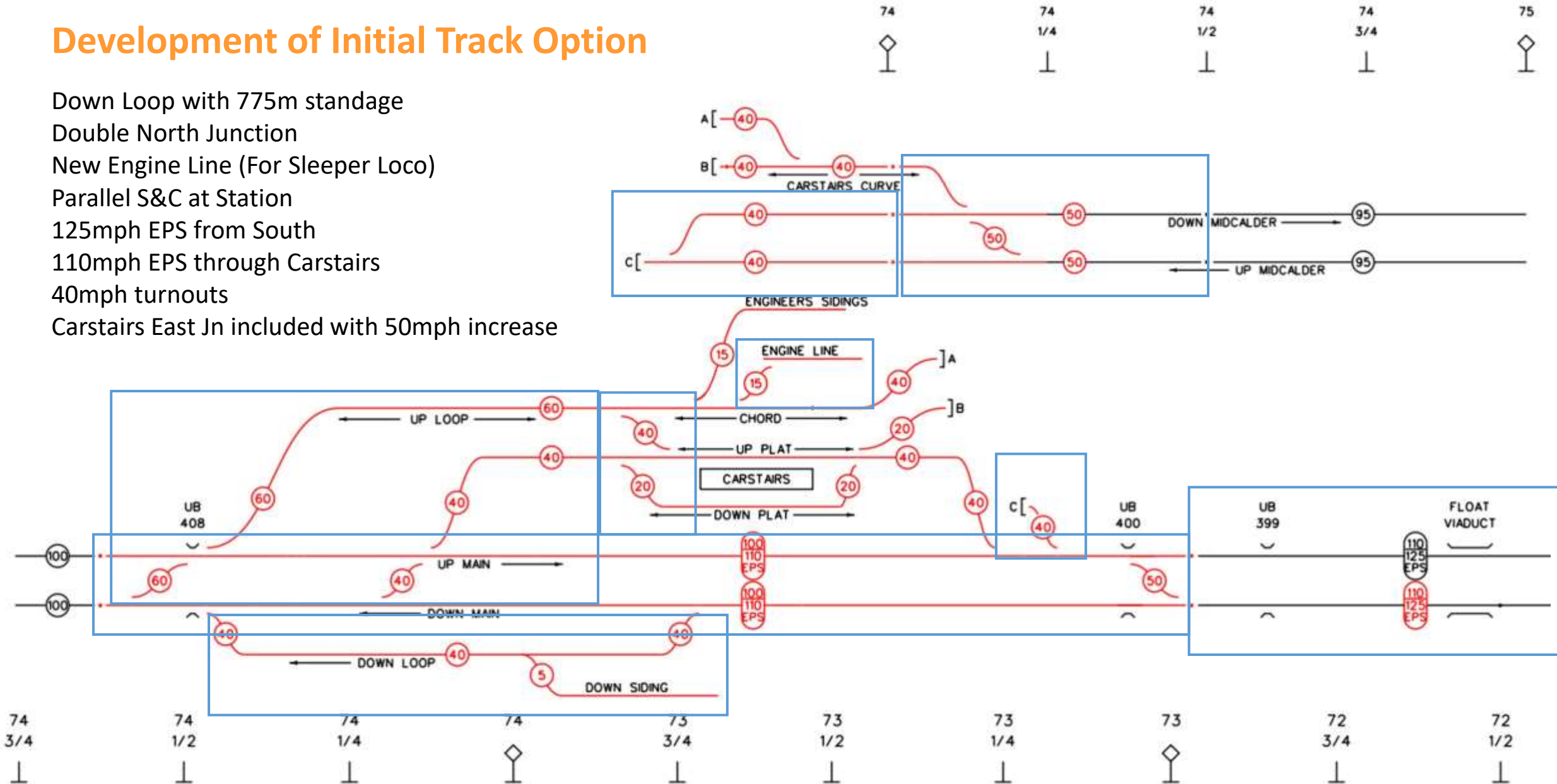
Parallel S&C at Station

125mph EPS from South

110mph EPS through Carstairs

40mph turnouts

Carstairs East Jn included with 50mph increase



Design and Delivery Teams



Signalling Collaborative Partnership
Signalling Design & Construction



NRDD
Signalling Scheme
Design



Principal Contractor
BIM, Track, OLE, Civils Design
Track & Civils Construction



One Team Approach

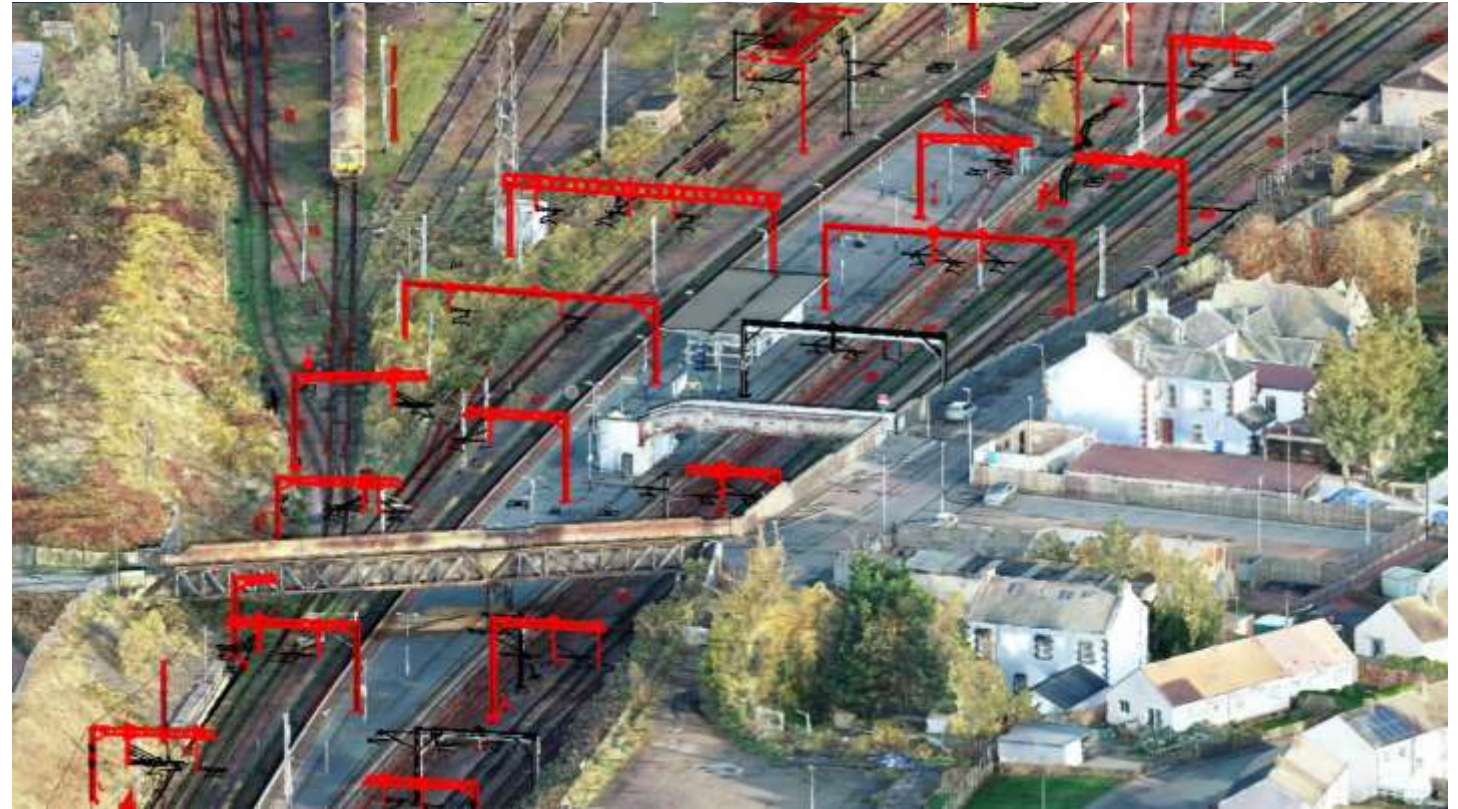


Overhead Line Construction

Modelling

Building Information Model

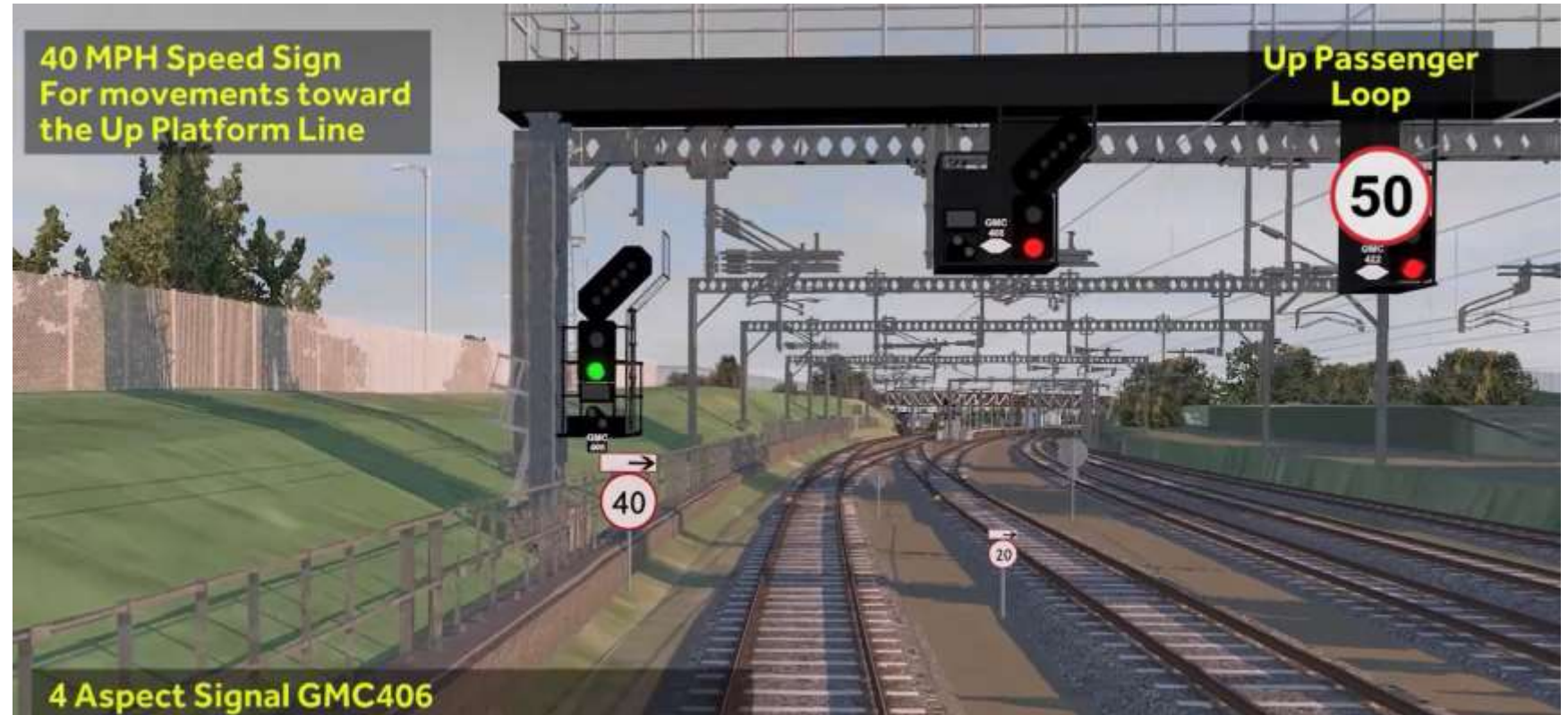
- Gathering of survey data
- Integration of design models
- Digital IDC's between design teams
- Clash detection
- Visual modelling for stakeholders
- Construction Staging



Modelling

Signal Sighting Model

- Integration of Track and OLE models
- Rendering of landscape, buildings and structures
- Driver Training Material



Modelling

Capacity analysis and timetable modelling of new layout

- 2-3 minute journey time improvement
- Avanti might get their 4 hours London – Glasgow!

Class 66 + 1400t SRTs		
Section	Existing Layout	New Layout
Abington - Auchengray	25.5	23.5
Auchengray - Abington	25	23
Lanark Jn - Auchengray	16	13.5
Auchengray - Lanark Jn	13	10

Class 390 SRTs		
Section	Existing Layout	New Layout
Abington - Auchengray	15.5	13.5
Auchengray - Abington	15	13
Lanark Jn - Auchengray	11	7.5
Auchengray - Lanark Jn	9.5	7.5

Access Strategy

The new layout was planned to be commissioned in a multi-stage strategy

- Starting in 2021
- Weekly track stages – WCML Access Weeks 1-10
- Extended engineering access on bank holidays
- Final commissioning May 2023
- Cost £30M over budget

Year 3 - 2021/22						
Access	Week	Stage	Track	Sig	OLE	Civils
66	1	East Junction				
41 (28)	2	Pull and weld on 314/315, Civils work on Down Main, OLE work around station				
41	3	Ballast work on 314/315, Civils work on Down and Up Main, OLE work around East Jct				
41 (28)	4	Civils work on Down and Up main, OLE work around East Jct				
68	5	OLE work at North Jct and around station				
41 (28)	6	Civils work on Down and Up main, OLE work around station				
41 (28)	7	Civils work on Down and Up main, OLE work around station				
41 (28)	8	OLE work at North Jct and around station				
68	9	Civils work on Down and Up main, OLE work around station				
41 (28)	10	Civils work on Down and Up main, OLE work around station				
11 (ENDTR)	Week 11-13	Track: A Sig: OLE: Civils				
9 (KOTR)	Week 14-17	Track: B + C Sig: OLE: Civils				
11 (ENDTR)	Week 28-31	Track: Sig: OLE: Civils				
29hrs	Week 29 (Down white period)	All discipline prep work				
29hrs	Week 40 (Down white period)	All discipline prep work				
11 (ENDTR)	Week 41-51	All discipline prep work				

Year 4 - 2022/23									
Access	Week	Stage	Movable Stage?	Predecessor	Successor	Track	Signalling	OLE	
54	32	OLE	Yes	None	D				
54	1	D	Yes but must be before stage F	OLE wiring	E				
54	2	E	Yes but must be before stage M		F				
76	3	F	Yes		G				
54	4	G	Yes but must be before stage M		H				
54	5	H	Yes	D	I				
54	6	I	Yes Must be before Xmas		None				
54	7	Track Contingency							
54	8	J	Yes Must be before Xmas	OLE wiring	None				
76	9	K	Yes Must be before stage K	A	P				
27	10	OLE/Sig							
27	11	OLE/Sig							
27	12	L	Yes but must be before stage Xmas	Civils work	None				
KOTR	31-38	M	Yes		None				
9 days	39-40	None	Yes	B	I				
KOTR	31-52	N	Yes	None	L				

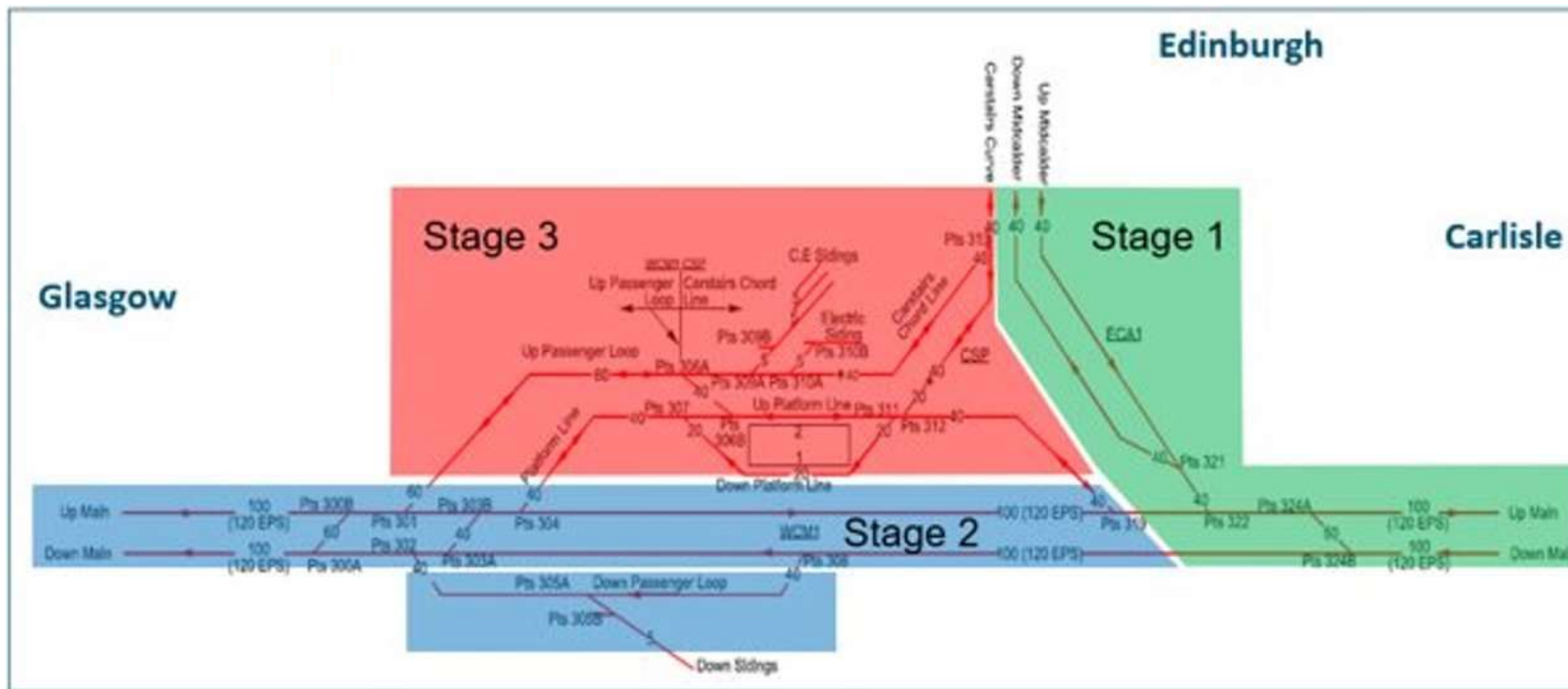
Year 5 - 2023/24									
Access	Week	Stage	Movable Stage?	Predecessor	Successor	Track	Signalling	OLE	
54	1	D	Yes, Any time before Final Commission	None	S				
76	2	F	Yes	None	G				
54	3	G	Yes, Any time before Final Commission	F	S				
54	4	H	Yes can be done anytime after Xmas	None	I				
76	5	I	Yes but must be after stage H	None	P				
54	6	J	Yes, any time	None	None				
54	7	K	Yes, any time	None	N/A				
54	8	L	Yes, any time	F	S				
76	9	OLE/Sig or Track Contingency							
27	10	OLE/Sig or Track Contingency							
27	11	OLE/Sig							
27	12	Trackwork							

Access Strategy

The Carstairs Project was challenged to a “big bang” Commissioning

Stakeholders agreed to a 88 Day Blockade Strategy

- Stage 1: Midcalder Lines – Day 17
- Stage 2: WCML & Midcalder Lines – Day 52
- Stage 3: All Lines & Station – Day 88



Benefits

- Minimised abortive works
- De-risked weekly stage strategy
- Could be delivered to budget
- Mid-week open to traffic after each stage
- No temporary signals or routes
- One set of Driver and Signaller training
- All signalling data and testing to final

Challenges

- Enabling programme
- Resource planning
- New Programme integration
- Plant hire
- Engineering train paths

		Day -3		Day -2		Day -1		Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Day 8		Day 9		Day 10		Day 11		Day 12		Day 13		Day 14		Day 15		Day 16		Day 17		Day 18		Day 19		Day 20		Day 21		Day 22		Day 23		Day 24		Day 25		Day 26		Day 27		Day 28		Day 29		Day 30		Day 31		Day 32		Day 33		Day 34		Day 35		Day 36		Day 37		Day 38		Day 39		Day 40		Day 41		Day 42		Day 43		Day 44		Day 45		Day 46		Day 47		Day 48		Day 49		Day 50		Day 51		Day 52		Day 53		Day 54		Day 55		Day 56		Day 57		Day 58		Day 59		Day 60		Day 61		Day 62		Day 63		Day 64		Day 65		Day 66		Day 67		Day 68		Day 69		Day 70		Day 71		Day 72		Day 73		Day 74		Day 75		Day 76		Day 77		Day 78		Day 79		Day 80		Day 81		Day 82		Day 83		Day 84		Day 85		Day 86		Day 87		Day 88		Day 89		Day 90		Day 91		Day 92		Day 93		Day 94		Day 95		Day 96																																																																																																																											
Strategy	Date	01/03/2023	02/03/2023	03/03/2023	04/03/2023	05/03/2023	06/03/2023	07/03/2023	08/03/2023	09/03/2023	10/03/2023	11/03/2023	12/03/2023	13/03/2023	14/03/2023	15/03/2023	16/03/2023	17/03/2023	18/03/2023	19/03/2023	20/03/2023	21/03/2023	22/03/2023	23/03/2023	24/03/2023	25/03/2023	26/03/2023	27/03/2023	28/03/2023	29/03/2023	30/03/2023	31/03/2023	01/04/2023	02/04/2023	03/04/2023	04/04/2023	05/04/2023	06/04/2023	07/04/2023	08/04/2023	09/04/2023	10/04/2023	11/04/2023	12/04/2023	13/04/2023	14/04/2023	15/04/2023	16/04/2023	17/04/2023	18/04/2023	19/04/2023	20/04/2023	21/04/2023	22/04/2023	23/04/2023	24/04/2023	25/04/2023	26/04/2023	27/04/2023	28/04/2023	29/04/2023	30/04/2023	01/05/2023	02/05/2023	03/05/2023	04/05/2023	05/05/2023	06/05/2023	07/05/2023	08/05/2023	09/05/2023	10/05/2023	11/05/2023	12/05/2023	13/05/2023	14/05/2023	15/05/2023	16/05/2023	17/05/2023	18/05/2023	19/05/2023	20/05/2023	21/05/2023	22/05/2023	23/05/2023	24/05/2023	25/05/2023	26/05/2023	27/05/2023	28/05/2023	29/05/2023	30/05/2023	31/05/2023	01/06/2023	02/06/2023	03/06/2023	04/06/2023	05/06/2023	06/06/2023	07/06/2023	08/06/2023	09/06/2023	10/06/2023	11/06/2023	12/06/2023	13/06/2023	14/06/2023	15/06/2023	16/06/2023	17/06/2023	18/06/2023	19/06/2023	20/06/2023	21/06/2023	22/06/2023	23/06/2023	24/06/2023	25/06/2023	26/06/2023	27/06/2023	28/06/2023	29/06/2023	30/06/2023																																																																																																																																																																																																						
Strategy Revision	All lines open	Stage 1 - 16 days All Lines Blocked																Stage 2 - South Junction to Midcalders open Other line closed for construction of WCML Up & Down and Down Passenger Loop																All																Wk 4 54hr Pwly																Wk 5 54hr pwly																Wk 6 54hr OLE																Wk 7 54hr OLE																Wk 8 54hr OLE																Wk 9 - 60hr May BH (Sig only)																All Lines Open																Wk 10 30 Tamp																All Lines Open																																																																																																																																															
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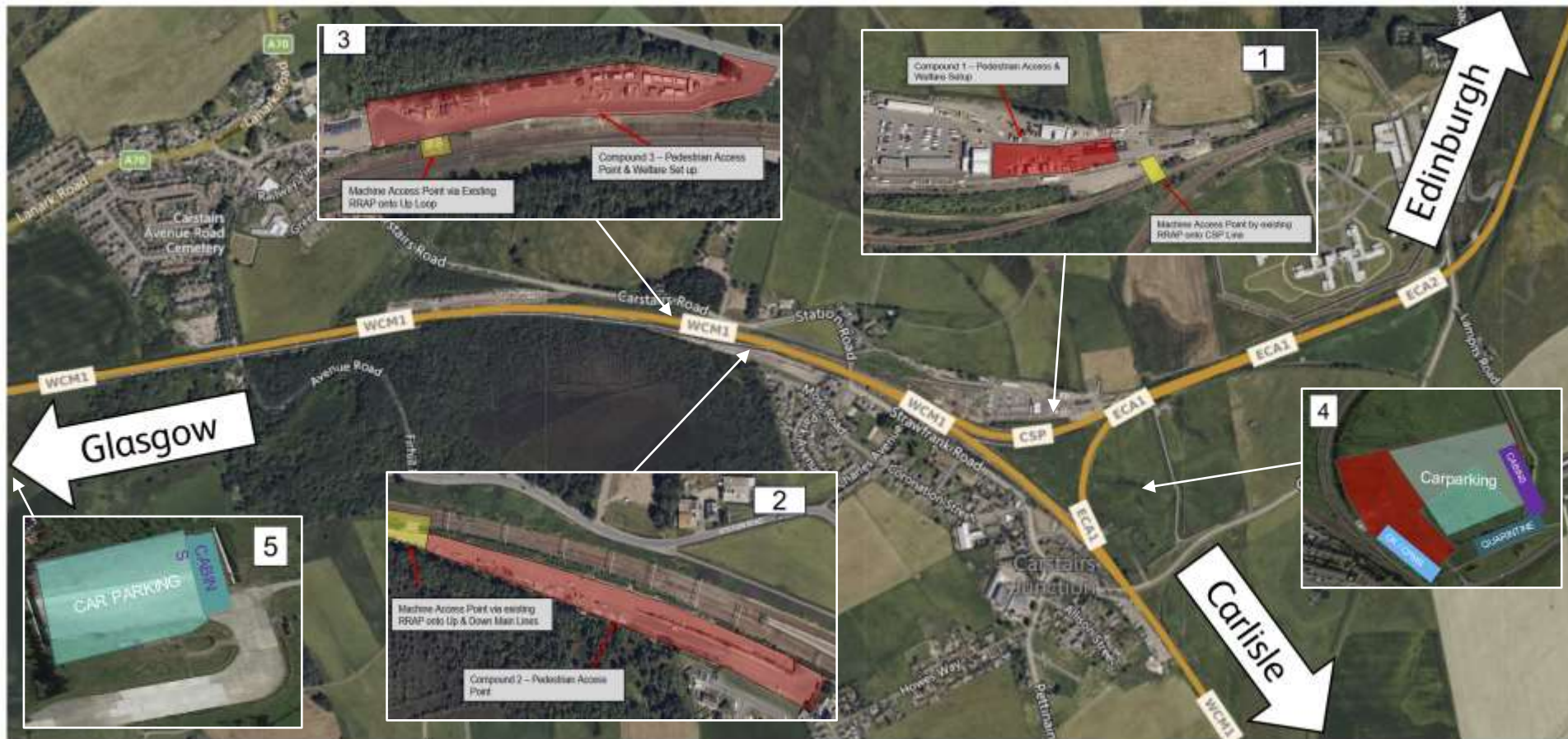
Construction Challenges – Access to Carstairs Junction

- 20mph single lane and tight bend through village
- Narrow access through UB6
- Pettinain Road Bridge closed from South



Construction Challenges – Compounds

- Three Compound areas were set up in 2021 for enabling works
- Compounds 4 and 5 were added for main blockade
- Compound 5 at Ravenstruther Yard was sign in point with site buses to transport staff to other compounds



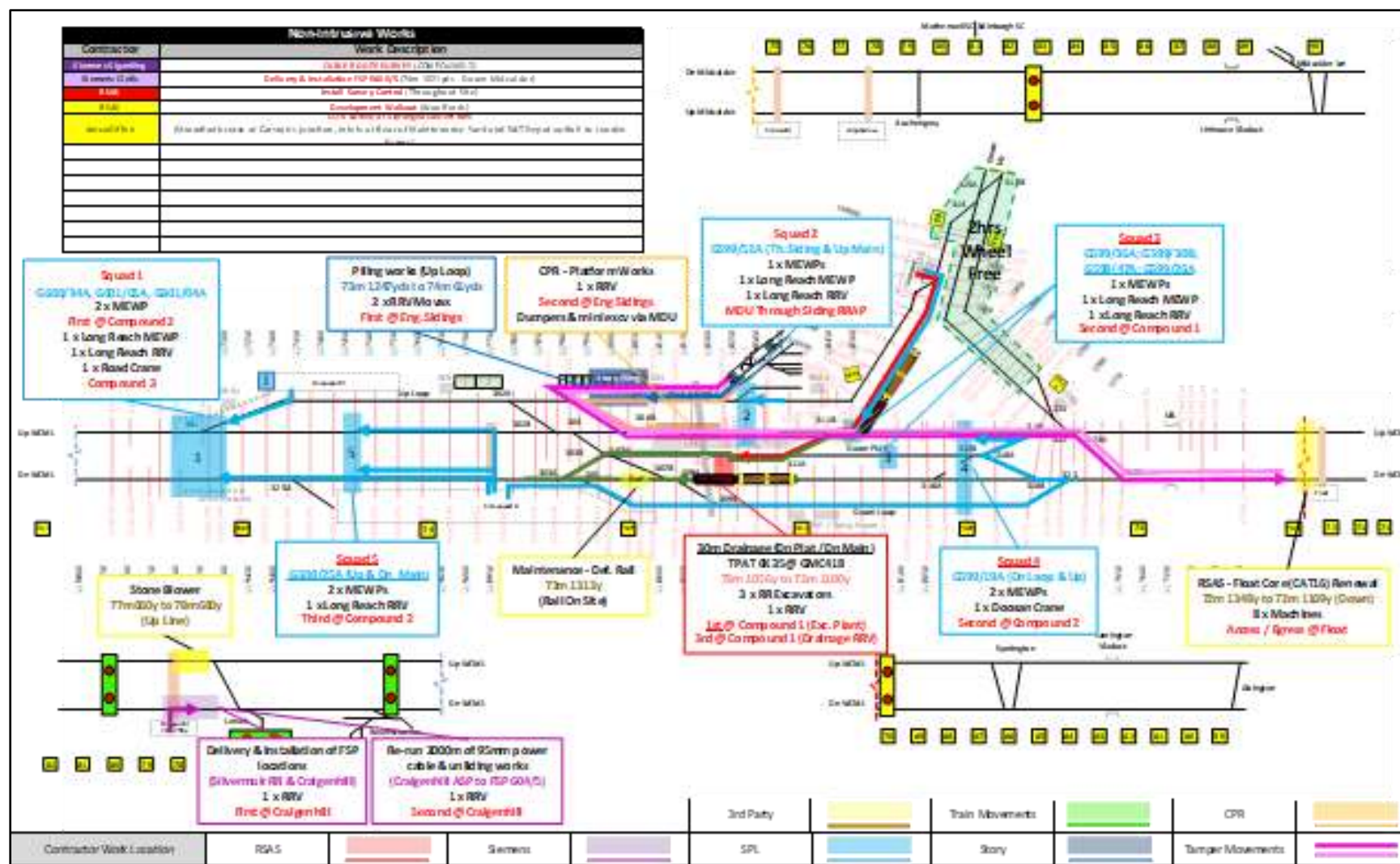
Construction Challenges – Enabling

Ahead of the final blockade, Carstairs was built on Saturday nights starting in 2020.

- Number of Possessions a Week = 1
- Possession Time = approx. 520mins
- Isolation Time = approx. 345mins
- Number of Earths = 120
- Average No. of personnel on Site = approx. 160
- Average number of C/C's = 33
- Average number of COSS's = 55
- Average No. of On Track Plant = 26 -30



Example of weekly integration plans



Construction Challenges – 314/315 Points

Carstairs East Jn added into project scope

S&C renewed in Week 9 2021 as part of early enabling works

First set of Mark 3 Hy-Drives installed



Construction Challenges – Signalling Enabling

6 new REB's delivered to site

New Siemens Westlock WTS Interlocking



Construction Challenges – OLE Enabling

New OLE layout built on top of operational railway in Saturday nights ROTR access.

Project Totals:

- 192 Piled Foundations
- 144 Existing Overhead Line Structure Removed
- 135 New Overhead Line structures Installed
- 17km of Existing Overhead Line Wire Removed
- 23km of New Overhead Line Wire Installed
- 22 New OLE Switches installed

Down Main January 2023



Construction Challenges – Blockade

After more than 2 years of enabling works, the final 88 Day Blockade started in March 2023



Construction Challenges – Contaminated ballast

Known contaminated ballast in the area

Additional surveys were carried out in 2022 that found higher than expected levels

Engineering trains were originally planned for Millerhill, but due to the expected levels of contaminated ballast, they had to be routed to Kingsmoor

Blockade programme and signalling test plans had to be re-worked



Construction Challenges – Managing Engineering Trains

Total of 119 Engineering Trains in Blockade

Removing 55,000 tones of spoil from existing trackbed

Installed 43,600 tonnes of new ballast

Delivering new plain line and S&C panels



Construction Challenges – Theft

750m of contact wire was stolen south of Carstairs during Stage 1

Wider Carstairs area was under isolation

Engineering trains were routed from Down to Up WCML



Construction Challenges – Track bed

Peat and clay were identified in the track bed investigations

But during excavation works it was found to be worse than expected



Up and Down WCML

Construction Challenges – Track bed

This required more excavation and backfilling with granular materials
To achieve level required for geocell layers



Construction Challenges – Drainage

Drainage was a huge challenge in construction due to the amount of earthworks disturbed

Unknown culvert through station was damaged

2km of track drainage was installed



Construction Challenges – Drainage

The signalling cable route was in the Down Cess.
This needed recovered for the new Down Loop and the new cable route on the Up Cess



Construction Challenges – Civils

Widening the north embankment

The track support zone needed to be widened for the new layout



Construction Challenges – Civils

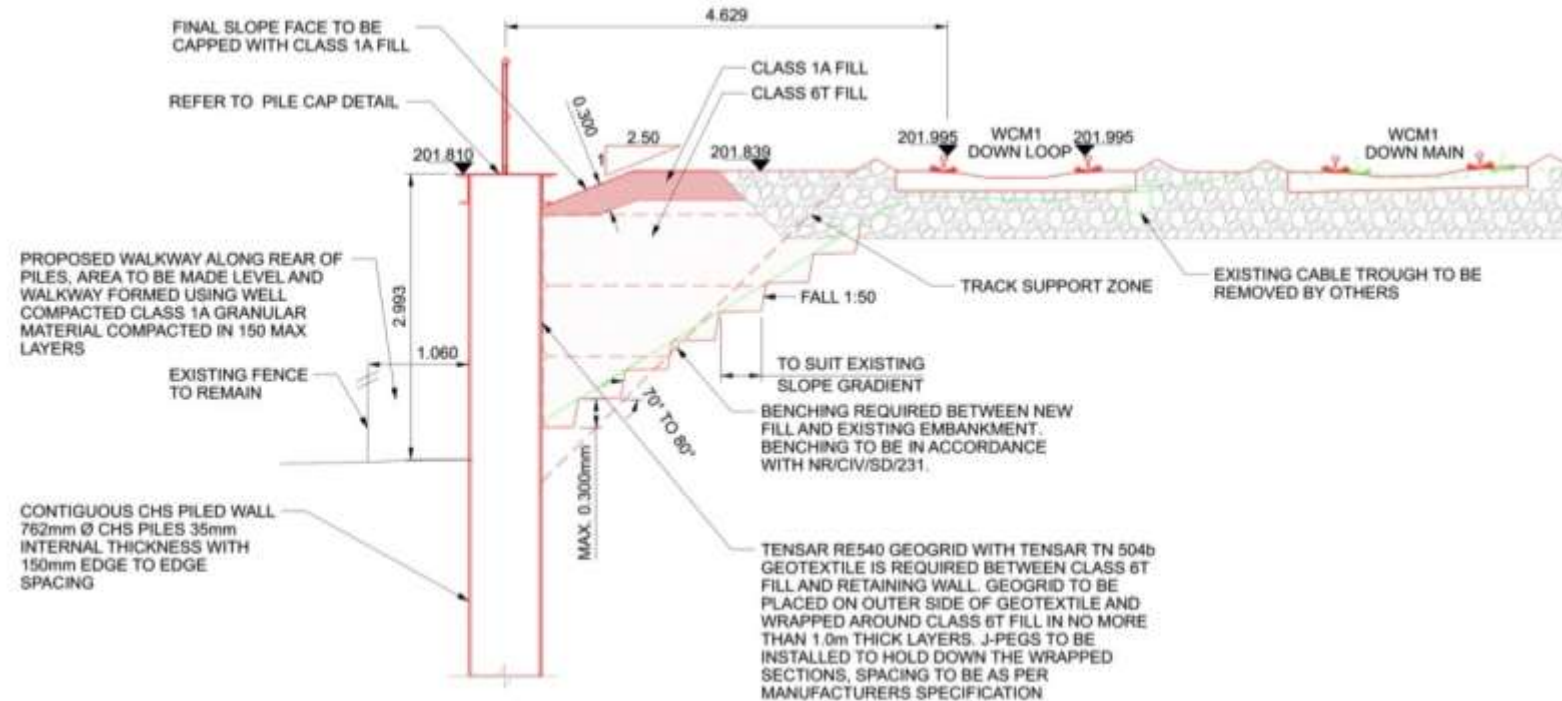
Widening the north embankment

The new track bed needed

supported with piles

Down cess – 103 x 912mm piles

Up cess – 62 x 912mm piles



PILING SCHEDULE

DETAIL	UPLINE / DOWNLINE	CHAINAGE FROM	TO	NUMBER OF PILES REQUIRED	PILE SPACING CENTRE TO CENTRE (mm)	PILE TYPE	PILE INTERNAL THICKNESS (mm)	PILE HEAD LEVEL (m AOD)	TOTAL PILE LENGTH (m)	MAXIMUM PERMANENT RETAINED HEIGHT (m)
1	UPLINE	117096	117120	27	912	762mm DIA. CHS	35	199.748	14	2.0
2	UPLINE	117120	117147	30	912	762mm DIA. CHS	35	200.027	14	2.0
3	UPLINE	117162	117167	5	912	762mm DIA. CHS	35	200.322	16.5	2.3
4	DOWNLINE	119475	119495	20	912	762mm DIA. CHS	35	201.607	16	3.0
5	DOWNLINE	119495	119516	24	912	762mm DIA. CHS	35	201.800	16	3.0
6	DOWNLINE	119516	119520	4	912	762mm DIA. CHS	35	201.319	16	3.0
7	DOWNLINE	119520	119532	12	912	762mm DIA. CHS	35	200.887	16	3.0
8	DOWNLINE	119532	119550	20	912	762mm DIA. CHS	35	200.683	16	3.0
9	DOWNLINE	119563	119585	23	912	762mm DIA. CHS	35	200.028	14	2.0

Construction Challenges – Civils

Widening the north embankment

Up Cess



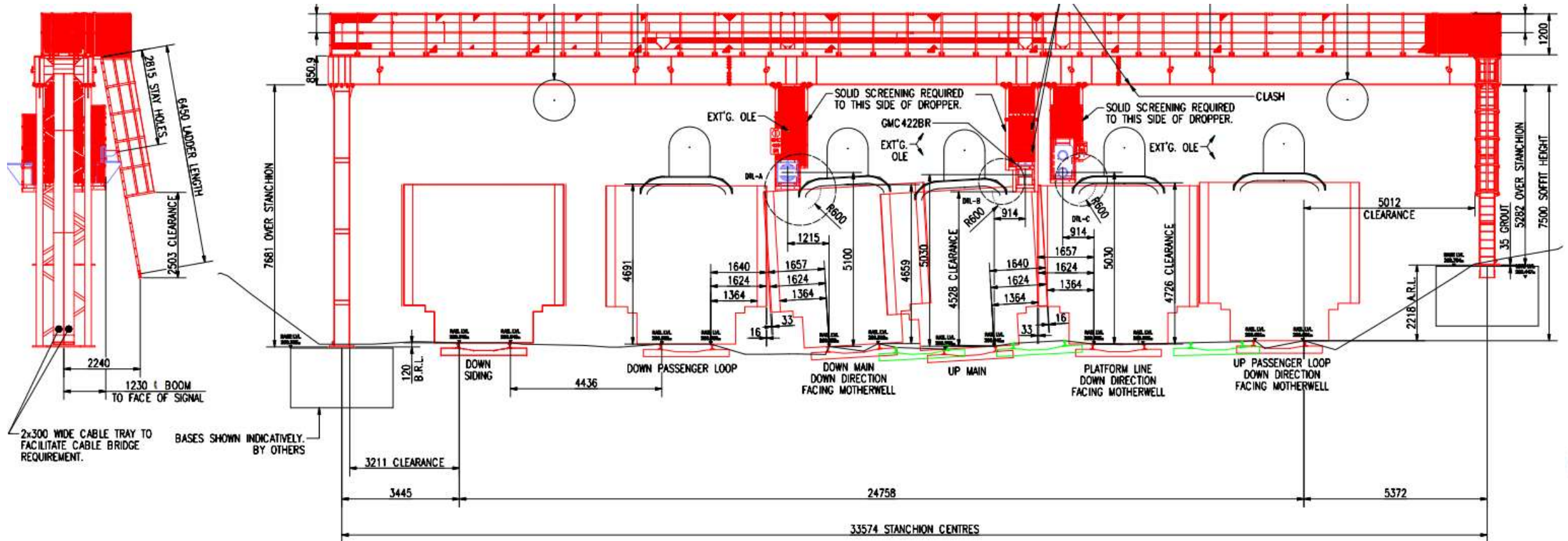
Down Cess



Construction Challenges – Signal Gantries

Two signal gantries were required for cable routing and for new signals

- Gantry GMC401 – 34m wide
- Crosses 6 tracks



Construction Challenges – Signal Gantries

Late design meant Signal Gantry piles were installed late in the final blockade
Blockade Stage 2 opening of Down Sidings was delayed to Stage 3



Construction Challenges – Signal Gantries

Gantry booms assembled on site

New hall road for crane needed constructed



Construction Challenges – Signalling OTX

Planned UTX to feed
Up/Down WCML through
Chord/Platform lines

But couldn't be installed
due to track staging

Arcadis and SPL designed
and installed a structure
for cable route



Construction Challenges – Signalling Technology

Vortok AWS



**TASS
Eurobalise**



**LOD(T)
Lockouts**



**iLS
Integrated
Lightweight Signals**



**with assisted
trunnion lift**



**Siemens
Westrace Trackside System**



Construction Challenges – Signalling

Project Totals:

- 90km of recovered signalling cables
- 76km of new signalling cables
- 37 recovered signal structures
- 42 new signals
- 75 lineside cabinets recovered
- 78 new lineside cabinets
- 14 new DNO installations



Construction Challenges – E&P

New PSP to power Carstairs for dual end fed 650V Class II Feeders

Conventional crane could not get to PSP location

Modular crane was used which was delivered in parts

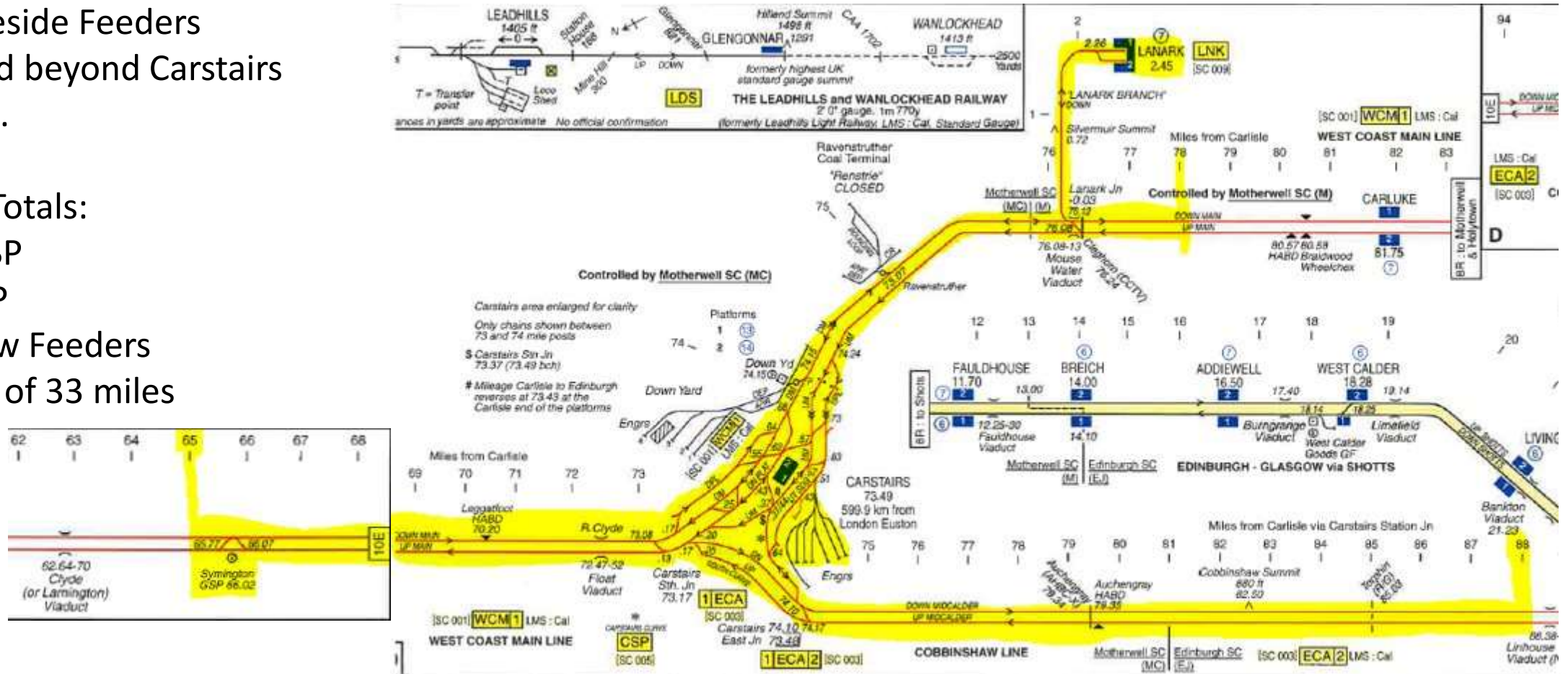


Construction Challenges – E&P

E&P Lineside Feeders extended beyond Carstairs Junction.

Project Totals:

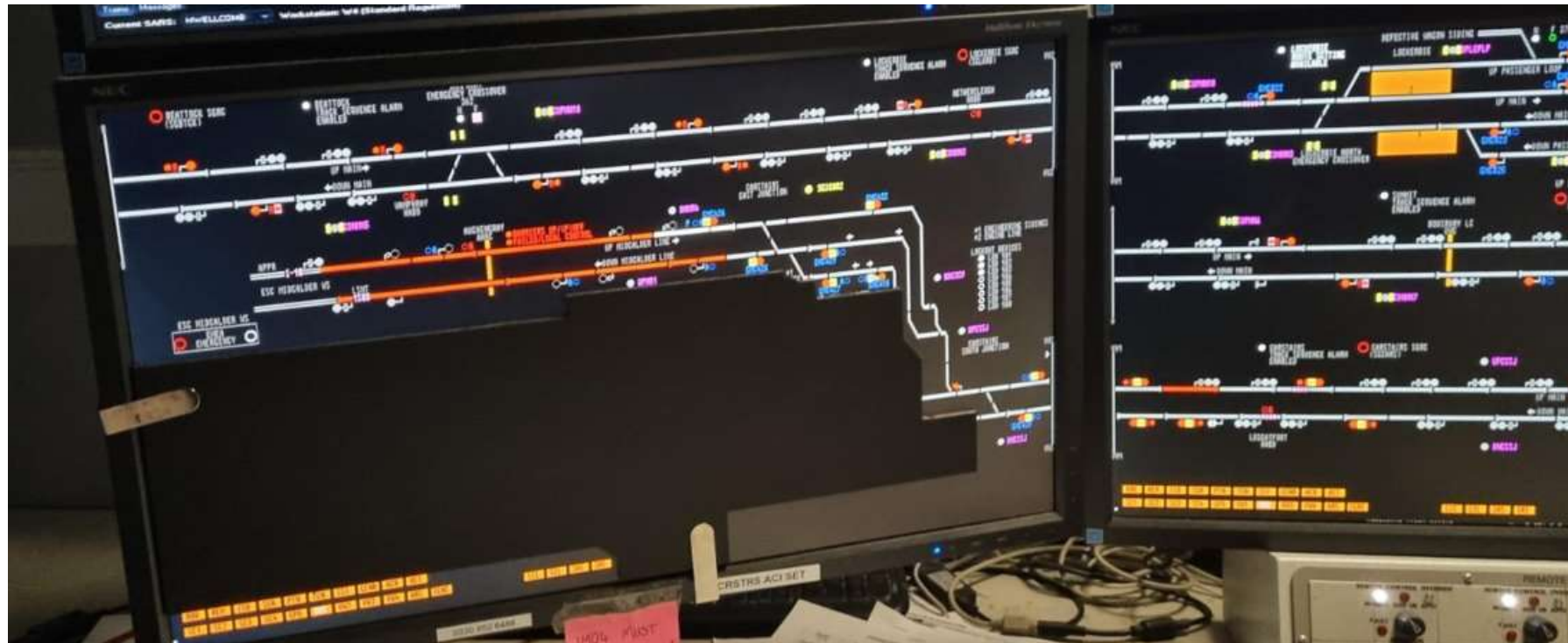
- 85 FSP
- 6 ASP
- 6 New Feeders
- Total of 33 miles



Construction Challenges – Stages open to traffic

At the end of Stage 1 the WCML – Midcalder Lines was open to traffic

Our agreed solution to manage the out of correspondence indications with West of Scotland Signalling Centre



Construction Challenges – Stages open to traffic

In Stages 2 and 3, routes were open to traffic midweek

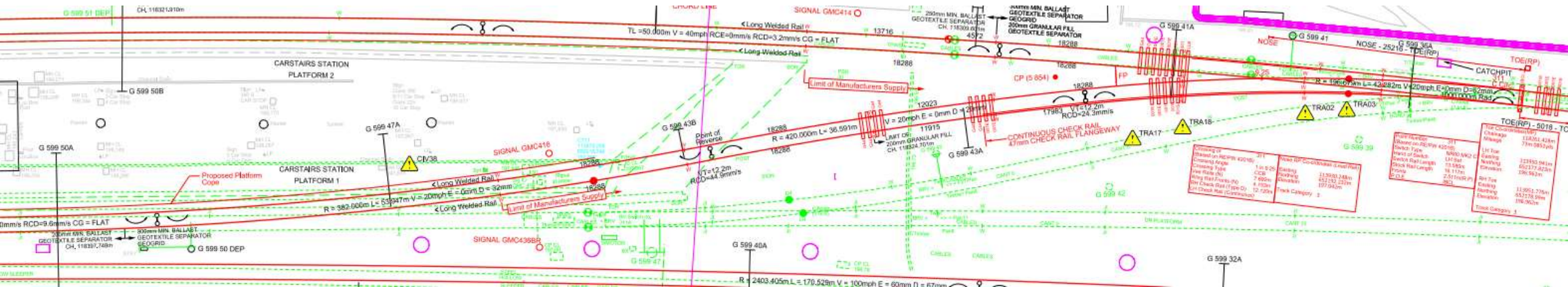
Vortok fencing installed along the open lines



Construction Challenges – Station Platform

Carstairs Station is 300m long

South end of Carstairs Station needed tapered for new 311 points track alignment



Construction Challenges – Station Platform

Re-coping to the new track geometry

Platform ramps removed



Construction Challenges – Station Platform

Maintained operation platform lengths

Platform resurfaced new access stairs installed



First Train at Carstairs

First Scotrail service at Carstairs Station after 88 days

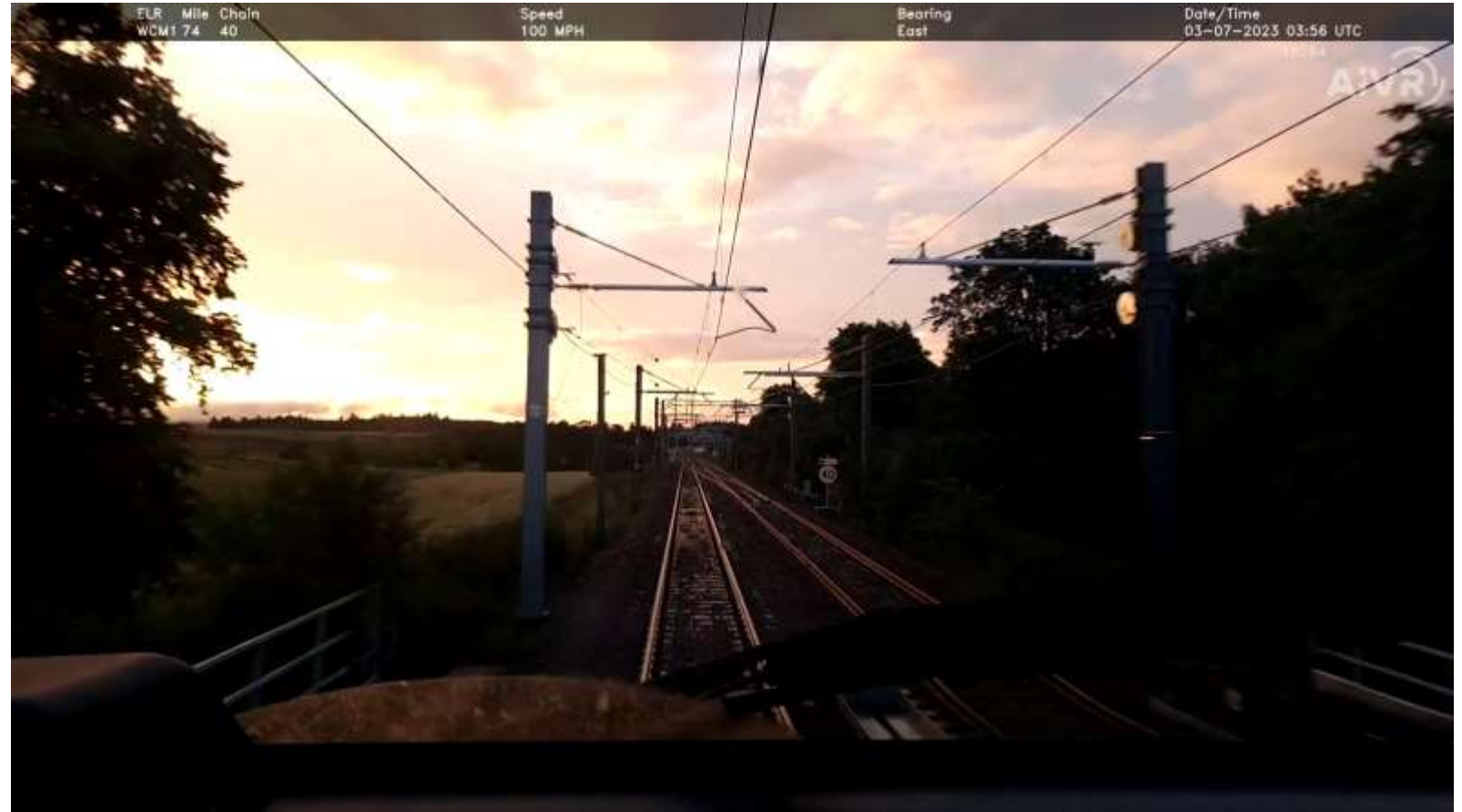


Carstairs after the TSR's

Avanti Pendolino on the new Up WCML above 100mph

Project Totals:

- 28 new S&C
- 10km of plain line
- 30.5km of geotextiles
- Including 11.5km of Geocell
- 11,800 new sleepers
- 123 new IRJ's
- 753 welds
- 119 Engineering Trains
- 43,600 tonnes of new ballast
- 12,500 tonnes of sand & Type 1
- 51 Tamping Shifts



Thanks for listening!