

Series 1 Structures

Why so **Large**?

Rob Daffern

March 2024

Furrer+Frey
Overhead contact lines



Agenda

- + Quick recap
- + Remit and priorities
- + Distractions
- + Case study: Monoboom
- + Case study: TTC
- + Case Study: SSA
- + Allocation
- + State of mind / Perception / Reality
- + 2024 usage
- + Lessons
- + Questions

Rob Daffern

MEng MIMechE MPWI

- + 23 years in Rail
- + Balfour Beatty
- + Network Rail Mtce
- + Network Rail projects
- + Furrer+Frey

Assumptions:

Audience know basics of OLE “competent”

Audience are broadly familiar with Series 1 / GWEP

This is my **Personal** experience and opinion

Many educated estimates (not hard figures).

Don't share what I say here unless you are “competent” to understand it properly!

GWEP Priority ~2012

- + New fleet of trains. Mostly EMU (some Bi Modes)
 - + Paddington to Swansea in service by 2017
 - + High Output Plant construction
-
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 - + High Output Plant construction
-
- + Paddington to Swansea in service by 2017
 - + High Output Plant construction
 - + Cost
 - + Other things that seem important now with hindsight

GWEP Overheads

- + ~1,200 office staff (£5m a week = £2k minute)

- + Priority = Speed

(Steel was approx. £700 a tonne*)

- + £ ~ 3 tonnes a minute of steel in design/management

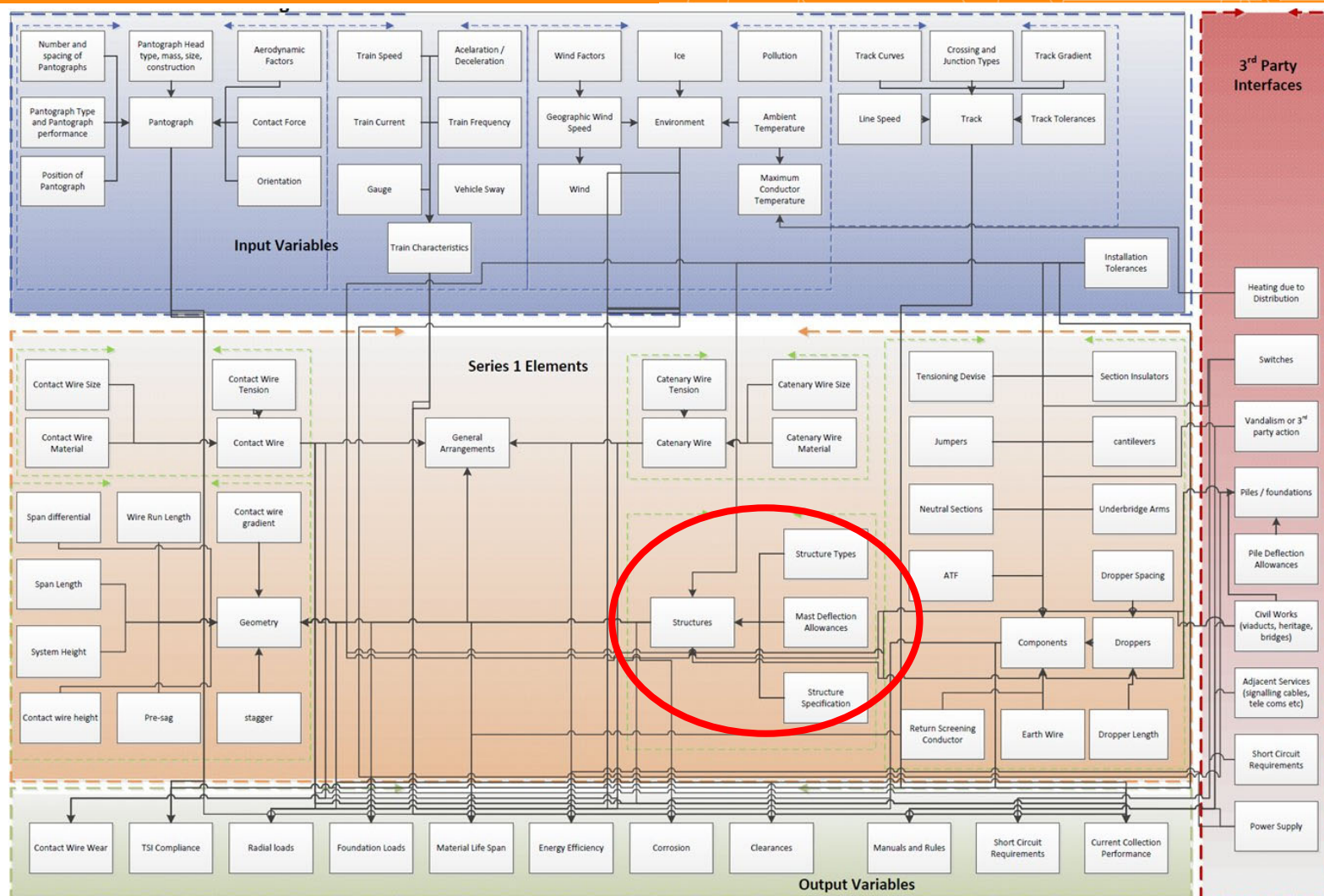
- + *ONS Jan 2024.

Series 1: Remit ~ 2012

- + 140mph multi pantograph
- + ATF and EW
- + Step change reliability improvement
- + TSI compliance / Interoperable
- + Improved safety
- + Reduced maintenance / 120yr structure life
- + “High output” construction
- + “High output” design
- + Mechanically independent wire runs (no tail wires)
- + Safety by design: Mechanised on site. Assembled off site
- + Modularisation of procurement / assemblies (*one size fits all*)

Distractions

- + System Design WIP
- + Allocation Design WIP



Distractions = Early Unknowns

“Get the piles in the ground”

+ Linespeed

Tension / Wire size / System height / Overspeed = **LOADS**

+ GL/RT1210

Wire heights/ Level crossings = **HEIGHTS**

+ Windspeed (Pre Civ 072 073, Pre Pan 97)

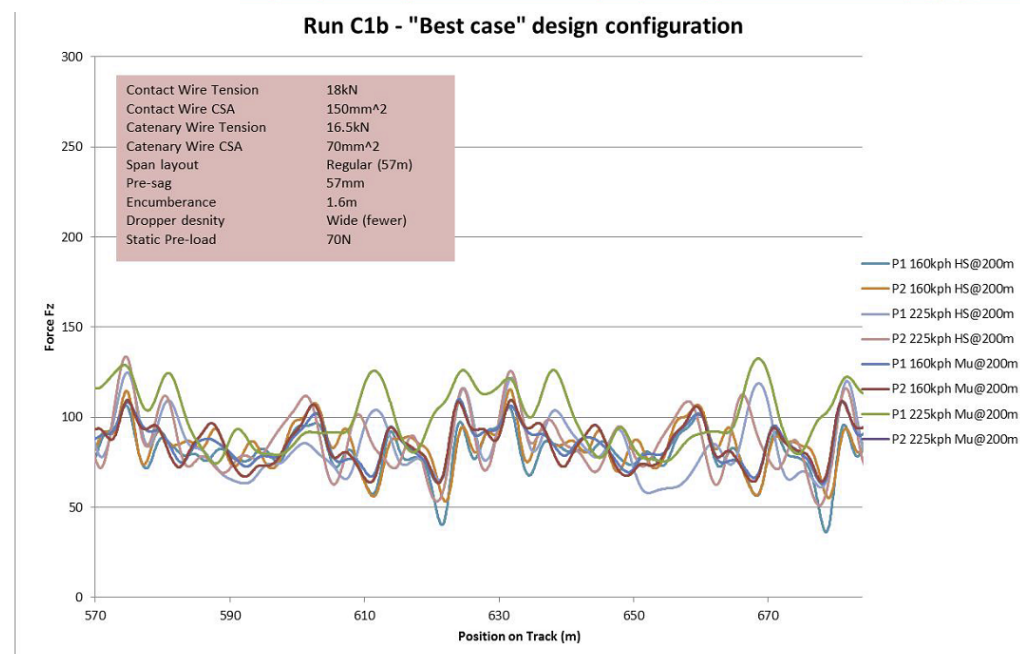
Mast sizes / Baseplate loads / Span lengths / Foundation loads / No PAN yet = **LOADS**

+ Resilience & Reliability

Tension, mast deflection, Wire size, system height, dropper spacing, pre sag, span length = **LOADS**

+ TSI compliance

Wire heights / TMLA / tolerances / Tension / Over speed / Pan configurations = **LOADS** and **HEIGHTS**



Distractions = Early Unknowns

- + **Electrical safety:** ATF (Pre Pan 83)

Clearance 600mm / ATF vicinity permits / dangles vs fixed posts = **LOADS** and **HEIGHTS**

- + **Crash Safety**

Spaceframe / lattice, then oval, round, square/rectangle, H/I. = **LOADS**

- + **HOP train**

ORR involvement, safe work zones, stillages, which track is it on..... = Lengths = **Heights**

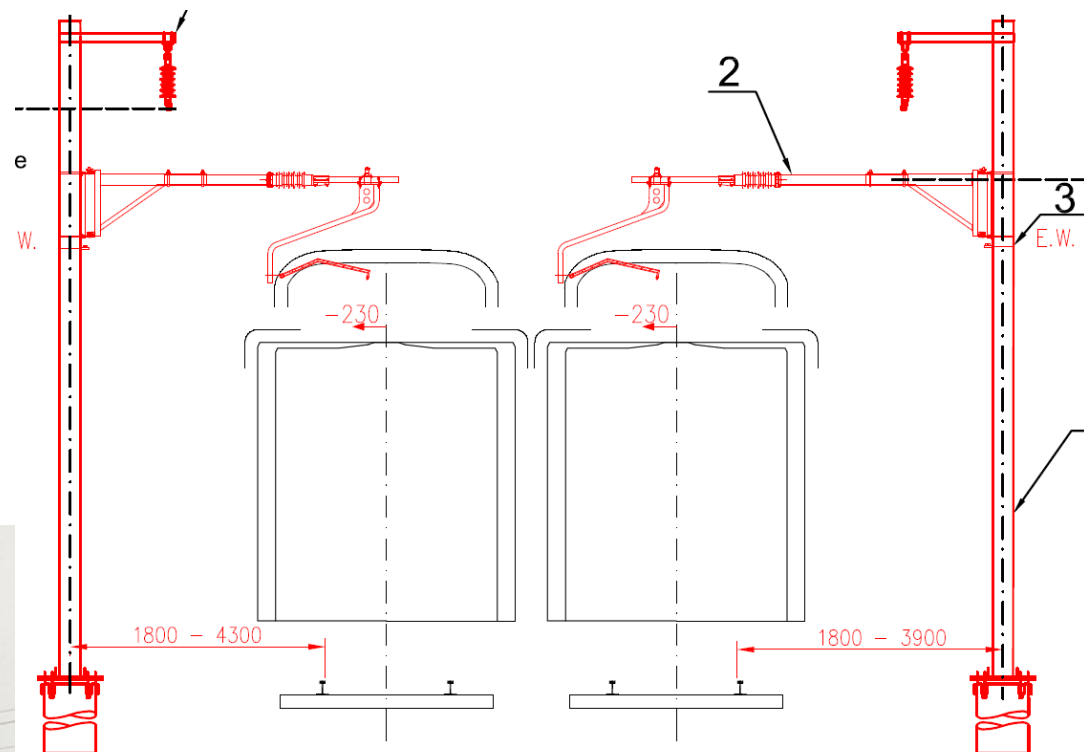
- + OLEMI vs **Eurocodes** 2010

FOS / Assumptions / arguments = **LOADS**

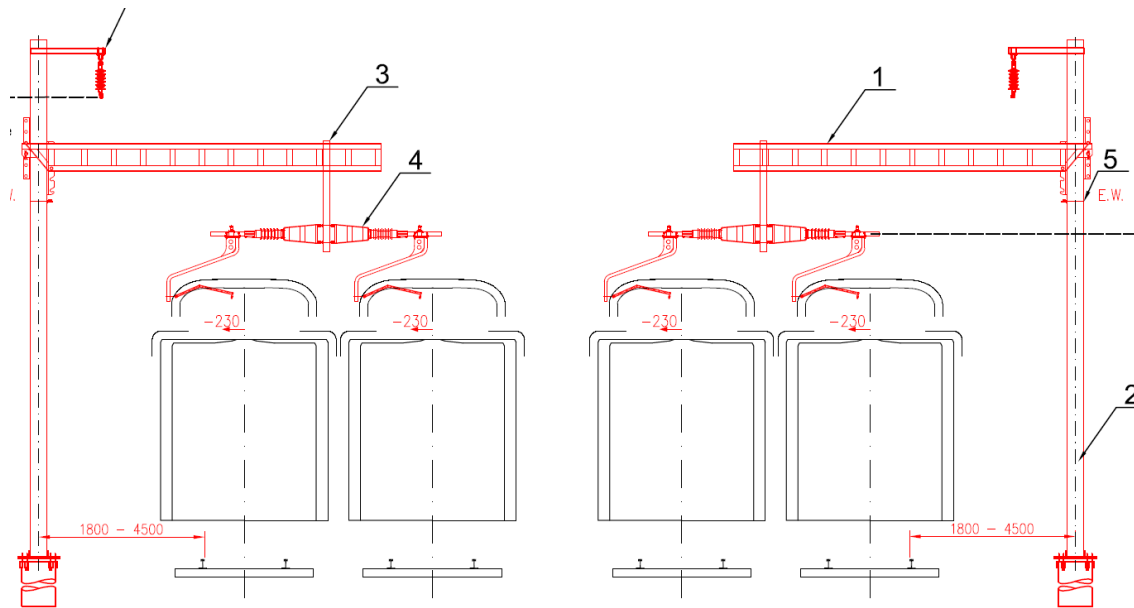
- + 2015-16 **Value engineering**



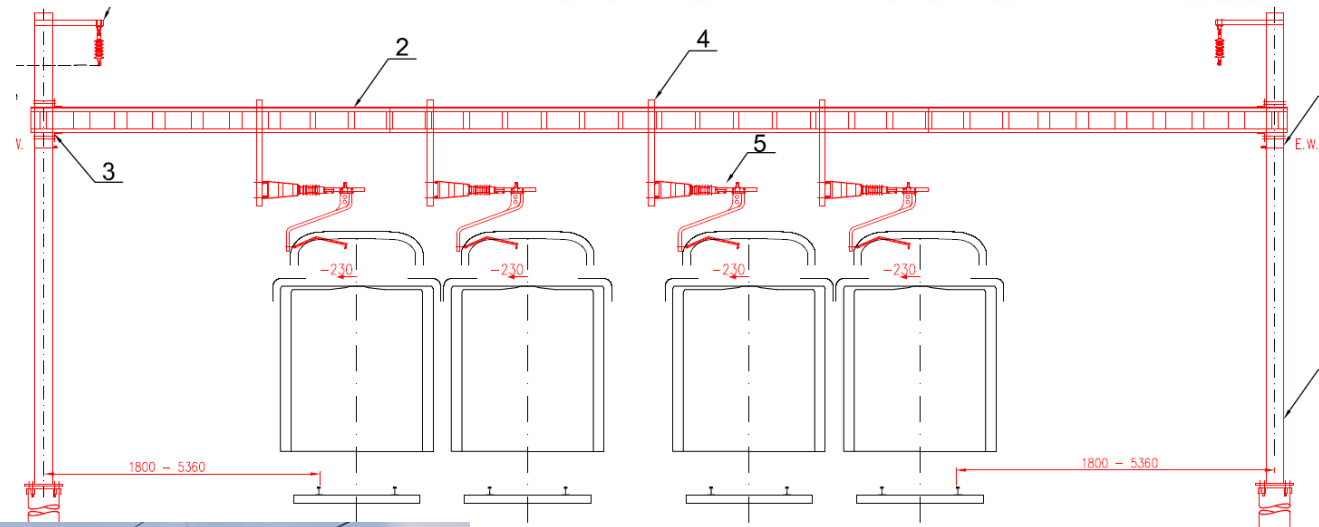
Series 1 Structures Range: STC



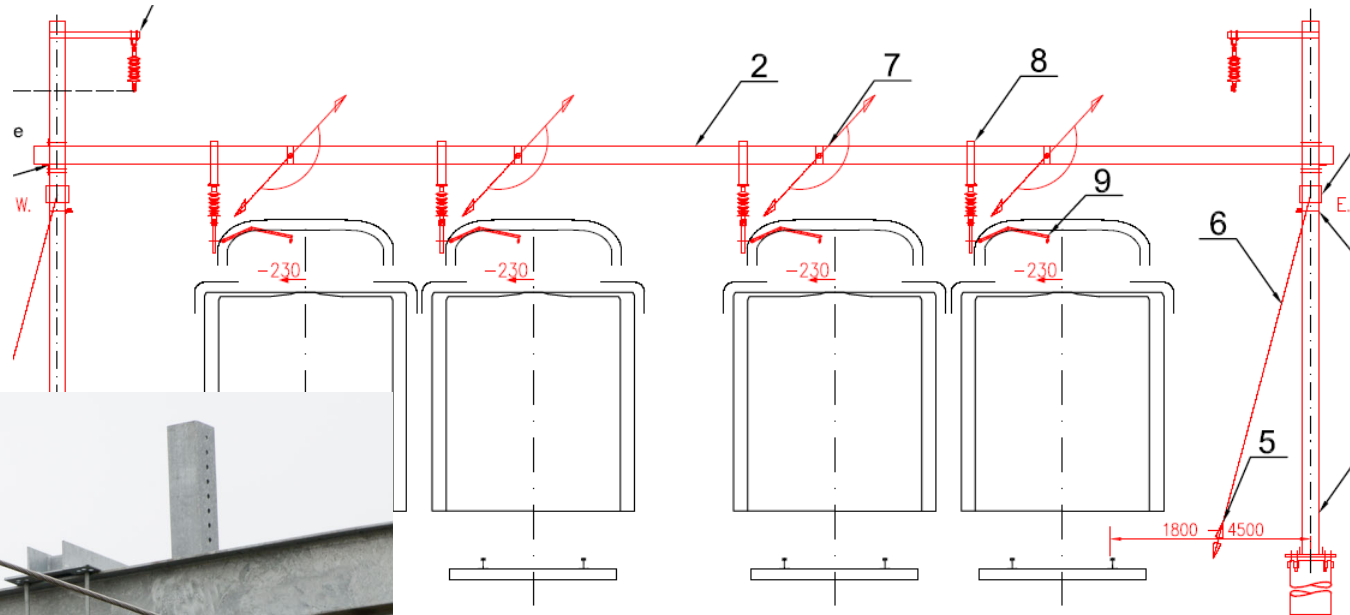
TTC



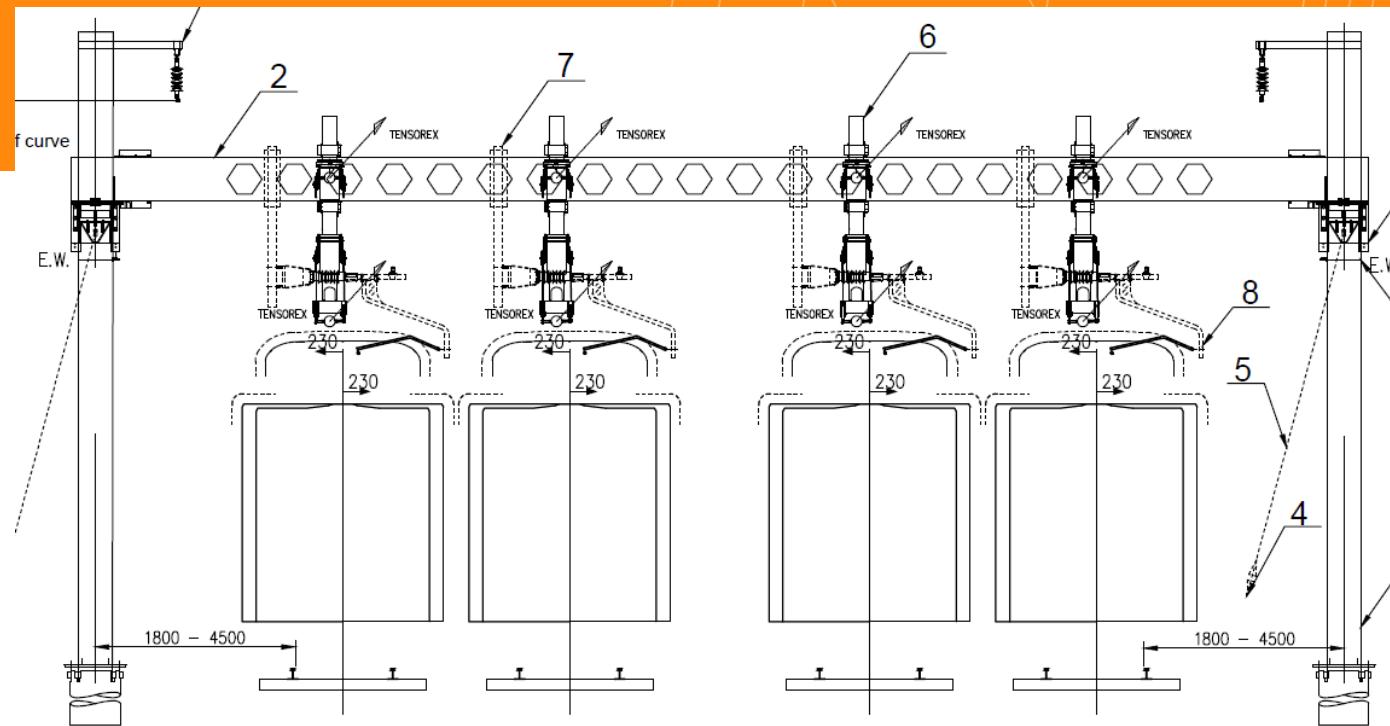
Q Boom



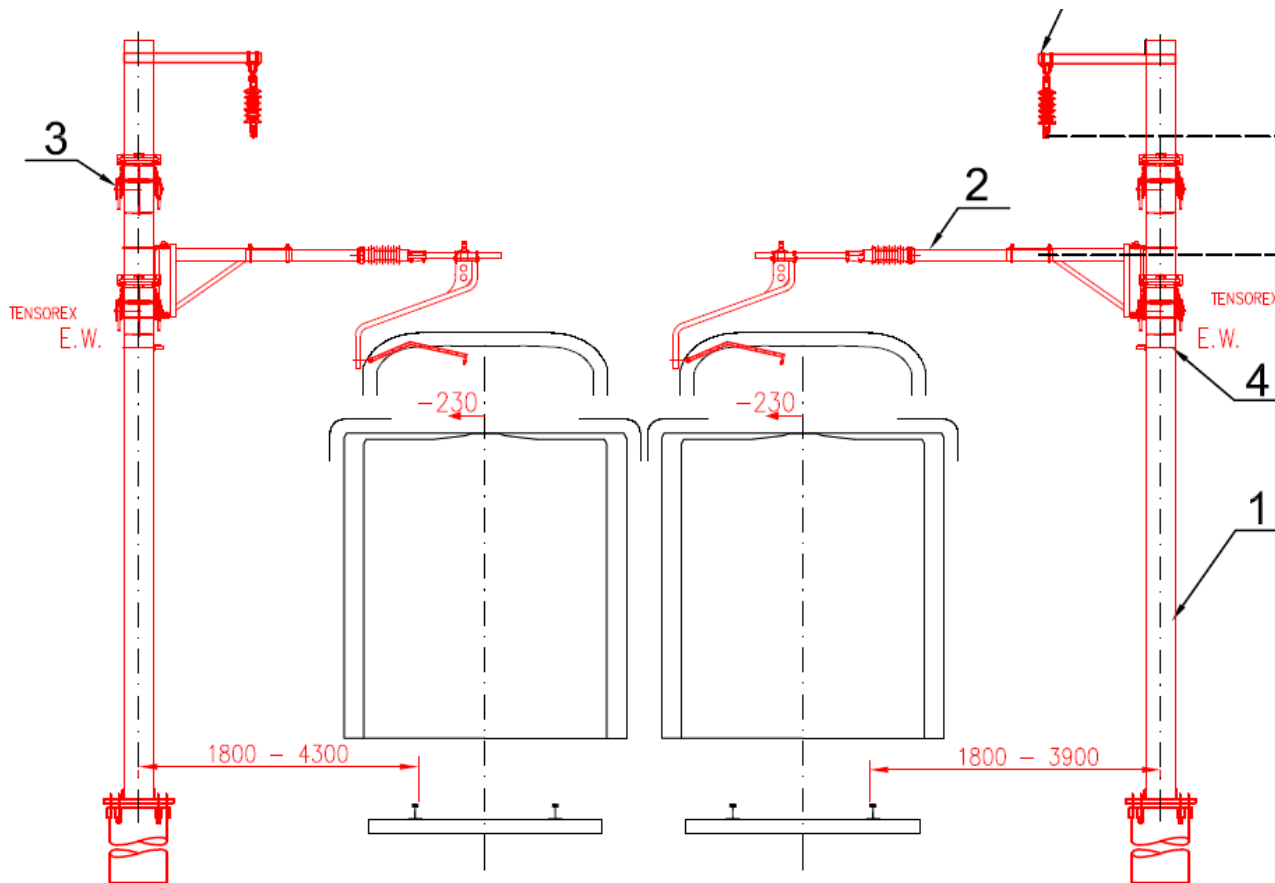
MPA (F Boom)



Monoboomb



Series 1 SSA



Case Study 1: Monoboam Anchor Portal

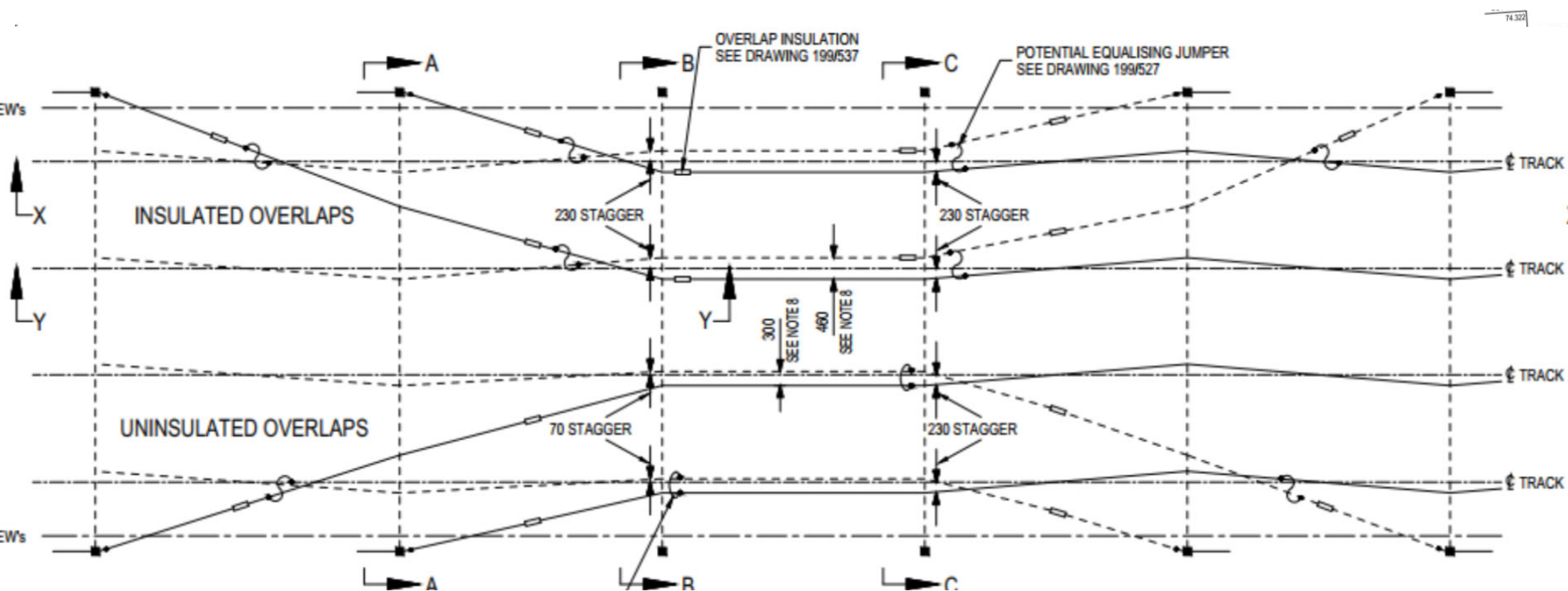
- + Remit: Mechanical Independence. (No Tail wires)

Examples:

- + Mk3b ECML
- + Heathrow Portal: Too many problems
- + Most of Europe
- + Series 1

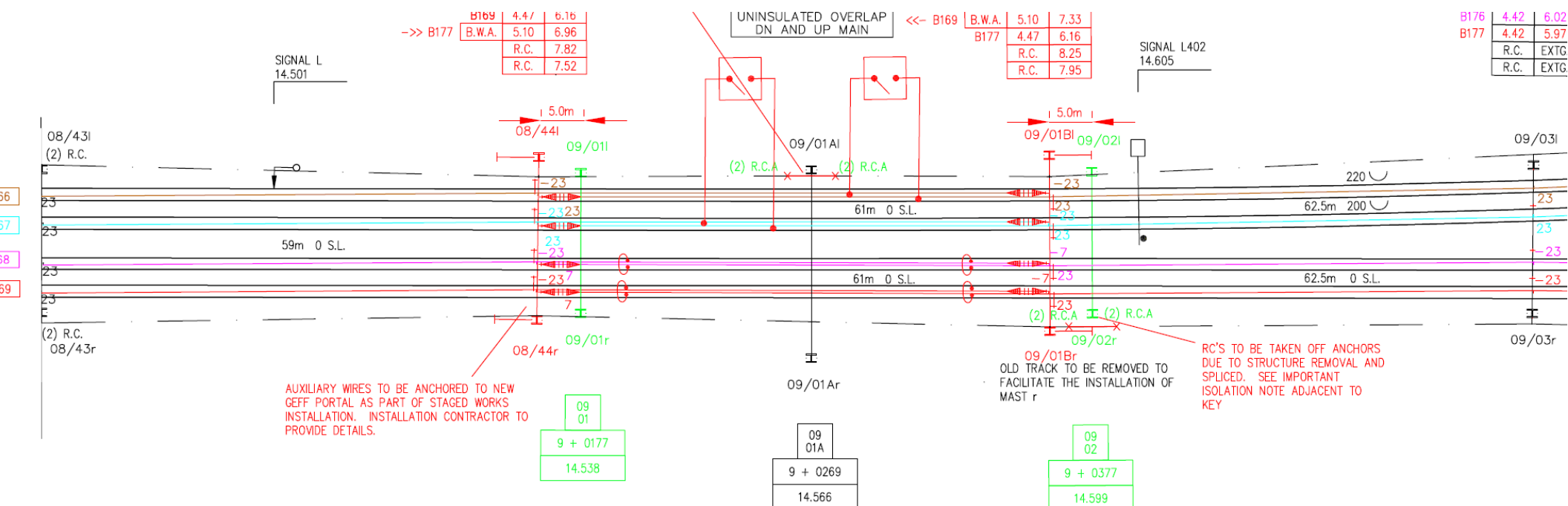
MK3b ECML / MML

- + No Mechanical Independence. 5 span overlap eg 300metres long.
- + Lots of insulators, lots of threading / flaking wires at construction
- + ~~High Output~~
- + 1 failure takes out 4 tracks
- + Anchors out in cess



Most of Europe (GEFF)

+ Single (or three) span Overlap



Most of Europe (GEFF)

- + Mechanical Independence
- + Needs catenary flaking through: NOT high output
- + Anchor above 4'
- + Slow to structures to install
- + Designed for concrete foundations
- + “Ladder” ties/struts
- + Loaded mainly in bending



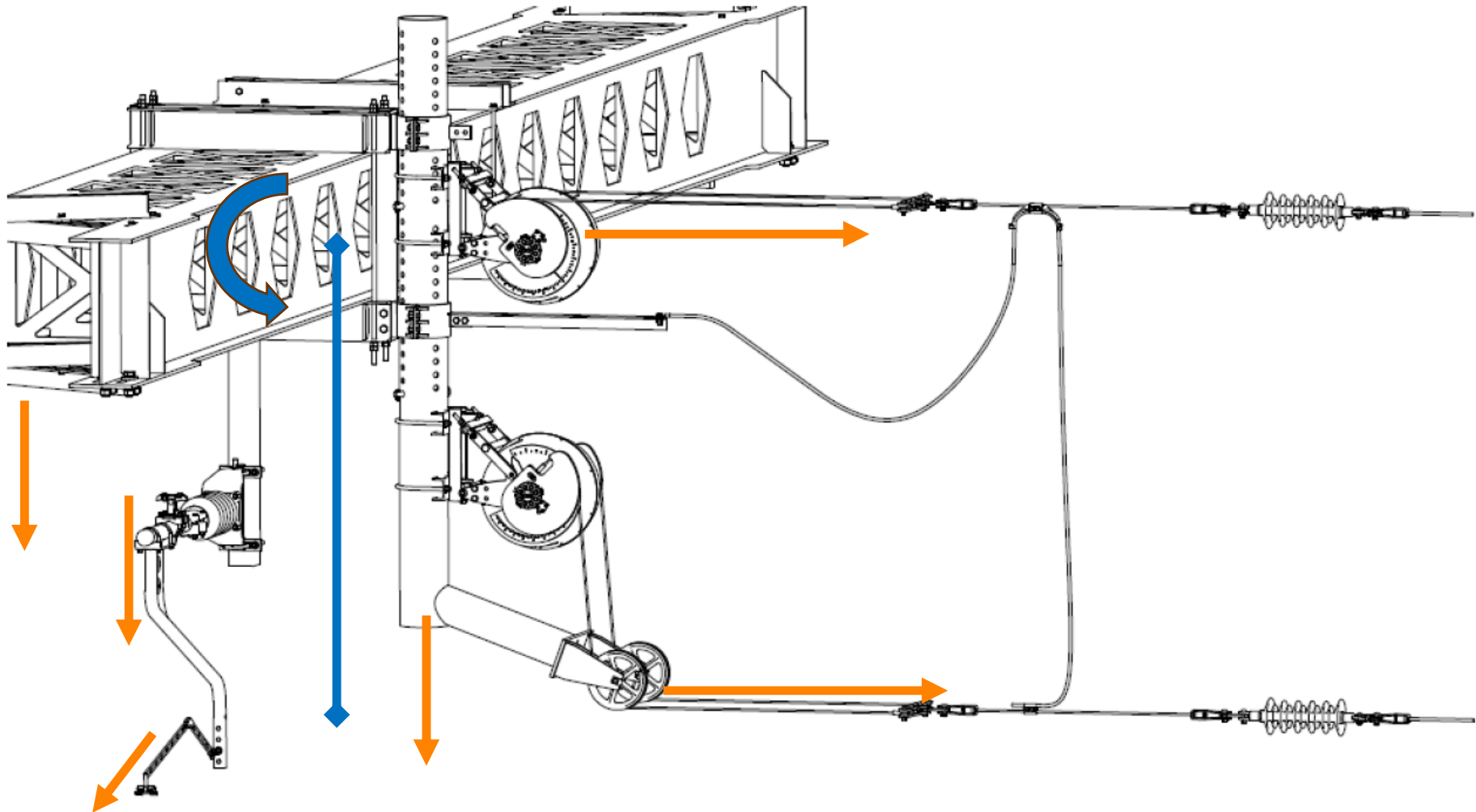
Monoboomb^(Pat) Anchor

- + Mechanically independent
- + No Flaking: HOP
- + Anchor above 4': HOP
- + Designed for CHS piles
- + Single span overlaps: HOP
- + Allows each wire run to be approx. 120m longer (saves 5-10% overlaps)
- + Looks big and heavy
- + Is big and heavy



Monoboam Anchor Loading

- + Loaded in Bending AND Torsion

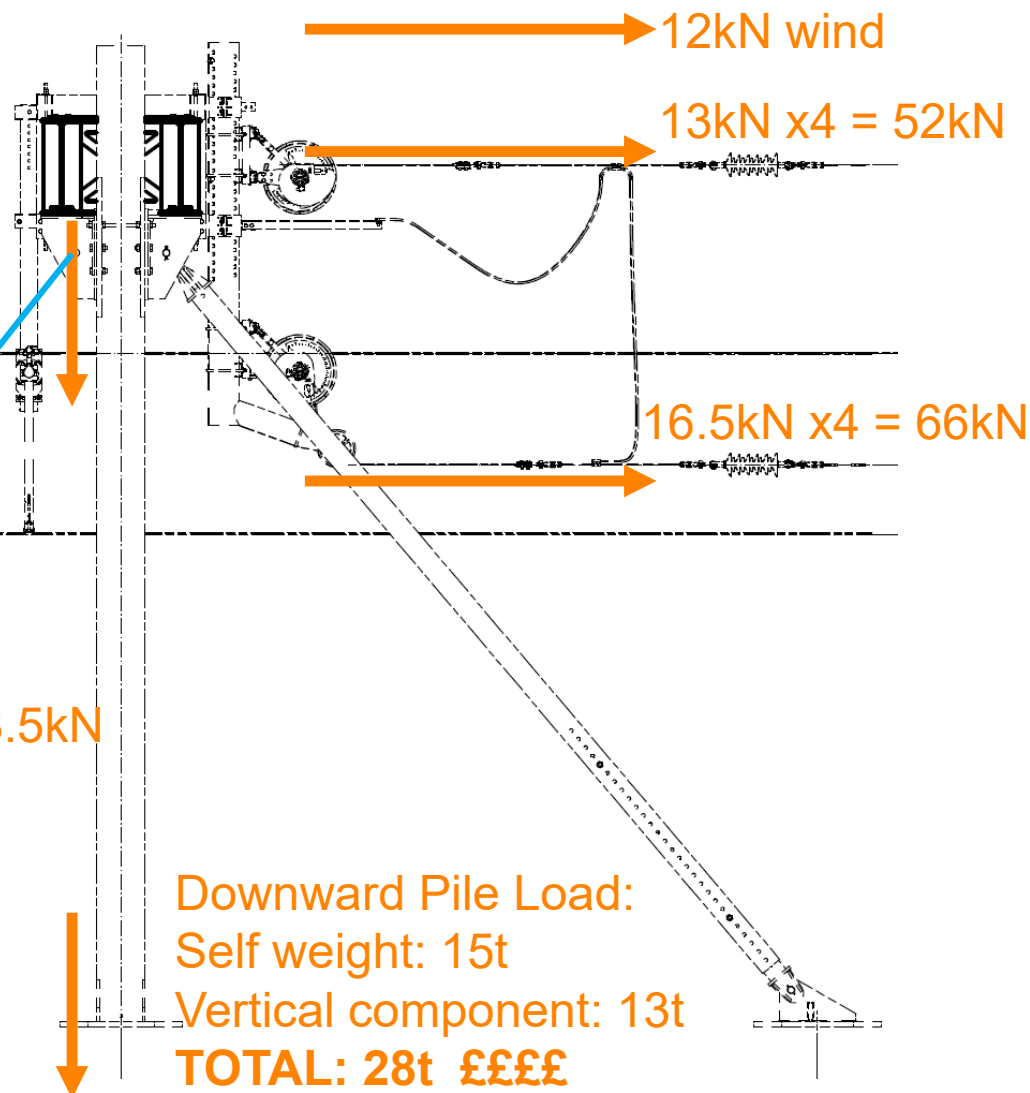


Example “CHEAP TIE”

Self Weight:
 Boom 7.5t
 Tx/SPS: 2.5t
 Wires/Cantilvers: 1t
 Mast: 4t
VERTICAL: 15t

Tension = 18.5kN

45deg



Along Track:
 Cat: 5.2t
 Con: 6.6t
 Wind 1.2t
Along: 13t

Example “CHEAP TIE”

Self Weight:
 Boom 7.5t
 Tx/SPS: 2.5t
 Wires/Cantilvers: 1t
 Mast: 2t
VERTICAL: 13t

Tension = 18.5kN

45deg

Downward Pile Load:
 Self weight: 13t
 Vertical component: 15t
TOTAL: 28t £££££

12kN wind

13kN x 4 = 52kN

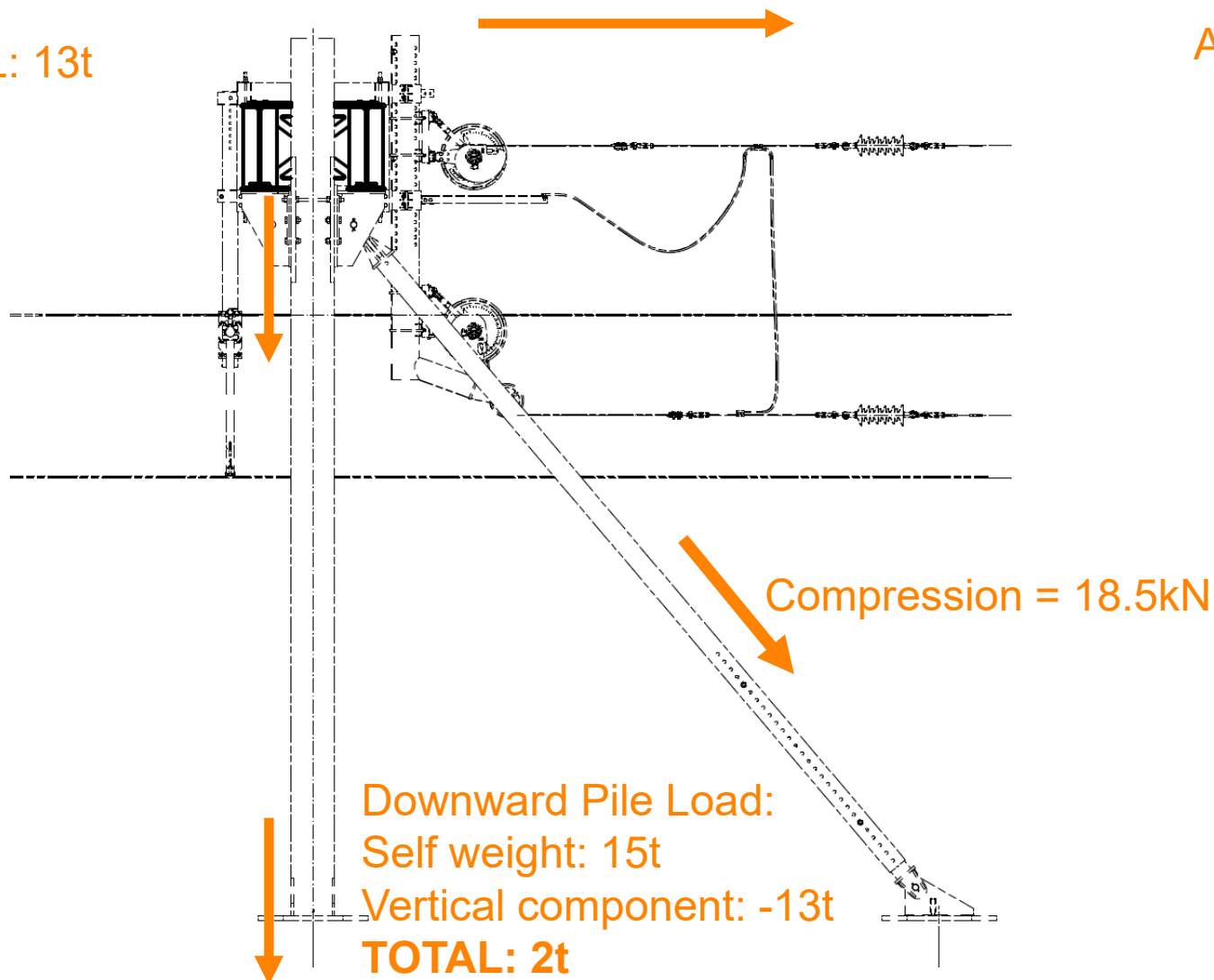
16.5kN x 4 = 66kN

Along Track:
 Cat: 5.2t
 Con: 6.6t
 Wind 1.2t
Along: 13t

“OVER-ENGINEERED STRUT bigger than some masts”

VERTICAL: 13t

Along Track: 13t



Strut vs Tie

- + Cheap tie =
 - Deep pile
 - Concrete infill
 - Refusal risk
 - Fewer piles per shift
 - Angry neighbours
 - “Sometimes impossible”: Covert to concrete
 - NOT HIGH OUTPUT

- + “Over-engineered strut” =
 - Smaller piles
 - Lower risk
 - More piles per shift
 - Less noise
 - No concrete
 - HIGH OUTPUT

“One size fits all”: Procurement efficiency?



Case Study 2: TTC

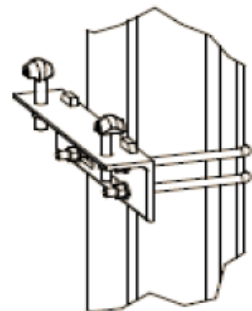
Remit: Paddington to Swansea in service by 2017

High Output Plant construction

- + “Portals are better engineered” “more efficient” “cheaper” “easier”



- + Need all track access
- + Saturday nights or <2hrs mid week
- + Land+Leave® = Faster construction than olemi (increases boom loads)



TTC



TTC

itv NEWS

TTC (MAST) Economics: OLEMI Vs Series 1 (No ATF)



OLEMI 381x102 DC 8m Mast

- + Load capacity: SAME
- + Weight: 1175kg
- + Cost: (**2017**) £2,800
- + Fabrication: 28hrs (fillet welding)



Series 1 SHS350x12.5 8m Mast

- 1150kg
- £2100
- 8hrs (butt welding)

TTC Economics: Mast

- + Estimate 3,000 TTCs
- + Series 1: 3,400 working days fab (over 15 working years)
- + OLEMI: 12,000 working days fab (over 52 working years)

UK Fabrication industry?

20teen

Labour expensive

Materials cheap

Project duration expensive

Remit:

- + *Paddington to Swansea in service by 2017*
- + *High Output Plant construction*



TTC (Boom) Economics: OLEMI Vs Series 1



- + Boom installation: 40mins
- + ~~High Output~~



- 2mins (Land+Leave®)
- High Output

TTC



TTC Economics: Installation

- + Estimate 3,000 TTCs
- + Mid-week nights
- + 5-6hour 2 track access.
- + OLEMI max 3-6 / night = ~500 - 1,000 shifts
- + Series 1 Proven 30 / night = ~100 shifts

Remember:

- + *Paddington to Swansea in service by 2017*
- + *High Output Plant construction*



Case Study 3 SSAs

- + Most people don't like SSAs
- + Saves 1 foundation EACH
- + OLEMI 356x368 needed
- + Series 1 SHS 350x16
- + One size fits all*
- + Level crossings

Aesthetics?

*RHS 500x300x16....



High Output Allocation Design

+ OLEMI: Summary of calc sheets

+ Series 1: Allocation Charts

Great:

+ Negligible competence needed

+ Fast, low skilled allocation design

+ Very efficient way to design / allocate

But:

+ Everything is rounded UP

+ Not the most efficient way to use steel

+ Revised 2016 after Value Engineering

Selection Chart - Q-Booms / Masts --> Windzone ULS 0.90 (across / longitudinal)

Mast centre line to mast centre line [m]		Span length [m]																																Mast centre line to mast centre line [m]																					
		9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00	25.50	26.00	26.50	27.00	27.50	28.00	28.50	29.00	29.50	30.00	30.50	31.00	31.50	32.00	32.50	33.00	33.50	34.00	34.50	35.00		
Q80		Q80																																Q80																					
Q100		Q100																																Q100																					
Q120		Q120																																Q120																					
Number of equipments on the boom																																																							
up to 4 equipments		up to 4 equipments																																up to 4 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
TOP to track: -0.5 m		TOP to track: -0.5 m																																TOP to track: -0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
5-6 equipments		5-6 equipments																																5-6 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
7-8 equipments		7-8 equipments																																7-8 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
9-10 equipments		9-10 equipments																																9-10 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
TOP to track: -0.5 m		TOP to track: -0.5 m																																TOP to track: -0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
11-12 equipments		11-12 equipments																																11-12 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
TOP to track: -0.5 m		TOP to track: -0.5 m																																TOP to track: -0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
13-14 equipments		13-14 equipments																																13-14 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
TOP to track: -0.5 m		TOP to track: -0.5 m																																TOP to track: -0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					
15-16 equipments		15-16 equipments																																15-16 equipments																					
TOP to track: +0.5 m		TOP to track: +0.5 m																																TOP to track: +0.5 m																					
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TOP to track: -2.5 m		TOP to track: -2.5 m																																TOP to track: -2.5 m																					

Booms		Masts		calculated for ...		span-length		c		all wires with the same span-length (c) and angle (α)	
Q80	250x12.5 (TP610)	250x250x12.5	TP610 (6xM30 / 4xM36)	angle	α = 65°	all wires with the same span-length (c) and angle (α)					
Q100	350x12.5 (TP610)	350x350x12.5	TP610 (6xM30 / 4xM36)	boom-height (underside)	h _{boom} = 7.20 m	ContW	CuAg120	maxF _{CuW} = 13.0 kN	(F _{CuW} = 6.10m)		
Q120	350x16.0 (TP762)	350x350x16.0	TP610 (6xM30 / 4xM36)	mast-types	TP _{max} = TP _{max} ATF	AAAC263	maxF _{ATF} = 16.0 kN	h _{ATF} = 9.35m	on both masts		
	350x16.0 (TP762)	350x350x16.0	TP762 (6xM39)	foundation-height	h _{base} = h _{base}	EW	AAAC167	maxF _{EW} = 10.2 kN	h _{EW} = 6.00m	on both masts	
	checked on case		to be checked on a case by case basis	mast-length	l _{max} = l _{max}						

Attention:
If the following conditions are not met a detailed analysis is required:
- the wireruns are distributed symmetrically over the whole boom span. This excludes high load concentration in the centre of span or high eccentricity to one side. The outermost wire runs must have an across track separation of at least:
Q80: 1-2 equipments: 0m 3- 4 equipments: ~12m * 5- 6 equipments: ~12m
Q100: 1-2 equipments: 0m 3-10 equipments: ~12m 11-16 equipments: ~21m
Q120: 1-2 equipments: 0m 3- 8 equipments: ~12m 9- 16 equipments: ~21m
- equipment load distribution should not be more than 60% / 40% between left and right masts

Selection Chart - Q-Booms / Masts --> Windzone ULS 0.90 (across / longitudinal)

[illegible]

Procurement?

Remember:

- + *Paddington to Swansea in service by 2017*
- + *High Output Plant construction*



Procurement?

- + Accidental over ordering....
- + Re-use of “scrap”:



What's happening now?

- + **MML**
Monobooms 2 & 4 track, F Boom MPAs
- + **Trans Pennine**
TTCs Small & Large, Monobooms 2 & 4 track
- + **SSV**
TTCs, Monobooms, F Boom MPAs
- + **Crossrail East & West**
Monoboom anchors
- + **Scotland**
Monoboom anchors
- + **TFW**
Q Booms, TTC, F Boom
- + **Anglia MK1 replacement**
 - + TTCs, **Self supporting** F Boom MPAs (save 4x foundations), SSAs

What's happening now?

- + Copies from competitors are in development
- + F Boom, TTC, Monoboam: In UKMS
- + F+F Licence Series 1 to NR and anyone in the UK can use them (for NR).
- + Outside UK F+F own all design rights.

THINK! Perception vs Reality

I Can See

NOW, today

Height / width

Big anchor struts

Big anchor booms

Aesthetics

Commercial Sense

THINK! Perception vs Reality

I Can See	I Can't See
NOW, today	The past
Height / width	Wall thickness
Big anchor struts	Pile depths (Monoboom)
Big anchor booms	Piles not needed (SSA / F Boom)
Aesthetics	Manual Flaking Avoided
	Shorter possessions
Commercial Sense	Weight
	Costs / time saved
	Accidents avoided

Reflection

Remember:

- + *Paddington to Swansea in service by 2017*
- + *High Output Plant construction*

Lessons:

- + Simon Skinner SPL MML “*Series 1 is actually not that bad!*”
- + Series 1 Structures are bigger than we are used to!
- + Not unreasonably heavy
- + Not over engineered
- + Delivered their remit of high output / fast construction
- + The design saves a huge amount of **unseen** cost and time
- + Any additional steel is trivial vs benefits
- + The industry often forgets this...

Reflection

I wish....

I Hope... Share the benefits.

Anyone can blame big structures.....

Future Electrification:

Real Project costs is management, not steel:

- + Minimise Change
- + Minimise mid-project innovation
- + Value engineer BEFORE starting
- + Agree key parameters BEFORE starting

Series 1 structures are large, but free-up efficient (unseen) electrification.

Questions?

Contact: Rob Daffern

GB@furrerfrey.co.uk

www.furrerfrey.ch

Furrer+Frey
Overhead contact lines

