The Challenges of Maintaining a High Speed Railway

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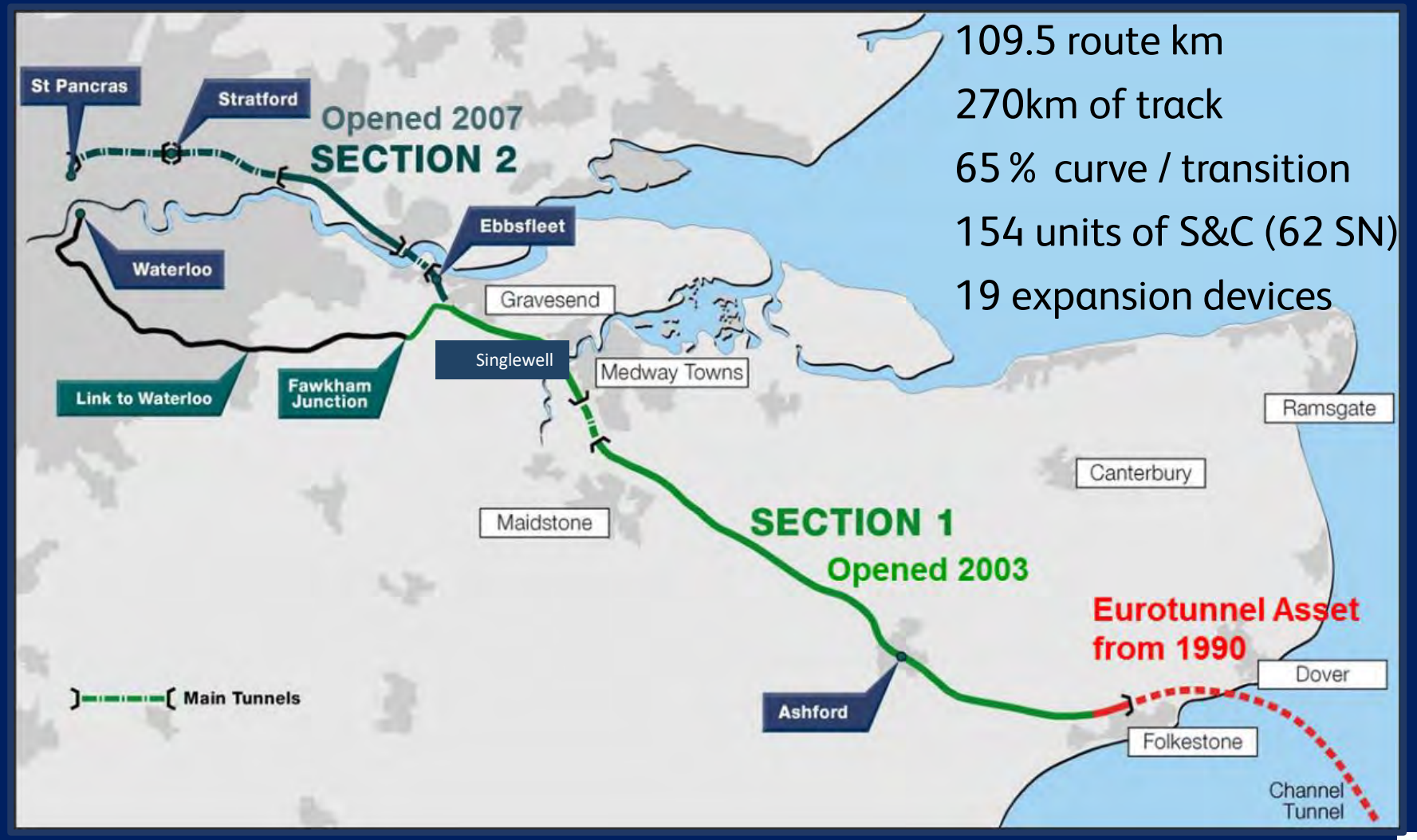
Summary of Track Asset



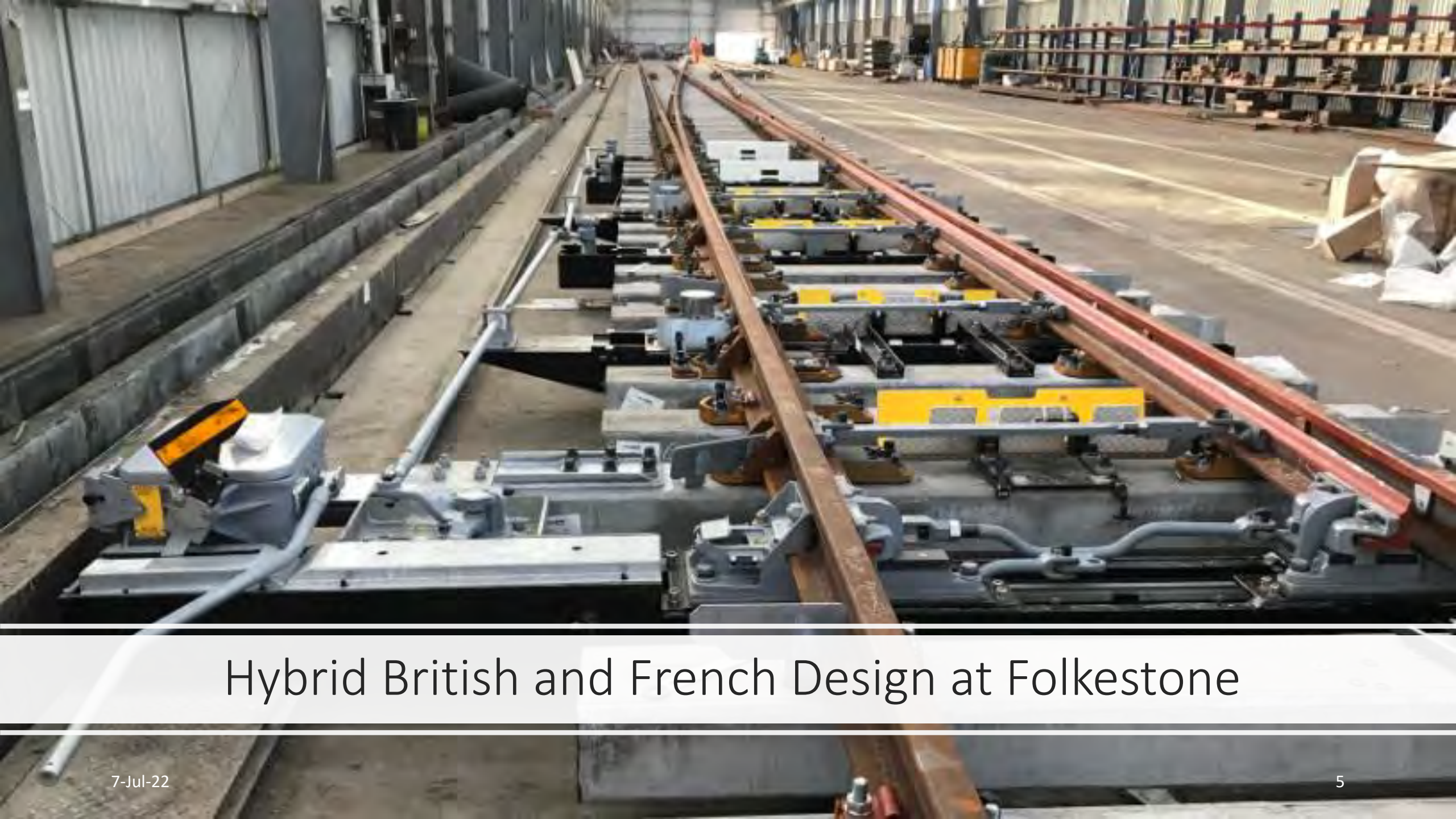
UK Rail Speed Record
Eurostar Class 373 (2003)

334.7 km/h

Photo taken from internet

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



Hybrid British and French Design at Folkestone

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 construction & gauge	Minimum track centre line spacing **4500 mm**.	Minimum track centre line spacing **4200 mm**.
	Ballast Track in long tunnels (North Downs have 180mm clearances between UIC GC kinematic envelope and the high level walkways.	**Ballast and slab (~40km)** Slab-track is provided in long tunnels (London & Thames). The clearance to the evacuation walkway is 50 mm.

Typical plain line on twin-block sleepers

- 10 weekly – alumicart (<7km/h or 4 mph) or on foot
- 6 weekly St Pancras plain line
- 13 weekly depot Inspections
- Twice yearly supervisor inspections
- 2 yearly Engineers inspection
- Annual Rail depth/condition in tunnels
- Minimum Annual RCF inspection curves >3000m

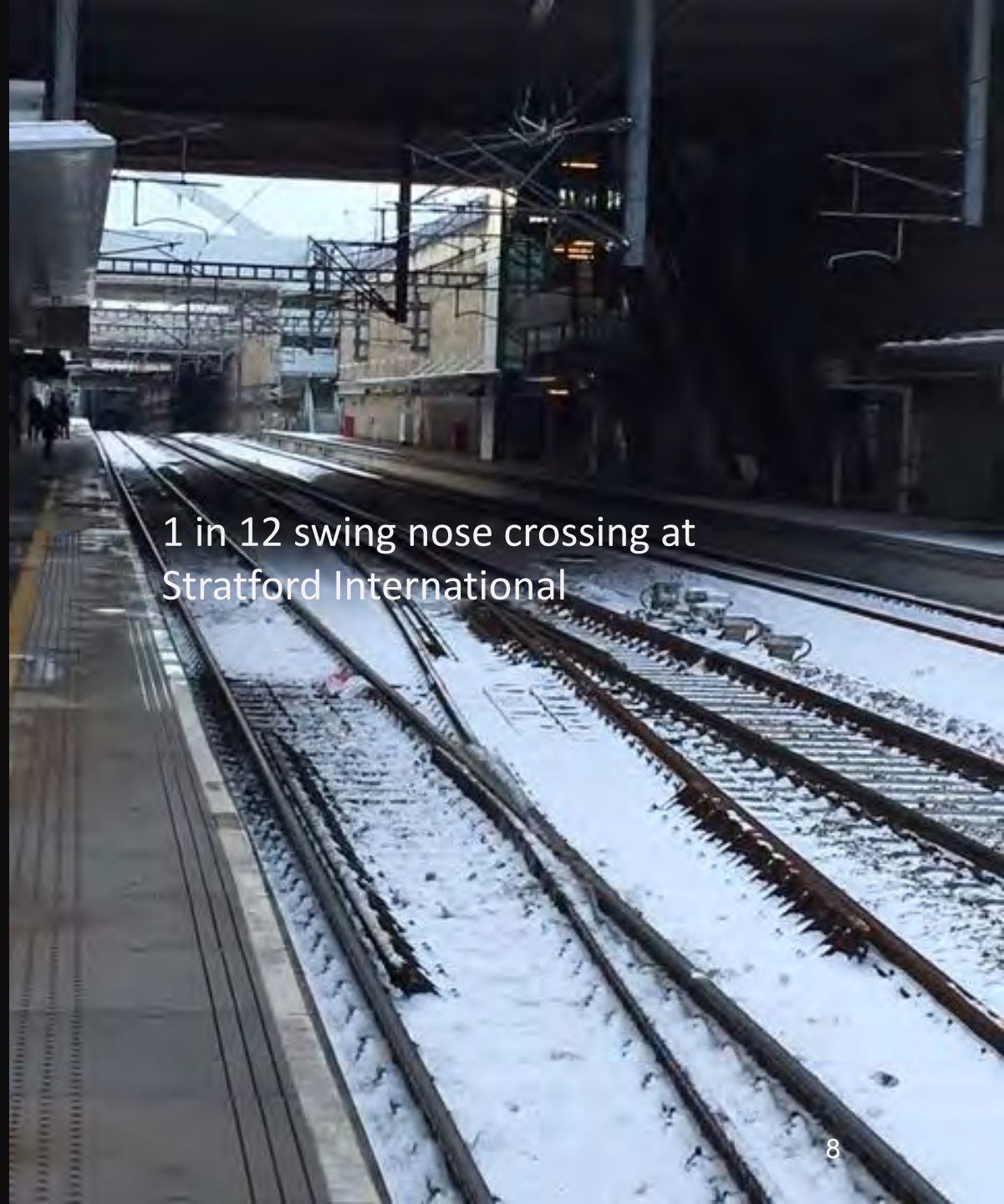
S&C Inspections

High Speed

- 5 weekly – basic visual
- 6 monthly – detailed component
- 12 monthly – full gauge check

St Pancras

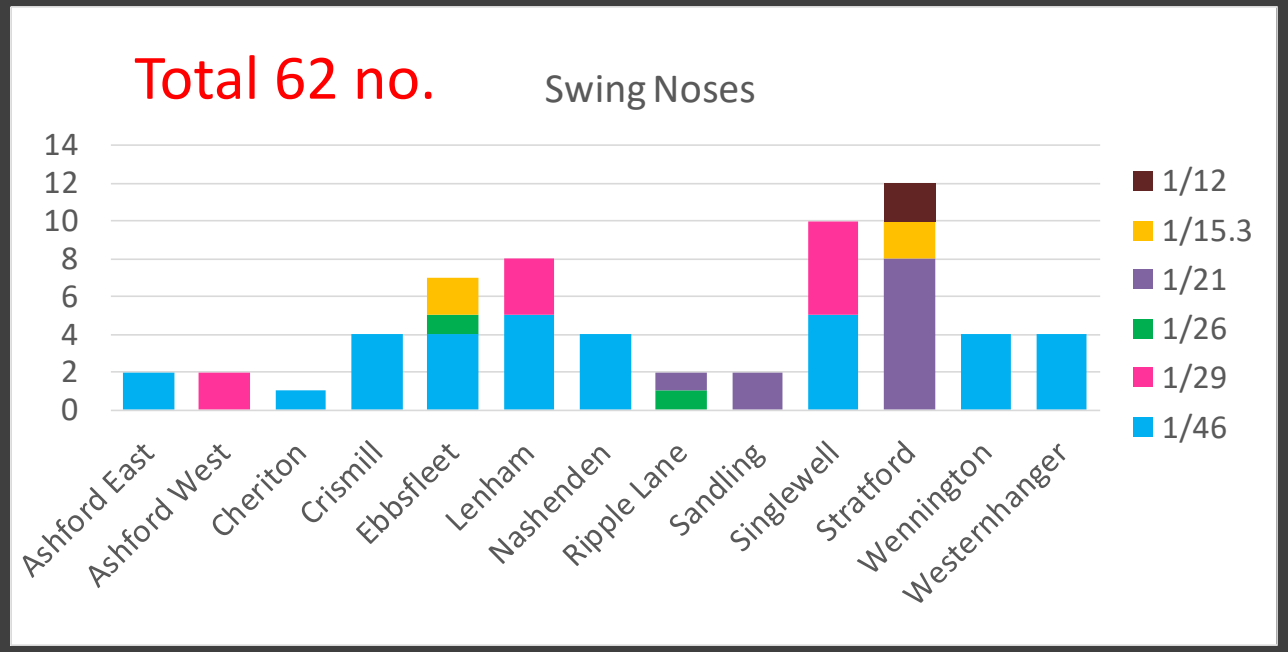
- 2 weekly visual
- Risk-based derailment hazard inspections
- 6-monthly cast crossing inspections



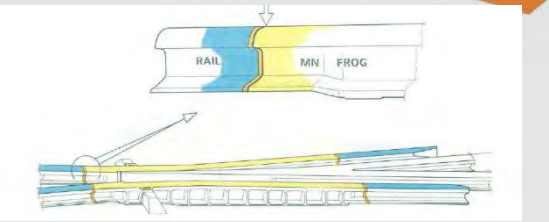
1 in 12 swing nose crossing at Stratford International

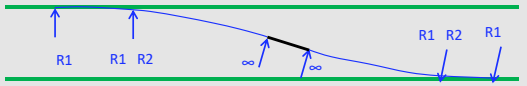
Switches and Crossings

- 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



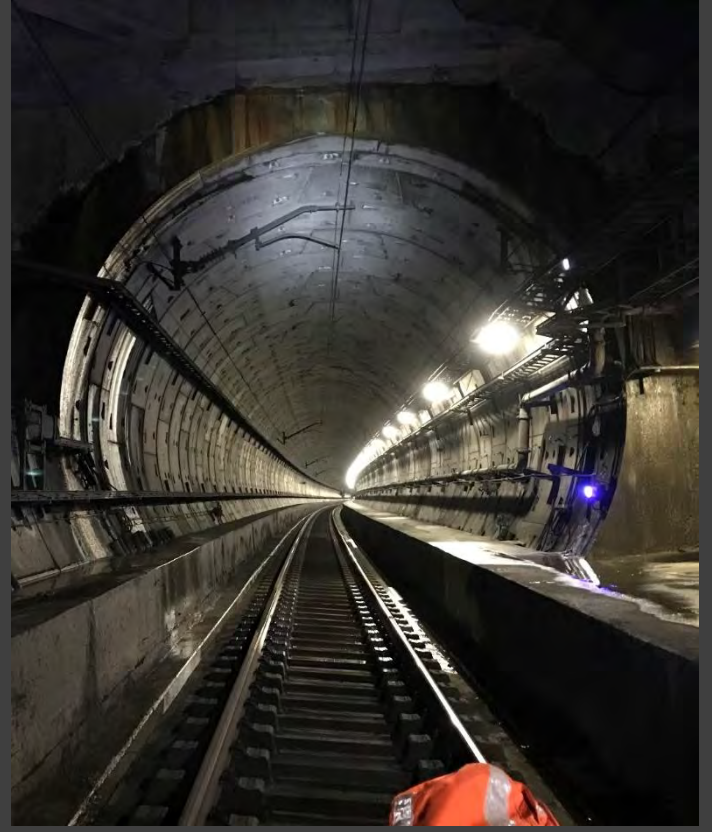


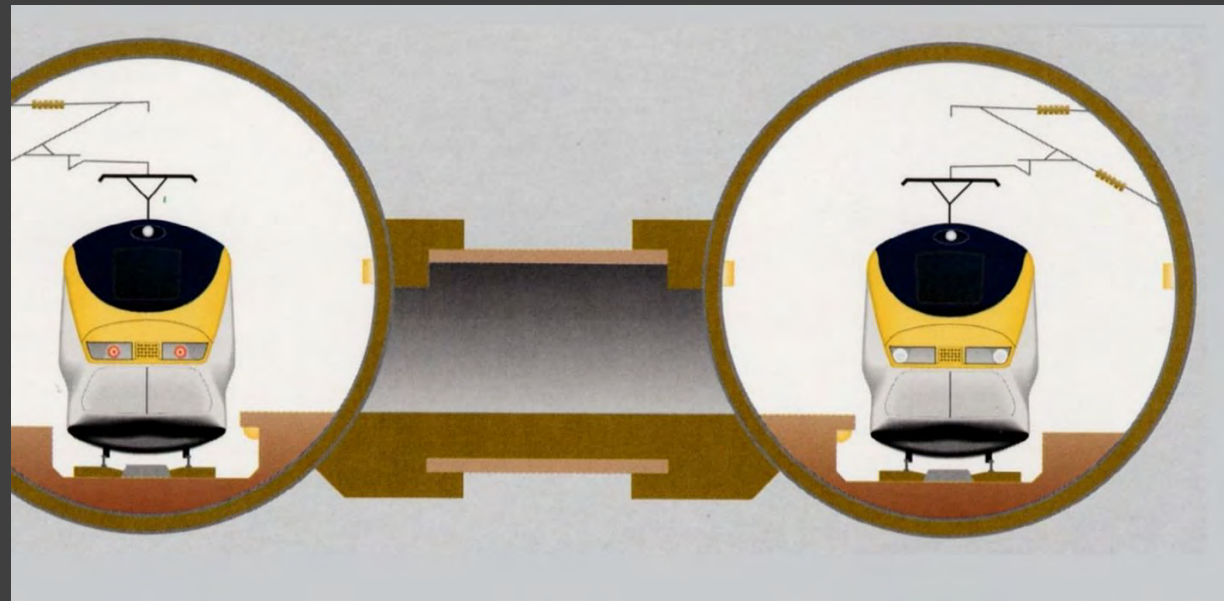
- Toe to heel length 43m
- Tip to tip 300m
- Concrete bearers
- Nabla fastenings
- MCEM91 points machines
- All on straight track

- 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

Special features/considerations

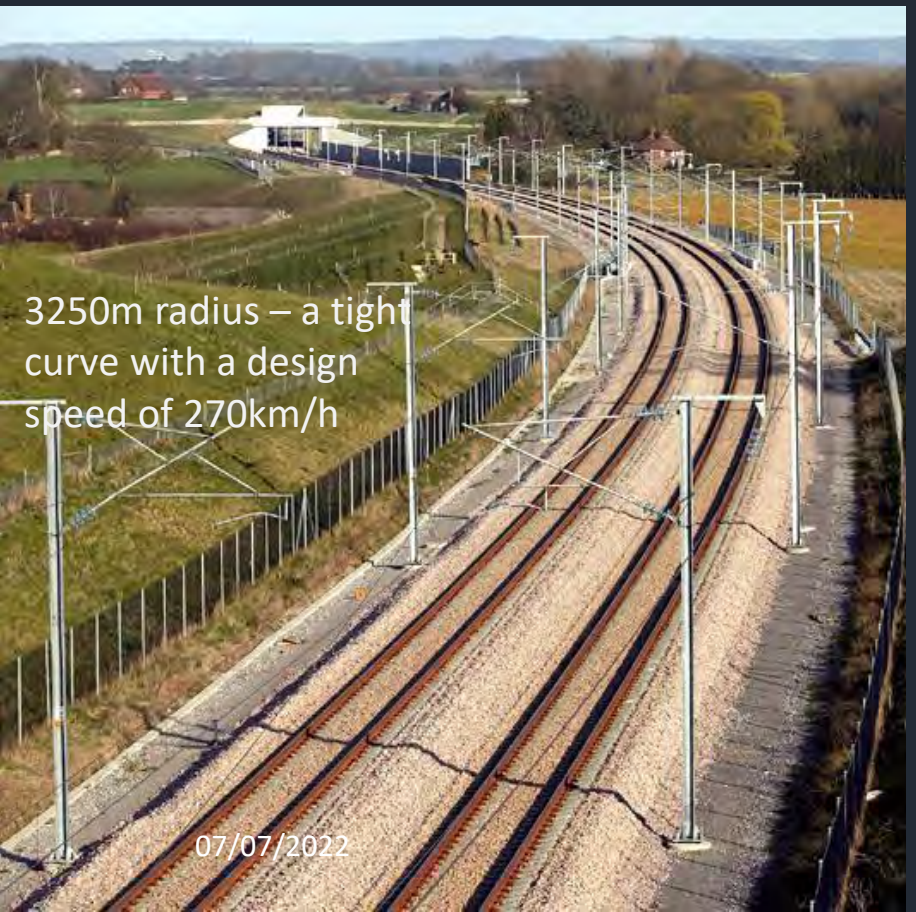
- Tunnels
- Twin bore
- Single slab track
- 230km/h
- 8m diameter
- Cross passages



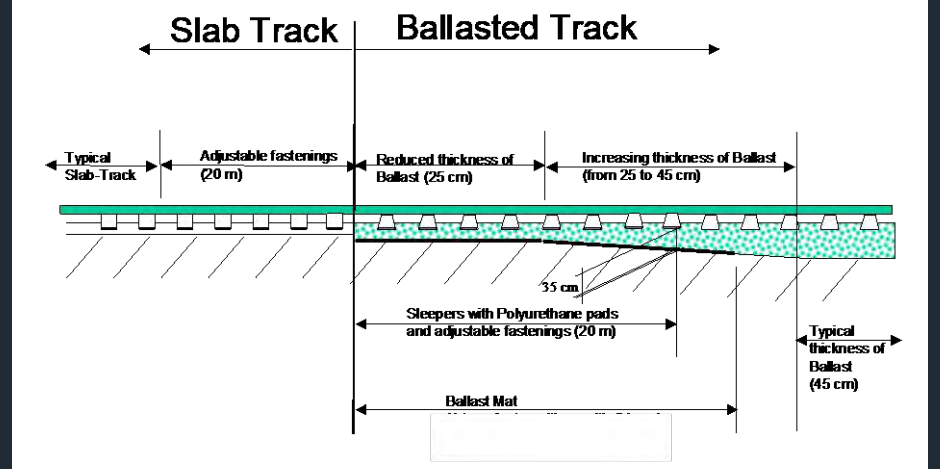


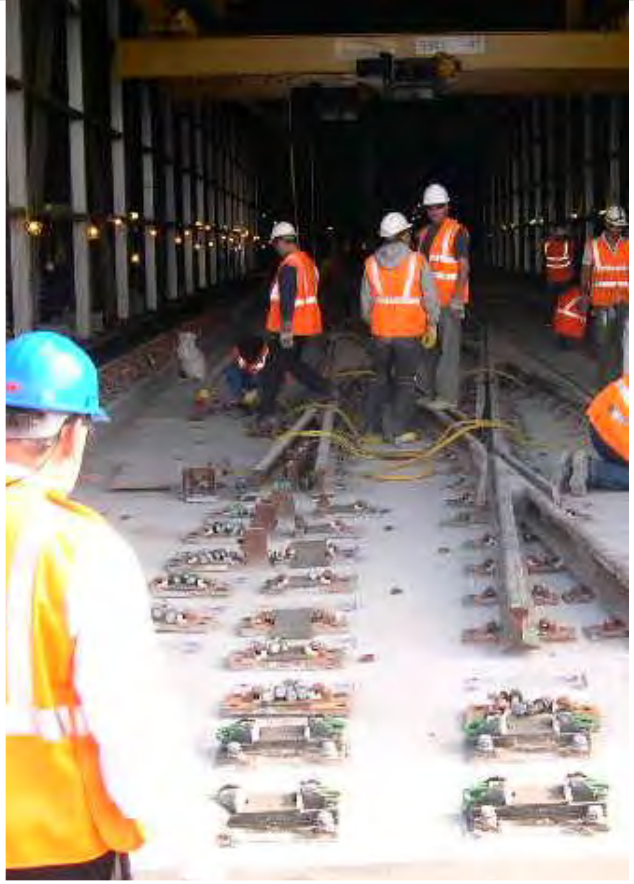
Special features/considerations

- Tight curves
- Steep Gradients
- Long Expansion switches
- Ballast / slab transitions
- UTX hard Spots



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



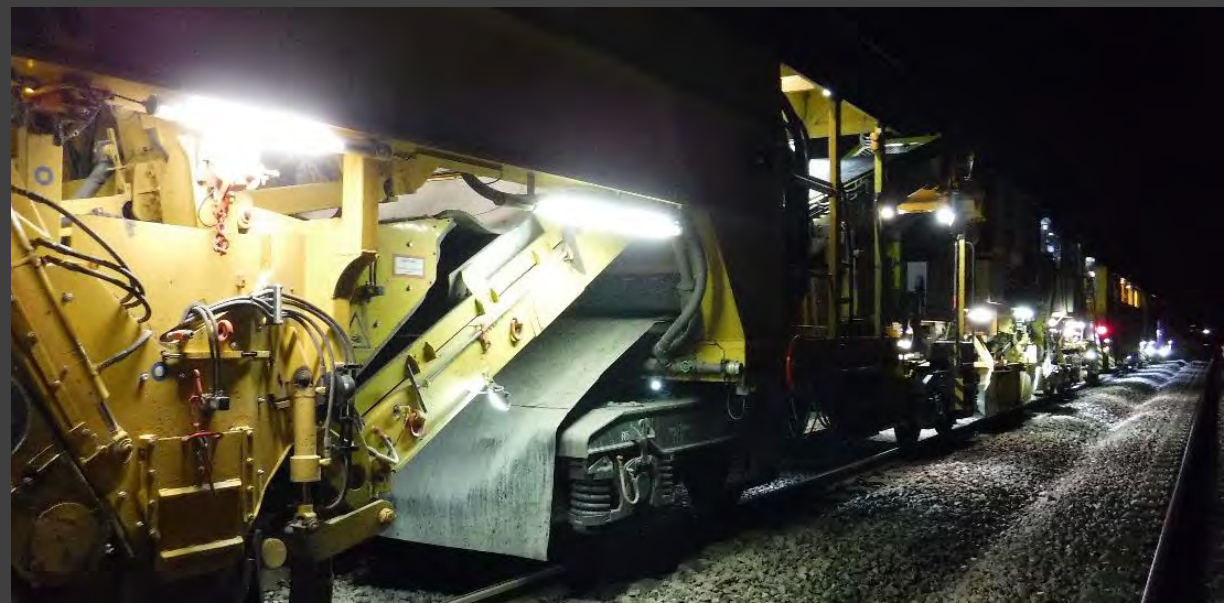
ECML Box

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

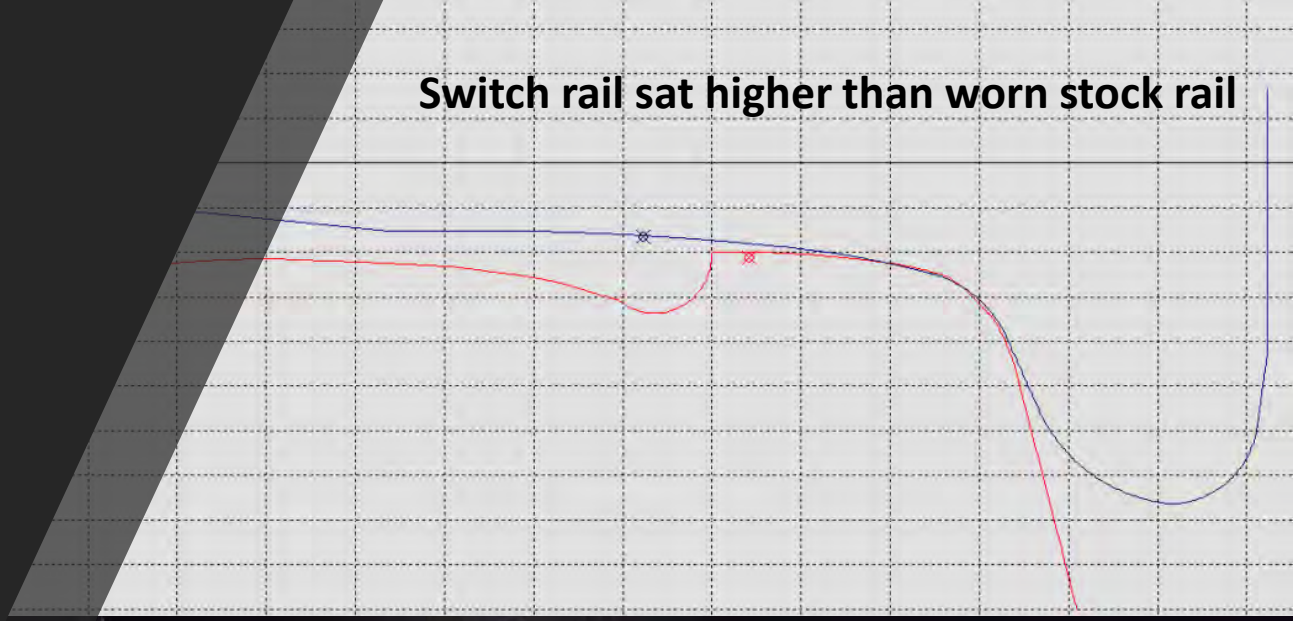
Maintenance - Tamping

- 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

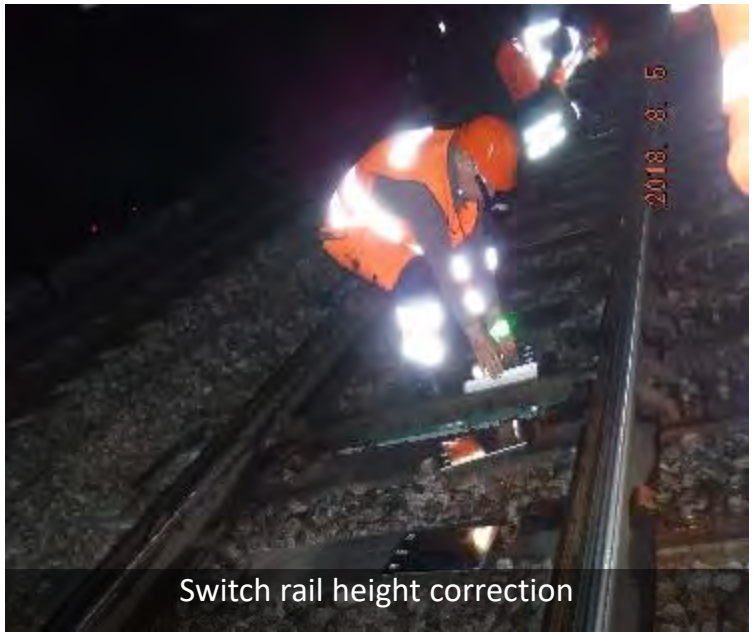


Maintenance - Grinding

- Annual proactive rail grinding programme
    - 24 stones for S&C
    - 48 stones for plain line
    - CEN60E2 profile
- Critical to manage conicity for acoustic purposes and ride comfort at high speed
- Reactive when rail head is damaged by ice during winter
- Development of strategy for best whole life performance
- Trial of rail milling to manage RCF propagation and corrugation



Ground swing nose crossing

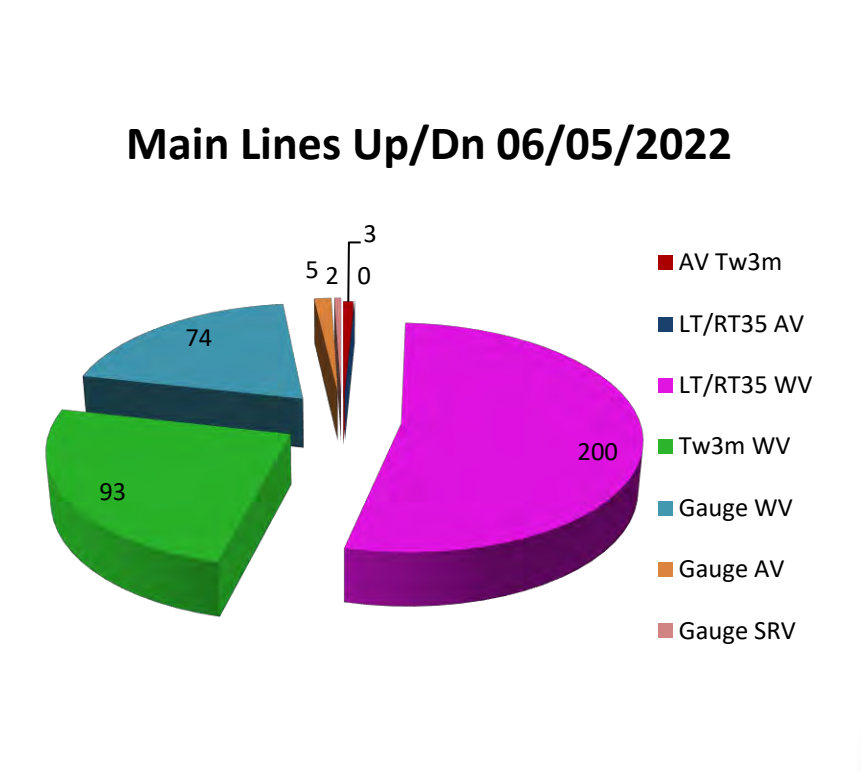


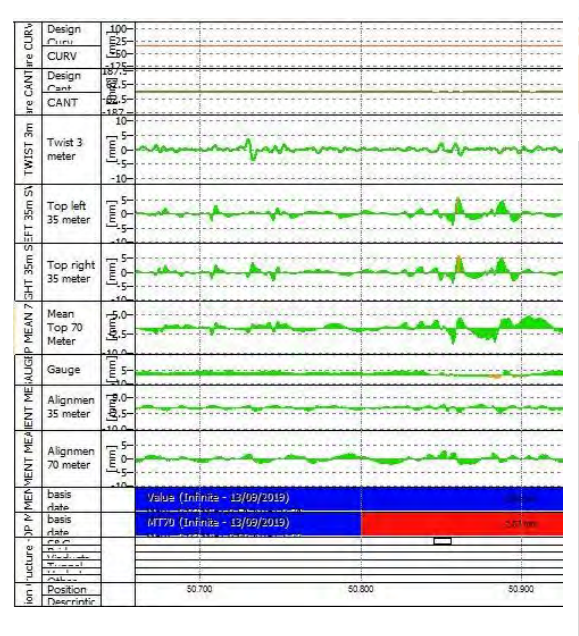
Switch rail height correction

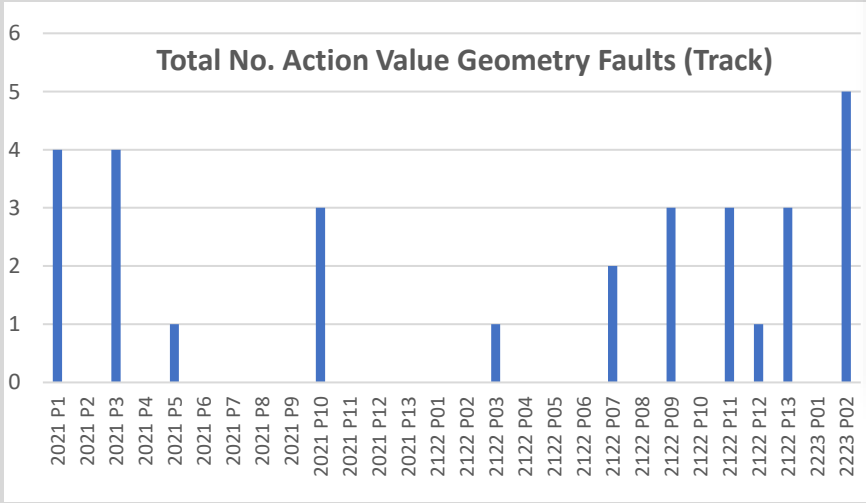
S&C Grinding

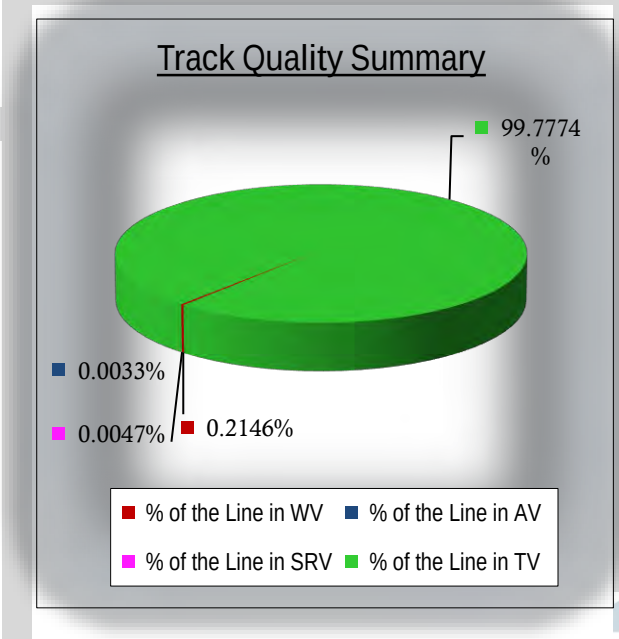
Dynamic Inspections

- Track Geometry Recording Vehicles
  - 6 weekly main lines
  - 12 weekly crossovers
  - 12 weekly loops
  - 26 weekly interface areas
- UTU 16 weekly
- Cab rides - 4 weekly Eurostar and 2 weekly on Class 395, Hitachi Javelins
- Lineside asset inspections under traffic
- Use of Erdmann IRISsys to analyse, predict and report



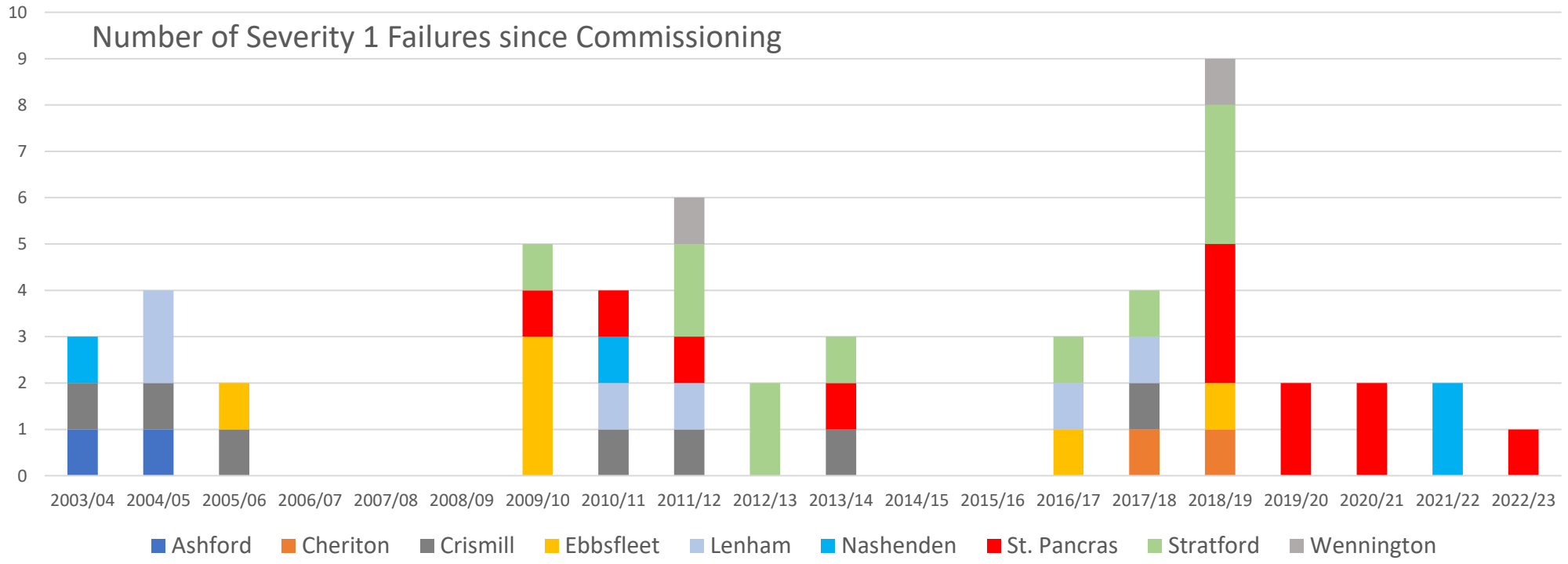






Track Performance – Service Affecting Failures

20th year of operation (2003-2023) total 52 no.- 8 relating to S&C



Track Defects on HS1

- RCF
- Switch rail damage
- Corrosion
- Ballast and Ice pitting
- Cracked crossings
- Cracked/broken fishplates



Track Defects on HS1

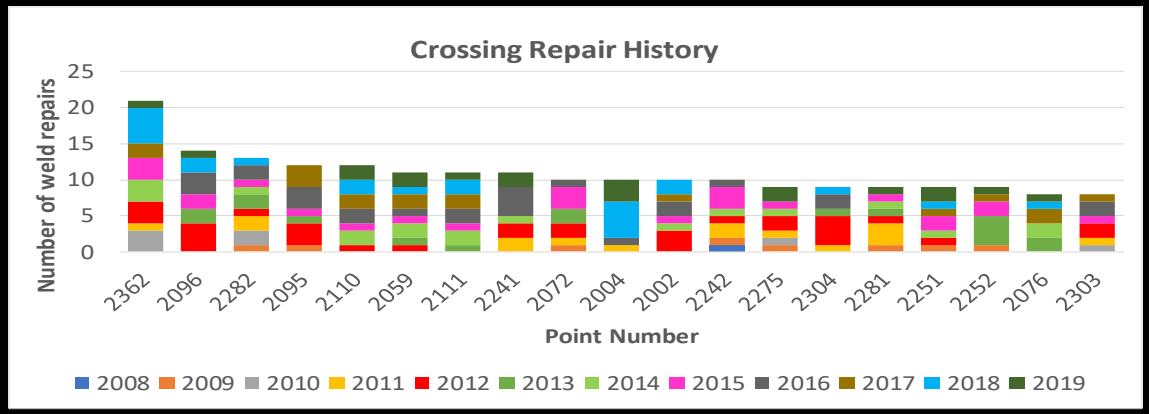
Track Defects on HS1

NRHS is evolving…(in terms of Predictive Maintenance)

- Adoption of new technologies to improve maintenance efficiencies
- New Track renewal strategy developed in 2018 and continuing to evolve
- Evolution of maintenance strategy to integrate with renewals plan
- Plant and new product approvals
- Development into inspection / maintenance / renewal organisation
- Review of Standards – more descriptive, less subjective; lessons learned from SNCF, Infrabel and Spanish High Speed line
- Review of competencies and redrawing of competence framework

Track Renewal Strategy

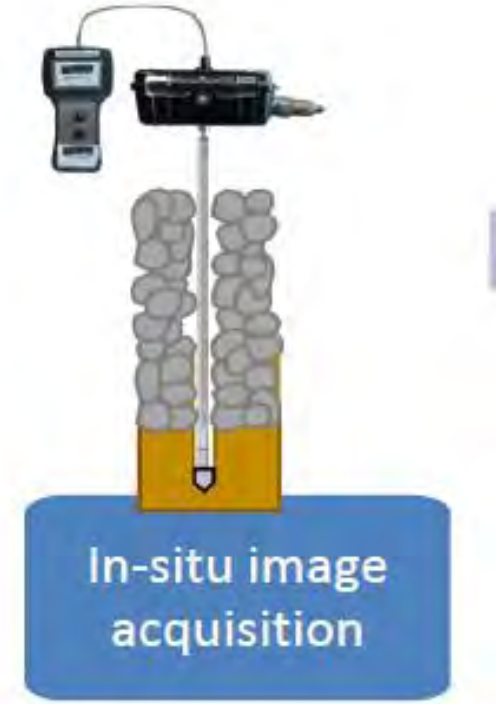
- Based on current asset condition and HS1's Asset Management Objectives
- Phasing of delivery to minimise service disruption
- Project definition and delivery in flight:
  - **Switch and crossing renewal**
  - **Ballast refurbishment / renewal / cleaning of 30km of track**
  - **Re-rail 10km of track at Section 1 and St. Pancras curves**
  - **Long expansion joint replacement**
- Future challenges:
  - **Ballast condition in S&C**
  - **Delivery integration and optimisation of whole-life cost**
  - **Renewal of long switches**

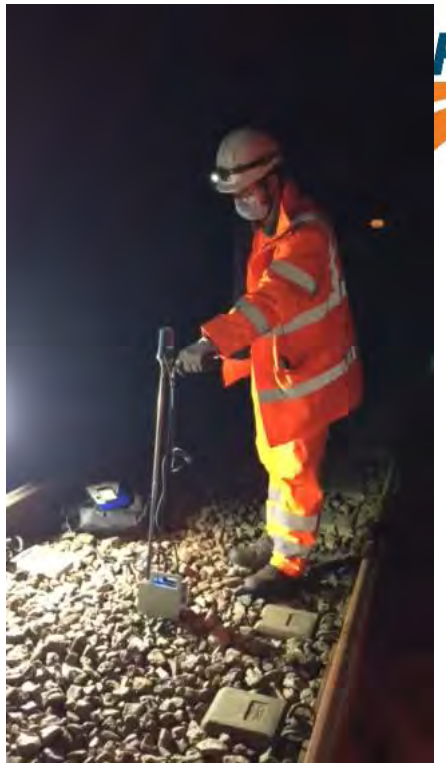


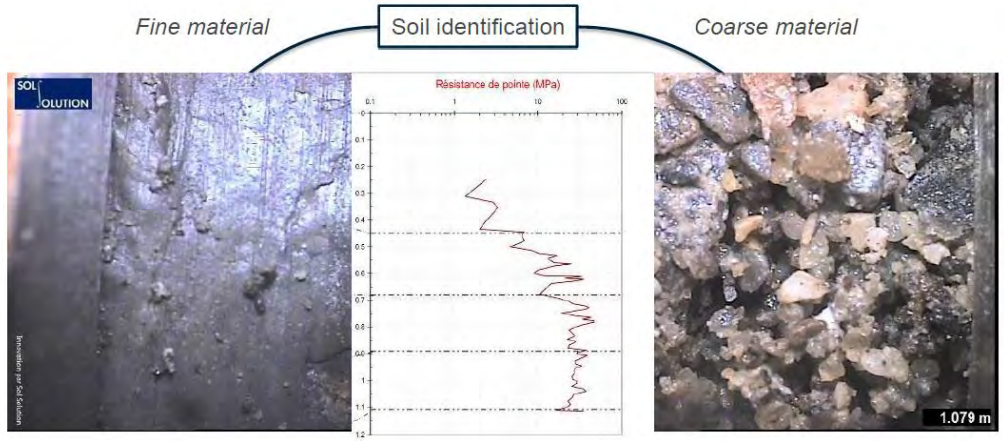
Condition led prioritisation

Non-Intrusive Trackbed Investigation Technique

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



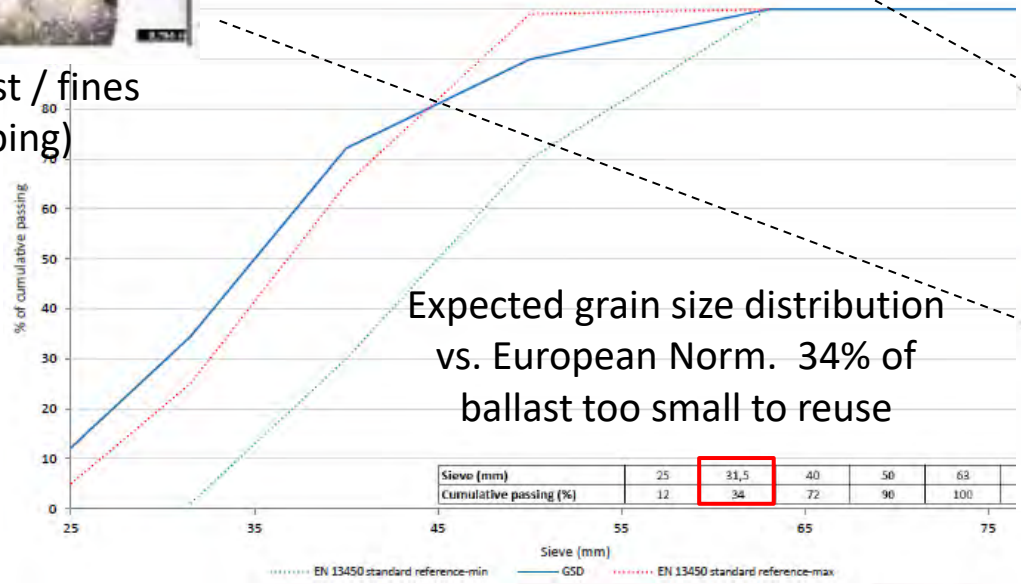




PandaScope campaign and results

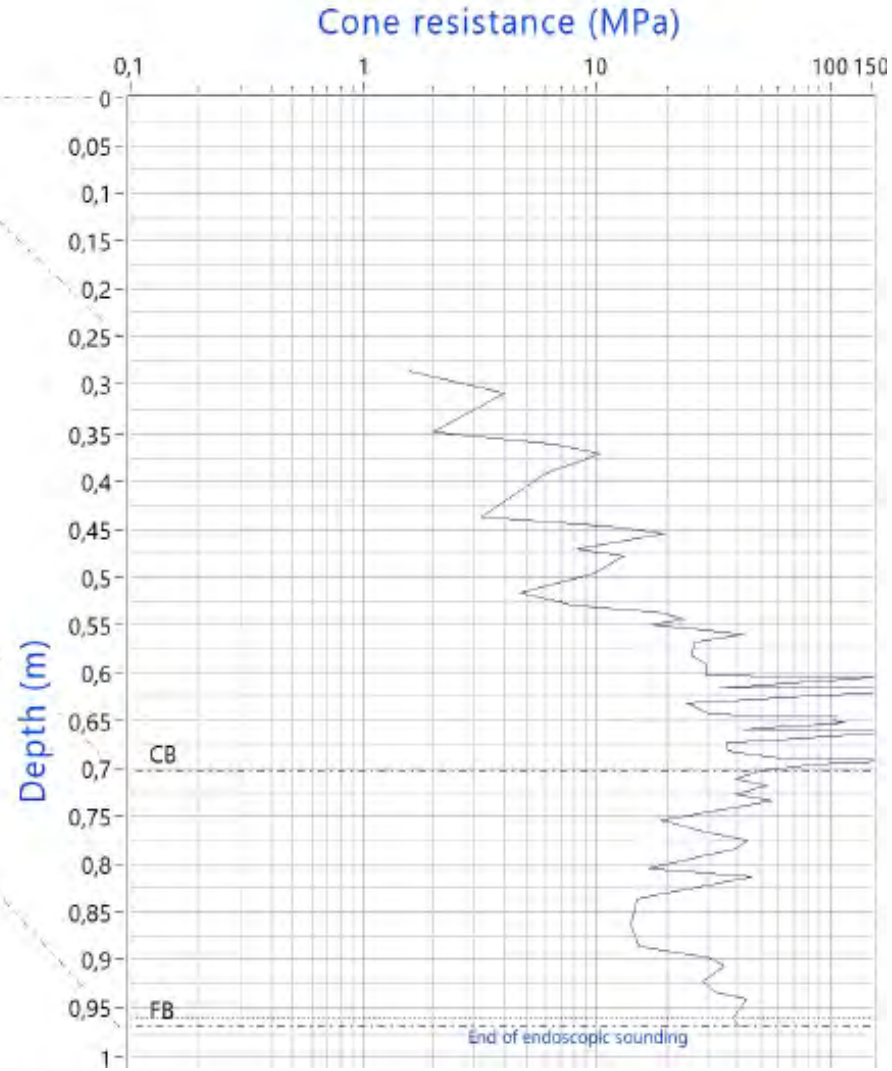
Clean Ballast depth

Fouled Ballast depth (dust / fines generated from tamping)



Sieve (mm)	25	31,5	40	50	63
Cumulative passing (%)	12	34	72	90	100

Expected grain size distribution vs. European Norm. 34% of ballast too small to reuse

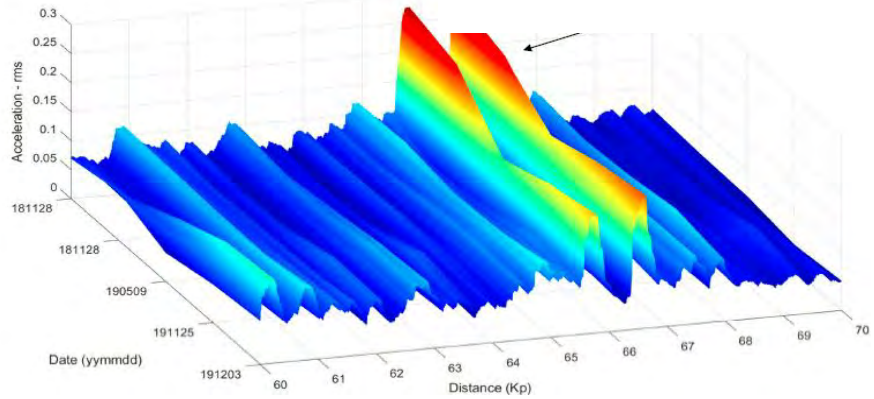


Pandascope Technology – Non-intrusive trackbed investigation

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.
- Demonstrated potential for in-service monitoring

Crismill



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

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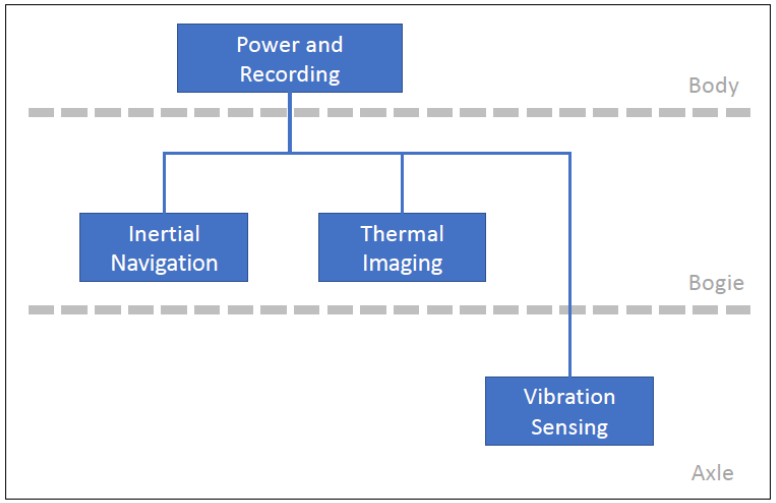
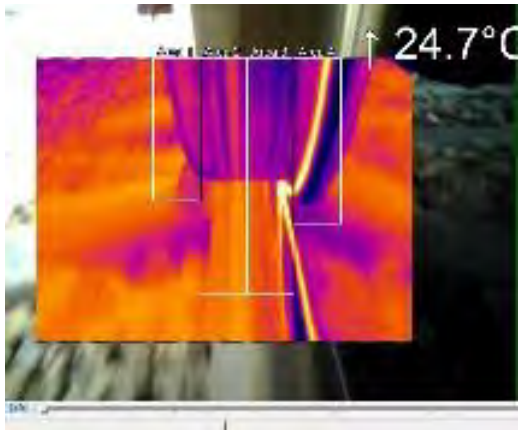
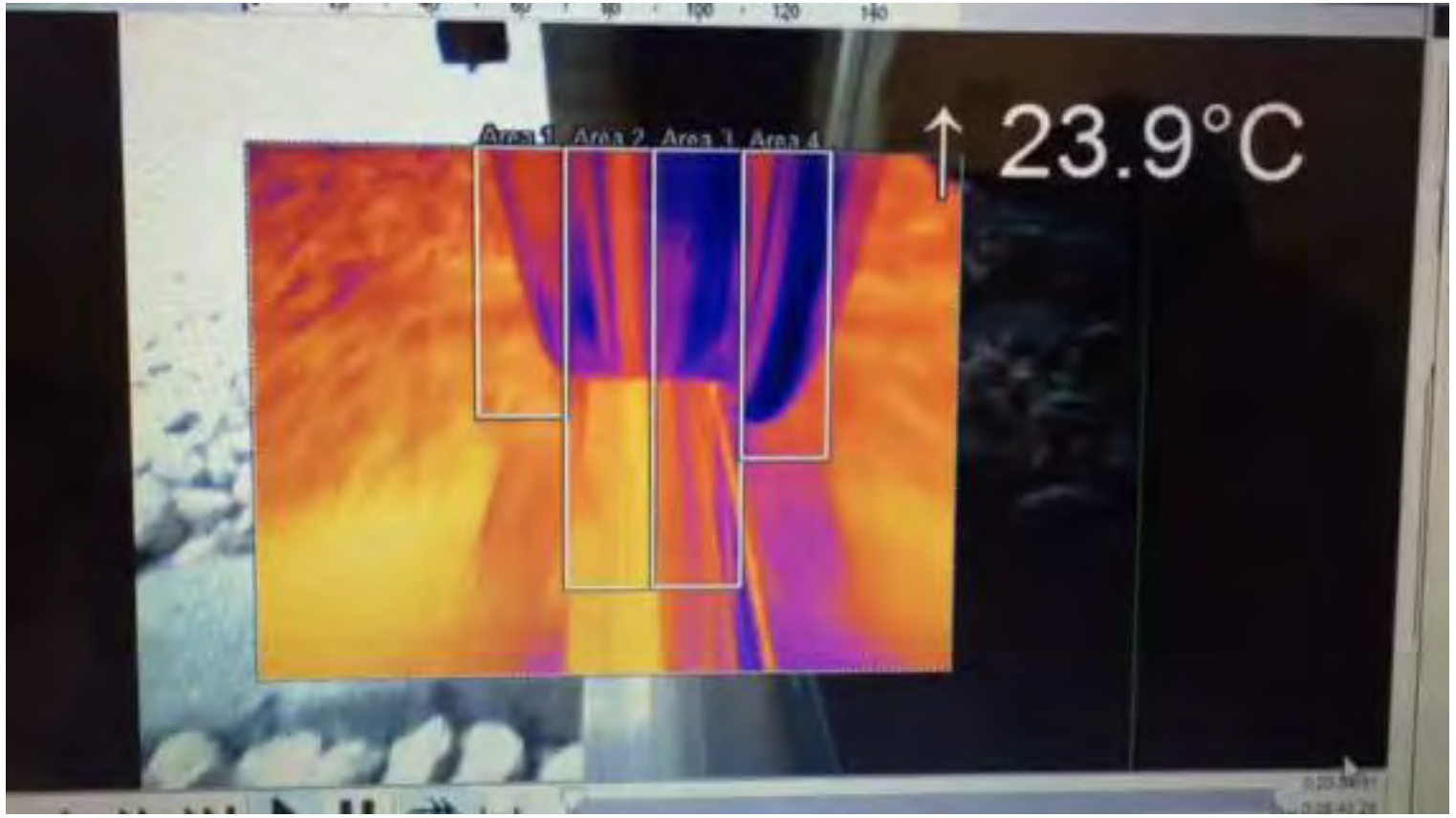
Wheel/Rail interface monitoring on in-service trains

Using a Thermal camera on the Eurostar directed at the WRI to detect high impact forces as a means of preventative maintenance for both Train Operator and Infrastructure Maintainer



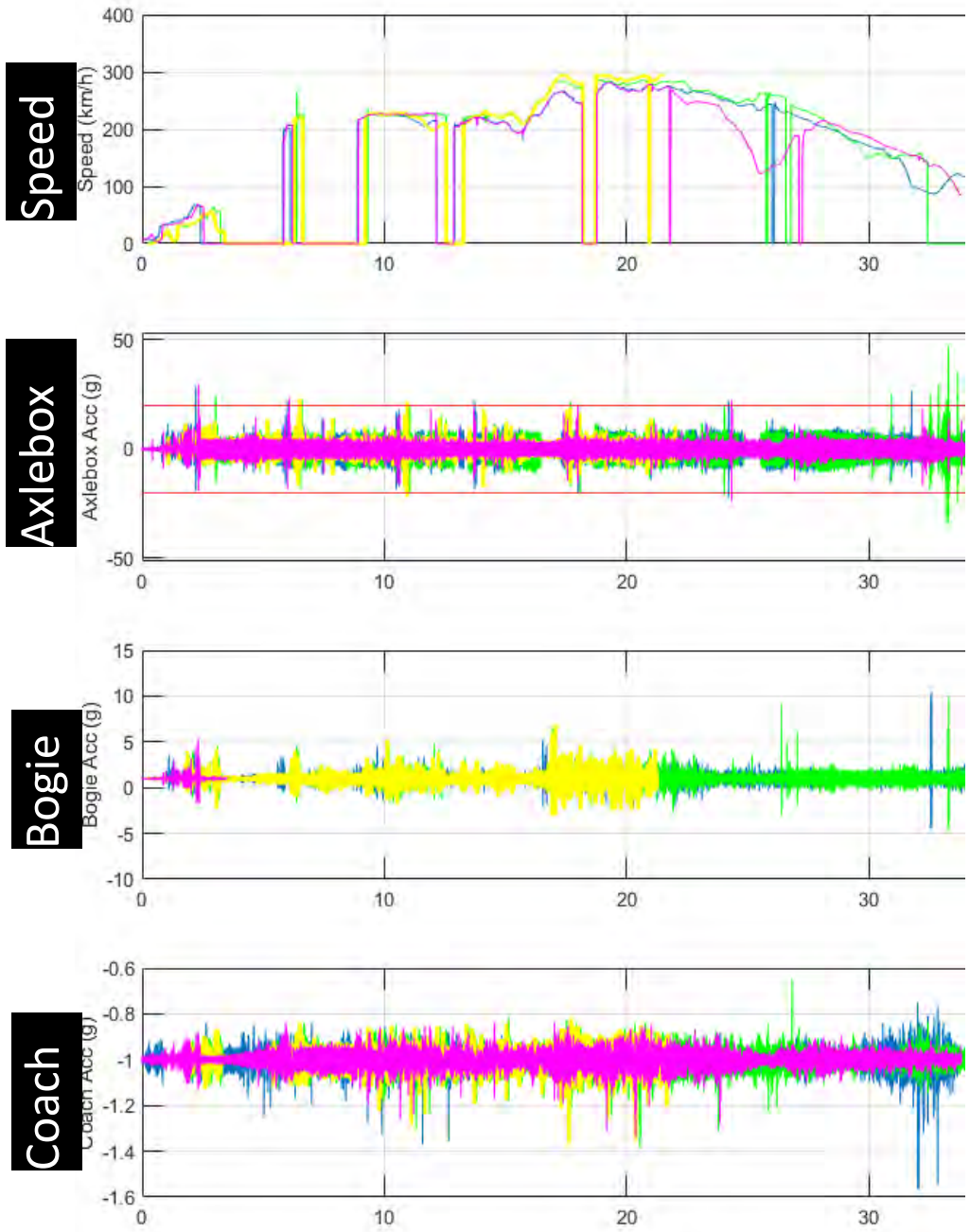


Thermal Camera



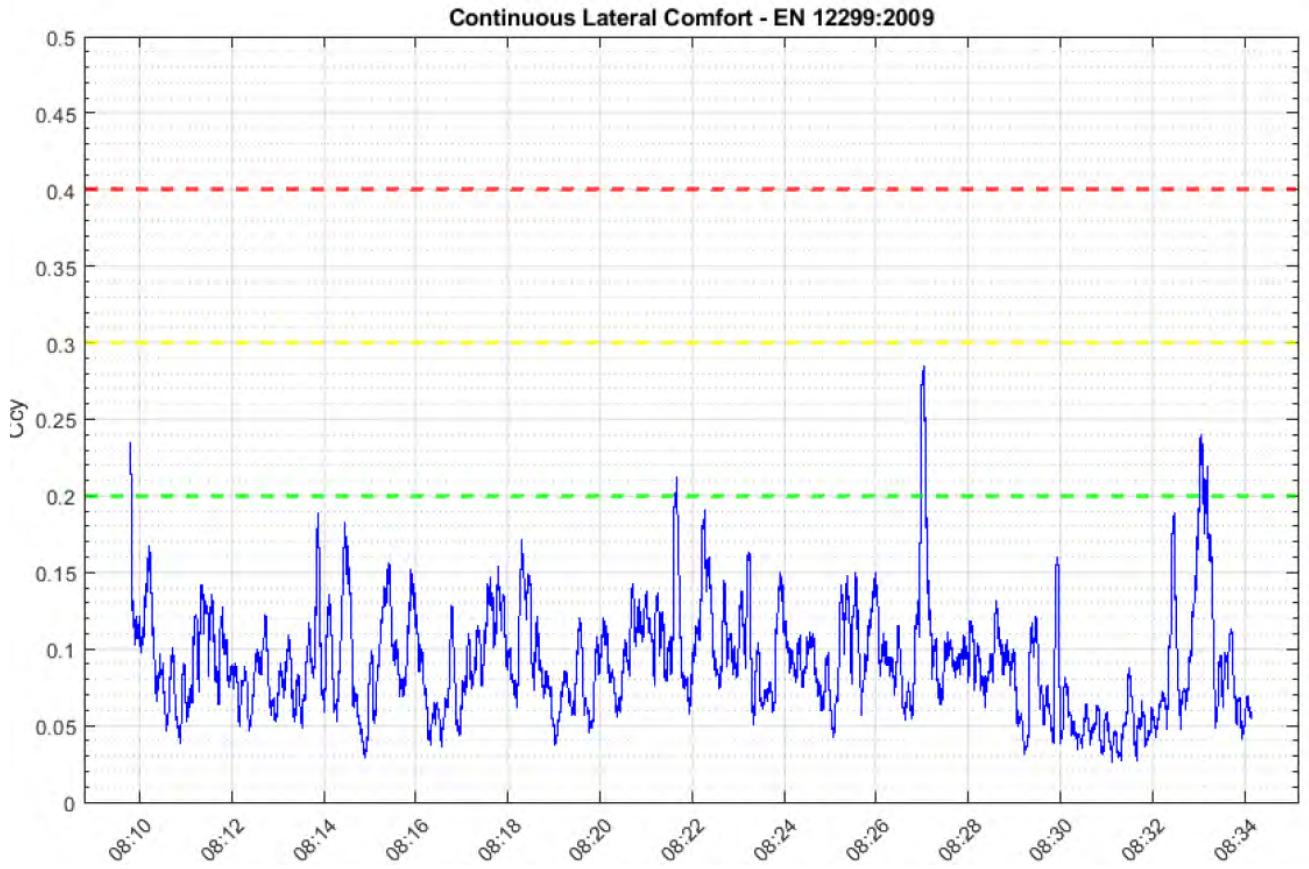
Outbound Data Analysis

- 5 consistent occurrences of axlebox acceleration exceeding 20g
- Actions plan will be developed to address these (mainly through rail grinding):
  1. ECML box scissors crossover
  2. Stratford box, likely to be Pts 2076
  3. Ebbsfleet crossover, likely to be Pts 2101
  4. Medway viaduct and Nashenden crossover, likely to be Pts 2243
  5. Lenham crossover, likely to be Pts 2278



In-Service Monitoring

Semi-permanent installation of axle box and vehicle body acceleration monitors to correlate acceleration with measured track geometry and observed defects



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EUROSTAR

Summary

Working in collaboration with universities and Train operating companies

Using new Technologies to improve asset performance and reliability

Utilising data to identify precursors to failures based on in-service trains

Thank you for listening!