Cost-Efficient and Reliable High-Capacity Infrastructure

Internal Final Event

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101012456
Why Final Event?
Show results
Day 1 - Internal

- Project participants (mainly)
- Few but long presentations → insight
- Closure of the In2Track series and Shift2Rail

Day 2 - External

- Anyone interested
- Many short presentations → overview
- Insight in the value of research (?)
Audience day 1

- 60+ persons
- 26 companies
- 12 countries
- IMs, operators, scientists, technicians/specialists, product developers
Audience day 2

- 70 + 80 persons
- 53 companies
- 16 countries
- IMs, operators, scientists, technicians/specialists, product developers
Dissemination, exploitation and innovations; results and barriers

Ulrika Wahlström & Jonas Normann, Spinverse
Martin Schilke, Trafikverket

Cross-cutting activities and standardisation
Anders Ekberg, Chalmers

Obligations of the consortium following the closure of a project and next steps
Sébastien Denis, In2Track3 PO

voestalpine Shift2Rail demonstrator
Christian Ebner-Mürzl, voestalpine Railway Systems

Tamping and Urban grinding
Alejandro Salanova, Plasser & Theurer

José Solís Hernandez, Cemosa

Heterogenous data into bridge asset mgmt platform
Pär Söderström, SJ
Mats Berg, KTH
Matthias Asplund & Martin Li, Trafikverket

Improved riding comfort
Alfredo García Farré, Acciona

Shear capacity improvement in concrete bridges

Innovations; results and barriers

2023-12-15
▪ Välkomna

▪ Syfte med dagen, varför har vi de här presentationerna och upplägget? Skicka även ut det i mailen inför mötet.

▪ Vad vi ska gå igenom
26 partners in 11 Countries
Example:
3MB SlabTrack

Image rights: Acciona Construccion SA
In2Track3 Europe in visual demonstrators
What do we leave for the future?
From: In2Track3
To: The Future
The ATMO for improved grinding in cities
Improved maintenance through the EMAT trolley
Smart Material for measuring rail health
The 3MB slab track for easier maintenance
Possibly new ways to separate damage slab tracks
The optimised cast manganese frog
The Discrete Defect Repair technique to weld cracks
The ROUV for detection of scour
A new method for repairing brick-lined tunnels
An autonomous tunnel drainage rover
Improved repair methods through laser cladding
A new type of tramway crossing
...and much, much more...
So how have we shown our results?
Overview

Objectives

Project Structure

Partners

Results and Publications

Projects News & Events

Latest Project's News

16 June 2015
Webinar on Vegetation Management in Railways

22 September 2015
Webinar on Axle Box measurements for railway condition monitoring

18 October 2015
Webinar on Digital solutions for the railway

Contacts

Results and Publications

D1.1 Enhanced S&C system midterm report
Download

D6.1 Project Handbook
Download

D8.1 Communication material about the project - presentation 1
Download

D8.1 Communication material about the project - presentation 2
Download

D8.2 Data Management Plan
Download

D8.3 Dissemination and Exploitation plan
Download

All deliverables, results and publications here with provided reflects only the author's view and the S2R JJ is not responsible for any use that may be made of the information it contains.
Are we there yet?
Reporting Period 3

• Write it as soon as possible (get rid of it). Hard deadline: January 8th

• Templates are prepared, you find them here

...which is also where you store your finished text, as usual
Financial reporting

January 19th
Documentation

- Our space on Projectplace will be shut down January 19th
- No information will be automatically saved – you need to save what you want to keep
- Formal documents (deliverables, news etc) will be transferred to CT4
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Concluding technical report
Why? What? How?

- Project documentation – not a scientific report

- Readers- Public authorities, Railway associations and federations, Railway supply industry, other projects...

- Distribution

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Jan 2024
Sending for print

Jan 2024
January 8th is the last day for submitting texts (here)
Editing the book, collecting images etc

Feb 2024
Distribution

Oct 2023
Invitation to partners to collaborate in writing the book
Shift2Rail demonstrator

Christian Ebner-Mürzl, voestalpine Railway systems
S2R–Demonstrator

Austria – Vienna

Liesing
S2R – Demonstrator – Vienna Liesing

Design – Installation – Measurement
Agenda

» Motivation of vaRS for S2R
» Innovative features of the S2R – Demonstrator
» Installation of the S2R – turnouts
» Measurement campaigns at the S2R – turnouts
» Evaluations of the measurements
» Questions
Motivation of vaRS for S2R

Costs for:
- Manufacturing
- Installation

Costs for:
- Maintenance
- Replacement
- Downtime
- ...

Total lifecycle costs
Motivation of vaRS for S2R

» Project team with massive railway expertise, consisting of:
  » vaRS, vaW, vaSIG, vaBWG, VASI, Getzner, KFTH
  » Scientific support by MCL, VIF
  » Railway Authority ÖBB

» With the target to optimise the LCC of the whole system „Turnout“
  » Expand the lifetime of the components
  » Stretch the maintenance cycles
  » Or even leave maintenance works behind

S2R VISION

To deliver, through railway research and innovation, the capabilities to bring about the most sustainable, cost-efficient, high-performing, time driven, digital and competitive customer-centred transport mode for Europe.
Problems to solve

- Breakouts at tip
- RCF
- Dipping
- Wear/RCF
- Ramping at short bearers
- Settlement of turnout
- Load distribution
- Ballast destruction
Solutions of the S2R – Demonstrator

- Optimised geometry, Bearer independent
- Wear/RCF
- Optimized bedding and elasticity
- Settlement of turnout
- Ramping at short bearers
- Bearer connectors
- Elastic fastening
- Load distribution
- Ballast destruction
- Optimised bedding and elasticity
- Dipping
- RCF
- Rail 400UHC
- Breakouts at tip
- Rail 400UHC
- Special machining TOZ+
- Ramping at transition
- Transition zone
Innovative features of the S2R – Demonstrator

» Enhanced cast crossing design
» Enhanced S&C bearer design
» Enhanced fastening system ERL NG
» Enhanced stock- & switch rails
» Self-detecting switch rail
» Bearer coupling system
Innovative features of the S2R – Demonstrator

» Point machine ECOSTAR
» Polygon setting device
» Locking device SPHEROLOCK NG
» Hollow bearer
» Monitoring and Diagnostic system RML 4.0
Innovative features of the S2R - Demonstrator
Innovative features of the S2R – Demonstrator
Installation of the S2R – turnouts

» Final assembly of the turnout components took place at voestalpine in Zeltweg

» Transportation of switch panel, crossing panel and closure panel on tilt wagons to Vienna
Installation of the S2R – turnouts

» Final transportation of the pre-assembled turnouts with a rail driven crane truck

» Lifting and adjusting the turnouts for its installation position
Installation of the S2R – turnouts

» Tamping of the installed turnouts
» Dynamic track stabilization
» Rail welding
Measurement campaigns at the S2R – turnouts

» The validation of the innovation is done by different measurement strategies:
  » Permanent measurement
  » Measurement campaigns
  » Short time measurements
Measurement campaigns at the S2R – turnouts

» Deflection, stress and acceleration measurement at the crossing
» Deflections with measurement campaigns
» Ground vibration measurement
» Geometrical CALIPRI measurement campaigns
Evaluation of the measurements – deflection measurements

- All deflections in downward direction between reference and component are shown as a (+) and upward direction as (−)
  - E.g. Sleeper<->Rail: Reference is the sleeper & movement of rail is displayed
- Each train is evaluated for one representative max/min displacement

![Deflection Diagram]

**voestalpine Railway Systems**

18 | December 15, 2023 | S2R - Demonstrator
Evaluation of the measurements – deflection measurements

» Highest median displacement
  » Fastening point for W4
  » Sleeper for W3

![Diagram showing deflection measurements comparison between W3 and W4 with labeled sensor positions and downward displacement values for each sensor position for W4 and W3.]
Evaluation of the measurements – deflection measurements

- Little deflection at fastening system at reference turnout (W3) in a range of 0.4 mm compared to S2R (W4) with 1.4 mm
- Higher sleeper deflection on reference turnout (W3) with 1.5 – 2 mm compared with S2R (W4) 0.5 - 1mm
Thank you

Christian Ebner-Mürzl
T. +43/50304/28-759
chris.ebner@voestalpine.com
Shear capacity in trough bridges
Alfredo García Farré, Acciona
The work included demonstration of the shear strengthening technology that was developed in In2Track2 to be applied to concrete trough bridges without causing traffic disruptions.

Research was expected to reach TRL7.

ACC led the work, developed and tested a fibre optics monitoring system for the shear strengthening technology based on smart FRP rebar.

ACC will demonstrate the developed solution on a selected bridge. FTA provided a bridge in Finland for demonstration, national approval and site safety and TRV supported with expertise.
There are more than 300,000 railway bridges in Europe, about two thirds of which are more than 50 years old.

Over time, the codes have become increasingly restrictive.

There is a growing number of bridges in Europe that are reaching the end of their service life or require an enhancement of their performance to cope with increasing load demands.

Previous shear reinforcement systems for through-type bridges required stopping road traffic during strengthening operations.

The limited deformations in reinforcement bars and challenges in their placement hinder effective monitoring. Verifying the system's load-bearing capacity becomes difficult, compromising its intended function of strengthening the structure.

The concrete trough bridge is a standard bridge type that was built in Sweden during the 1950s, with maximum axle loads of 250 kN. Today, as new railway lines are designed for higher loads (maximum axle loads of 330 to 400 kN), these structures need to be strengthened to increase their service lives.
The main drawback to develop an appropriate shear strengthening system for concrete trough railway bridges is the \textit{inaccessibility to both sides} of the main girders without disturbing traffic.

Two solutions were considered:
- a) \textit{externally-bonded FRP sheets} (only placed on the exterior face of the longitudinal girder and properly anchored)
- b) \textit{embedded through-section (ETS)} technique
Previous Works in In2Track2

- An experimental campaign that was carried out during the project to test ETS reinforcement technology.
An increase of 76 % and 130 % of the shear resistance for beams strengthened with 3 ETS and 5 ETS, respectively, for the case with no steel stirrups.

An increase of 24 % and 21 % of the shear resistance for beams strengthened with 3 ETS and 5 ETS, respectively, for the case with Ø8mm steel stirrups.

An increase of 12 % and 27 % of the shear resistance for beams strengthened with 3 ETS and 5 ETS, respectively, for the case with Ø10mm steel stirrups.

The results from the monitoring of the beams during the tests confirm the reduction of the strain level in the steel stirrups when the beam is shear strengthened, compared to a similar beam non-strengthened.
FTA provided a bridge in Finland for demonstration of the technology

The selected bridge needed to meet the following criteria:

- Type of structure: trough railway bridge (reinforced concrete)
- Short span, simply supported (isostatic)
- Easy accessibility from underneath
- The bridge was to be in use, with predictable and constant traffic.

**Option number 1**
10,5 m span, newer deck replaced around 1980’s

**Option number 2**
Span 10,8 m. From 1976

**Option number 3**
Span 10 m. Build in 1981

**Vuoksenniskan underpass**
Located on the Imatra-Parikkala Railway Line
Bridge Selection

Selection of a bridge in Finland for demonstration (FTA)

Kouvola–Joensuu Railway Line

Vuoksenniskan underpass
Bridge Selection

Selection of a bridge in Finland for demonstration (FTA)

Drawings from 20/11/1980

Bridge deck: 10.5 m trough beam (span), 95 tn (D.L.)

Concrete: K40-1 ($f_{ck} = 40$ MPa)

Steel reinforcement: A 400 H ($f_{yk} = 400$ MPa)

Load: VR 1974
Structural calculations
ETS Strengthening Solution
ETS Strengthening Solution

Steel stirrups contribution:

\[ V_S = z \cdot \frac{A_{sw}}{s_{sw}} \cdot f_{ywd} \cdot \left( \cot \theta + \cot \beta_S \right) \cdot \sin \beta_S = 1116 \, kN \]

\[ z = 850 \, mm; \quad A_{sw} = 679 \, mm^2 \quad (3 \times 2 \quad \phi 12); \quad s_{sw} = 180 \, mm; \quad f_{ywd} = 348 \, MPa; \quad \theta = 45^\circ; \quad \beta_S = 90^\circ \]

CFRP ETS bars contribution:

\[ V_f = h_w \cdot \frac{A_{fw}}{s_{fw}} \cdot \varepsilon_{fe} \cdot E_{fw} \cdot \left( \cot \theta + \cot \beta_f \right) \cdot \sin \beta_f = 317 \, kN \]

\[ h_w = 850 \, mm; \quad A_{sw} = 201 \, mm^2 \quad (1 \quad \phi 16); \quad s_{sw} = 360 \, mm; \quad \varepsilon_{fe} = 0.004; \quad E_{fw} = 120 \, GPa; \quad \theta = 45^\circ; \quad \beta_f = 55^\circ \]

\[ V_{R,\text{tot}} = 1116 + 317 = 1433 \, kN \]

\[ \Delta V_R = 28 \% \quad \text{(after strengthening)} \]
Fiber Bragg grating (FBG)

Sand coated pultruded C-FRP bars

Diameter of 16 mm and a length of 1.0 m

Elastic modulus higher than 150 GPa

Ultimate tensile strength of 2300 MPa
"Fiber Bragg grating (FBG) sensors are nowadays utilized in SHM because of advantages suchs as fast response, electrical passivity, corrosion resistance, multi-point sensing capability, and high accuracy and resolution over a long period"
Fiber Bragg grating (FBG)

FRP reinforcement - 1 m

Lead-out fiber - cut off when fiber is bonded

3 mm Armored Cable 10 m

Splice protection

FBG1

FRP bar

FBG24

Splice protection

Minimum length that should be bonded to FRP bar
Fiber Bragg grating (FBG)

1. A 0.6 mm groove was cut in the bars, filled with glue.
Fiber Bragg grating (FBG)

2. The fibers were placed and the bars were provided with a 3D printed device.
Fiber Bragg grating (FBG)

3. Epoxy was applied on the fibers and a Teflon coated wire was pushed down in the groove.
Fiber Bragg grating (FBG)

4. A long plastic sheet was put around the FRP bar during curing.
ETS Strengthening Solution
ETS Strengthening Solution
ETS Strengthening Solution
ETS Strengthening Solution

- A total of 6 reinforcement bars (ETS) were installed and monitored, with each reinforcement bar comprising 24 sensors spaced 4 cm apart, resulting in a total of 144 sensors.

- The measurements were divided into one-hour segments, amounting to 42 hours of monitoring and generating a total of 6048 data files.
Results In2Track3

- Initially, the **calculations assumed that the section of the bridge was cracked** due to shear loads, and, therefore, most of the shear stresses were supported by the vertical stirrups.

- According to this assumption, it was calculated that the new ETS reinforcement bars, in an ideal scenario, should experience an elongation of 0.000677 (mm/mm) or $677\mu\varepsilon$—**About 200 times more strain than was actually observed**!

- Therefore, the concrete section should **not have been cracked**, or presented very small cracks that allowed the passage of shear stresses through the concrete without hardly producing strain in the reinforcement bars.
A 2D model in Ansys was created to verify this theory.

The results of the numerical simulation showed that in case the concrete was not cracked, the strains produced by the passage of a train would be 6µε, which agrees with the strains experimentally found in the ETS bars.

This proves that ETS bars introduced into an uncracked concrete section can act as reinforcement to the passive armor.
Results In2Track3

- 42-hour monitoring of reinforcement bar number 2 at sensors 03, 11, & 23.
- The first thing to notice is the significant cyclic variation between day and night.
- Each small spike observed in the graph represents a train passing over the bridge. There is no appreciable difference in strain before and after the passage of the trains.
Results In2Track3

- To carry out the demonstrator, the Vuoksenniskan underpass bridge located on the Imatra-Parikkala Railway Line (Finland) was selected.
- For monitoring ETS (embedded through-section) bars, a Fiber Bragg grating system was used, successfully allowing the monitoring of strains obtained along the entire length of the bars.
- Despite the low strains experienced in the reinforcement bars, it was demonstrated that the bars come under load due to the passage of trains.
- It was proven that the passage of trains during the curing of the resin does not affect the efficiency of the system.
- The technology was tested in a real-world environment, demonstrating its viability as strengthening system for railway bridges.
Future work on the topic

- The result was successful, demonstrating that the technology is valid for repairing through-type reinforced concrete bridges.
- Future research will be necessary to determine the behavior of ETS bars when introduced into a cracked section.
- More information can be found in the In2track3 deliverable in Section D5.4 or in Appendix T5.4.1.
Integration of heterogeneous data into a bridge asset management platform

IN2TRACK3 | Internal Final Event
29\textsuperscript{th} November 2023
Jose Solís Hernández
Table of Contents

1. Addressed challenges in IN2TRACK.

2. Infrastructure Inspection ROUV: Objectives and results.


4. Conclusions and future work.
Addressed Challenges
Addressed Challenges

1. Large numbers of rail infrastructure assets:
   - Are currently close or beyond their design life-cycle.
   - Require maintenance and rehabilitation actions.
2. There is a pressing need for new methods to inspect, monitor and analyse infrastructure state.
   - Progressing towards predictive maintenance.
3. Large volumes of data are generated:
   - New systems must be conceived in a sector with a low level of digitalisation.
   - Miscellaneous data sources need to be stored, analysed and made available to the infrastructure manager.
4. The new technologies must help improve services, reduce costs, and reduce emissions.
IN2TRACK3 Developments

**Infrastructure Inspection ROUV**
- Underwater inspection of infrastructure such as bridges.
- Improvement of current procedures.
- Improvement in inspection process safety.

**Digital Twin Bridge Asset Management Platform**
- Integration of data from miscellaneous sources.
- Management of large volumes of data.
- Analysis of monitoring and inspection data.
Infrastructure Inspection ROUV
CEMOSA has built, ensembled and integrated an infrastructure inspection ROUV, including:

- Cameras.
- Water quality sensor.
- Gripper.
- Sonar.
- Other navigation support sensors.

The system has been tested in different scenarios. The inspection feedback has been used to propose new sensors and applications. Also, underwater inspection procedures have been defined.
Infrastructure Inspection ROUV

Demonstration

1. In-lab tests.
2. Rules Dam, Granada: Initial visibility/stability tests.
3. Port of Marbella: Inspection of the state of submerged elements in different areas of the port.
5. Port of Málaga: Overall inspection.
6. Access bridges to Port of Málaga: Scour and debris inspection.

Objective: Incorporate the ROUV as a service in CEMOSA’s portfolio.
Demonstrators

Demonstrator 3. Port of Marbella.

Objectives:

- Inspect zones A, B and C of the port.
- Settlements. Inspection of the state of the pillars.

Outcomes:

✓ Checked actual state of the pillars supporting the deck.
✓ Obtained useful information for the following interventions: retaining wall.
✓ Testing in a salty environment and relatively high turbidity.
Demonstrators

Demonstrator 4. Cable Tower.

Objectives:
• Analysis of the state of the foundation of a cargo tower.
• Important topics: scour and detachments.

Outcomes:
✓ Analysis of the current state of the tower.
✓ Areas with detachments were characterised.
✓ Testing in high currents and open sea.
Demonstrators

Demonstrator 5. Port of Málaga.

Objectives:
• Routinary inspection of a section of the deck.
• Training for ROUV controllers.

Outcomes:
✓ No pathologies were spotted.
✓ Training of people external to the project was successful.
✓ Testing in optimal conditions: salty water, low turbidity.
Demonstrators

Demonstrator 6. Access Bridges, Port of Málaga.

Objectives:
• Inspection of bridges in the port of Málaga.
• Important topics: scour and bridge surroundings.

Outcomes:
✓ Analysis of the current state of the bridges.
✓ No structural problems found.
✓ No scour was found in any of the 9 piles.
✓ Testing in high turbidity areas. Low lighting.
Underwater Inspection Guidelines

The experience in the previous five demonstrators has been used to write inspection and control guidelines for the ROV.

Main areas analysed and reported are the following:


b. Inspection planning:
   a. Inspection element: bridge, port, reservoir, etc.
   b. Type of waterbody.
   c. Specific environment limitations.
   d. Inspection sequence and external factors.
   e. Types of defects.

c. Technical checks for inspection.

d. Inspection execution and sequence: following Adif and Spanish Transport Ministry guidelines.

e. Security measures and maintenance procedures.
Digital Twin oriented Bridge Asset Management Platform
CEMBOX. Digital Twin

CEMBOX Infra
Linear transport infrastructure Digital Twin.
- Asset management and inventory.
- Inspection.
- Monitoring and analysis.
- Maintenance planning.

CEMBOX Buildings
Energy efficiency Digital Twin for buildings (and rail stations).
- Data visualisation: historical and real time.
- Energy and air quality analysis and control.
- Building energy calibration and dynamic analysis.
- Energy and air quality simulations.
CEMBOX INFRA: Concept

Overall Concept

**Digital Twin**: BIM-GIS environment enabling the interaction with static and dynamic data and addressing:

- **Integration** of different data sources and asset visualisation.
- Analysis and **prediction** of infrastructure condition.
- **Simulation** of scenarios (decision making).

Specific Objectives

1. **Robust data management** system:
   - ROUV, IoT, UAS data, traditional sources.
2. **Interoperable** architecture.
3. **Focus on analytical** applications: bridge SHM, pavements.
4. **Integration in a modular** asset management platform.
CEMBOX INFRA: Platform

Platform Services

- **Management** of assets.
- **Inspection**
  a. Visits Module.
  b. Pathologies Module.
  c. Point Cloud Module.
  d. Pavements Module.
- **Monitoring**
  a. Devices Module.
  b. Data Module.
  c. Analytics Module.
- **Planning** (in progress).
CEMBOX INFRA: Management

Coordination and inventory of the information related to a particular project or contract.

- BIM models.
- Engineering drawings.
- Documentation.
- Structural models.
- Etc.
CEMBOX INFRA: Inspection (I)

Modules for:
- Point Cloud Analysis.
- Pavements (roads).
- Visits.
- Pathologies.

Condition state analysis of pavements based on historical information from IRI, SFC or deflexion.
CEMBOX INFRA: Inspection (II)

**Modules for:**
- Point Cloud Analysis.
- Pavements (roads).
- Visits.
- Pathologies.

**Pathologies Module:**
- Damage visualization.
- Evolution over time (BIM-DB Link).
- Characteristics and criticality.
CEMBOX INFRA: Monitoring

**Modules:**
- IoT Devices.
- IoT Data.
- Analysis.

**Analysis (SHM):**
- Extract and clean data.
- Statistical analysis.
- Condition state analysis: OMA or Full Data-Driven.

**Sensors**
- Accelerometers, Others

**Edge Node**
- Preprocessing, Sending Data

**Communication**
- Via 4G & MQTT Prot.

**Platform**
- Storage in SAP HANA DB
CEMBOX INFRA: Demonstrators

Dúrcal Bridge Analysis, Granada

_Operational Modal Analysis Approach_

- **Monitoring**: High frequency Monitoring
- **OMA**: Long time-span.
- **Mode Shape Evolution**: Analysis of trends

- **Sensors**: Array of triaxial accelerometers.
- **Sampling**: 512 Hz, 1 measurement per hour.
- **No issues** detected... Analysis still ongoing.
CEMBOX INFRA: Demonstrators

HSL Bridge, Spain

_Full Data-Driven Approach_

The **objectives** are to:

- Complement and validate OMA approach.
- Detect anomalies which motivate maintenance and inspection actions.

The **methodologies** analysed are:

- Statistical process control.
- K-Nearest Neighbours.
- Clustering using OPTICS.
- Neural Networks.
- Other (ongoing).
Conclusions & Future Work
Inspection ROUV has been incorporated to CEMOSA’s portfolio.

_Improvements in the area of computer vision are being considered.

**CEMBOX Platform:**

a. **User-friendly** Digital Twin environment:
   _Management, Inspection, Monitoring and Planning.

b. **Analytics** on key applications:
   _SHM bridges, pavements, earthworks, among others.

c. **Easy integration** and management of critical infrastructure:
   _Better service. Sustainability.
   _Reduction of costs.

**Next steps:**

_SHM workflow to be applied to more case studies.
_Progress on the statistical and AI analytics.
Future work

**FP3-IAM4RAIL.** HSL Bridge Digital Twin (CEMOSA, ADIF).
- **HSL Madrid-Valencia.** IoT Monitoring of deck & pot bearings.
- **OMA of the bridge:** Condition state analysis (use of AI).
- **Pot bearings degradation analysis:** Fatigue and anomaly detection.

**FP3-IAM4RAIL.** Earthworks Digital Twin (CEMOSA, ADIF).
- **Palencia-La Coruña Conventional Line.** Slope Monitoring.
- **Data fusion:** Satellite, monitoring data, historical data & geotechnics.
- **Evaluation of condition state.**

**CEMBOX:** Integration of developments into Platform.

*Source: Adif*
Thank you for your attention

Jose Solís Hernández | jose.solis@cemosa.es | +34 610 76 87 93

In2Track3

cemosa
Ingeniería y Control
Dissemination, Communication and Exploitation Activities

Ulrika Wahlström & Jonas Norrman, Spinverse

2023-11-29

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101012456
Dissemination, Communication & Exploitation support from Spinverse

Ulrika Wahlström
Senior Consultant
Writer of EU-proposals – parts regarding impact, exploitation, IPR, financial instruments, business models, communication and dissemination
WP-leader of WP Business Innovation & Outreach in H2020-project United-Grid
WP-leader of WP Barriers to innovation, Exploitation and deployment, Financial instruments in H2020-project FlexiGrid
WP-leader of Development of Bankable Business models and Exploitation activities in H2020 IRIS Smart Cities project
Background in strategic communication

Jonas Norrman
Principal Consultant
Change management expert assisting clients developing their business with Sustainability in focus.
Business model and finance manager for EU funded projects.
Experienced in development and implementation of change projects. Focusing on clear impact results for both business and society.
Experience Business Intelligence leader supporting annual business plan evaluations and updates
Background as CEO and board member

Mats Tiborn
Senior Consultant
Responsible for communication, engagement and dissemination in the H2020-project FlexiGrid, and the EU-collaboration hu Celsius Initiative.
Responsible for communication activities in research centres within electromobility, AI, and maritime technology.
Worked as a news reporter for the Swedish public radio
Background as a Communications officer at the Department of Chemistry and Chemical Engineering at Chalmers University of Technology
Quick reminder of what we mean by:

COMMUNICATION - Inform about the project

DISSEMINATION – Inform about results

EXPLOITATION – Making results available for use
Dissemination AND Communication
A great journey together with you!

Dissemination & Exploitation objectives

• Disseminate and communicate key findings and outcomes
• Do it in a way that maximizes project impact to key stakeholders
• Develop a strategy for this and implement it
Project results

Communication channels & content
- Website
- LinkedIn
- Articles
- Youtube
- Webinars

Impact

Impact reached through your:
- Involvement
- Facts, figures, information
- Shares, likes, comments
- Competence
- Network of relevant people
A website – learnings along the way

**Important**
- Linking to the overall program
- EU-related

**Lacking**
- Attractiveness towards target groups
A website – contributing to market impact

Success factors

- Attractive content
- Easy to provide links for posts in social media
- Handles pictures
- EU visibility secured
A growing fan club on LinkedIn

Success factors

• Project partners' shares & likes & positively commenting
• Project partners as administrators
• The use of relevant #
• The use of @
• Relevant followers
• Interesting content
• A consistent flow of posts
Discrete Defect Repair method

Upgrading the regulation for bridge constructions

Rail maintenance made easy with the EMAT

Remote underwater inspections of rail constructions improve safety

Virtual Vehicle improving maintenance
Youtube channel

Additional social media channel

- To better handle video material
- Easy to share videos
- People are used to use this channel to learn about things
### Webinars: Exploitation towards Target groups

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 14, 2023</td>
<td>Vegetation management</td>
<td>The purpose of the webinar was to bring infrastructure managers closer to a mutual vision of vegetation management along the tracks, and to facilitate and enable procurement of the right kind of chemicals for handling vegetation and tools to minimize their use.</td>
</tr>
<tr>
<td>Sept 22, 2023</td>
<td>Axle box acceleration</td>
<td>Presentation of 2 of In2Track key exploitable results and discussion on current challenges and possible paths toward deployment of the technology in the industry. The key exploitable results: - Detection of Rolling Contact Fatigue (RCF) using axle box acceleration (ABA) measurements - Railway track stiffness evaluation using axle box accelerations</td>
</tr>
<tr>
<td>Oct 18, 2023</td>
<td>Digital Twin Solutions for Railways</td>
<td>The purpose of the webinar was to demonstrate the results in IN2TRACK3 and promote upscaling and replication. In the webinar two of the exploitable results were presented, from the perspective of a developer and end-user.</td>
</tr>
</tbody>
</table>
The webinar on Axle box measurements for railway condition monitoring was held on September 22nd.

- 122 participants
- 22 countries
Exploitation of project results
Wide array of participants

Infrastructure owners/managers and operators

Universities and research & development centres

Industry partners
Your innovation process and In2Track3

- **Identify organizational needs and trends**
  - Market research on emerging trends, technological advancements, regulatory changes.

- **Idea Generation and Brainstorming**
  - Ideas could focus on improving operational efficiency, developing new investment strategies, leveraging technology for better analysis.

- **Prototyping and Testing**
  - Conduct pilot tests or simulations to gather feedback from a select group of users.

- **Implementation and Integration**
  - Integrating the innovation into your asset management processes. Collaborate relevant teams to ensure a smooth transition.

- **Continuous Evaluation and Improvement**
  - Set up metrics and key performance indicators (KPIs) to measure the success of the implemented innovation.
The exploitation preparation process

- Exploitation preparation process
  - Key Exploitable Results methodology

- Solutions evaluation
  - Joint evaluation and prioritization of results

- Market communication process
  - Webinars
  - Communication
Exploitation preparation activities

- **Involving the right people**
- **First version of In2Track3 KERs collected**
- **Workshop 2: KER prioritisation activity held with IM managers**
- **Workshop 3: Discussion on Exploitation barriers held with IM managers**
- **Webinar 2: Axle Box Acceleration Measurements.**
- **Interviews with infrastructure managers**
- **Conclusions for the continued work**

**Exploitation preparation process**

**Solution evaluation process**

**Market communication process**

**Introduction to the KER methodology**

**Workshop 1: Value chain design and commercialisation barriers and success factors**

**Report of potential exploitable results summarized and sent out to IM managers**

**List of top 10 KERs identified for the continued work**

**Webinar 1: Vegetation Management**

**Webinar 3: Digital Twin Solutions for Railways**

**Final version of top 10 KERs finalized.**
Joint prioritization of results

In2Track2

Foreseen results
Brief descriptions of all results with potential
All partners

Prioritising of 45 Exploitable Results

In2Track3

List with 10 Key Exploitable Results; Beyond TRL7
Solution suppliers and providers. Market uptake plan

KER = Key Exploitable Result
## Prioritized Key Exploitable Results

<table>
<thead>
<tr>
<th>Results</th>
<th>Focus for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation management through electromagnetic waves</td>
<td>• Continuous collaboration</td>
</tr>
<tr>
<td>Track design and track maintenance guidelines to reduce curve squeal</td>
<td>• Preparation for implementation</td>
</tr>
<tr>
<td>NDT Rail Stress Measurement Device</td>
<td>• Identification of market barriers</td>
</tr>
<tr>
<td>Detection of rolling Contact Fatigue (RCF) using Axle Box Acceleration (ABA) Measurement</td>
<td>• Market communication</td>
</tr>
<tr>
<td>Intelligent sensor network for track/S&amp;C System monitoring</td>
<td></td>
</tr>
<tr>
<td>Railway track stiffness evaluation using axle box acceleration</td>
<td></td>
</tr>
<tr>
<td>Digital twin solution for crossing panels</td>
<td></td>
</tr>
<tr>
<td>A new methodology to predict the long-term performance of the transition zoned</td>
<td></td>
</tr>
<tr>
<td>Innovative Smart Transition Zone Monitoring whole-system</td>
<td></td>
</tr>
<tr>
<td>Diagnostic of trackbed applied to high speed lines</td>
<td></td>
</tr>
</tbody>
</table>
Prepare implementation with colleagues…
Hand over project results to the internal innovation process

... with skills in:
• Operations
• Development
• Procurement
• Communication

Aligning and transforming railway infrastructure management
## Continuous cooperation removing market barriers

<table>
<thead>
<tr>
<th>Area</th>
<th>Market Barriers</th>
<th>How to overcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulations/legislation</td>
<td>• Regulations (technical specifications)</td>
<td>• Stage-gate process (low consideration of regulations at start of R&amp;D required)</td>
</tr>
<tr>
<td></td>
<td>• Lack of logic behind regulations (established long time before, by a small group or even one person)</td>
<td>• Changing regulations at certain level of development (safety vs. responsibility)</td>
</tr>
<tr>
<td></td>
<td>• Outdated regulations hold back innovations.</td>
<td>• Removal outdated regulations or detailing existing ones (standardisation and best practice, international exchange)</td>
</tr>
<tr>
<td></td>
<td>• Legislation requires approvals (time consuming and costly)</td>
<td>• Collaboration with infrastructure owner and procurement departments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Virtual testing and validation</td>
</tr>
<tr>
<td>Development, testing, validation</td>
<td>• Development, testing, validation, implementation takes time – developing something that will be used in 30 years (changes in whole systems)</td>
<td>• Innovation procurement – share the risk (infrastructure owner need to be involved)</td>
</tr>
<tr>
<td></td>
<td>• Lack of track availability for testing new technology</td>
<td>• Partnership with infrastructure owner (&amp; S2R)</td>
</tr>
</tbody>
</table>
Many things to consider:

- Background
- Grant Agreement
- Foreground
- Different categories of project partners
- Engage the right people
- Have an on-going analysis
- Without FTO you may not be able to make, use or sell your solution

Intellectual Property Rights (IPR) - a barrier and an enabler

Have you secured Freedom to operate?
No protection:
- The explanation of the wear defaults of the rail made of bainitic rail (WP3)
- The pieces of work related to the Building Information Modeling (WP2 and WP4).

Full ownership:
- Some results, which are mainly software and algorithms, are 100% Railenium property. These results will be protected:
  - the Agence pour la Protection des Données (APP) organization that delivers an IDDN number.
    - The Switch & crossing monitoring system (WP1 and WP2)
    - Simulation of the S&C transition zone (WP2) and
    - The EMAT sensor (WP4)

Shared ownership:
- The results of the simulation of the ballast behaviour (WP3) piece of work is shared with the Institut Mines Telecom Nord Europe and will be protected by the APP organization.
- In discussion with the University Mines de Paris to patent together the procedure to use the Coldspray technology to repair some kind of rail (WP4).
TU Delft (for ProRail) has two key exploitable results coming out of In2Track3.

Detection of Rolling Contact Fatigue (RCF) using Axle Box Acceleration (ABA) measurement
- TU Delft has the IPR for this technology.
- TU Delft has filed International patent applications via the PCT procedure for worldwide IPR protection.
- The PCT patents have already been granted.

Railway track stiffness evaluation using axle box accelerations
- TU Delft has IPR for this technology.
- To protect the IPR, TU Delft has filed a national patent in the Netherlands, which has been granted (NL2028399B1).
- TU Delft is now filing an International patent application via the PCT procedure for worldwide IPR protection.
The work EHU carried out consists of two parts:

1) The work that has been carried out by a specialized company and
2) The work carried out by the UPV/EHU for IN2TRACK3 (UPV Universidad Del Pais Vasco)

The work carried out by a specialized company
- Involved the design and manufacture of an open microwave generating device, specifically applicable to the dismantling of the slab track.
- Its name is YIDAKI©, and the name is protected for registration by the specialized company that manufactured it for the UPV/EHU, following the indications of UPV/EHU’s needs.
- This company will include this device in its catalogue of machines and will offer it to possible future clients.

The work carried out by the UPV/EHU
- Involved a new specific procedure based on microwaves, suitable to facilitate the maintenance and repair of certain type of slab tracks after they have been damaged. The slab tracks need to have a specific conceptual design and specific constituent layers with appropriate materials. It is this procedure and combination of materials that can be registered by the UPV/EHU.
- Various acronyms are being considered to designate it, one of the possible ones being MIWATRAMA – MIcroWAveTRACKMAintenance.
- EHU is going to have conversations with the Industrial Property Office of the UPV/EHU to study the feasibility of a patent. The possibility of a utility model might be closed for this case, being basically a procedure.
Conclusions from exploitation preparation process

- KER template
  Engagement from more colleagues to develop implementation criteria.

- Prioritisation
  Need and readiness should be better evaluated.

- Market barriers
  continue the cross-border collaboration

- Establish a transformation Team
Improved ride comfort
Sub-task 3.3.1 Wheel/rail management

Matthias Asplund, Trafikverket
Pär Söderström, SJ
Martin Li, Trafikverket
Mats Berg, KTH

In2Track3 Final Event, 29th November 2023
Wheel/rail management – Improved ride comfort

Agenda

- Introduction and background
- New wheel/rail indicators and standardisation
- Sum-up and the benefit of this work
- Questions
Ride Comfort

- Ride Comfort is a product of the infrastructure and rolling stock, both must be in good condition to obtain a good ride comfort.
- The entire system needs to perform well.
- Good ride comfort is also a prominent issue for the credibility of railway transports.
- Besides reducing the appeal of rail transport, poor ride comfort also inhibits the capacity on track by speed restrictions and leads to loss of punctuality.
- Good ride comfort supports the shift to more green transport modes and sustainable transport solutions.

Approach and goals

- The work has been carried out as a unique collaborative project between infrastructure managers, railway undertakers, vehicle dynamic experts and academia.
- The goal has been to find relevant wheel/rail quantities and corresponding limit values to be implemented on the vehicle and track, respectively.
- Furthermore, to propose a streamlined process of reporting and communication between train operators and infrastructure manager to handle comfort-related issues.
Wheel/rail management – Improved ride comfort

Scope of the work

• The wheel/rail system is complex
• Many variables that interact with each other
• Many stakeholders are impacted
• Wheel and rail geometry (profiles) impact the performance of the system
Wheel/rail management – Improved ride comfort

Investigating Gradient Index Profile and its Correlations with Equivalent Conicity and Rail Surface Management

Martin Li¹, Lars-Ove Jönsson², Ingemar Persson³, Mats Berg⁴ and Matthias Asplund⁵

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Presented at the 28th IAVSD International Symposium on Dynamics of Vehicles on Roads and Tracks,
August 21-25, 2023, Ottawa, Canada
Wheel/rail management – Improved ride comfort

Definition of indicators GIPw, GIPr and GIP

\[
GIPw = 100 \cdot \frac{dZw}{dYw}; \quad GIPr = 100 \cdot \frac{dZr}{dYr}
\]

\[
GIP = \frac{GIPw_L - GIPr_L}{GIPw_L + GIPr_L} + \frac{GIPw_R - GIPr_R}{GIPw_R + GIPr_R}
\]

- GIPw: GIP for wheel, GIPwL and GIPwR, left and right side respectively
- GIPr: GIP for rail, GIPrL and GIPrR, left and right side respectively
- GIP: GIP combined, a combination of the four values above (wheel and rail, left and right)
- Bw: = 750 mm, the lateral distance of the reference point from centre of wheelset
- dYw: = 15 mm, for finding the vertical position to determine dZw
- Br: = 751 mm, the lateral distance of the reference point from centre of track
- dYr: = 16 mm, for finding the vertical position to determine dZr

Goal: To support IMs and RUs to implement the TSI requirements for Equivalent Conicity (EC) related to running stability, to establish a close relation between EC and maintenance actions for wheel/rail profiles
Wheel/rail management – Improved ride comfort

- The Swedish Western Main Line: Stockholm-Gothenburg (application of indicators)
  - 455 km long, ballasted double track
  - About 2 million passengers/year, plus freight
  - Maximum speed 200 km/h, max axle load 22.5 ton
  - Infranord Track Recording Vehicles IMV100/200
  - Track geometry: 6 times/year, Rail profiles: 1 time/year
  - Only tangent tracks are studied here
  - 178 516 pairs of rail profiles are investigated (GIPr)
Wheel/rail management – Improved ride comfort

- On-track results: distribution functions of GIPr

- GIPrL and GIPrR show reasonably normal distributions
- The difference between GIPrL and GIPrR indicates different worn conditions of the left and right rails
- There are outliers, indicating that rail profiles are not good at some locations and maintenance actions may be needed
Wheel/rail management – Improved ride comfort

- **On-track results: 2D histograms of GIPr vs EC**

  - Clear correlations between GIPr and EC, decreasing trend in the area of lower GIPr
  - The dots are coloured in a logarithmic scale according to the number of occurrences at each location
  - Most GIPr values are between 8 and 14, comparable to the design values of GIPr
  - High EC values occur in the area of lower GIPr values

- **GIPw**
  - S1002: 6.45
  - Ref. worn: 7.61
Wheel/rail management – Improved ride comfort

- Proposal for the maintenance limits of GIPr

  - Following the approach of TSI INF and EN 13845-5, three main levels shall be considered:
    
    - **Immediate Action Limit (IAL): not relevant**
    
    - **Intervention Limit (IL)** Corrective maintenance in order that the IAL shall not be reached before the next inspection
    
    - **Alert Limit (AL)** The track geometry condition is analysed and considered in the regularity planned maintenance operations

  - Our proposal for GIPr minima on tracks with \( R \geq 10\,000 \) m:
    
    - \( 160 < V \leq 230 \) km/h: GIPr IL = 6.5 and GIPr AL = 8.0
Wheel/rail management – Improved ride comfort

- On-track results: Bdl 416U km157-158

- There were reports of running instability on this part of track sections and high EC. Narrow track gauge (TG) was identified as the main cause
- Grinding was performed in early 2018
- The TG values have been improved since 2018, within IL = −4 mm, though still tight
- Track EC S1002 differs from in-service EC ref. worn
- Positive values for the Nonlinearity Parameter (NP), type A, higher critical speeds
- GIPr values are around 10 at most positions, > GIPr_AL = 8, indicating a good condition of rail profiles, except at the location around km157.4, where GIPr_AL is reached
- The values of GIP S1002 and GIP ref. worn are negative, i.e., the results are positively “good”
Wheel/rail management – Improved ride comfort

- **Bdl 416U: km 157.4**
  - EC ref. worn > 0.3
  - GIPrL, GIPr < GIPrAL = 8
  - GIP is close to zero
- **It is a level crossing!**
- **No grinding was performed in 2018, leaving the original worn profiles unchanged!**
Wheel/rail management – Improved ride comfort

Some concluding remarks

- Wheel/rail (vehicle/track) interaction needs a system perspective
- This calls for stakeholder interaction in system design, operation and maintenance
- In “Improved ride comfort” stakeholders have joined in a fruitful collaboration
- The design and degradation of wheel and rail profiles have been studied in detail
- The means of measurements and simulations have strengthened each other
- New quantities of wheels and rails (GIPw, GIPr, GIP) have been defined & standarized
- An alternative wheel profile has been suggested
- Further collaboration is ongoing and planned
Condition monitoring of vehicle-track interaction

KTH collaboration with Trafikverket, SJ and Perpetuum (partly funded by In2Track3)

Focus on vehicle running instability and the wheel-rail interfaces
Condition monitoring of vehicle-track interaction

Track irregularities (Track curves and S&C) (Wheel out-of-roundness)

Wheel–rail contacts, wear and fatigue

Vehicle dynamic response
Safety and fatigue

Safety and comfort (Freight damage)

KTH collaboration with Politecnico di Milano (part of "Improved ride comfort")

Focus on track irregularities, vehicle response and ride comfort
Cross-cutting research and input to standards

Anders Ekberg, Chalmers/Trafikverket

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101012456
Some research in In2Track3 is relevant for several work packages, and for other (Shift2Rail) projects
- Some examples of obvious, and not so obvious areas
- Challenges in cross-cutting / cross-disciplinary activities and possibilities

Much research in In2Track3 (and research projects in general) can contribute to standardisation
- Some examples of obvious, and not so obvious areas
- Examples of how e can contribute

Focus mainly on areas I am familiar with
Cross-cutting research – some examples

- Noise and vibrations
  - Generation related to vehicles and track
  - Additional influence of S&C and bridges
  - Also e.g., road applications
- Video/photo-based inspections
  - Applicable to all mechanical components (in a broad sense)
- Weld repair
- Sensors

and findings in many more areas can be used for other applications
Cross-cutting research – less obvious examples

- Analyses (e.g., material)
  - Improved methods, materials, treatment
  - Data on material characteristics

- Numerical modelling (e.g., dynamics)
  - Improved models, calibrated parameters, methodology

- Improved processes (e.g., repair)
  - Extreme needs for planning and safety

- Multiphysics applications
  - For example, dynamics, thermomechanics and deterioration
Obtaining cross-fertilisation

- **Challenges**
  - Distilling knowledge
  - Spreading knowledge
  - Knowing/indicating what is generally applicable
  - Pre-knowledge in other sectors and

- **Possibilities**
  - Concluding technical report
  - Publication also in more general scientific journals
  - Companies, engineers and researchers active also in other projects and fields

23 technical deliverables
Standards vs research vs development

- Scope
  - General vs specific
  - All aspects vs specific focus vs develop specific solution

- Level
  - “Lowest allowed” vs cutting edge

- Time scales
  - Decades vs a few years/months

- Approach
  - Consensus vs “the truth” vs working solution
  - “Everyone” vs small group vs company involved

- Legal aspects
  - Basis for contracts vs peer review vs safe, functional product
Example of contributions to standards

- **Enhanced knowledge**
  - Relates to essentially all parts of In2Track3
  - Furthest away from inclusion in standards

- **Exploring how standards (and legislation) limit development**
  - I2T3 example: current drone legislations

- **Providing input to enhance existing standards**
  - I2T3 example: producing and testing of anisotropic rail steel specimen

- **Providing ideas to improve the approach in standards**
  - I2T3 examples: Loads from out-of-round wheels and relation to risk of rail break. Slab track design based on more accurate loads, and risk of cracks

- **Providing bases for new standards**
  - I2T3 example: possibility to improve welding processes using simulations

- **Highlighting the need for new standards**
  - I2T3 example: Innovative inspection methods need standards to gain acceptance, and provide comparable results
Future work for all of us

- Spread the word about the good results starting tomorrow
- Contribute to Concluding technical report
- Think about other areas of application for your research (results)
- Consider if research relates to a standard
- Contact standardisation bodies
- Initiate further research projects
- Be proud!
Enhancement and demo of tamping parameters

Alejandro Salanova, Plasser & Theurer

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101012456
2.1.4 Enhancement and demo of tamping parameters
2.1.4 Enhancement and demo of tamping parameters

Why Track Tamping?

Deterioration of the track geometry

- Vertical, lateral and longitudinal geometrical faults
- Small deviations irregular in nature → deteriorate the riding quality, safety and increase dynamic loads
- Traveling speed restrictions
2.1.4 Enhancement and demo of tamping parameters

**Tamping process**
- Consists of 1-3 squeezing processes + tamping unit relocation to the next sleeper

**Squeezing process**
- Consists of:
  - BALLAST PENETRATION
  - SQUEEZING MOVEMENT
  - LIFTING / RELOCATION
2.1.4 Enhancement and demo of tamping parameters

Variable Tamping Parameters

Different standards worldwide

- Tamping Force
- Frequency
- Amplitude
- Clean Ballast
- Moderately Fouled Ballast
- Fouled Ballast

Correction Values
Tamping Depth
Squeezing Time
Number of Insertions
2.1.4 Enhancement and demo of tamping parameters

**TAMP System - Sensor Setup**

- **Accelerometers**: for measuring tine arms movement and remaining vibrations on the tamping unit and satellite frames.
- **Strain Gauges**: for measuring lowering and lateral forces on the tines and forces on the tamping arms.
- **600 bar Pressure sensors**: on the lines that fed the squeezing cylinders for measuring the horizontal force applied to the ballast.
- **1000 bar Pressure sensors**: on the lines that fed the squeezing cylinders for measuring the force applied to the ballast.
- **Angle encoders**: for measuring the squeezing movement of the tamping arms.
2.1.4 Enhancement and demo of tamping parameters
Data from the machine

Data from the Infrastructure Manager

Data analyses and condition assessment

~240 parameters
sample rate 1000 Hz

~600,000 data points per sleeper (single squeezing process)

Section data and local condition (ballast excavation)

How to combine all \( \rightarrow \) Absolute Track Geometry
2.1.4 Enhancement and demo of tamping parameters

**Absolute Track Geometry System**

- The ATG system measures the track position up to 80 km/h.
- Uses two stereo-cameras mounted on each side of the vehicle for measuring the distance between the wheel flange point and the reference point.
2.1.4 Enhancement and demo of tamping parameters

Absolute Track Geometry System

Stereo-camera distance measurement

+ IMU

Relative + Absolute track geometry
2.1.4 Enhancement and demo of tamping parameters

Reference Point Markers

- Needs absolute geometry reference points every ~40-50 meters
- Mounted on Reference Bolts
- No interference by extraneous light
- Mount & reuse with bolts or glue
- Multiple types of marker available for different track conditions.
2.1.4 Enhancement and demo of tamping parameters

Attarp: Section equipped with position markers
2.1.4 Enhancement and demo of tamping parameters

Both systems are mounted in the UNIMAT 09-4x4/4S E3 hybrid tamping machine.
2.1.4 Enhancement and demo of tamping parameters

Tamping Areas

- Kristianstad-Hassleholm (1-3):
  Stable situation, low degradation, medium/high standard deviation
- Osby – Hästveda (4-5):
  Stable situation, low degradation, low standard deviation
- Falkenberg area (6-8):
  Stable situation, low degradation, low standard deviation
2.1.4 Enhancement and demo of tamping parameters

Tamping machine in Sweden
Data analysis – preliminary results

**Cycle based analysis**

**Analysed tamping areas:**

- Kristianstad - Hässleholm
  - 28.11.2022 300 sleepers
  - 29.11.2022 100 sleepers *(remark): singularity – “fouled” ballast condition in the train station area, working direction left)*

- General description: clean ballast conditions, low degradation
Data analysis – preliminary results

**Cycle based analysis - 300 sleepers**

**UNIMAT 04-4x4/4s E³**

- 16 tamping tines

**Selected comparison**

- **Left** to **Right** (LeftBack to RightBack)
- **Front** to **Back** (RightFront to RightBack)
- **Outside** to **Inside** (RightFront to RightFrontIn)

**Compared parameters**

- max. Penetration Resistance Force per cycle
- max. Reaction Force per cycle
- Energy per cycle
- Loading response
Data analysis – preliminary results
Cycle based analysis - 300 sleepers

28.11.2022 - 300 sleepers analyzed
• 16 tamping tines

Selected comparison
• Left to Right (LeftBack to RightBack)
• Front to Back (RightFront to RightBack)
• Outside to Inside (RightFront to RightFrontIn)

Compared parameters
• max. Penetration Resistance Force per cycle
• max. Reaction Force per cycle
• Energy per cycle
• Loading response
Data analysis – preliminary results
Cycle based analysis - 300 sleepers – **Left vs. Right**
Data analysis – preliminary results
Cycle based analysis - 300 sleepers – Left vs. Right

LB

RB
Data analysis – preliminary results

Cycle based analysis - 300 sleepers – Front vs. Back

RB

RF
Data analysis – preliminary results

Cycle based analysis - 300 sleepers – Front vs. Back

RB

RF
Data analysis – preliminary results
Cycle based analysis - 300 sleepers – **Inside vs. Outside**
Data analysis – preliminary results
Cycle based analysis - 300 sleepers – Inside vs. Outside

RFi

RF

2023-12-15
29.11.2022 Singularity – “fouled” ballast conditions in the train station area, working direction left

Selected comparison

- Different ballast conditions (Clean vs. Fouled)
- Left to Right (Left Back to Right Back)

Compared parameters

- max. Penetration Resistance Force per cycle
- max. Reaction Force per cycle
- Energy per cycle
- Loading response
Data analysis – preliminary results

Cycle based analysis - Left vs. Right (fouled ballast)
Data analysis – preliminary results

Cycle based analysis - Left vs. Right (fouled ballast)
Data analysis – preliminary results

Cycle based analysis - **Clean vs. Fouled**

**LB - fouled**

**LB - clean**
Data analysis – preliminary results
Cycle based analysis - Clean vs. Fouled

**LB - fouled**

**LB - clean**
Graphical analysis of the squeezing movement
Comparison of ballast conditions – example for one sleeper

Heatmaps

CLEAN BALLAST

FOULED BALLAST
Graphical analysis of the squeezing movement
Comparison of ballast conditions – example for one sleeper

Ballast Samples Collection

Two locations were chosen for collecting ballast samples, both on the same track where the nightshift on the 29th of November was performed. These were collected in April 2023 for the analysis in laboratory. GRAIN SIZE DISTRIBUTION -SS-EN 933-1:2012
Graphical analysis of the squeezing movement
Comparison of ballast conditions – example for one sleeper

Ballast Samples Collection
Penetration resistance force analysis

- > 95% (> 102 kN)*
- ≥ 75% & ≤ 95% (> 82 kN)*
- < 75% (< 82 kN)*

*forces per tamping unit
Statistical Data analysis – preliminary results

Sleeper based analysis

Penetration resistance force analysis

> 95% (> 102 kN)

≥ 75% & ≤ 95% (> 82 kN)

< 75% (< 82 kN)
2.1.4 Enhancement and demo of tamping parameters

ATG live with stats
2.1.4 Enhancement and demo of tamping parameters

ATG outcome

- Post-processing absolute coordinates with GNSS reference station data.
- Exact position of the markers in .klm format
2.1.4 Enhancement and demo of tamping parameters

ATG outcome

- Trayectory of the section tamped
2.1.4 Enhancement and demo of tamping parameters

**Outcome**

- The work was performed from 27.11 until 5.12
- One night shift had to be skipped
- Everything worked really well, 7 successful night shifts
- Great amount of data to be analyzed
- Good synchronization with the pole markers.
2.1.4 Enhancement and demo of tamping parameters

**Future Steps**

Big interest from Trafikverket in the technologies tried:
- The hybrid technology with the use of pantograph
- The ATG system in order to implement it in new railway lines
- The future development of the TAMP system

P&T is working in the further development of the TAMP system in order to achieve the last step of a full automated tamping regime, next steps:
- Definition of tamping protocol
- Online ballast condition analysis
- Roll out “tamping control”

_Tamping Process Automation_
2.1.4 Enhancement and demo of tamping parameters
Urban grinding, ATMO

Alejandro Salanova, Plasser & Theurer

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101012456
ATMO – Automatic Track Machine Oscillator

Alejandro Salanova | TCP | 21.11.2023
Shift2Rail - Study

Challenges in Urban Space

- Shorter operating breaks
- Increasing loads
- Increasing passenger numbers
- Sound & Vibration
Wheel/rail interaction as dominant noise source (rolling noise)

- Discontinuities in the driving edge
- Curve squeel
- Rolling noise (depending on surface condition)
Herausforderungen im Urbanen Raum

Shift2Rail - Study

Defects on Rails Survey IMs – In2Track Study

- Wear
- Corrugation
- Squats
- Wheel Burn
- Shelling
• Rail grinding as a measure to reduce rail roughness
• Lubrication (head & flank)
• Noise barriers hardly feasible in urban areas
• Operation at lower speeds

Measures for Emission reduction and Avoidance Used by IMs

- Rail Grinding: 28.13%
- Conditioning of rails: 18.75%
- Infrastructure-side sound-proofing: 15.65%
- Operational measures: 15.65%
- Vehicle measures: 12.88%
Frequent acceleration and braking
Short intervals
Varying distances between stops
Moderate travel speed
Requirements for an Urban Grinding Machine

- Grinding in the urban network
- Short time window for maintenance
- Possibility to work during regular operation
- Narrow curve radius - 17m
- Flexibility in choice of towing vehicle
- Unmanned operation from traction unit
ATMO - Design Overview

A solution for urban rail treatment?
Technical Details

Operating modes → Oscillating and Sliding-stone

Frequency → 4 to 6 Hz
Amplitude → +/- 55 mm
Pressure → 40 to 100 bar

Contact surface grinding unit → 1,10 m
Water tank capacity → 2,600 l
Grinding Stones Study: Parameters testing

- Starting tests of the machine in the facilities of Wiener Linien from June to October 2021.
- Evaluation of different parameter combinations:
  - Loading pressure
  - Frequency
  - Grinding amplitude
  - Different grinding stones and speeds.

Average grinded surface of 0.011 mm/pass
Grinding Stones Study: Test Procedure

- Criterion: Improvement of corrugation in peak-to-peak values (%) in 30-100 mm and 100-300 mm wavelength ranges
- Measuring device: Goldschmidt Railstraight Wave
- Grinding Mode: Oscillating and Sliding mode
- Grinding speed: 30 km/h
- Location: Simmeringer Hauptstraße in Vienna.
Large-scale Prototype-test in Operational Environment
Large-scale Prototype-test in Operational Environment
Grinding Stones Study: Analysis

Mid-Soft Stone

- Best Performance
- Both oscillating and sliding 10 grinds enough
Oscillating Mode vs. Sliding Mode

Grinding Stones Study: Analysis

- Comparison of improvement in 10 grinds
- Oscillation mode shows a significantly higher effectiveness compared to the slipping stone method
ATMO

Large-scale Prototype-test in Operational Environment

Work in Odense, Denmark

- Single tram line of 14 km in each direction for a total of 28 km
- Work with the ATMO to remove a layer of dirt accumulated on top of the rails
- Preventive grinding performance
Work in Odense, Denmark

• Machines used for working with the ATMO:
  • Unimog truck pulling
  • Rail cleaning vehicle pushing
  • Tram pushed the machine in one direction, and pulled in the other
Work in Odense, Denmark

- The machine performed really well
- Removed the dirt almost completely
- No problems in switches nor crossings
Noise and vibrations

The measurement cross section is located in the area of Simmeringer Hauptstraße / Zentralfriedhof in Simmering in the 11th district in Vienna.

- 1x measurement **acoustic rail roughness** according to EN 15610 (in non-operating time)
- 1x measurement of **noise emissions** (sound level meter according to EN ISO 3095)
- 1x measurement of **vibration emissions** (vibration velocity transducer - 4.0 m 22 m or 30 m from the track axis track 1)
Sensors

- 3 Vibration sensors at 4, 22 and 30 meters distance from the track
- Sound level measurement device performed
- Acoustic rail roughness measured in 75 m
Acoustic rail roughness

- Significant improvement in roughness **up to 15 dB**
- Sound emissions less dependent on corrugations than on travel speed, general condition of the track and type of vehicle
The Flexity type vehicle shows the highest vibration emissions. The type ULF-B(6) the lowest.

On average, the reduction is about 50% at 4 m distance, about 30% at 22 m distance and 10% at 30 m distance.

<table>
<thead>
<tr>
<th>Gleis</th>
<th>Zugtyp</th>
<th>MP1 4 m</th>
<th>MP2 22 m</th>
<th>MP3 30 m</th>
<th>MP1 4 m</th>
<th>MP2 22 m</th>
<th>MP3 30 m</th>
<th>MP1 4 m</th>
<th>MP2 22 m</th>
<th>MP3 30 m</th>
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<td>0,5</td>
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<td>0,8</td>
<td>0,3</td>
<td>4,9</td>
<td>0,6</td>
<td>0,4</td>
</tr>
</tbody>
</table>
Sound analysis

- Emissions were reduced by up to 8 dB for Flexity and up to 4 dB for Ulf and ExCx up to approx. 300 Hz.
- In the higher frequency range, only minor changes can be detected (reproducibility)

Noise and vibrations

Noise Values in dB, Before and after

Significant frequency range for noise emission

+ values = improvement of the measured values
- values = deterioration of the measured values
Acoustic Rail Roughness
Significant changes in emission values up to 15 dB

Vibration
Significantly reduced by up to 50%

Sound
Emissions could be reduced up to 8 dB in the Flexity and for Ulf and ExCx up to 4 dB, but the absolute numbers are not that correlated to the corrugation itself.
ATMO – Product Development
- Electrification of the machine

ATMO – Machine
- Offer the machine as a service
IN2TRACK-3
Final Event – day 1:
Europe’s Rail Joint Undertaking

29/11/2023

Sébastien DENIS
Senior Programme Manager
Europe’s Rail JU
What next?
Obligations after the end of the project:

• **Dissemination** of the project’s final results, with the same visibility requirements (EU flag, ERJU logo, funding)

• **Protection** of the project’s final results: patent, trademark, industrial design, copyright, trade-secret, confidentiality

• **Exploitation** the final results in further research activities, developing a product, providing service, using in standardization

• **Access rights** for project partners and for the JU after the project (public deliverables, Transfer of Knowledge process)

• **Standardisation** of the project results with including a statement about JU and EU H2020 funding

• **Licensing**, transferring ownership of the results

• **Reviews & audits** after the project closure within 5 years
Thank you for your attention!

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