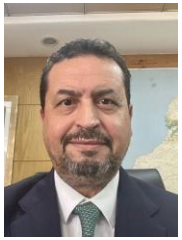
Session 5.3, Room Fez 1

Infrastructure / Maintenance and renewal



Moderator : Mr. Khalid KHAIRANE
ONCF, Morocco

ONCF UIC

Session 5.3
Infrastructure / Maintenance and renewal
Speaker Lists;

1	2	3	4	5	6
					
Mr.Fabian Hansmann	Mr.Le Hung Nguyen	Mr.Annalisa Pranno	Mr.REGAZZONI Philippe	Mr.Alain THIEBAUT	Mr. Gokhan Kizilirmak
Austria	France	Italy	France	France	Turkey

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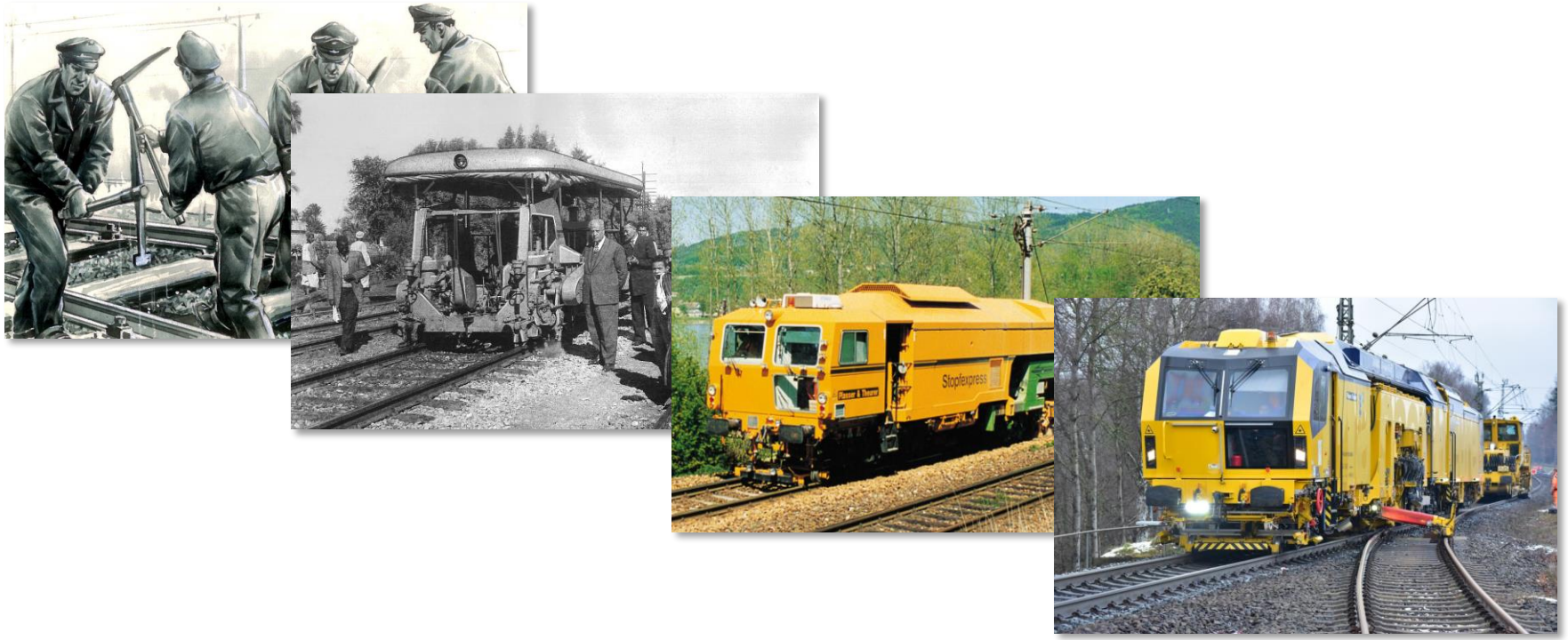
Marrakech, 7-10 MARCH 2023

SmartTamping – The Vision of an Autonomous Tamping Machine

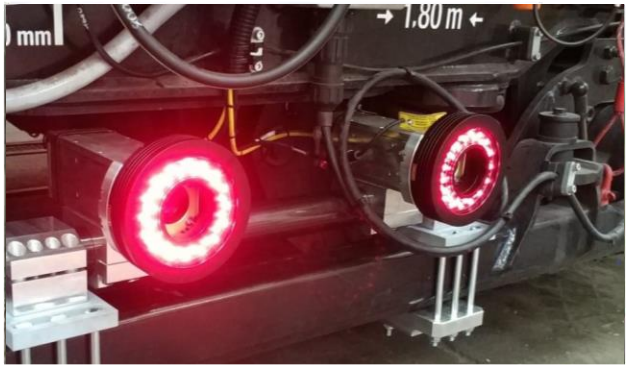
Dr. Fabian Hansmann
Deputy Director of Marketing
Plasser & Theurer, Austria
Session3-5.3 Infrastructure / Maintenance and renewal

DIFFERENT RAILROADS – SIMILAR CHALLENGES?

THE DEVELOPMENT OF TAMPING

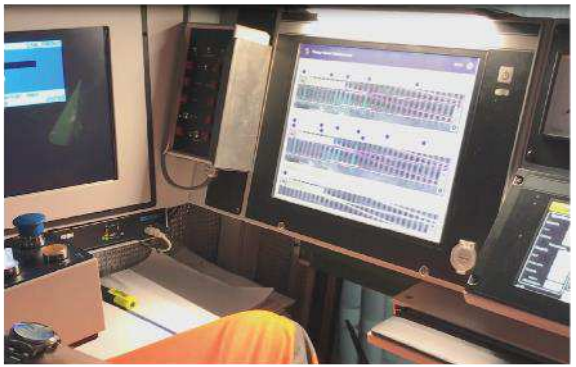


END2END SOLUTIONS FOR TRACK MAINTENANCE



Inspection / Surveying

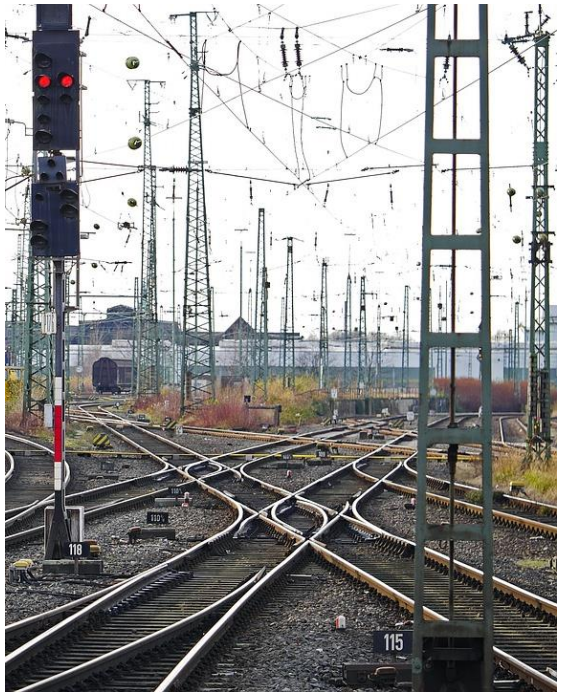
Track Work

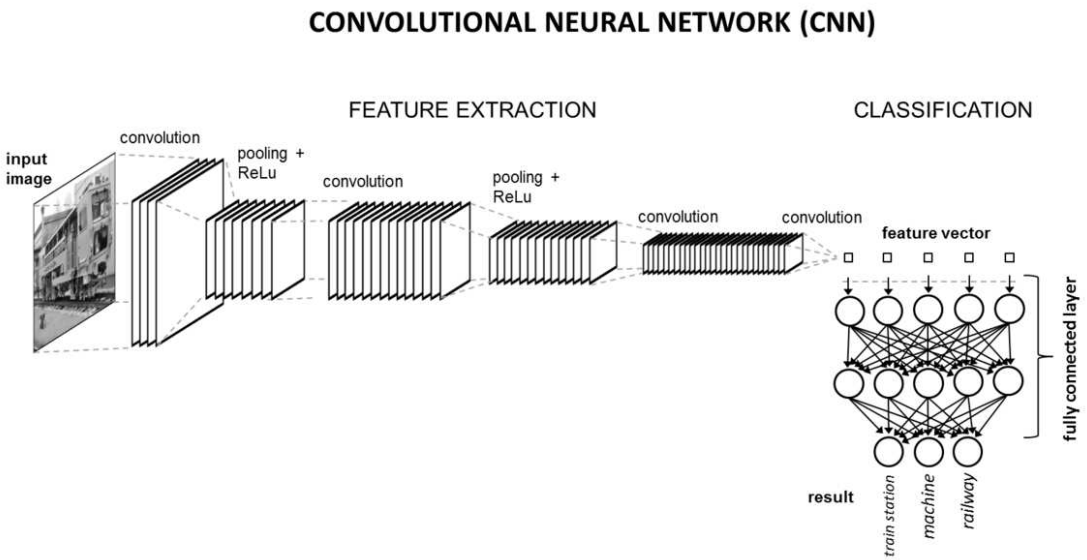


Hand Over Procedure

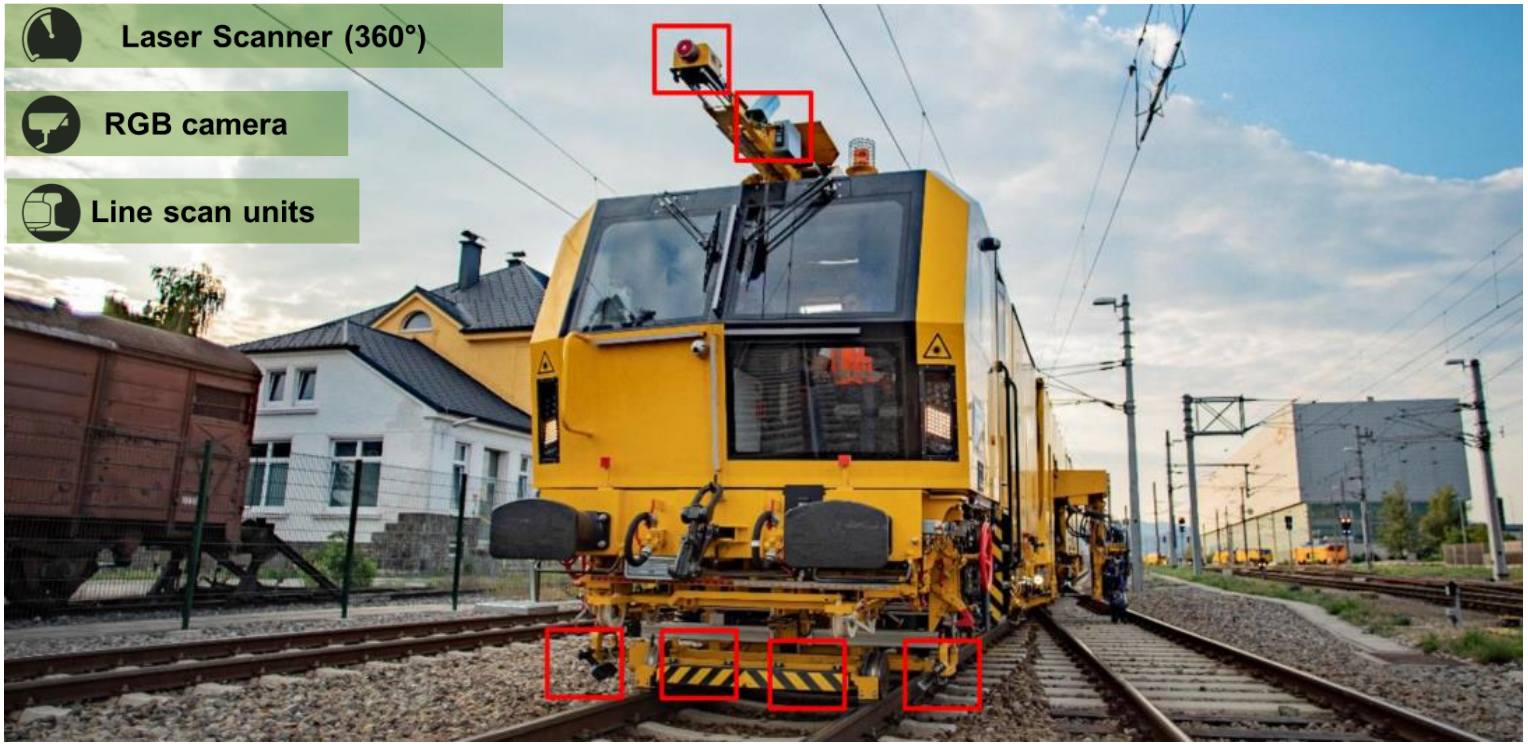
- Integration of track geometry data
- Assistance systems increasingly facilitate track work
- Acceptance of the work with new sensor technology

HOW TO TRAIN A TRACK MAINTENANCE MACHINE?





MAKING THE TAMPING MACHINE SMART



OBSTACLE DETECTION WITH ARTIFICIAL INTELLIGENCE

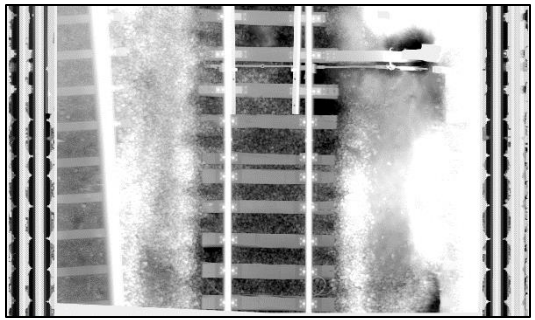
The Vision

Support the operator with managing the operational system of the machine up to a full automation of the whole process.

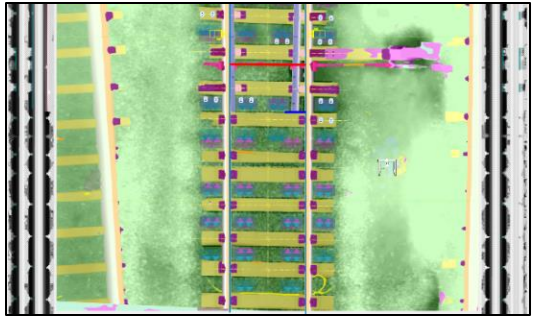
The Challenge

Automatic detection of the track with a large number of design variants and tamping obstacles

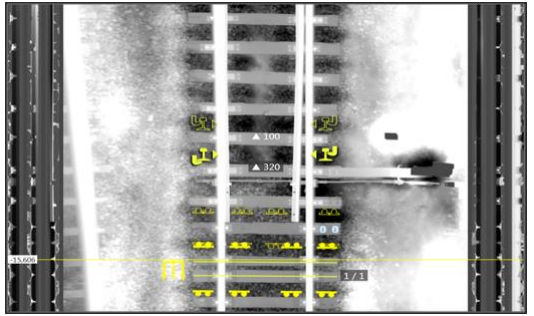
Recorded sensor data
(Depth map)



Processed data
(Model)



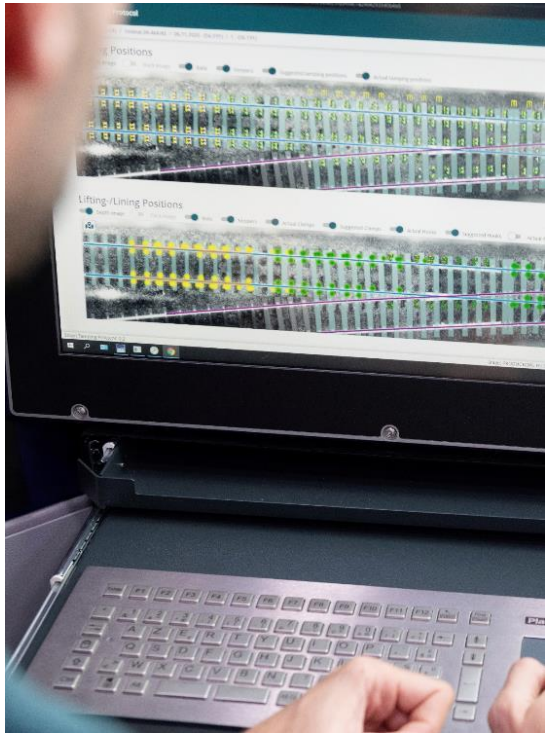
Recommended actions
(Reduced view)




PlasserSmartTamping
Plasser&Theurer

HAND OVER PROCEDURE – TAMPING REPORT

- **Transparent documentation**
- **Recording of** recommended **actions** and those **executed** by the machine operator
- **Web-based, multi-layer report** on all tamping work
- **Display / hide layered information**
  - Track image, rails, sleepers
  - Detected objects (e.g. turnout parts) and obstacles
  - Tamping and lifting positions
  - Recommended / actual selection (roller lifting clamps, lifting hook), configuration and positions (tamping tines) of the work units



THANK YOU

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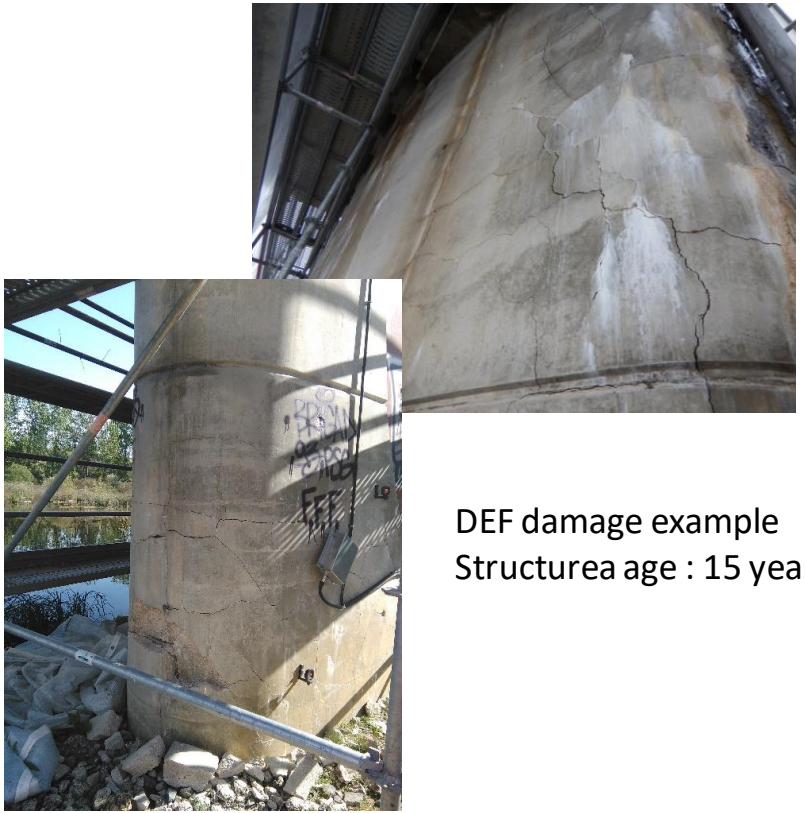
Carbon impact of reinforcement solutions for structures affected by delayed ettringite formation

Le Hung NGUYEN
Project manager, DTR OA, SNCF Réseau, France
Session3-5.3 Infrastructure / Maintenance and renewal

ONCF UIC

SUMMARY

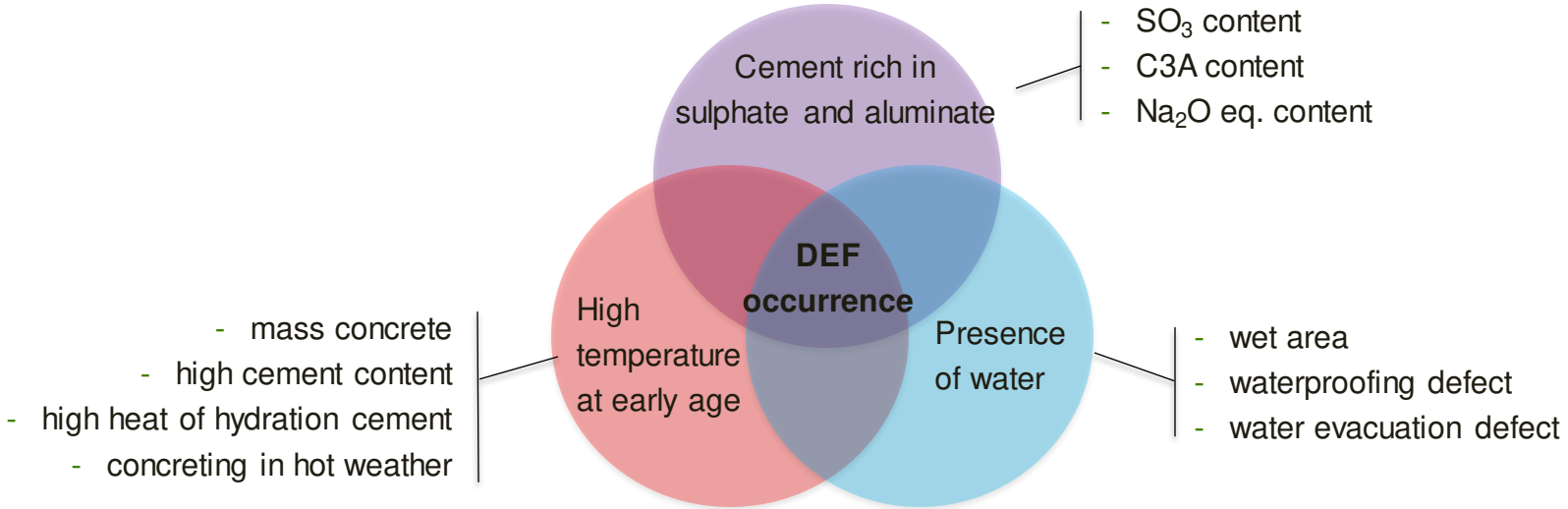
- Delayed ettringite formation in concrete
- Delayed ettringite formation problem management
- Case study : Viaduc de la Beuvronne – construction, investigation and monitoring
- Reinforcement flowchart and techniques
- Execution works
- Carbon impact of the reinforcement solutions



DEF damage example
Structurea age : 15 years

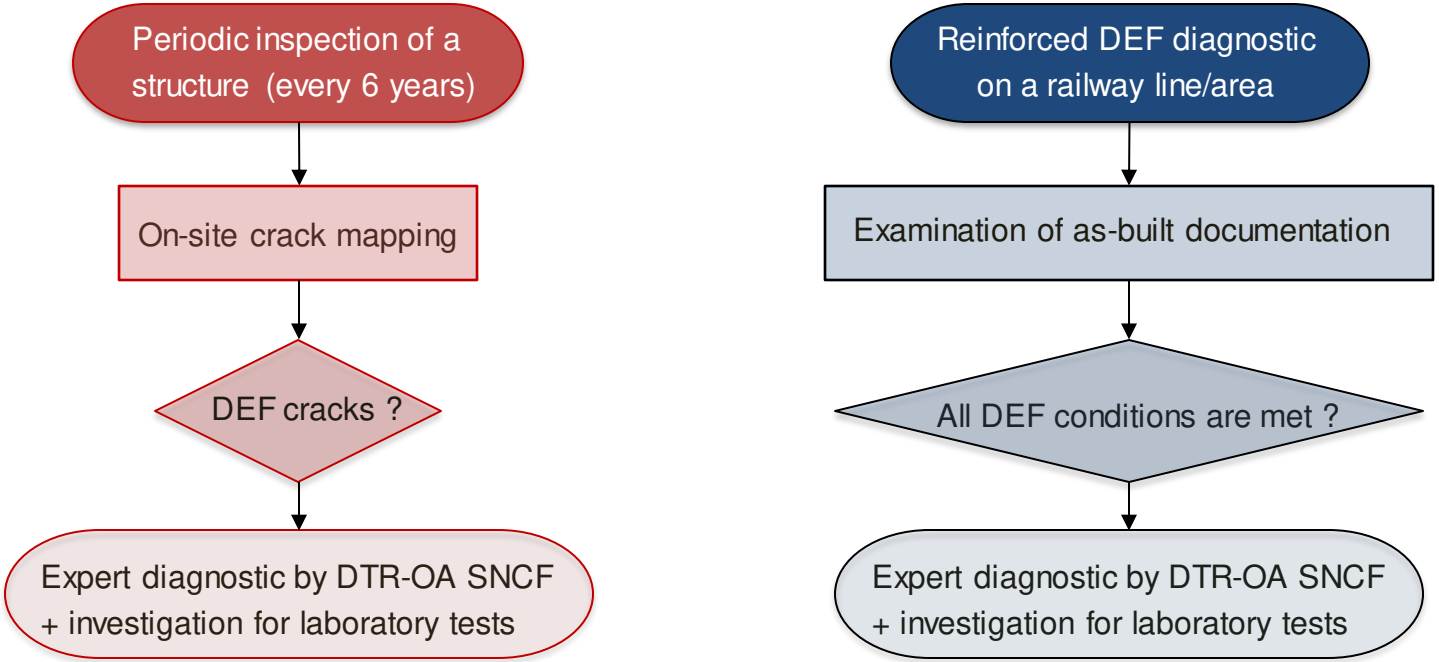
DELAYED ETTRINGITE FORMATION (DEF) IN CONCRETE

- Ettringite ($3CaO{\cdot}Al_2O_3{\cdot}3CaSO_4{\cdot}32H_2O$) is a **hydration product** in concrete.
- Delayed ettringite formation is a **significant deterioration process** in concrete where ettringite isn't stable and **precipitates after concrete hardening**.
- This phenomenon occurs if the following conditions are met :

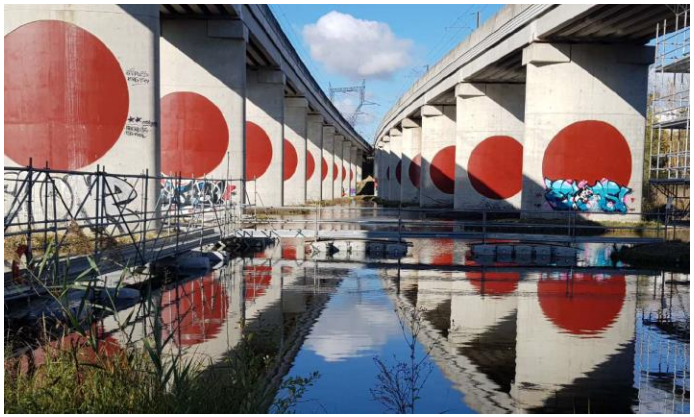


DEF PROBLEM MANAGEMENT

Two process for a single structure and for a railway line/area:



CASE STUDY : VIADUC DE LA BEUVRONNE

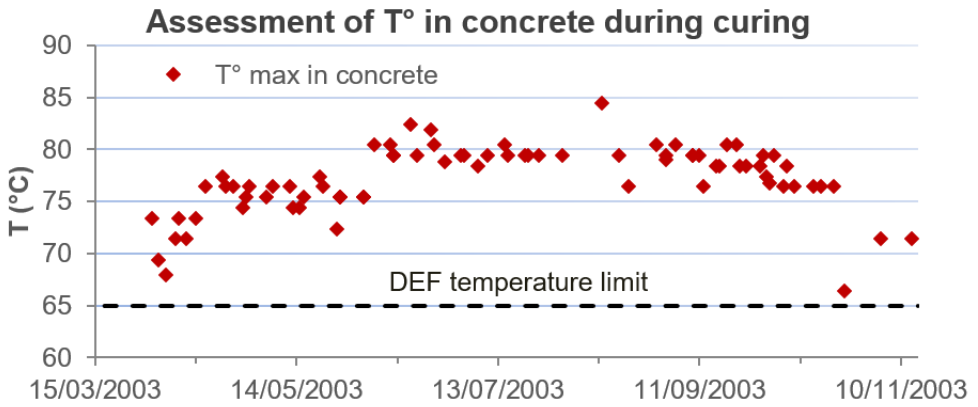


Construction features:

- Built in 2003
- Girder bridge with prestressed concrete beam
- 3 or 4 span deck
- 51 piers

DEF examination:

- Diagnostic in 2017 and 2019
- Assessment of the T° in concrete during curing based on as-built documentation
- All 51 piers suspected to be affected by DEF
- Sample taken from all piers for laboratory tests



INVESTIGATION

The following laboratory tests were carried out :

- Concrete strength
- Scanning electron microscope examination
- Cement composition
- Cement content and water to cement ratio
- Residual expansion test

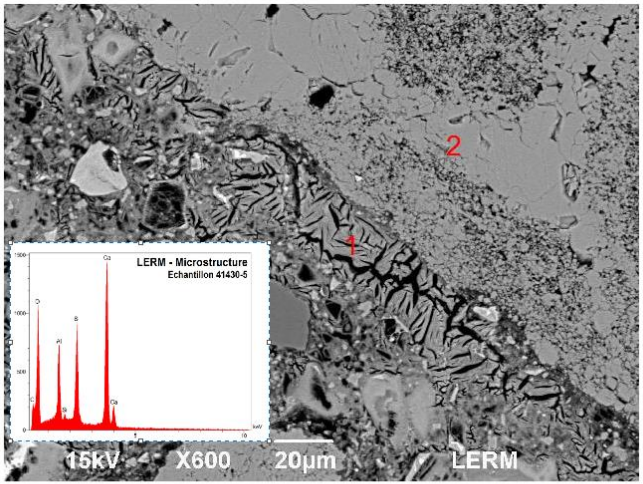
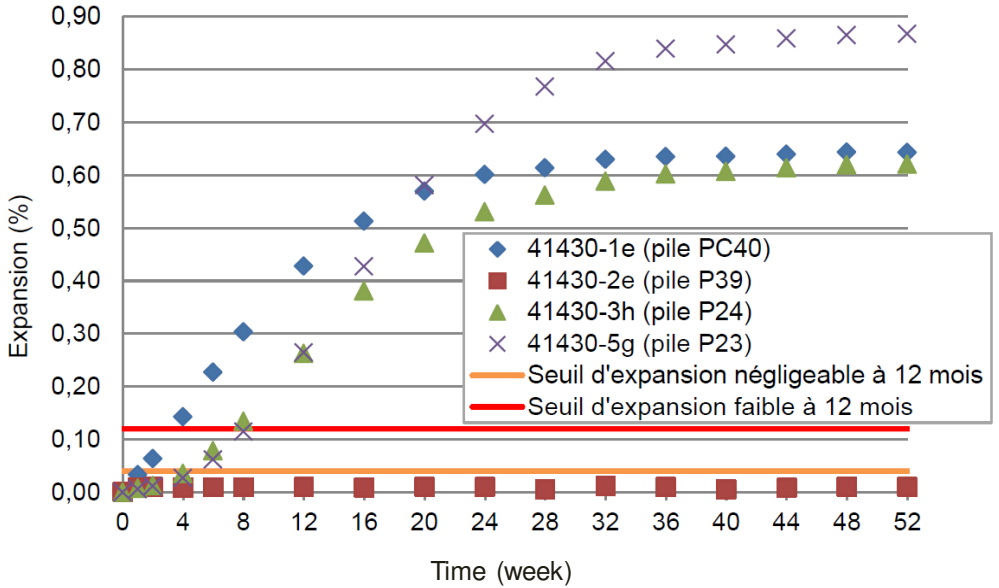


*Fig. 37 : Microscopie électronique à balayage. Echantillon **41430-5f***
Détail de la matrice de l'échantillon
1 : ettringite massive, 2 : granulat

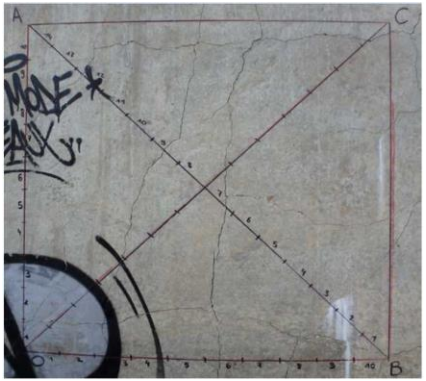


STRUCTURE MONITORING

Different monitoring techniques were used in order to ensure the rail traffic security:

Topographic monitoring

Extensometer

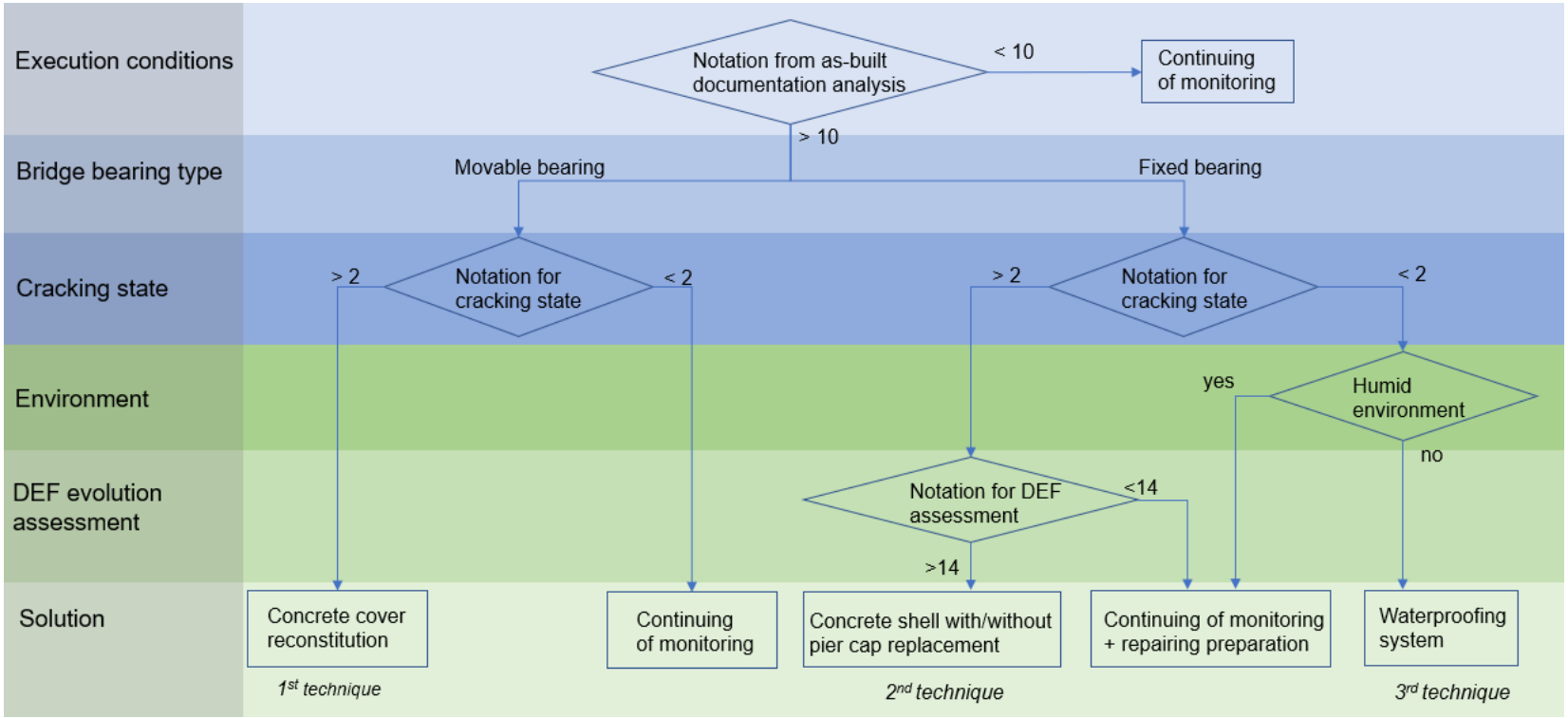


Cracking index

Crack meter

Inclinometer

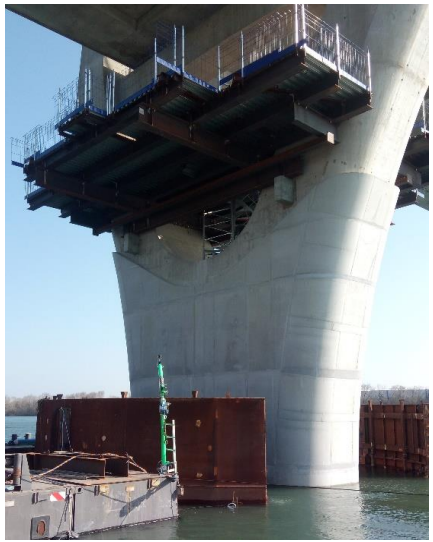
REINFORCEMENT FLOWCHART



REINFORCEMENT SOLUTIONS

Principle of solutions

1st technique : concrete cover hydrodemolition and reconstitution Viaduc de la Ricamarie (DIR Centre-Est)



2nd technique : concrete cover hydrodemolition and concrete shell construction – Pont Beaucaire (Département 13)

2nd technique : Replacement of the pier cap – Viaduc de Lodève (IFSTTAR)

REINFORCEMENT OF THE VIADUC DE LA BEUVRONNE

3rd technique : applying the waterproofing system on the entire perimeter of the piers

- Execution works from June 2022 to August 2022
- Waterproofing system based on epoxy resin and polyurethane resin
- 7 piers reinforced

Global view

Surface after sandblasting

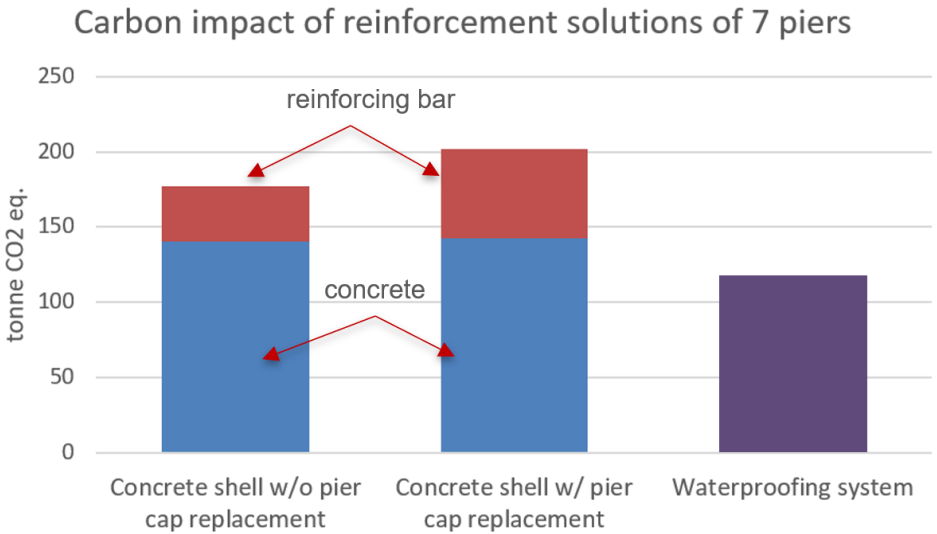
Crack fix

Suitability test

CARBON IMPACT OF THE REINFORCEMENT SOLUTIONS

Hypotheses of the carbon impact analysis:

- 1st technique isn't suitable for fixed bearing pier.
- Only construction materials are taken into account.
- Pier cap replacement is needed for evolving DEF expansion.
- Cement based injection is needed for concrete shell solution without pier cap replacement.
- Shell is 40 cm thick.
- Waterproofing system life expectancy is up to 20 years. Four waterproofing application will be carried out during bridge lifetime.



Analysis shows **lower carbon impact** of the waterproofing reinforcement than other solutions. This preventive solution helps to **avoid the further cost of an important repair** of damaged structures by DEF.

THANK YOU

Le Hung NGUYEN
Project manager, DTR OA, SNCF Réseau, France
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MOBILE MAPPING SYSTEMS AND ALGORITHM ASSESSMENT FOR BOLOGNA-FLORENCE HIGH SPEED TUNNELS

Annalisa, Pranno
Head of Tunnel Unit, Rete Ferroviaria Italiana, Italy
Session3-5.3 Infrastructure / Maintenance and renewal

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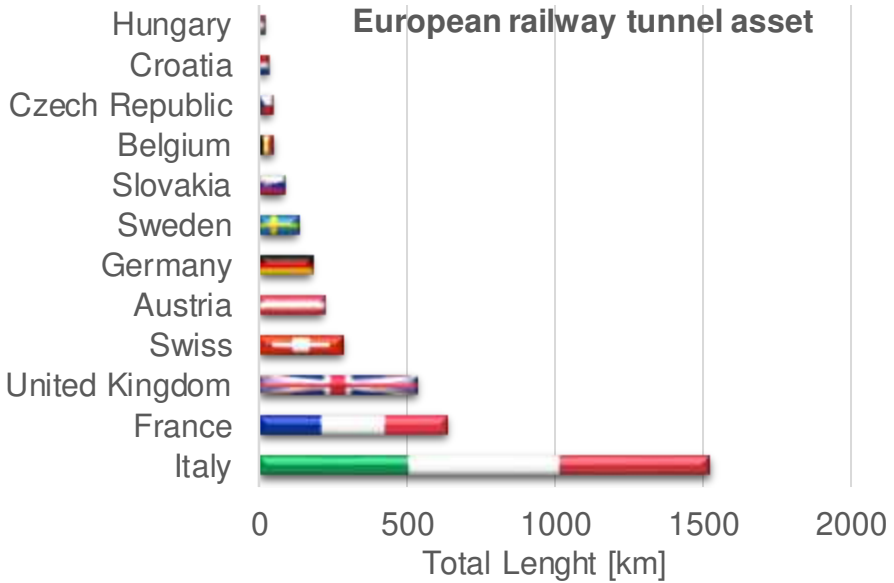
TUNNELS MANAGED BY RETE FERROVIARIA ITALIANA

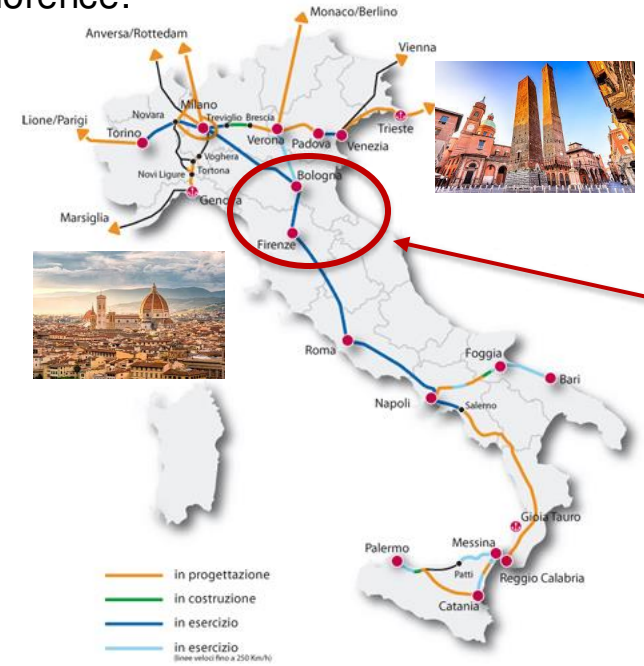


Italian railway network (RFI)	
$L_{railway\ network}$	~ 16800 km
$N_{tunnel\ railway\ network}$	1633
$L_{tunnel\ railway\ network}$	~ 1535 km
Tunnel Configuration	Double Track ~ 52%
$N_{tunnel\ L>1000m}$	353
$L_{high\ speed\ network}$	~ 1467 km

RFI has to manage the most conspicuous railway underground asset among all European nations.

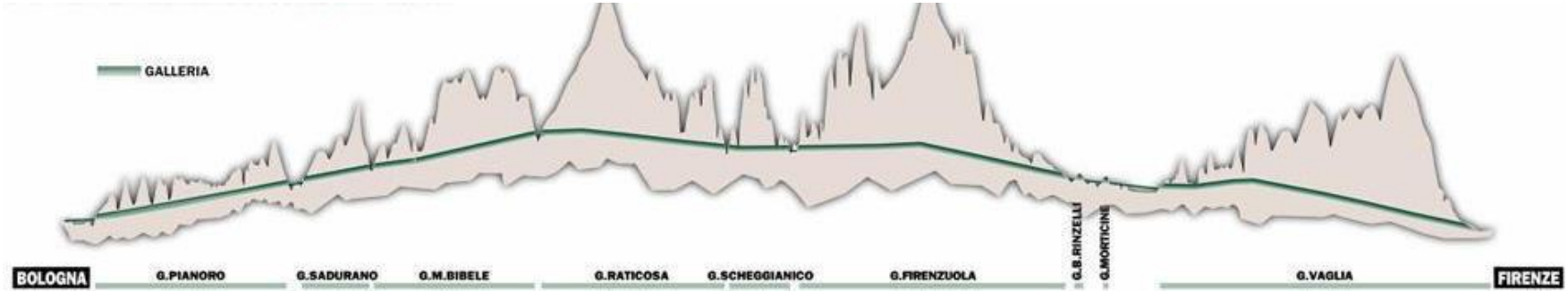
FOCUS ON BOLOGNA – FLORENCE HIGH SPEED LINE

The Bologna-Florence high-speed line crosses the Apennine Mountains to connect the cities of Bologna and Florence.



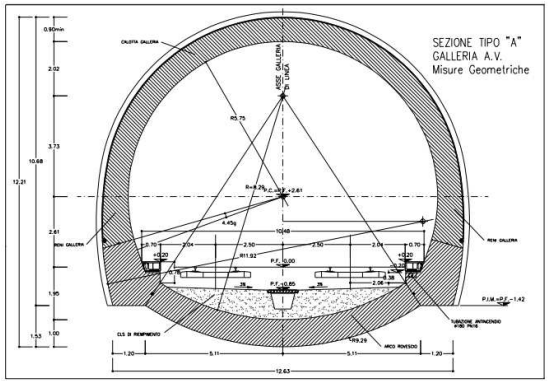
Bologna – Florence AV Characteristics	
Year activation	2009
L line	~78,5 km
V design	300 km/h
N tunnel line	12
L tunnel line	~73,5 km
Track type	Double Track
Area Cross Section	~82 m^2

FOCUS ON BOLOGNA – FLORENCE HIGH SPEED TUNNELS



Elevation profile: Bologna – Florence high speed line

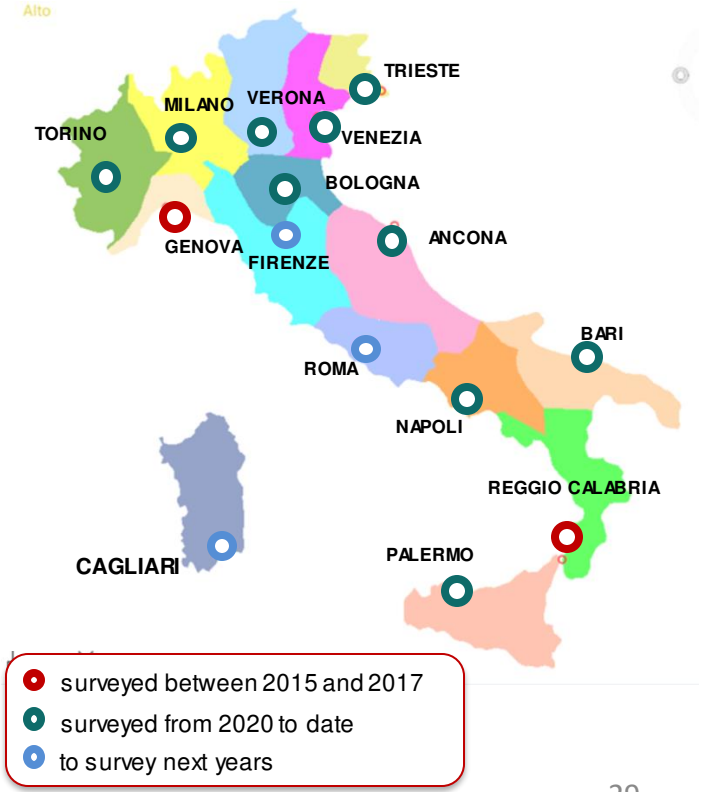
High speed Bologna-Florence line: Tunnel List			
Pianoro	10,8 km	Firenzuola	15,3 km
Laurinziano	0,1 km	Borgo Rinzelli	0,7 km
Sadurano	3,9 km	Morticine	0,7 km
Monte Bibele	9,2 km	Crocioni N.	0,2 km
Raticosa	10,4 km	Crocioni S.	0,2 km
Scheggianico	3,6 km	**Vaglia**	**18,2 km**



Bologna-Florence polycentric section of 82 m²

MOBILE MAPPING SYSTEMS RESEARCH PROJECT in RFI

- In 2013 RFI started a research project to evaluate the use of specific mobile system for railway tunnel assessment.
- Between 2015 and 2017, the system was tested for the survey of more than 400 km of railway tunnels (Reggio Calabria and Genova tunnels).
- Starting from July 2020, almost the 75% of the Italian tunnels have been surveyed, and the remaining tunnels will be survived in the next years.
- Actually, RFI is about to conclude the assignment of a procurement to acquire 4 diagnostic railway wagons equipped with the mobile mapping system for the survey of railway tunnels. The first system should be available in 2025.



MOBILE MAPPING SYSTEM EQUIPMENT

The inspections are carried out by a **bimodal vehicle** equipped with a mobile mapping system based on the use of **high-speed laser cameras** able to guarantee a survey with millimetric precision at a **speed up to 30 km/h.**

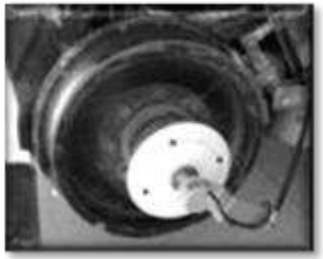
In addition, the system has:

- an high precision **odometer** to trigger the 3D laser camera each millimeter;
- an **inertial motion** unit on each 3D laser camera.

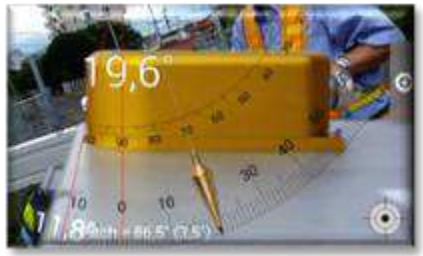
The system can operate under all types of lighting conditions.

Bimodal vehicle

3D Laser Camera



Odometer



Inertial motion unit

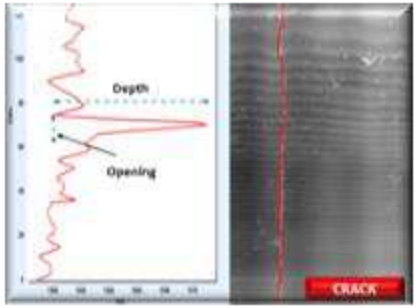
AUTOMATED DETECTION OF TUNNEL DAMAGES - SOFTWARE & REPORTS

Post processing software elaborates survey data and identifies the damages on tunnel lining.

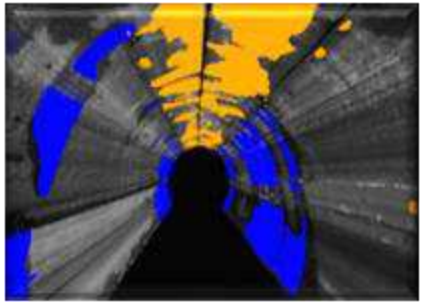
To group and sum up the defects surveyed, each tunnel is divided in longitudinal sectors of 25 meters.

Visualization software allows to view tunnel lining as 2D pictures or 3D clouds with the damages detected.

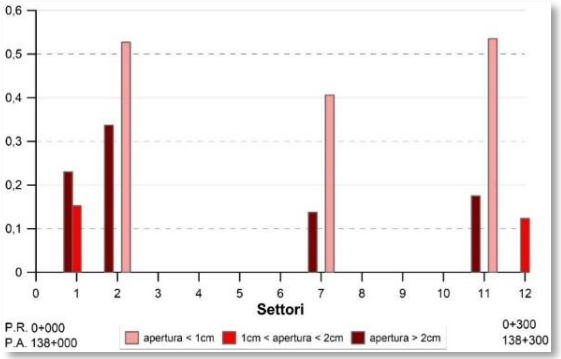
Report contains general information about tunnel and survey, appendix with detection of material lining, mapping of damages and transversal section.



Visualization of damages



3D clouds with the damages



Graph of detected cracks

AUTOMATED DETECTION OF TUNNEL DAMAGES – ALGORITHM

The Algorithm was developed in collaboration with the University of Trento. It is based on the Most Critical Damage Principle.

The damage detected is classified by **typology, intensity**, **extension** and lining material.

Here the 7 damage typologies:

- Cracks (Longitudinal, Transversal and Diagonal)
- Mortar loss
- Damp patches
- Lining loss
- Deformation/detachments

For each tunnel:

- **DAMAGE INDEX ID**

Indicates the severity of the damage;

- **SPREAD INDEX I_{DIFF}**

Indicates the spread of the damage.

For the same ID, I_{DIFF} will allow to define the priorities of the repairing works.

Difetto	
Estensione	Indice di Danno (ID)
Soglia 1	1
Soglia 2	2
Soglia 3	3
Soglia 4	4
Soglia 5	5
Soglia 6	6
Soglia 7	7
Soglia 8	8
Soglia 9	9
Soglia 10	10
Soglia 11	11

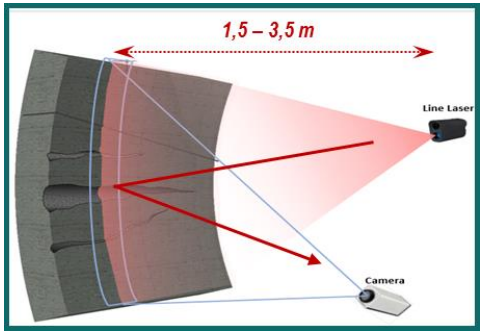
Galleria A	
ID	n° settori
1	0
2	91
3	37
4	3
5	2
6	3
7	0
8	0
9	0
10	0
11	0
I_{DIFF}	6.24

- ✓ Identification of the tunnel state of conservation;
- ✓ Identification of priorities of the repairing works.

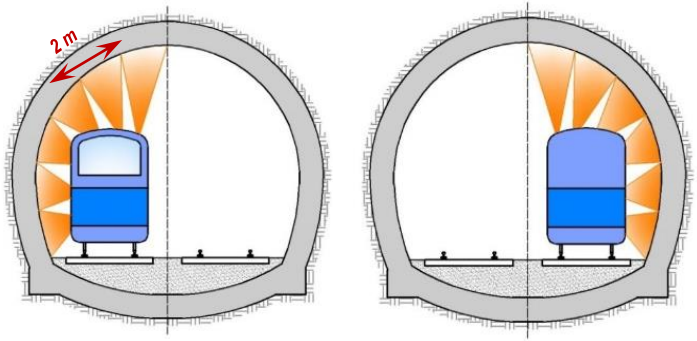
FOCUS ON BOLOGNA – FLORENCE HIGH SPEED INSPECTIONS

Laser camera allows the survey of a lining section at a range distance of **1.5 m** to **3.5 m** from the camera with a resolution of 1 - 3 mm in longitudinal, 1 mm in transversal and 0,5 mm in radial direction. Each 3D laser camera inspects a **2 m** wide section profile.
Therefore, with a double passage, the laser camera has covered the entire tunnel sections of the Bologna-Florence high speed although section dimension.

Vaglia Tunnel: polycentric section of 82 m2



Operational principles

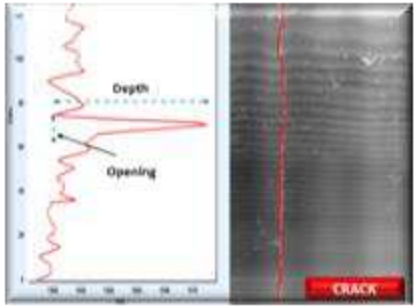


Double track

VIDEO BOLOGNA – FLORENCE HIGH SPEED INSPECTIONS

ADVANTAGES AND LIMITS OF MOBILE MAPPING SYSTEM

- Objective knowledge of the tunnel state of conservation;
- Streamlining of the procedures for carrying out inspections of railway tunnels;
- Possibility to inspect long tunnels in less time and with higher resolution;
- Difficulty of camera configuration in case of enlargement of the sections;
- Need of customized camera configuration for different sections.



Advantage – objective knowledge of tunnel

Limit– Configuration in case of enlargement of the section

THANK YOU

Annalisa Pranno - a.pranno@rfi.it

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Marrakech, 7-10 MARCH 2023

MESEA
Contribution of engineering to Integrated Logistic Support of Tours-Bordeaux high-speed line

Philippe Regazzoni
Senior adviser, Systra-France
Session3-5.3 Infrastructure / Maintenance and renewal

ONCF UIC

THE TOURS-BORDEAUX HIGH-SPEED LINE (SEA)

First PPP in railway with concession of 50 years (until 2061). Revenue service July 2017

Functional goals:

- Links Paris to Bordeaux by train in 2 hours
- Improves train service towards Spain & Toulouse
- 302 km high speed line + 40 km junctions

Investment: €6,7bn (construction cost: about €16.5M/km).

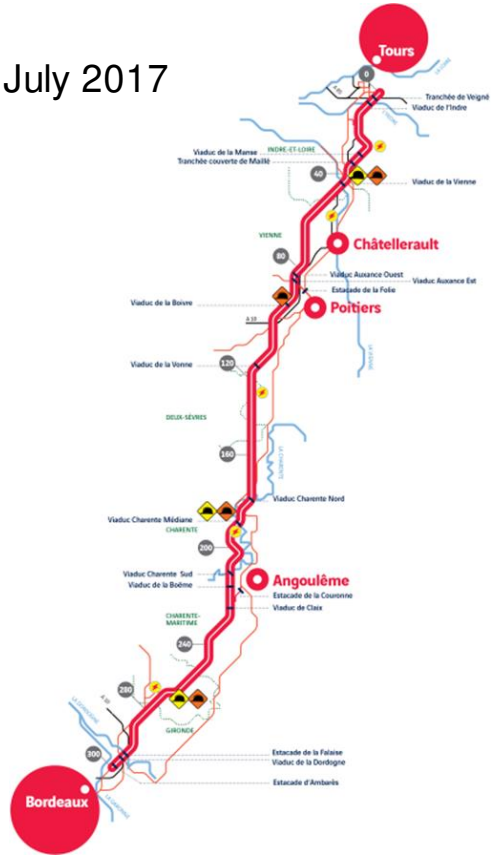
20M of travelers in 2017 ➔ Increase of 5M per year

A community transportation project approach:

- Consultation with 117 municipalities, 6 departments & 3 impacted regions

Focus on environment:

- 3 500 hectares of compensation sites
- 220 protected species



TECHNICAL DESCRIPTION

Design speed: 350 km/h

Operating speed: 320 km/h with ERTMS

Electrification: 2 x 25 kV

Signalling: TVM 300 & ERTMS

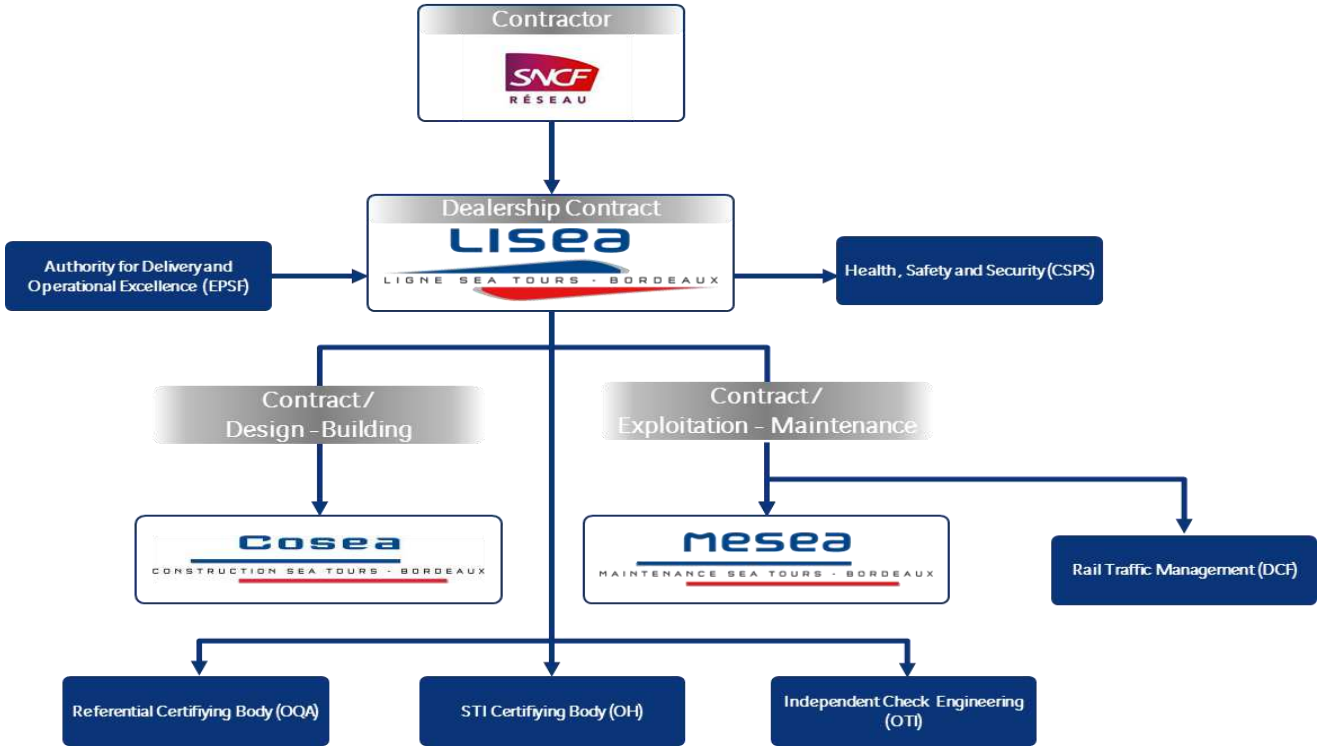
10 junctions to the national railway (no new stations)

25 interaction areas with the highway network

400 engineering structures including 19 viaducts and 7 cut & cover tunnels

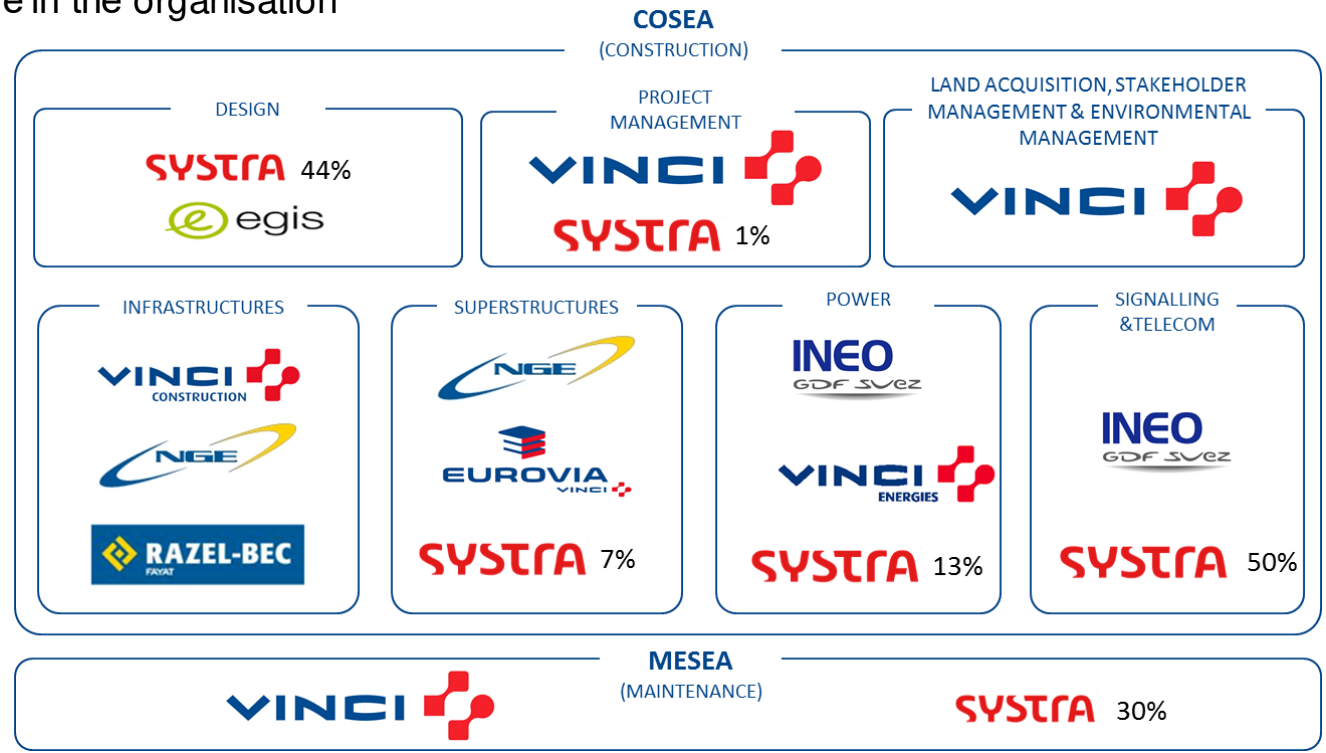
- **13,000 catenary pillars**
- **640 km of track and ballast**
- **50 million cubic tons of excavated material**
- **7,000 people working at peak times**

PROJECT ORGANISATION



ROLE OF THE ENGINEERING PARTNER

SYSTRA's share in the organisation



ROLE OF THE ENGINEERING PARTNER: INTEGRATED DESIGN

- ✓ SEA is an infrastructure concession with stringent requirements:
  - ❖ On performance (travel time, headway)
  - ❖ On RAM KPI's
  - ❖ On safety
- ✓ Not meeting these performances is heavily penalized

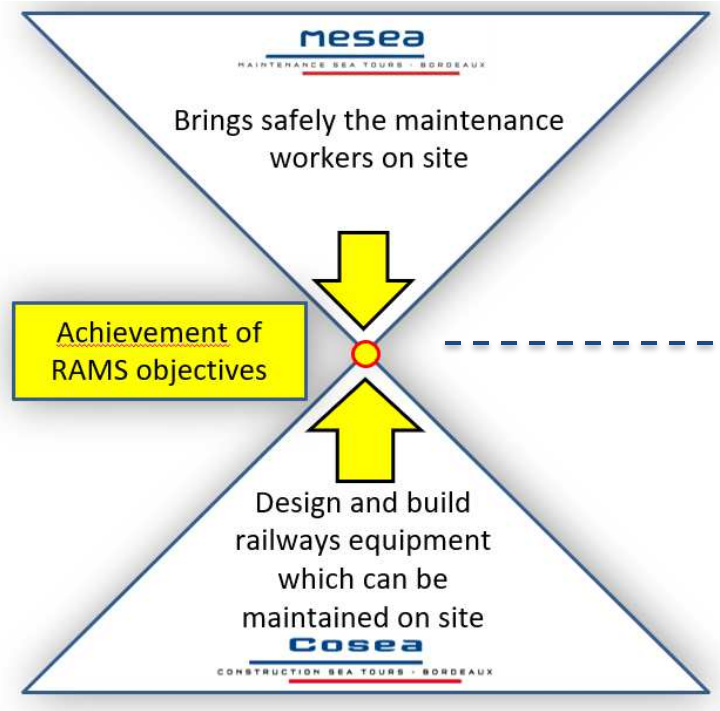
- ✓ Design must have these requirements integrated in the initial technical bid
- ✓ Maintenance & operation concepts are integrated
- ✓ Constant optimization design-maintenance
- ✓ Innovation on maintenance focused on organization and tools

- ✓ Global follow-up of performance is kept during construction design
- ✓ And during construction works

- ✓ The whole quality assurance system
- ✓ As well as integration & commissioning tests
- ✓ Will contribute to prove that theses goals are reached

- ✓ Operation & maintenance based on principles applied from tender stage
- ✓ A five-year constructor warranty covers these commitments

CONVERGENCE OF INTEGRATED LOGISTIC SUPPORT

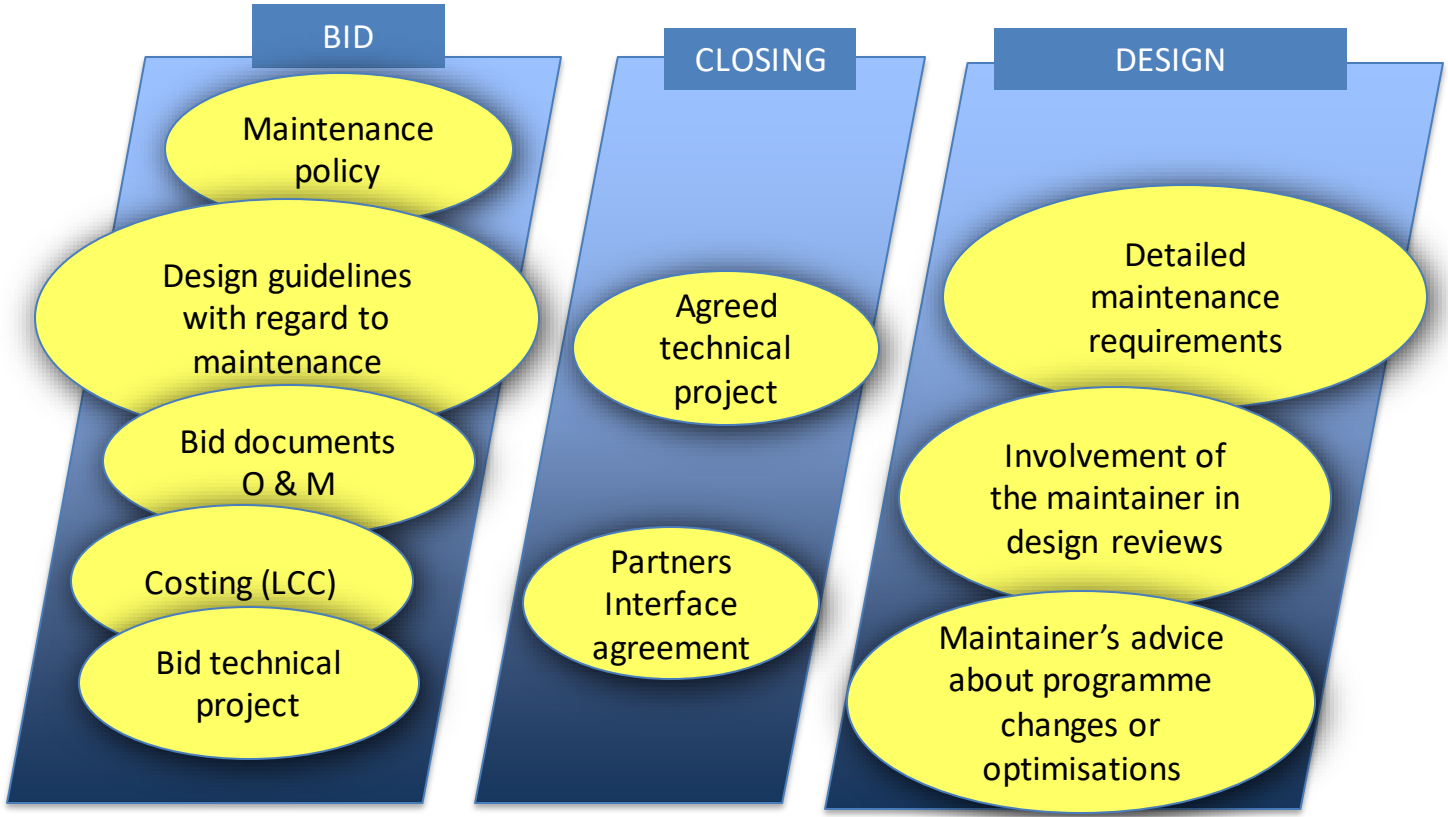


- Recruit, train and empower workers
- Equip workers with documentation, vehicles, machines, tools, metrology & measurement devices etc.
- Supervise remotely railway installations
- Give access to the line
- Provide safety communication means to staff
- Give means to avoid railways hazards during work
- Plan & insert maintenance works between commercial trains

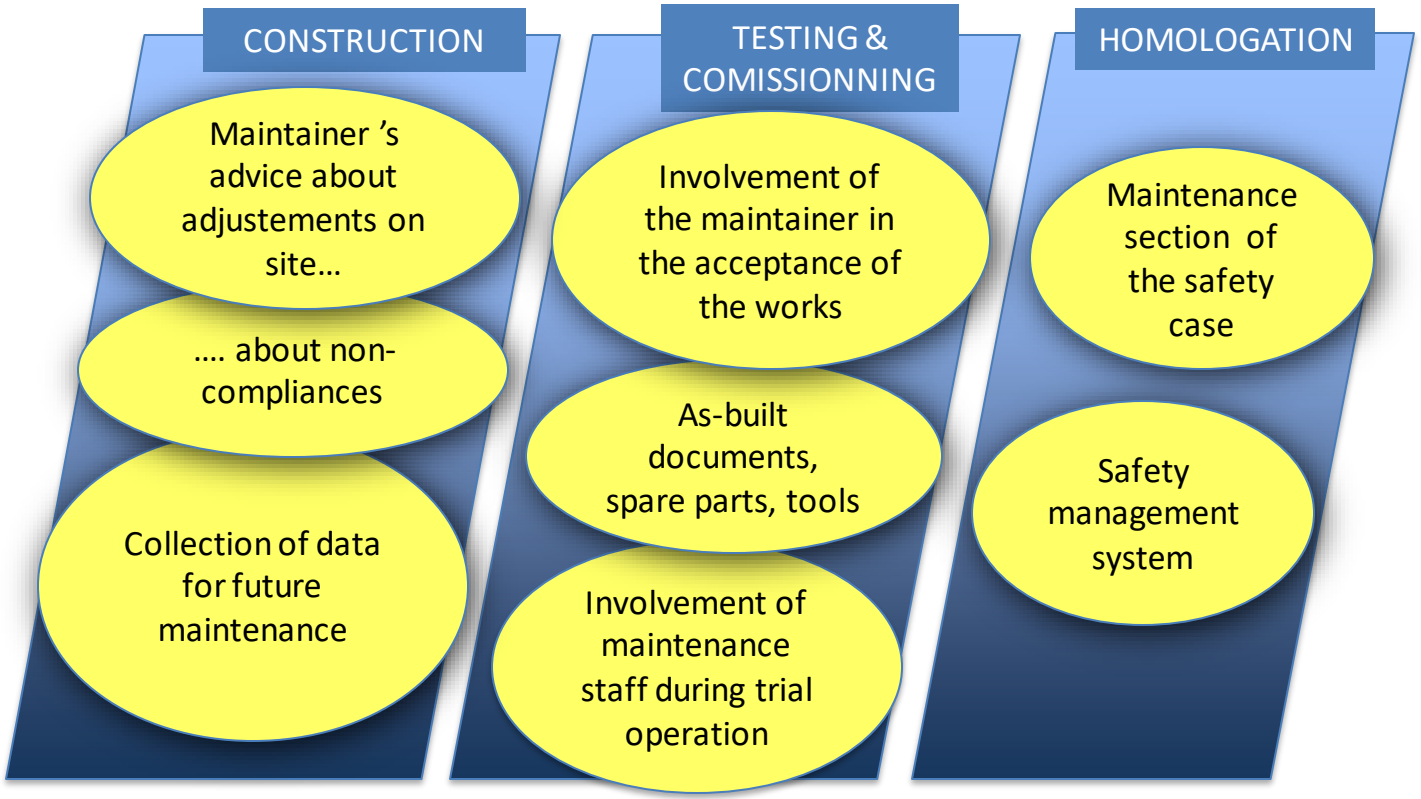
- Define the elementary maintenance tasks & conditions necessary for achieving global RAMS objectives
- Build support equipement
- Supply special tools
- Supply the first batch of spare parts

THE ILS WHEEL APPLIED ON THE PROJECT

PREPARING FOR COMMISSIONING & HAND-OVER



PREPARING FOR COMMISSIONING AND HAND OVER



HUMAN RESOURCES

An organisation centered around the maintenance workers

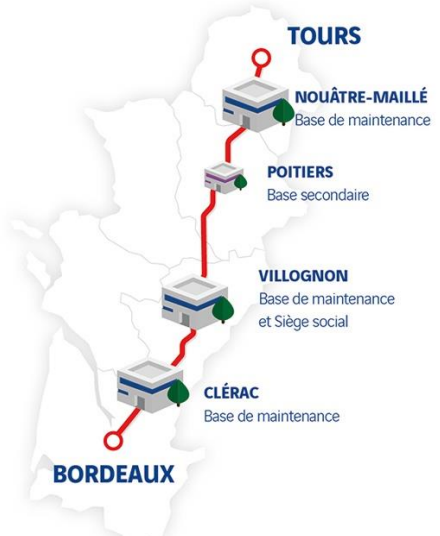
Support processes objective: provide the workers all the resources needed within the framework of the Safety management system

The skilled workers have three principal qualifications covering :

- « Infrastructure »: maintenance of track & OHL & surroundings
- « S&C »: maintenance of the whole of HSL switches
- « Systems »

Dedicated 24-hour Remote Monitoring Center

- All our « systems » maintainers have tours of duty at the RMC in order to hold the post of supervisor



THE RESULTS AFTER 5 YEARS OF OPERATION

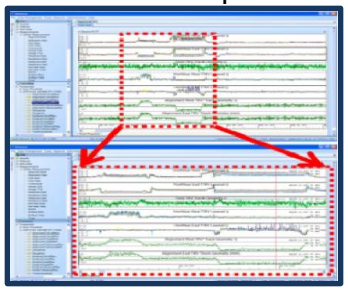
Compliance with stringent performance KPIs, with excellent levels in terms of regularity & reliability.

The early integration of maintenance requirements & logistic support made it possible to build a maintainable line meeting from day one the required performance.

Innovation in terms of organisation and tools without compromising on the performance.

MESEA continuously improves:

- Management of the data
- With the monitoring of the infrastructure, we have a reliable predictive model to anticipate track geometry evolutions as a result of traffic
- S&C and signaling predictive maintenance
- Sustainability
- …



THANK YOU

Email: pregazzoni@systra.com

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HIGH-SPEED RAIL : THE RIGHT SPEED FOR OUR PLANET

Under the High Patronage of his Majesty King Mohammed VI

11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

Ballast track renewal for High Speed mobility

How recent technical innovations will allow us to build a new model of track renewal for tomorrow

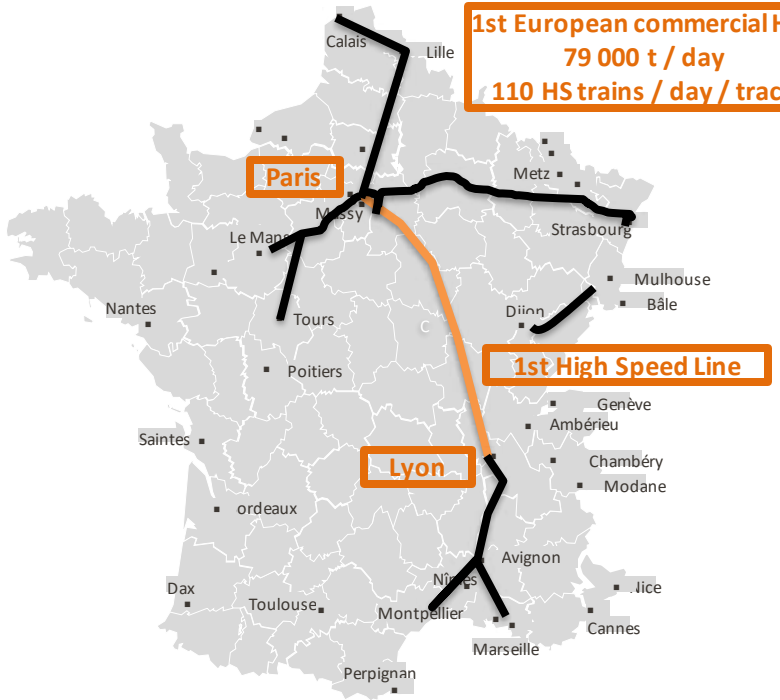
THIEBAUT Alain
Manager HSL - Technical Direction - SNCF RESEAU - France
Session 5.3 Infrastructure Maintenance and Renewal

SNCF RÉSEAU

ONCF UIC

After 42 years of High Speed : What track model for the future ?

❖ French High Speed Lines Network



HSL Paris-Lyon (380 km)
Commissioning in 1981 and 1983

❖ Renewal History :

1986 to 2006 : 600 km Track Lift
1996 to 2017 : 560 km Ballast Renewal
1996 to 2007 : 32 Signaling Center Turnout Renewal
1997 to 2016 : 10 Rail Expansion Joint Renewal
2003 to 2019 : 710 km Rails Renewal
2020 to 2023 : 115 km Ballast and Sleepers Renewal

❖ When to renew the concrete sleepers ?

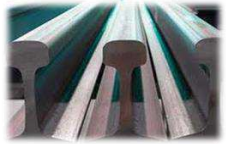
Theoretical sleepers end of life : after 50 years ?
Assets aging laws ?

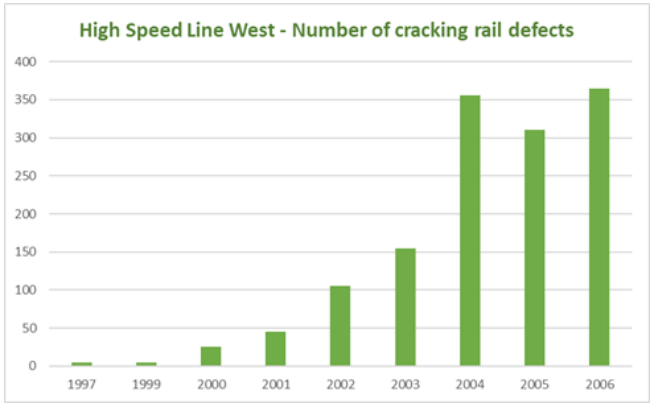
Track type ? New assets ?
Ecological impact ?

Industrial method ?
Speed restriction ?

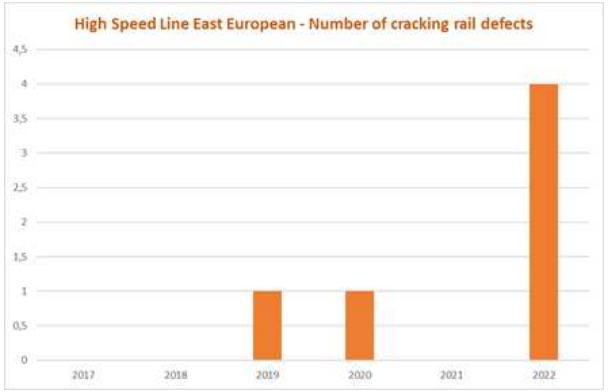
Impact of the new maintenance policy : life extension of rails

Number of cracking rail defect after 160 M cumulative tons





100 times less

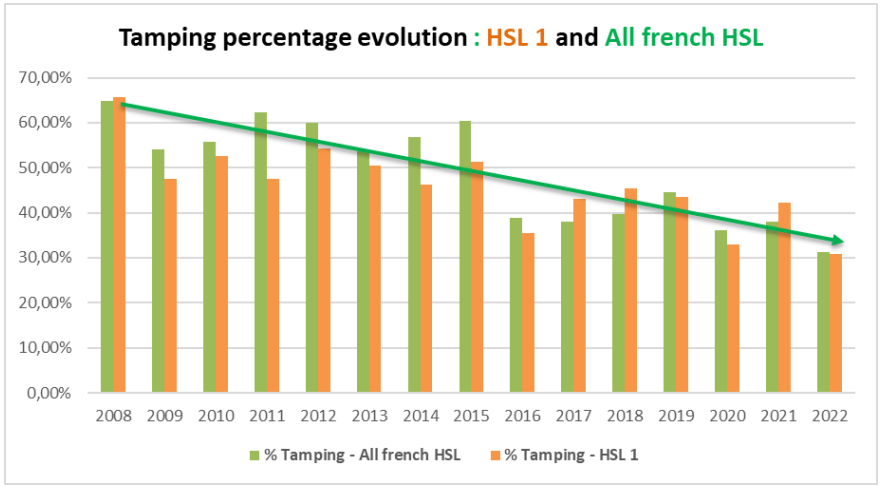


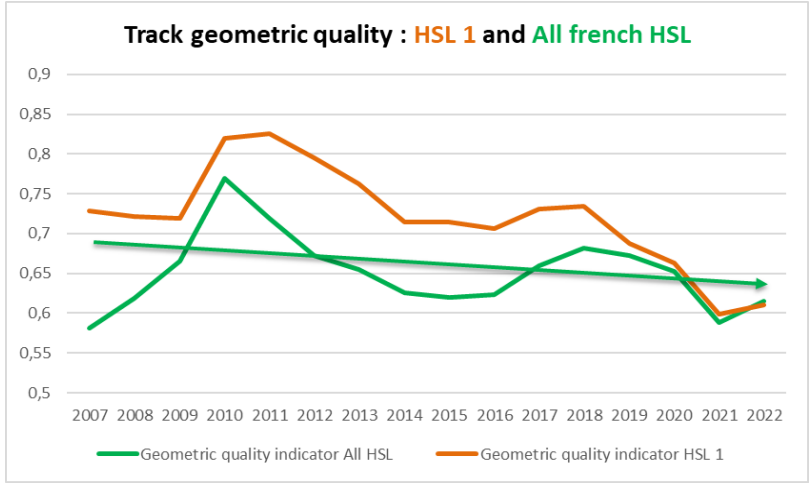
- South West High Speed Line (1989 - 300 km)
  Without rail maintenance policy
- 1st Rail renewal after 18 years (350 M tons)

- East European High Speed Line (2007 - 300 km)
  With rail maintenance policy
- Rail renewal planned after 40 years (Objective = 800 M tons)

Life Extension of HSL rails = Lower CO_2 emissions
55 % HSL Rails recycled for conventional lines

Impact of the new maintenance policy (2010) : life extension of ballast





❖ **Tamping reduction**

❖ **Geometric quality improvement**

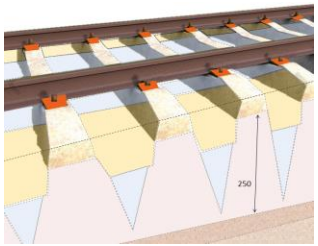
Continual improvement of the ballast maintenance process

Better maintenance efficiency : life extension of track assets
=> Financial economy and energy consumption reduction
Materials = 26 % CO_2 emissions in railway works

Ballast : questions about the renewal policy

Current ballast renewal policy at SNCF :

- At half-life of sleepers (25 years)
- or when the passing at 25 mm exceeds 30%
- or when the tamping count exceeds 28



However, these rules are not always fully applied, because the ballast does not age evenly (depending on the positions and stresses).

Used ballast on HSL often seems of better quality than expected

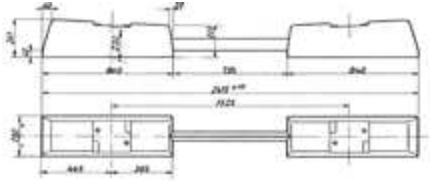
- 70+% of the ballast on the track is returned to the track after screening on the HSL
- large-scale ballast analyzes showed that the 25-year limit could be exceeded in most cases
- 28-tamping criterion seems unsuitable on HSL → many areas with 28+ tampings and no geometry problems

→ launch of studies to better target ballast renewal needs on HSL

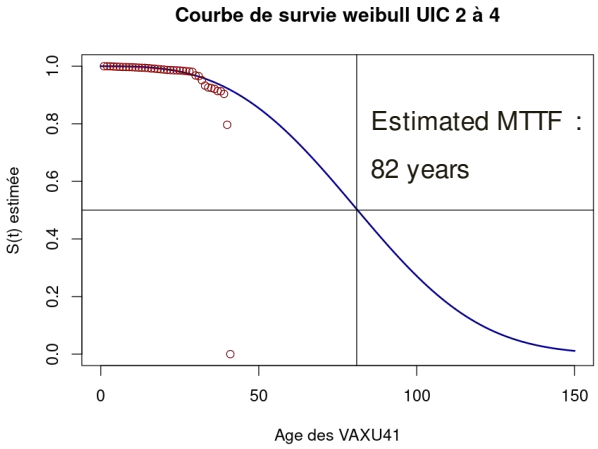
Sleepers : optimization of the aging laws

Since the 1970s, sleepers used by SNCF have been scheduled to be replaced after 50 years

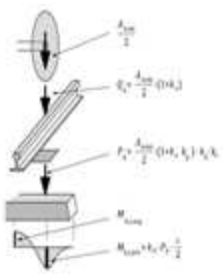
- 50 years → coming from old studies on common lines
- First HSL sleepers replacement → ~2030
- However, sleepers (VAX U41) used on Paris-Lyon (LGV1) seem to be in good condition in 2023

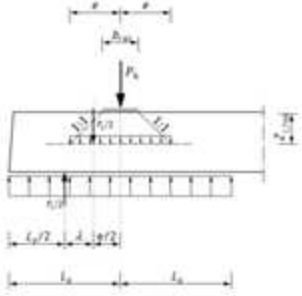


2-ways study of the aging laws for HSL : statistical (Weibull law) and mechanical (damage accumulation method)



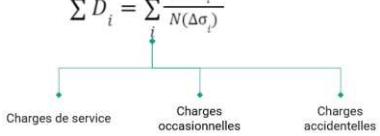
Minimum estimated lifetime : 87 years





Miner's rule

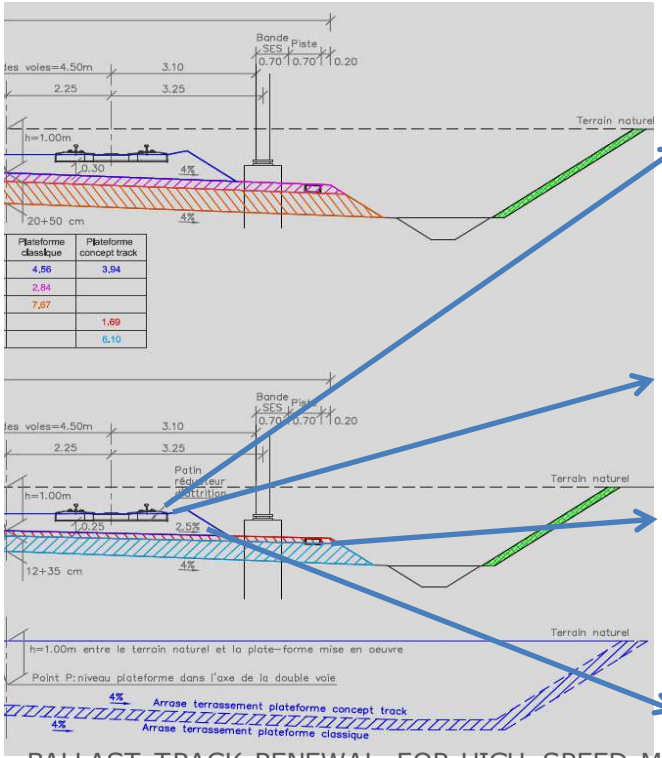
$$\sum D_i = \sum \frac{n(\Delta\sigma_i)}{N(\Delta\sigma_i)}$$

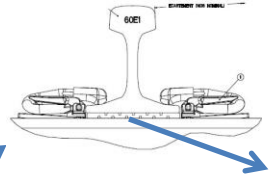


- Studies still in progress
- Precise life-cycle model under construction
- First conclusion, however : 2030 seems to be too early to launch massive sleepers replacement

Exploitation of the results of the “concept track”

“Concept track” : study launched in early 2010s to improve ballasted track / tests zones 2015-2020





Low and reinforced fastening system FCX
For a better resistance against maintenance and track work shocks

→ Effective : fastening system used for every new sleeper

Very soft rail pad
Mitigation of dynamic stresses

→ abandoned : bad results with geometry

Sleepers with USP
For a lasting track alignment quality and less ballast stress

→ Effective : USP used for every new sleeper on HSL

Asphalt sub ballast layer
- Reduction of layers thickness
- Improving track stability with a better waterproofing and ballast contact.

→ Effective but to be used only for new HSLs

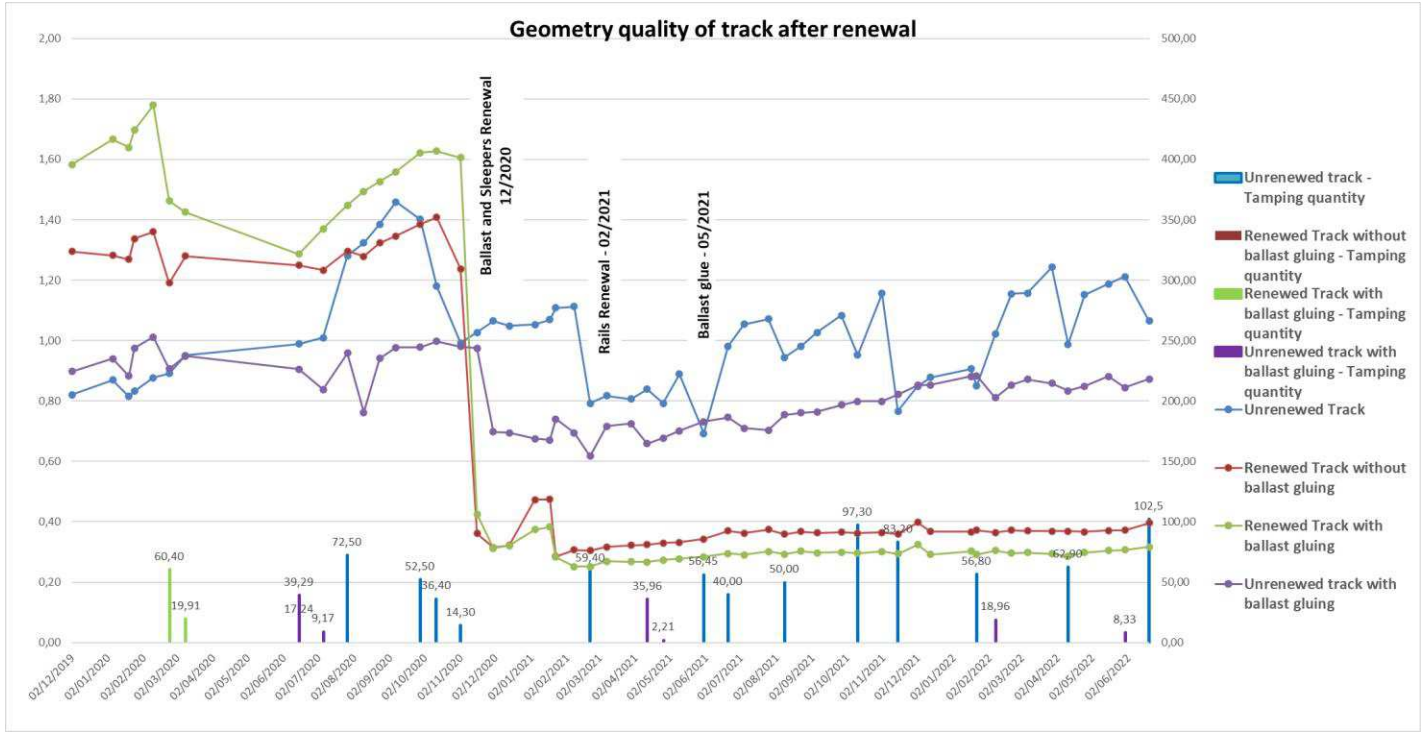
Removable glued surface of ballast
End of ballast flight
End of ballast creeping
Better track stability and lasting alignment quality

→ Effective but to be used only on defect zones

Ballast Track Renewal : New assets efficiency

Feedback after 18 months

- Renewal efficiency :
  - Geometry quality
  - Reduction of tamping
- Ballast gluing efficiency :
  - Especially on unrenewed track



Improvement of the trackworks

Historical trackworks for conventional lines : 60 km/h for 1st commercial train

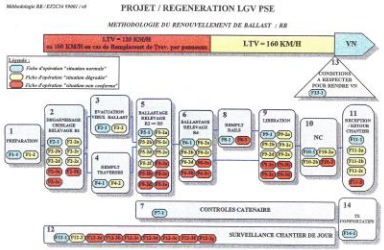
1996 : 1st ballast renewal on HSL : 100 km/h (1998 : 120 km/h)

2013 : ballast renewal on HSL : 160 km/h

2018 : 1st sleepers renewal on HSL : 120 km/h

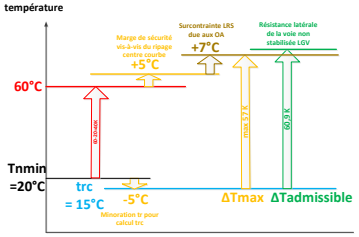
2023 : sleepers renewal on HSL : test @ 160 km/h

2027 : full track renewal : 160 km/h : lower impact on commercial traffic

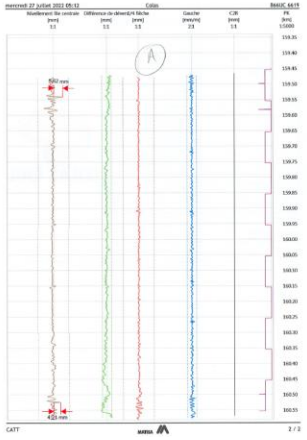


1998 V120 ballast renewal guidebook

2012 on-track measurements to prepare V160 ballast renewal

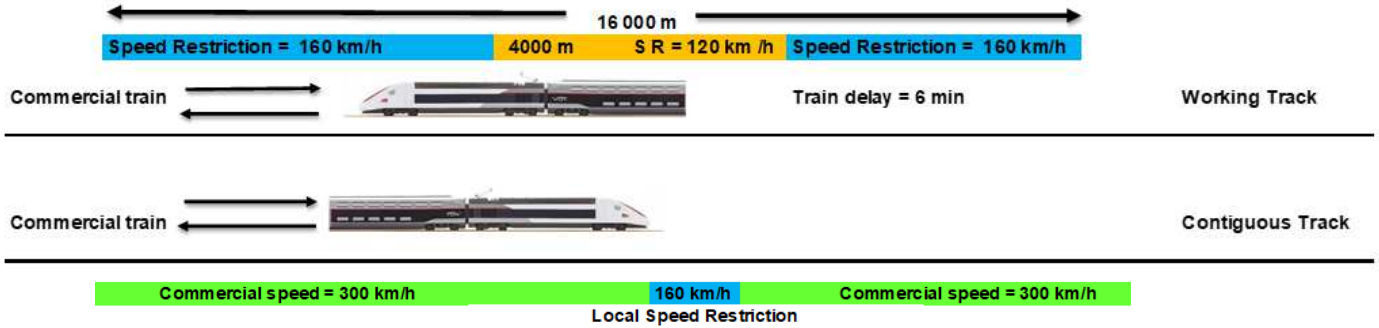


Part of the 2015 study to test V120 sleepers renewal



2022 Geometrical results for the V160 sleepers renewal

Renewal organisation : Capacity resources



1st night :
. Old ballast removal
. New ballast deposit (< 300 mm)
. Tamping

2nd to 4th night :
. Tamping for track alignment and levelling
. Ballast stabilisation

5th night :
. Tamping for final alignment
. Ballast stabilisation

6th to 8th night :
. Tamping for final levelling
. Ballast stabilisation

9th night :
. Rail temperature neutralization
. Ballast profile regulation

Objectives :

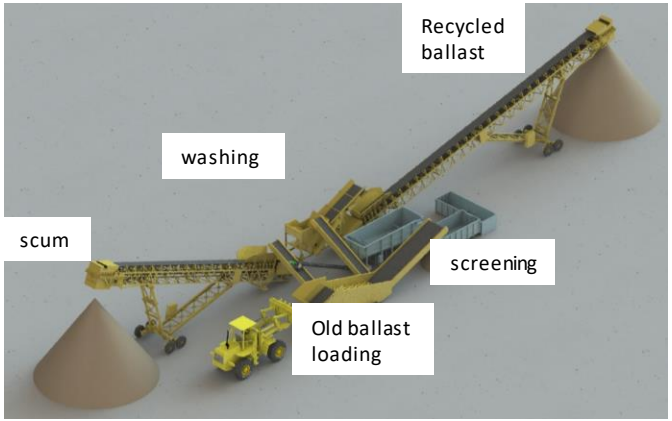
* Traffic impact as low as possible : Commercial traffic every day
* Reduce the Speed Restriction (Speed Limit and duration).

Climate change : more demand for train travel
→ reduce the impact of trackworks on commercial traffic

Ballast recycling to limit resource usage and costs

Several cases of ballast reuse :

- Directly after screening on track → for 40+ years, allows to recover 30% of the old ballast on conventional lines (70% on HSL)
- After screening at the trackworks base → since 2017, allows to recover 45% (30+15) of the old ballast
- After washing + screening at the trackworks base → since 2021, allows to recover 70% (30+40) of the old ballast



Earnings :

- 360 t CO_2 for a 45 km track renewal on conventional line
- 24 €/T

→ To be used on HS Lines to improve the reuse of 70 % of the old ballast (already reached after only on-track screening)

High Speed Line Ballast Track

Continual improvement of the maintenance process (assets lifecycle extension)

+

New model of industrial renewal (assets innovation, new methods, traffic impact reduction)

=

More high-speed mobility to serve the planet !

Merci !

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11TH WORLD CONGRESS OF HIGH-SPEED RAIL

Marrakech, 7-10 MARCH 2023

MONITORING OF RAILWAY'S DEFORMATION USING RADAR REMOTE SENSING SATELLITES

Gokhan, Kizilirmak
PhDc, Geodesy Engineer & SAR Analyst, TCDD, Türkiye
Session 3 - 5.3 Infrastructure / Maintenance and Renewal

ONCF UIC