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Permanent Way Institution

The Institution for Rail Infrastructure Engineers

London Section



The Challenges of Maintaining a High Speed Railway

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Eastern

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Summary of Track Asset

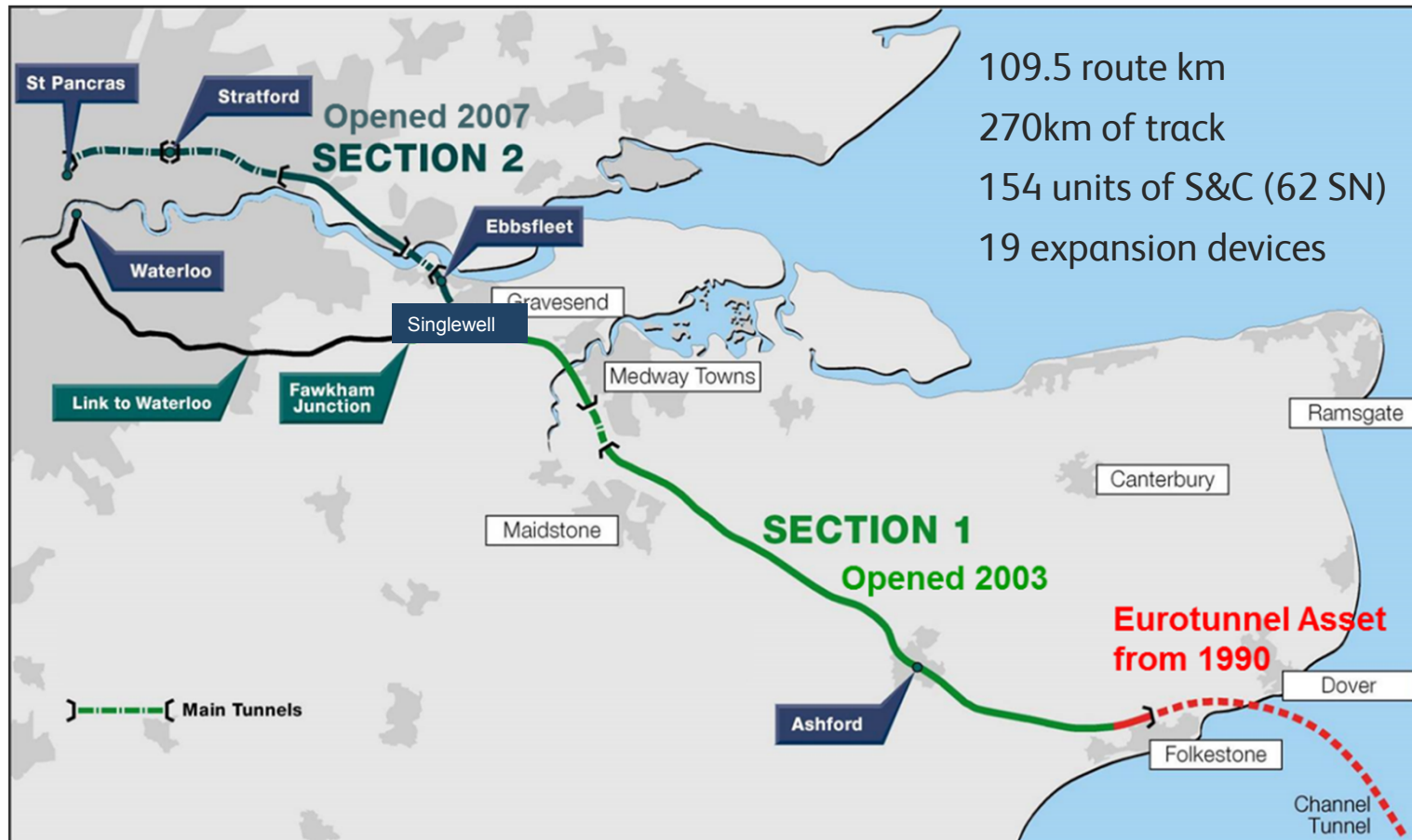




Photo taken from internet

UK Rail Speed Record Eurostar Class 373 (2003)
334.7 km/h

HS1 and NRHS

HS1 Ltd has the 30-year concession to own and operate High Speed 1

Network Rail High Speed is contracted to operate, maintain and renew the infrastructure

Track System designed for

- High speed international trains 300km/h - Eurostar Class 373 and Class 374
- Domestic trains 225km/h – Southeastern Class 395 Javelins
- Freight trains 140km/h – Class 92
- Pre-COVID traffic tonnage, around 8 – 20MGTPA



HS1 Reference System



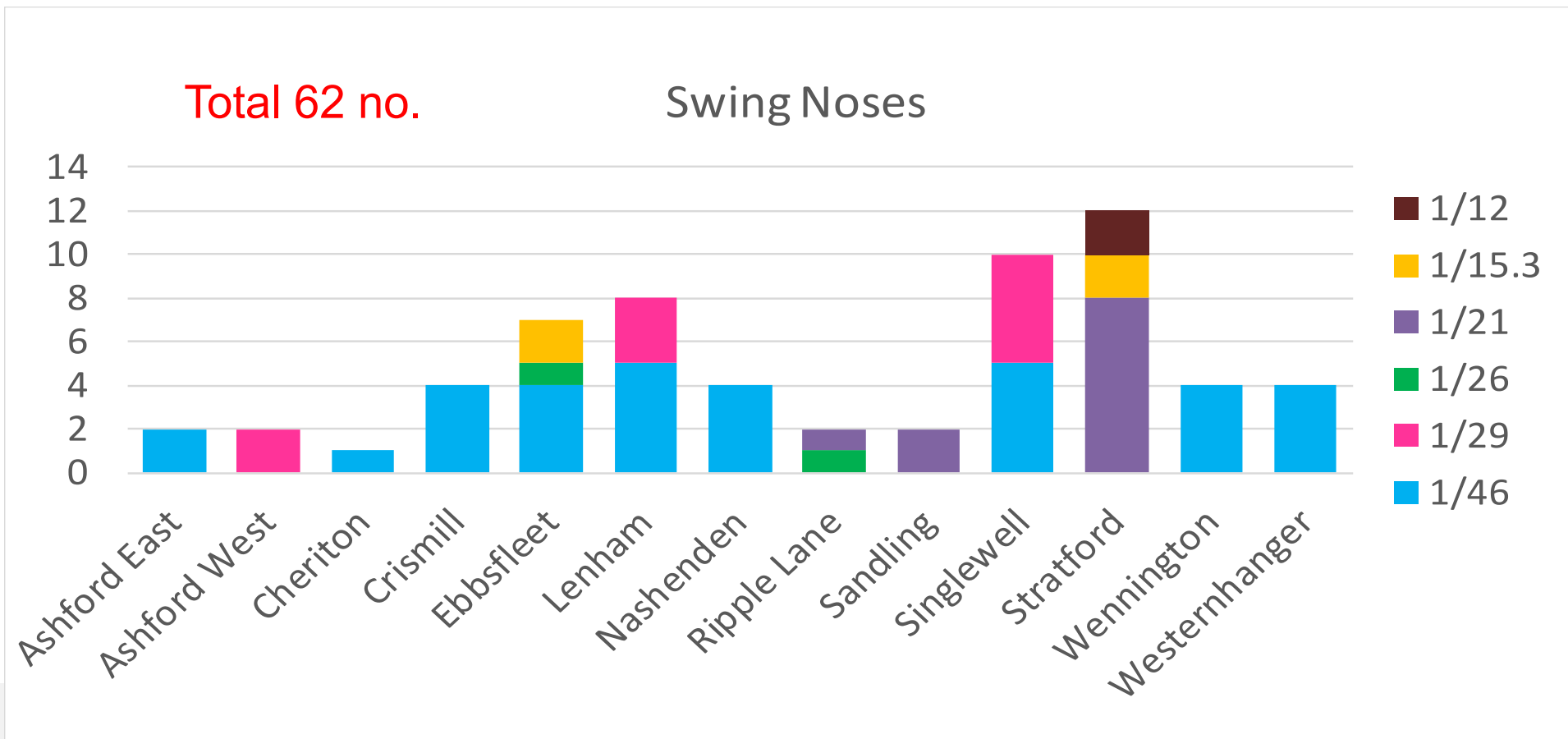
Reference System: SNCF TGV Med (Train a Grande Vitesse Mediterranee)

Application	Section 1	Section 2
Operational	Maximum line speed 300 km/h	Maximum line speed 230 km/h
	Maximum axle load 22.5 t/axle (to allow for freight operation)	Maximum axle load 22.5 t/axle (to allow for freight operation)
Track geometry & gauge	Minimum track centre line spacing 4500 mm.	Minimum track centre line spacing 4200 mm.
	Track in long tunnels (North Downs) on ballasted track having 180mm clearances between UIC GC kinematic envelope and high level walkways.	Slab-track is provided in long tunnels (London & Thames). The clearance to the evacuation walkway is 50 mm.

Switches and Crossings



- 32 units of British Design – RT60 (HPSS)
- 99 units of French Design – Vossloh Cogifer
- 2 units of hybrid British and French Design (installed in Feb 2020)

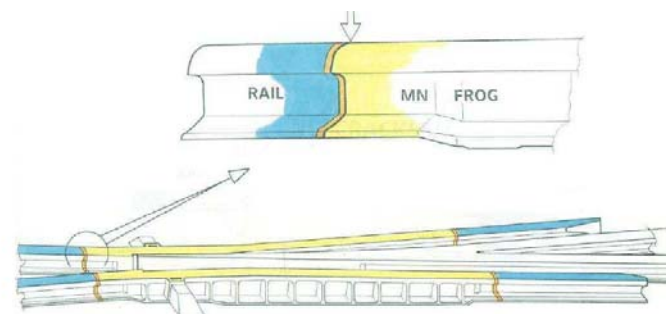
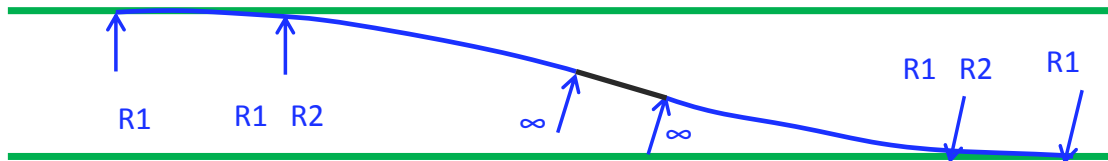


Vossloh Cogifer 1 in 46 Swing Nose Crossing

Tangential, double radius

Cant deficiency of up to 100mm for up to 160km/h; 85mm for above 160km/h

Manganese cast steel cradle, normal grade point and splice rail



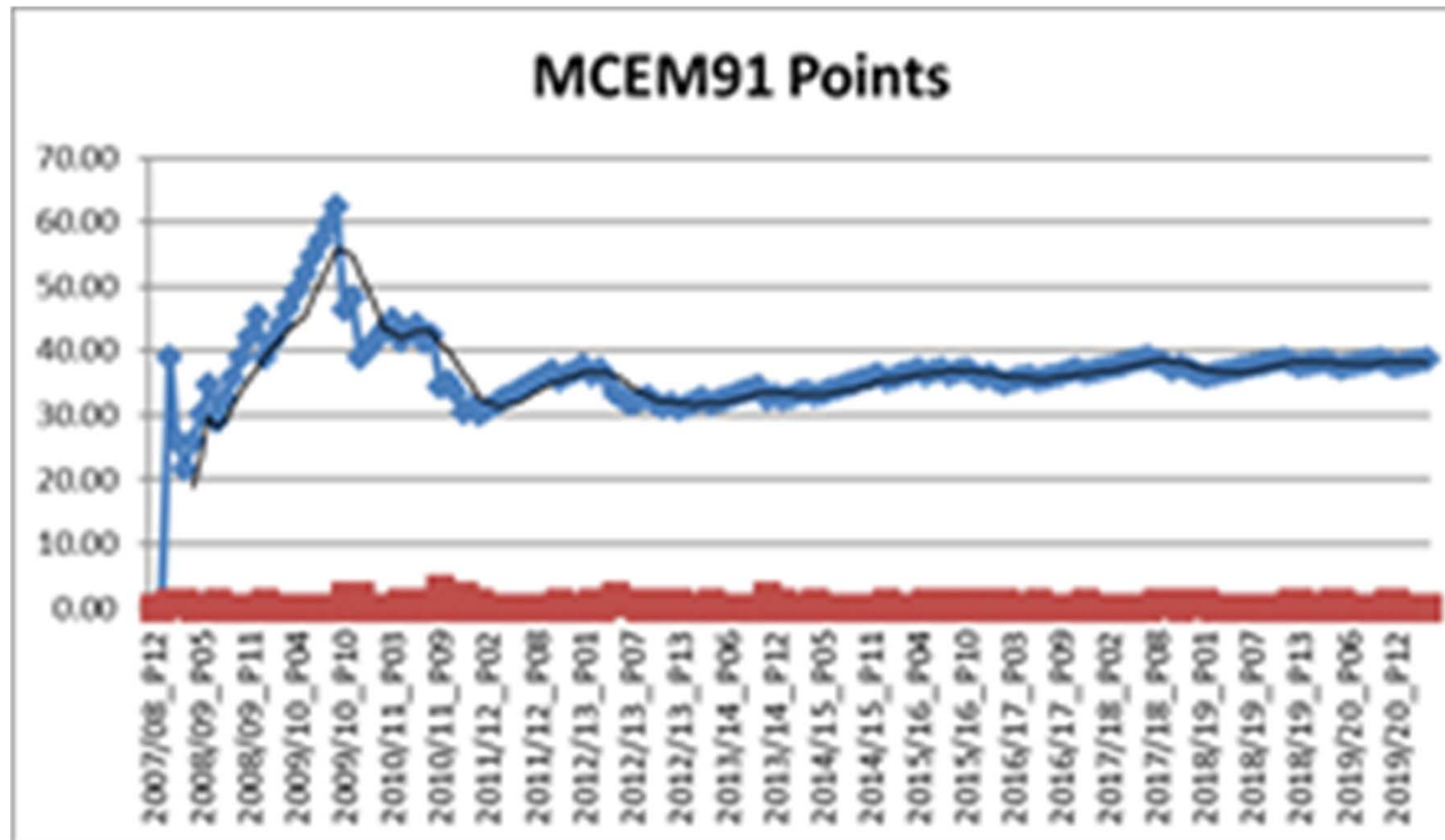
- 1 in 46 crossing
- Toe to heel length 43m
- Tip to tip 300m
- Concrete bearers
- Nabla fastenings
- All on straight track

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Hybrid British and French Design at Folkestone

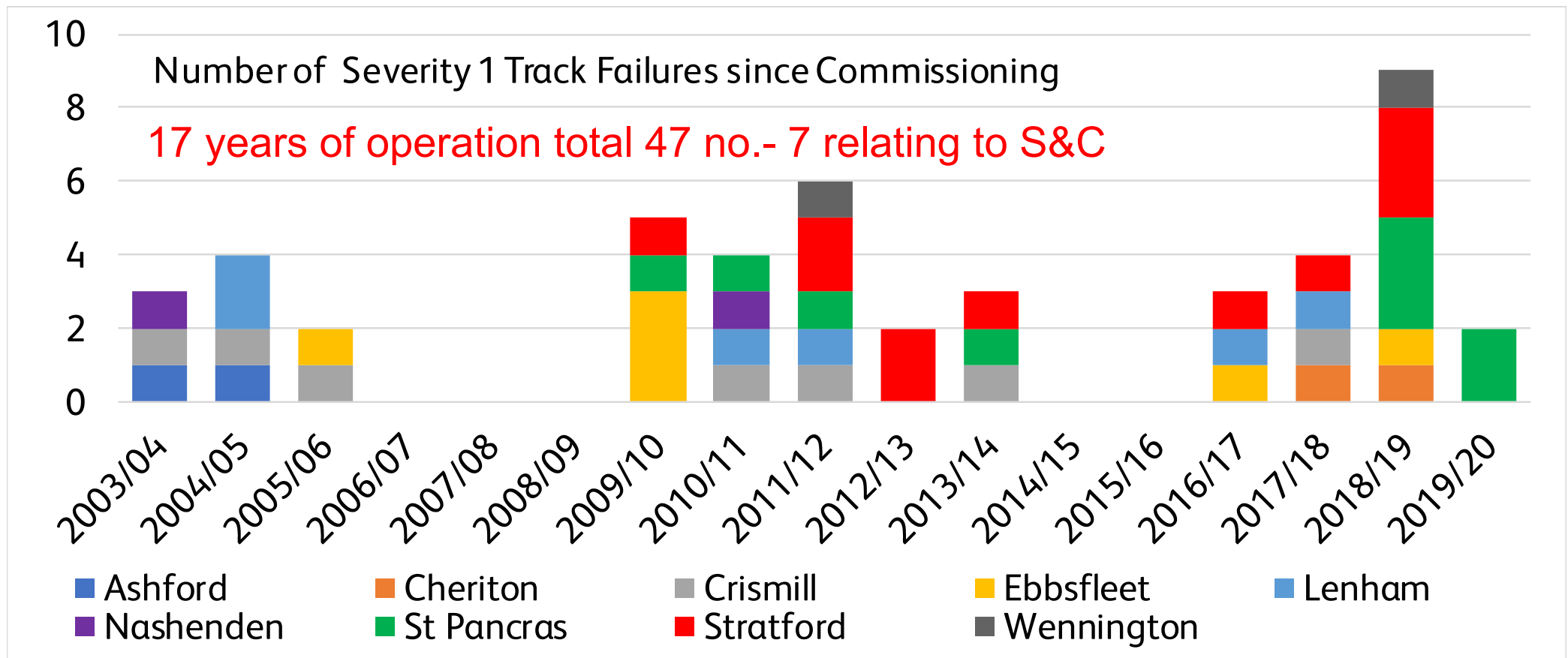


Points Performance - MTBSAF



Courtesy Eric Aliot

Track Performance – Service affecting failures



Construction / Maintenance Tolerances



Track Parameter	Network Rail	HS1
	100-125mph (160-200km/h)	over 220 km/h
3m Twist (mm)	6 / 15	3 / 7
Vertical alignment (mm)	+10, -20 / 18	5 / 10
Horizontal alignment (mm)	±10 / 11	6 / 8
Crosslevel / cant (mm)	3 / 15 (±2 for over 125mph)	3 / 10
Plain Line Gauge (mm)	1429 – 49	1432 - 1440

General Maintenance Concepts

Predictive Maintenance

Remote Condition Monitoring

Trend analysis

Preventative maintenance

Inspections

Preventative grinding

Lubrication of joints etc.

Corrective maintenance

Programmed activities from Inspections

Operations in reaction to an incident

Good **Predictive** and **Preventive** maintenance = less costs from corrective maintenance operations.

All maintenance activities at HS1 are **Green Zone**

S&C Inspections

High Speed

5 weekly – basic visual

6 monthly – detailed component

12 monthly – detailed component, check tightening of all fastenings

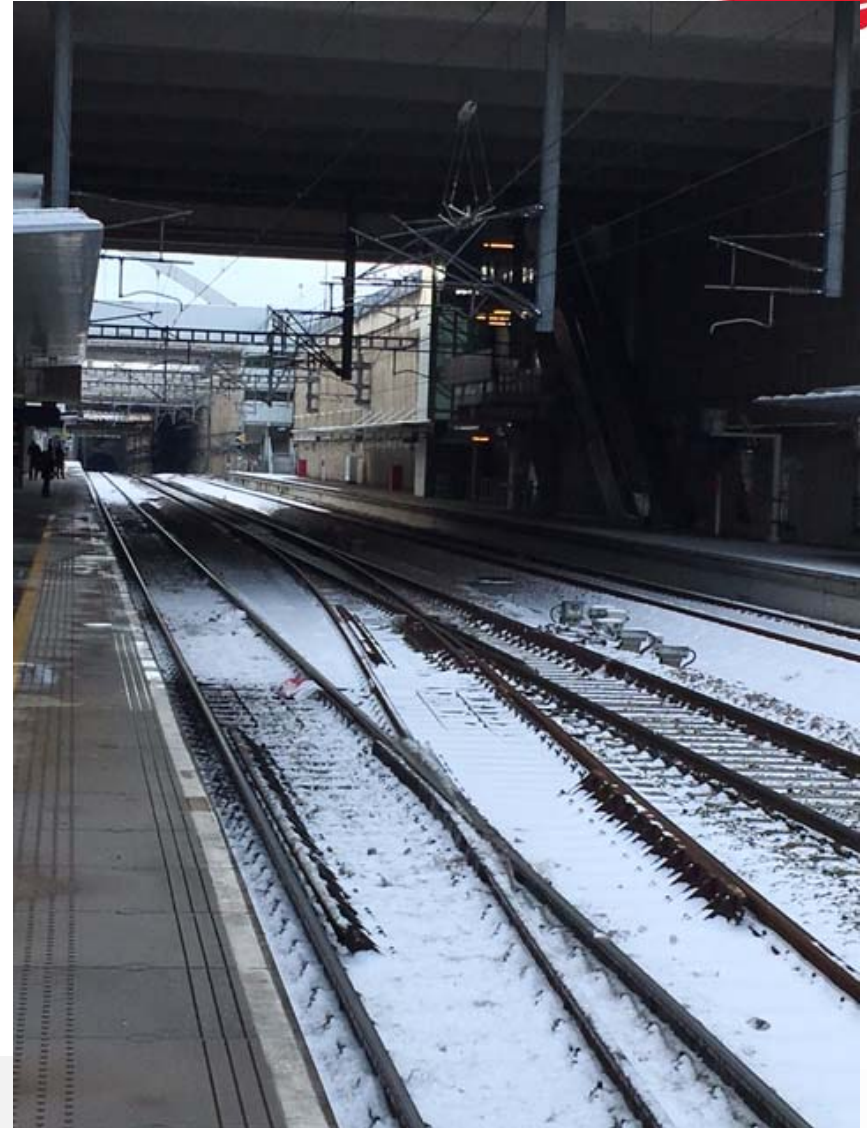
St Pancras

2 weekly visual

8/12 weekly derailment hazard inspections

Annual Cast Crossing inspections

1 in 12 swing nose crossing at
Stratford International



Typical plain line on twin-block sleepers

- 10 weekly – alumicart (<7kph) or on foot
- 6 weekly St Pancras plain line
- 13 weekly depot Inspections
- Yearly Supervisor inspections
- 2 yearly Engineers inspection
- Annual Rail depth/condition in tunnels
- Annual RCF inspection



Dynamic Inspections

Track Recording Vehicles

- ▶ 6 weekly main lines
- ▶ 12 weekly crossovers
- ▶ 12 weekly loops
- ▶ 26 weekly interface areas



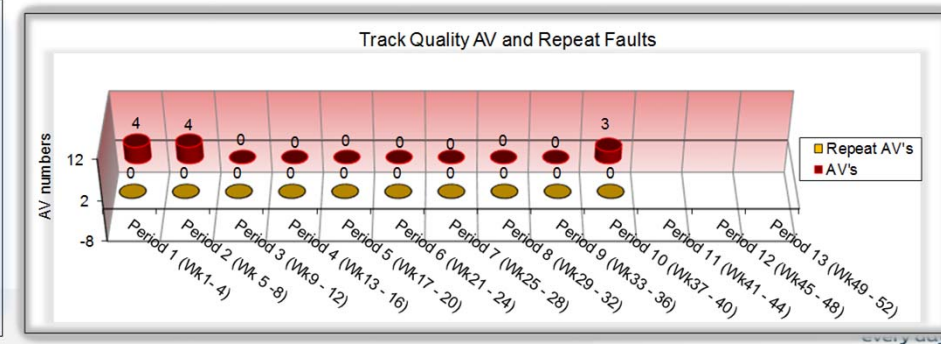
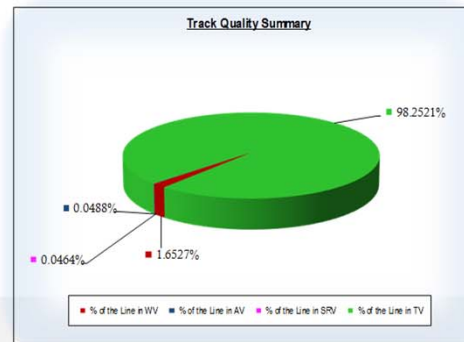
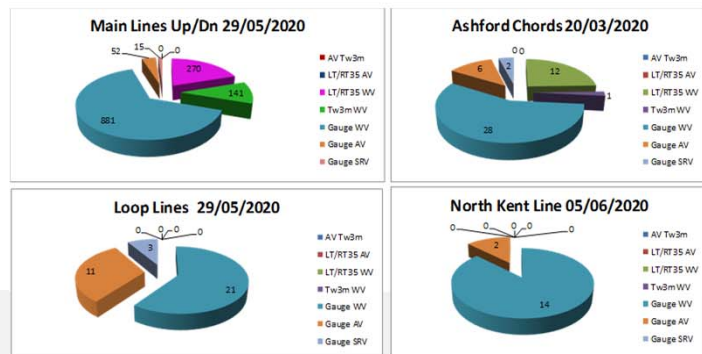
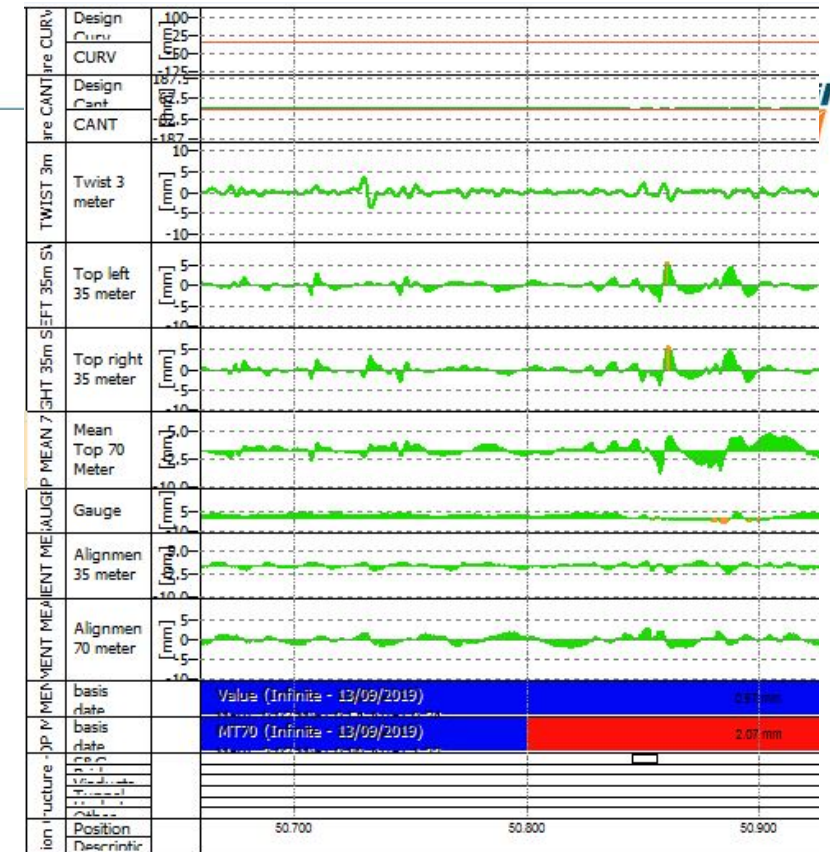
HS1 MPV with a UGMS module

UTU 16 weekly

Cab rides - 4 weekly Eurostar and 2 weekly on 395

Lineside asset inspections under traffic

Use of Erdmann IRISys to analyse, predict and report



Special features/considerations

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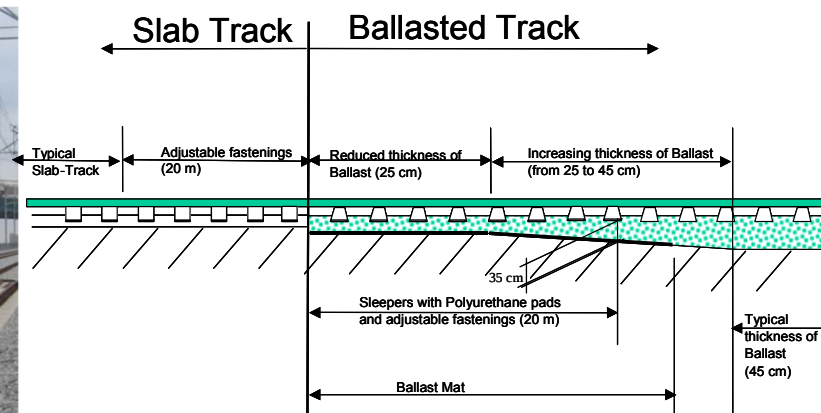
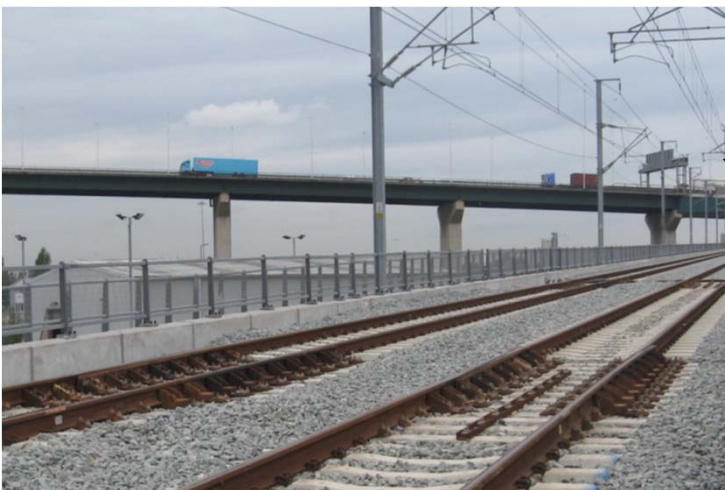
Tight curves

Long Expansion switches

Ballast / slab transitions

UTX hard Spots

3250m radius – a tight curve with a design speed of 270km/h



Special features/considerations

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Hot weather – restricted period, SFT's, ballast levels and profile



Grande Permissive Joints/ High Displacement Joints at low speed lines



Figure 4 – Reinforced Ballast Profile for Straight Track

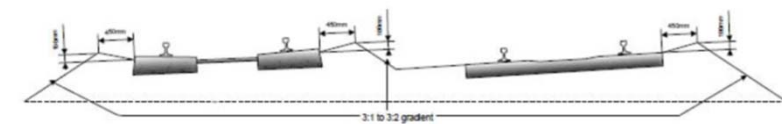


Figure 5 – Reinforced Ballast Profile for Canted Track



Figure 6 – Plain Ballast Profile for Straight Track

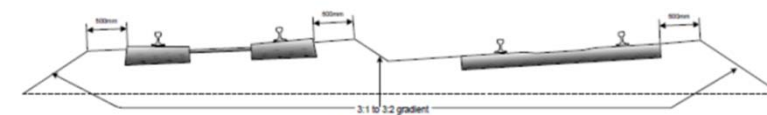
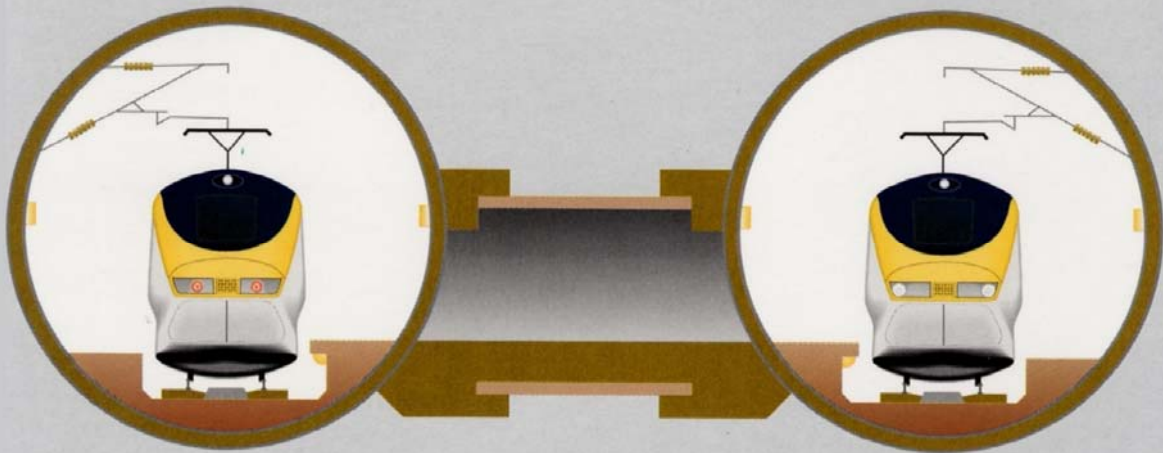
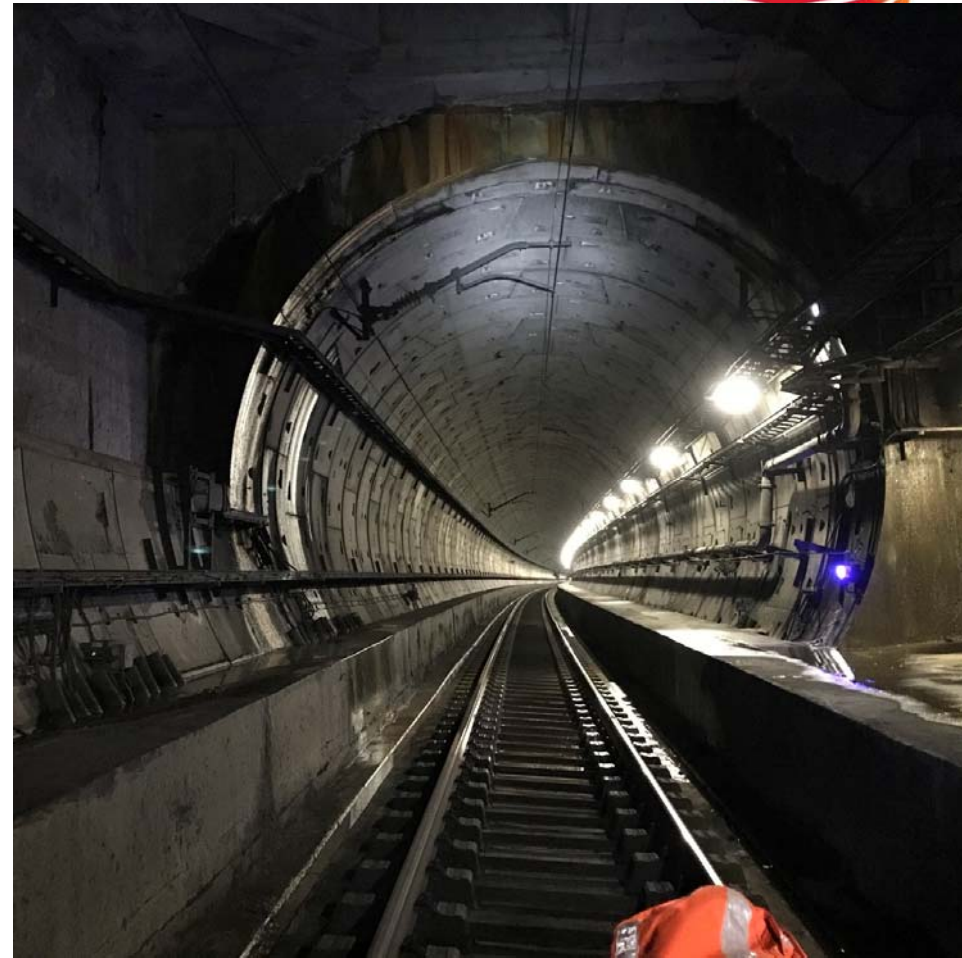


Figure 7 – Plain Ballast Profile for Canted Track

Special features/considerations

Tunnels

- Twin bore
- Single slab track
- 230km/h
- 8m diameter
- Cross passages



ECML Box

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Common Track Defects on HS1

RCF

Switch rail damage

Corrosion

Ballast and Ice pitting

Cracked crossings

Cracked/broken fishplates



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Maintenance - Tamping

Maintenance access

- 4 hours week nights
- 6 hours Saturday night
- Friday night 'trace free'; track recording runs

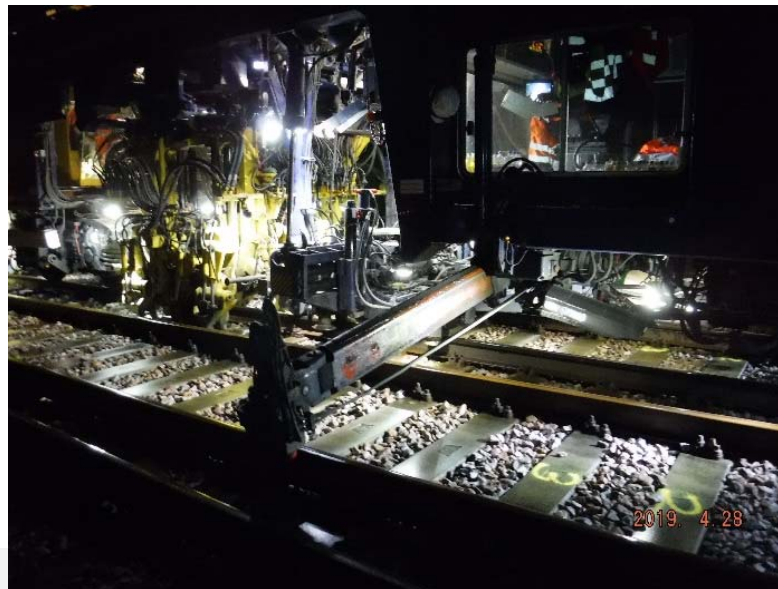
Track maintenance based on track quality intervention levels

Major Spring tamping campaign supplemented by the Sprinter tamping

Design tamping in all S&C with DTS and design to known fixed position – TAD

Monitor throughout works

- Mephisto/offsets
- ALC
- DRP Post survey



Maintenance - Grinding

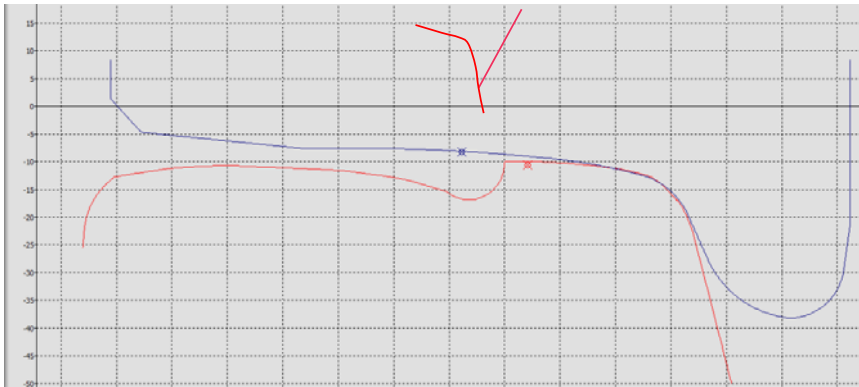


Annual proactive rail grinding programme

Critical to manage conicity for acoustic purposes and ride comfort at high speed

Reactive when rail head is damaged by ice during winter

- 24 stones for S&C
- 48 stones for plain line
- CEN60E2 profile

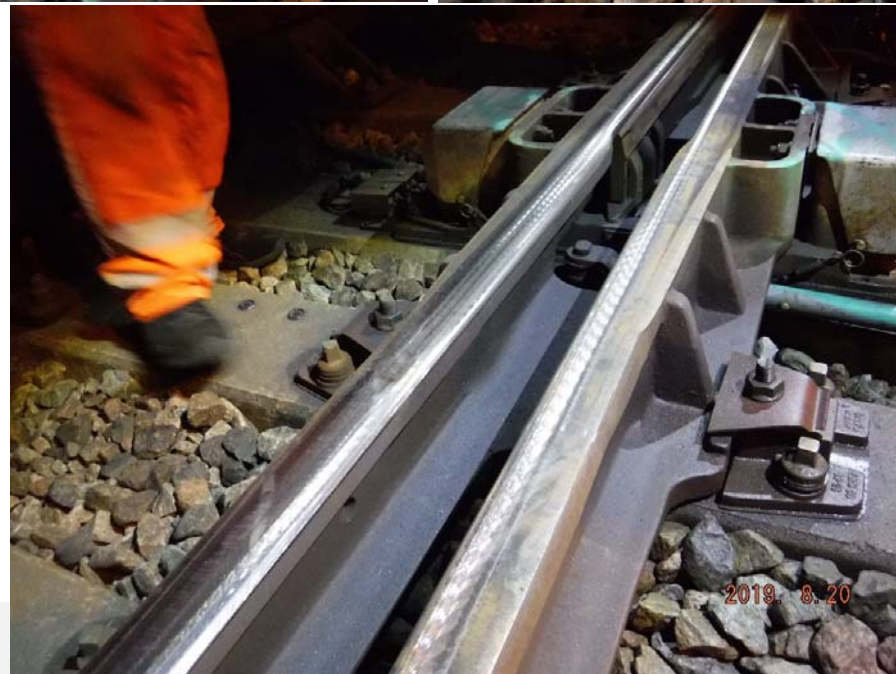


Switch rail sat higher than worn stock rail





Switch rail height correction



Ground swing
nose crossing

NRHS is evolving..

- NRHS re-organisation, including the Track department started in 2018
- New Track renewal strategy developed in 2018
- Evolution of maintenance strategy to integrate with renewals plan
- Review of Standards – more descriptive, less subjective; lessons learned from SNCF, Infrabel and Spanish High Speed line
- Review of competencies
- Plant and new product approvals
- Adoption of new technologies to improve maintenance efficiencies



Track Renewal Strategy

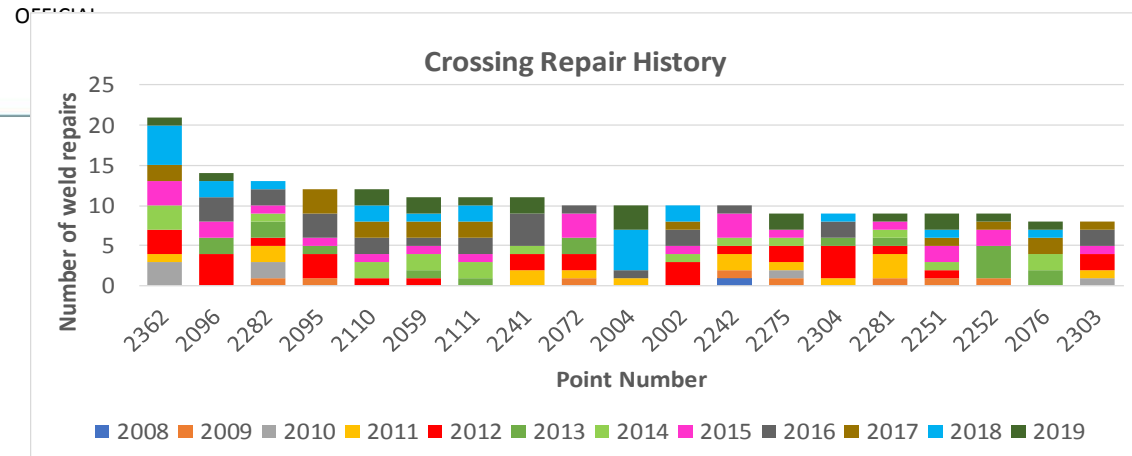
Based on current asset condition and HS1's Asset Management Objectives

Phasing of delivery to minimise service disruption

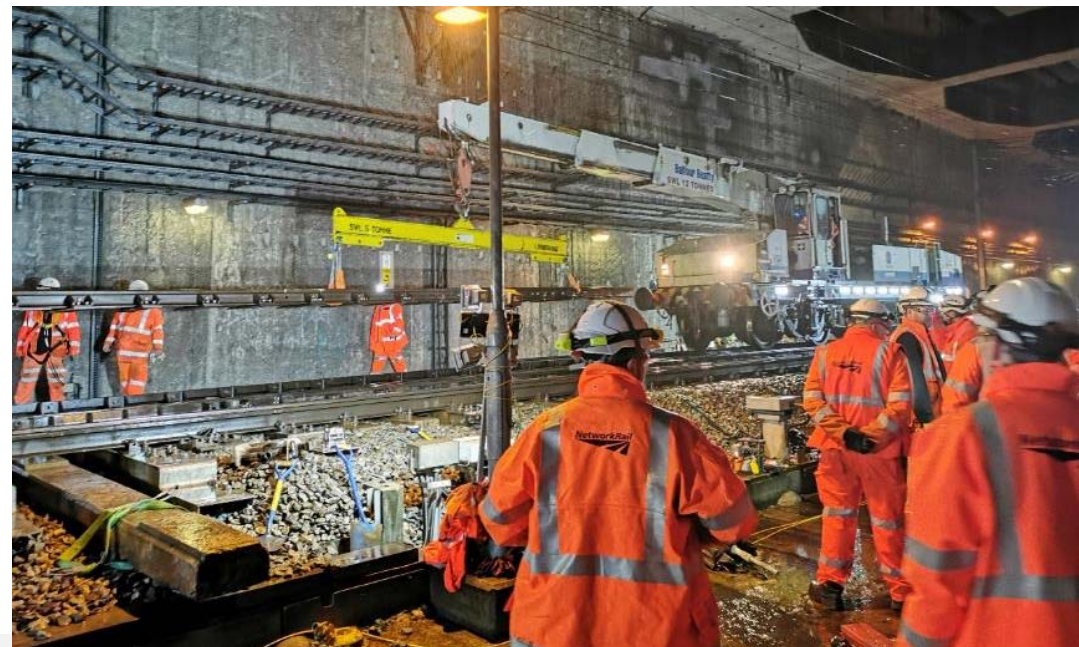
9 projects in flight:

1. **Install 5 new RRAPS to facilitate renewals**
2. Install under-sleeper pads to retard track geometry degradation
3. Replace 3 switches a year route wide
4. **Ballast refurbishment / renewal / cleaning of 30km of track**
5. Replace 6 crossings a year route wide
6. **Re-rail 10km of track at Section 1**
7. Accelerate 3km of re-railing at St Pancras
8. Replace 9 Insulated Block Joints at St Pancras per year
9. Accelerate renewal of Expansion Joints

Switch rail replacement at the Floating Track Slab



Condition led prioritisation



First swing nose replacement due to condition

40 year Track Renewal Plan based on Condition.....



Example S&C renewal

<i>Asset</i>	<i>Location</i>	<i>Original Design Life</i>	<i>NR(HS) Prediction</i>
Low Speed S&C	Eurotunnel	25	25
	St Pancras	20	10
	Section 1	25	25
	Section 2	25	25
High Speed S&C Crossing and Switch last 400MT, full renewal ~1000-1300MT [1]	Section 1	25	20
	Section 2	25	20

40 year Track Renewal Plan for S&C



Control Period →		CP2 15/16	CP3 20/21	CP4 25/26	CP5 30/31	CP6 35/36	CP7 40/41	CP8 45/46	CP9 50/51	Comments
S&C	Eurotunnel (2 units)	2							2 (restart cycle)	2 units have reached their design life
	HS1 Section 1 (60 units)			3	11	11	11	11	11	Units commissioned in 2003 and expected to last 25 years. Phased renewals to manage volume
	St Pancras (32 units)	6	15	11	6 (restart cycle)	6	6	6	5	To be renewed twice over 40- year period as expected service life is less than design life
	HS1 Section 2 outside St Pancras (49 units)	1	0	4	10	10	10	10	10 (restart cycle)	Units commissioned in 2007 with expected life of 25 years

Ballast Mid-Life Refurbishment

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To replace 30km of track ballast in the worst-affected location, from track geometry data, this is between North Downs Tunnel and Lenham.

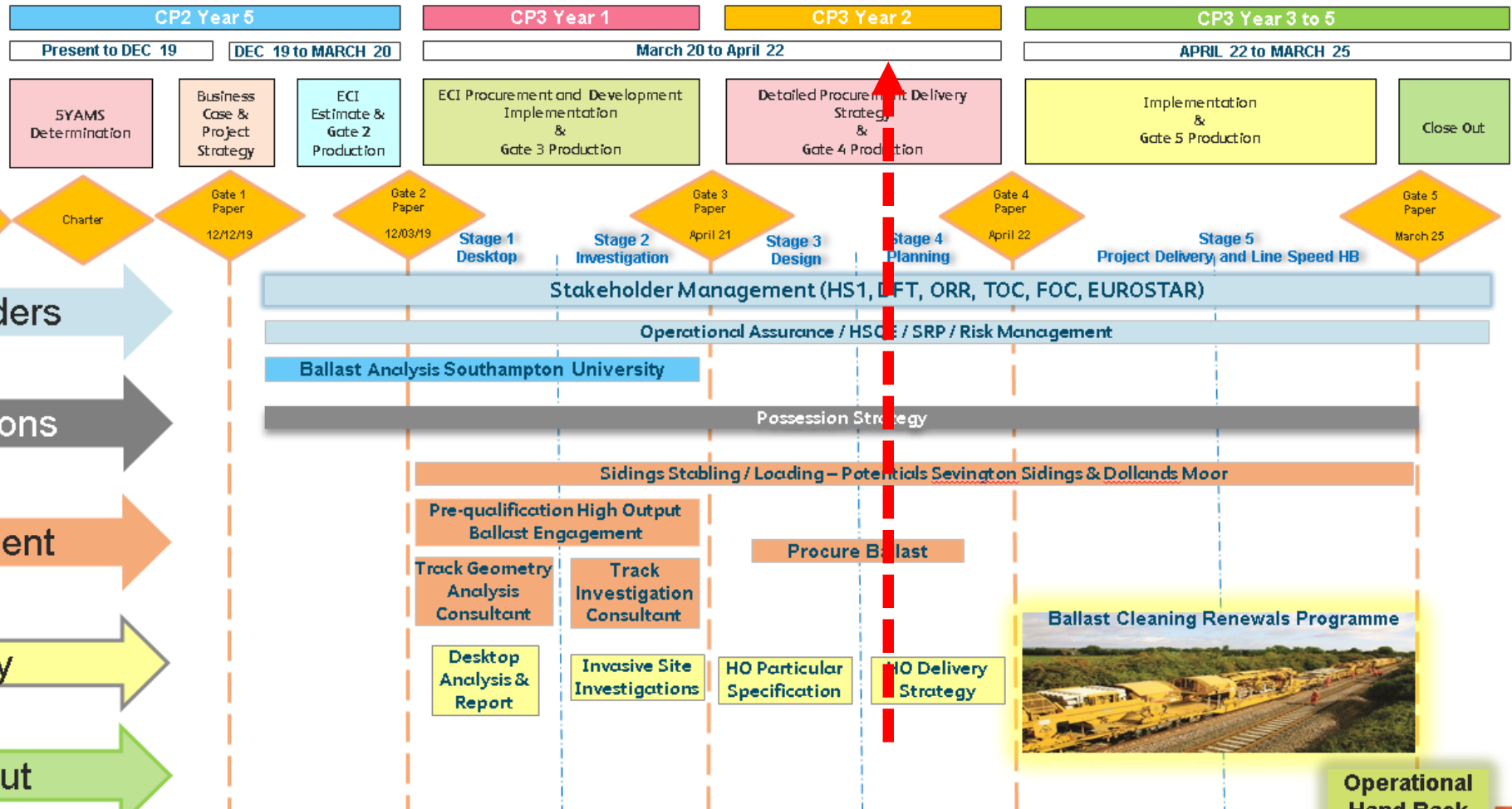


Ballast Mid-Life Refurbishment

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CP3 5YAMS



Operational Hand Back

Key Risks to Ballast Cleaning Delivery



No in-house delivery capacity

- Engaging with continental or alliance suppliers to deliver the first high speed ballast renewal in the UK etc.

Supply chain capability and appetite to deliver

- To date four companies have expressed interests – all Europeans
- Correct plant and experienced staff
- Materials availability and logistics, i.e. high specification ballast

Approval of plant

- All machines required for the delivery to be approved for use on HS1 infrastructure

Access

- Discussions have commenced with TOCs and FOCs on the disruptive possessions and associated speed restrictions after work
- Negotiations started with Southern Region to utilise/ lease the Sevington Sidings as the High Output Operating Base (HOOB)

Research Initiatives



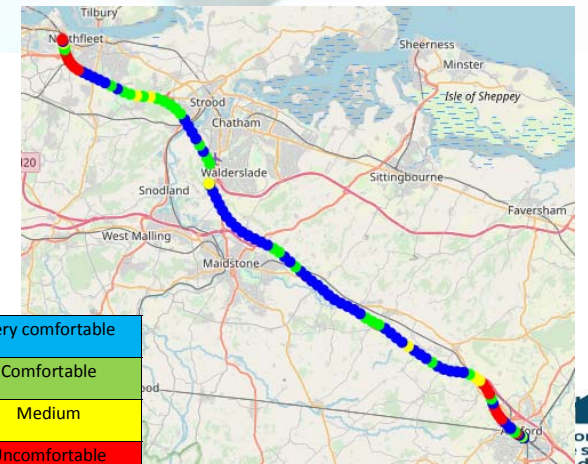
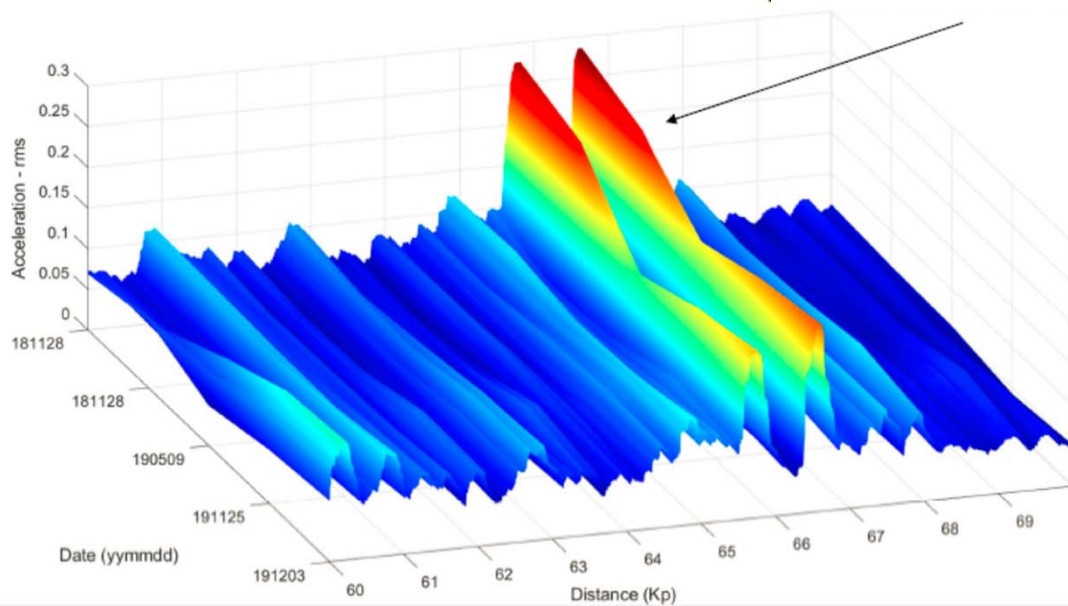
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Ride monitoring on in-service trains

Ride monitoring using a handheld IMU (inertia monitoring unit) for developing a preventative maintenance regime – manual or train-borne tamping.

Currently used during cab rides on Southeastern trains

Crismill



$C_{Cy}(t), C_{Cz}(t) < 0.20 \text{ m/s}^2$	Very comfortable
$0.20 \text{ m/s}^2 \leq C_{Cy}(t), C_{Cz}(t) < 0.30 \text{ m/s}^2$	Comfortable
$0.30 \text{ m/s}^2 \leq C_{Cy}(t), C_{Cz}(t) < 0.40 \text{ m/s}^2$	Medium
$0.40 \text{ m/s}^2 \leq C_{Cy}(t), C_{Cz}(t)$	Uncomfortable

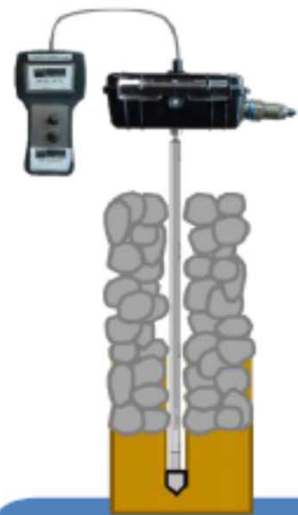
Ballast Mid-Life Refurbishment

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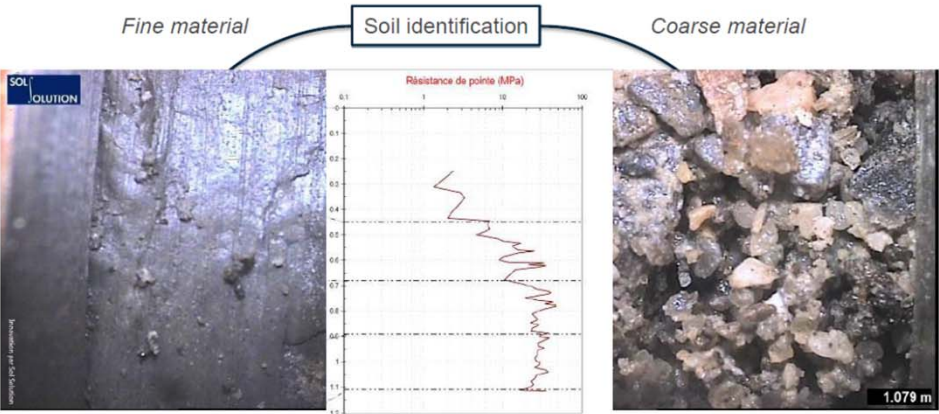


Ballast Renewal Prioritisation – 40 year programme

To prioritise sites, apply sustainable renewal and minimise service disruption using detailed desktop analysis and validated data from non-intrusive site investigation.

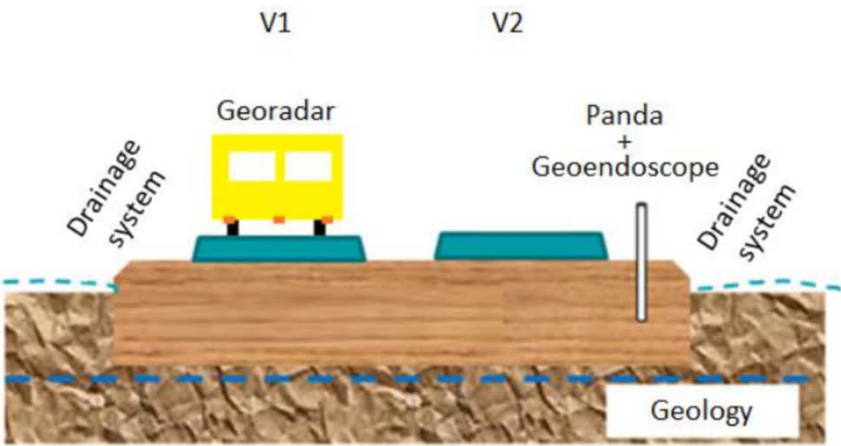


In-situ image acquisition



Structured site investigation processes

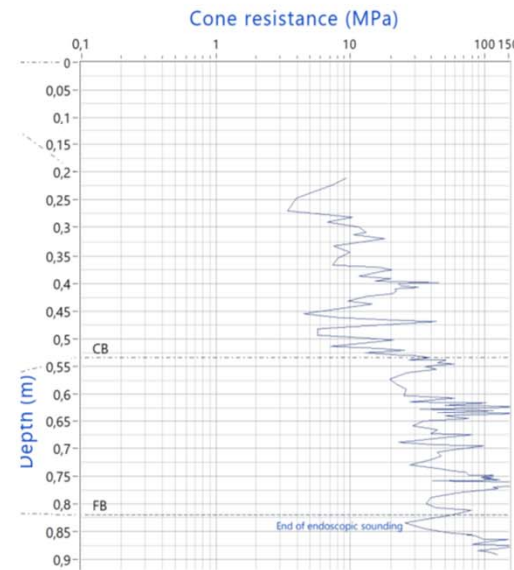
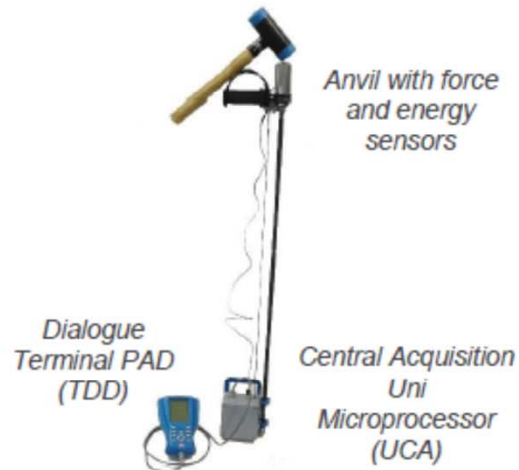
Wetlands
Groundwater rising risk



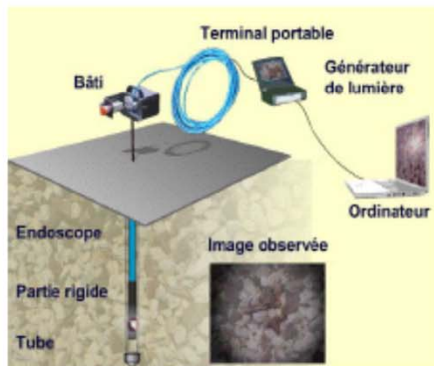
Multi-domain approach

PANDOSCOPE©

PANDA® : Variable energy dynamic penetration test



Geoendoscopy



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