1. Control

How can we improve assessments of the status of the railway? How do we detect and categorize faults? How do we ensure that operations are safe? Presentations give examples from the project related to these questions.
Integration of heterogeneous data into a bridge asset management platform, Robot underwater monitoring

Jose Solís Hernández
CEMOSA

[CEMOSA logo]
Challenge addressed

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 of 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.
Results In2Track3 (I)

**Bridge Inspection ROUV**
CEMOSA has built, ensembled and integrated an **infrastructure inspection ROUV**, including:

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

**Demonstration**

1. **Rules Dam, Granada**: Initial visibility/stability tests.
2. **Port of Málaga and Marbella**: State of the pillars supporting the decks. Overall inspection.
3. **Access bridges to port of Málaga**: Scour and debris inspection.

Inspection guidelines and best practices have been prepared.
Results In2Track3 (II)

CEMBOX: Digital Twin Asset Management Platform

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

1. Robust data management system: ROV, IoT, UAS data.
2. Interoperable architecture.
3. Focus on analytical applications: OMA on bridges, pavement degradation, etc.
4. Integration in a modular asset management platform.

Platform Services
- Management of assets.
- Inspection: field visits, pathologies, point clouds.
- Monitoring: IoT, OMA, degradation of bridges, ...
- Planning: In progress.
Future work on the topic

Inspection ROUV has been incorporated to CEMOSA’s portfolio.

**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
Detection of rail surface defects using the EMAT method

Denovan LAMPIN, Quentin MAYOLLE, Valentin VLIEGHE
IRT Railenium
Challenge addressed

- Rail defects can affect railway safety
- Monitoring the emergence and the evolution of defects can be optimized using EMAT sensors
- It allows to optimize costly maintenance operations and the lifetime of the railway infrastructure
- We focused on wear defects on the rail surface that may propagate to deeper levels
- EMAT contactless sensors can provide more precise information on these defects
Results In2Track3

- The acquisition system was fitted on a remotely controlled trolley. It has been tested and validated in field.
- EMAT sensors positioning is controlled using actuators.
- Denoising algorithms and machine learning tools are used to analyze the signals.
- Processing and characterization of the defects.
Future work on the topic

- Collecting data to enhance detection algorithms
- Increase the acquisition speed
- Discussions on integrating the technology into existing inspection systems
- Discussions on adding sensors for in-depth rail inspection and use of fusion of information algorithms

More information can be found in the following links:
- ARTEMIS trolley YouTube video
Influence of wheel tread characteristics on operational lives of rail and running gear

Michele Maglio
Chalmers University of Technology/Trafikverket
Challenge addressed

- Wheel tread damage
  e.g. wear, wheel flats, rolling contact fatigue, etc.
- Higher wheel–rail impact loads
  Higher noise levels, risk of system failures, delays, costs...
- Research on consequences of tread damage
  Simulations (in-house code) & field tests
Results In2Track3 – axle stress spectra

- Wheelset instrumented with strain gauges
  Collaboration Lucchini, SJ, Chalmers
- Axle bending stress spectra coupled to Swedish track characteristics

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<th>S&amp;C</th>
<th>curves</th>
<th>track quality</th>
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<td>std dev $P_1$</td>
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<td>std dev $P_2$</td>
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- Estimation of axle fatigue life and optimisation of maintenance intervals
Results In2Track3 – wheel–rail impact loads

- **Damaged wheelset passing wheel impact load detector** *(Trafikverket, SJ, Chalmers)*
  
  1) Identify damaged wheels causing high impact loads

  2) 3D laser scanning

  3) Surface post-processing

  4) Simulation of vertical contact forces

  5) Comparison with field measurements

- Simulated loads are used to compute the **fatigue stresses** for wheel rim, wheel hub and bearings
Future work on the topic

- Possibility to extrapolate track quality data from wheelset measurements
  
  Both train operator and track infrastructure manager can optimise maintenance plans

- Investigate effect of tread damage on wider range of operational cases
  
  Curving, effect of lateral forces due to switches, etc.

- Effect of axle and wheel design
  
  – On wheel–rail impact loads
  
  – On wheelset fatigue life
Sub-surface Tunnel Inspections

Andrew Brown
Network Rail
Sub-surface Tunnel Failures

Vierzy Tunnel, France collapse 1972

Schieburg Tunnel collapse - Luxembourg August 2022

The risk from voiding and geotechnical loading is currently difficult to determine.
Data from Ground Penetrating Radar (GPR) vs TSIR

Above: In a tunnel, GPR data is collected in multiple strips, this is time consuming and the data is difficult to interpret.

TSIR allows collection of data in 3D, with much reduced access and cross sections can be produced.

The rail mounted antenna
Future work

- TSIR assurance being led by engineering consultant currently
- Allow monitoring of grouting operations
- Improving risk identification of degrading assets
- Equipment remodel
Reliability-Based Improvement of Dynamic Design Methods of High-Speed Railway Bridges

Reza Allahvirdizadeh
KTH Royal Institute of Technology
Challenge addressed

- Running safety is governed by proposed vertical acceleration criteria.
- Improving **design method** using available criteria!
- Improving the **design criteria** itself.

Figure Reference: Zacher, M. and Baeßler, M. (2008), Dynamic behaviour of ballast on railway bridges, In: Dynamics of High-speed railway bridges.
Results In2Track3

- Proposing minimum mass and stiffness requirements to satisfy target safety level.
- Calibrating safety factor to $\gamma_a = 1.38$ updating current value (i.e. $\gamma_a = 2.0$)!

$m_{\text{min}} = 16030\exp(0.026L) \ [\text{kg/m}]$

$I_{\text{min}} = 0.011L^2 - 0.14L + 0.6 \ [\text{m}^4]$
Future work on the topic

- Soil-structure interaction effects should be investigated.
- Lack of knowledge (experimental data) can lead to non-conservative designs!
- Full-scale dynamic testing on a 7 m long bridge in LTU lab.
Risk management for track buckling

Elena Kabo & Anders Ekberg
Chalmers University of Technology
Track buckling – challenges

- Heating wants to expand the rail
- The expansion is restricted
  - in continuously welded rails
  - in jointed tracks when joints are closed
- Restricted expansion gives compressive forces along the rail
- If the track cannot resist lateral displacement, buckling will occur
- Trains going through the buckled section will worsen the situation
- Track buckling is a clear derailment risk
- How to identify critical sections along thousands of track kilometres?
Results in In2Track3

- Quantification of equivalent temperature increase of several key parameters
- Established relation between experience-based quantification and equivalent temperature increase
- Case study on track buckling along a line to test/validate the approach
- Some conclusions
  - High potential to prevent buckling by maintenance
  - Influence of “fixed points” is minor for all-welded tracks
  - Equivalent temperatures >50°C have clear risks for the conditions of the studied track
Future work on track buckling

- Research continues in Iam4Rail
- Increase knowledge and predictive abilities
  - Enhanced numerical model
  - Extended parametric study
- Enhance prevention
  - Improved track data collection and incident reports
  - Planning of maintenance actions
  - Quantification of maintenance actions
- Facilitate standardisation
  - Objective quantification by equivalent temperatures
  - Standardised definitions and reporting
  - Situations in different countries can be compared

Photo: Trafikverket
Monitoring of tunnel drainage systems

Tobias Schachinger
Vesna Micic Batka
ÖBB-Infrastruktur AG
Challenge addressed

- Scale deposits made of calcium carbonate occur in tunnel drainage pipes of railroad tunnels.
- Tunnel drainage pipes must be cleaned by flushing to avoid an increase in water pressure and possible damage or water infiltration.
- Condition of scale deposits currently detected by camera inspections → track or tunnel closure → massive operational restriction.
- Motivation: Remote detection of scale deposits with low operational restrictions & predictive maintenance.

Foto source: https://doi.org/10.1007/s00501-019-00918-6
Results In2Track3

- Construction of a tunnel drainage rover (TDR) prototype
  - Waterproof and corrosion resistant
  - Drives autonomously or can be remotely controlled
  - Estimated travel distance is ca. 10 km
  - With incorporated camera and light source
  - Inductive contactless charging
  - CAN bus interface for communication
  - Data can be transferred via WiFi

- Successful test of TDR in a real environment (TRL 7)
  - The quality of the record allows for early recognition of alterations in drainage pipes
Future work on the topic

- Constructing the next generation TDR with:
  - Increased capacity of the battery → done (500 Wh; estimated travel distance is now ca. 15 km)
  - Reduced charging time
  - Additional track for improved driving
  - Adjusted weight (by Al and steel) so it can’t be flushed out by the higher flows → done

- Development of software for autonomous driving

- (Long-time) test of the next generation TDR under real-conditions (tunnel), incl. extreme conditions (high extent of scale deposits, high water flow) → done

More information can be found in D5.2