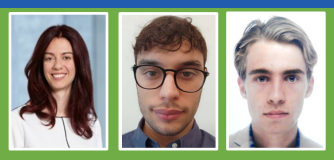
ETH zürich

Center for Sustainable Future Mobility (CSFM)

REASSESS – Early Detection and Assessment of Railway Substructure Moisture Using Remote Sensing






Project Team: O. Frey, P. Bernhard, M. Luck
Earth Observation & Remote Sensing

A. Wieser, P. Ruttner, N. Meyer
Geosensors and Engineering Geodesy

E. Chatzi, G. Arcieri, C. Hoelzl
Structural Mechanics and Monitoring, D-BAUG, ETH Zurich.

Partner: O .Schwery, D. Haener
SBB CFF FFS

1 Background / motivation

Problem statement:

- A frequent cause for deterioration of railway tracks is water intrusion leading to subsurface ballast moisture/wetness.

Potential of remote sensing:

- Remote sensing (satellite, drone, mobile mapping platforms) offers large potential for automated monitoring of railway infrastructure.
- Potential cost savings for SBB if ballast moisture can be detected and mitigated timely: up to 35 MCHF/year (estimate by SBB).

2 REASSESS project goals

Efficiently and timely **detect** and verify **hot spots** affected by **subsurface ballast moisture** by a **synergistic** use of three **remote sensing** approaches:

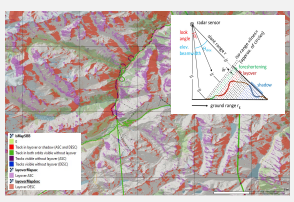
1. spaceborne synthetic aperture radar (SAR), for
   → network-level proxy-based detection of railway sections affected by moisture,
2. (airborne) laser scanning, for
   → assessment of deformation and ballast moisture proxies,
3. train-based ground penetrating radar (GPR), for
   → local assessment of ballast moisture.

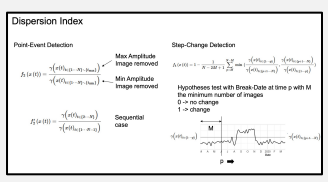

SBB CFF FFS D BAUG

3 Satellite SAR for network-level proxy-based detection

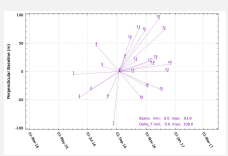
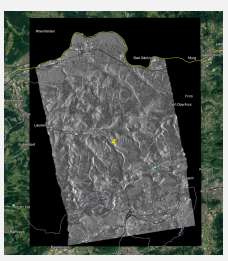
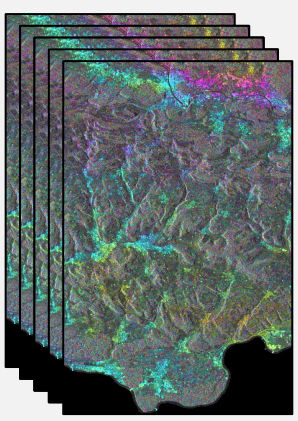
Analysis of time series of Copernicus Sentinel-1 imaging radar data to identify suitable proxies for ballast problem areas:

1. Change-detection in buffer region around SBB network.
2. Interferometry-derived ground subsidence/uplift as a proxy.


Visibility map in alpine terrain



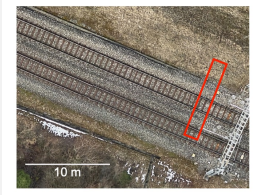
Change detection (amplitude dispersion)




Persistent scatterer interferometry / InSAR-based analysis of surface displacements

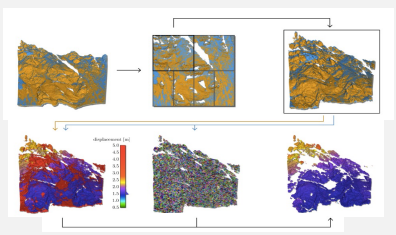
Earth Observation and Remote Sensing

4 Laser scanning for deformation and moisture proxies

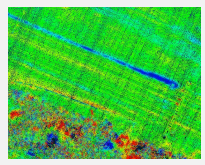
- Orthophoto and displacements orthog. to surface (algorithm: M3C2)



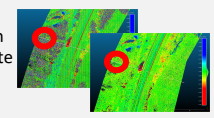
- Extending information content of analysis results


Q1: F2S3: ML-based approach to calculate dense 3D displacement vector field. Transferable for monitoring rail tracks?

Q2: How can deformation be distinguished from surface changes due to other reasons (track maintenance, vegetation, …)?



Q3: Under which conditions can deformation be quantified despite (dense) vegetation?

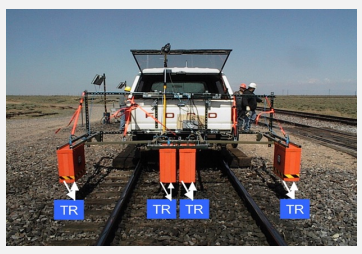


Geosensors and Engineering Geodesy

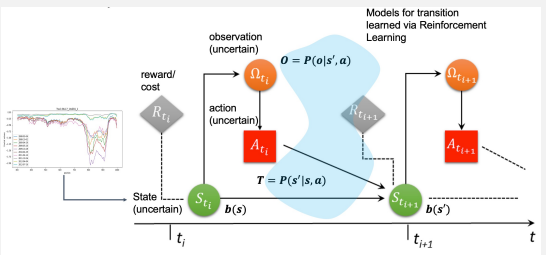
5 Ground penetrating radar for ballast assessment

Extraction of quantifiable indicators of condition for the ballast, using on-board GPR mounting using 2 approaches:

1. Multiple datasets in a single vehicle run → treatment of measurement noise, etc
   → extract robust condition indicator



2. Multiple measurements over time → use evolution of inferred condition indicator for decision support on maintenance planning (Reinforcement Learning)



Structural Mechanics and Monitoring

6 Next steps

Satellite imaging radar:

- Cont'd investigation of suitable proxies.
- Consolidation & choice of detection algorithm(s).

Laser scanning:

- Extending information content of point cloud analysis results.
- Automated selection of best point cloud analysis algorithm.

Ground-penetrating radar:

- Planning of an on-site experiment, with controlled wetting conditions.
- Refinement of the GPR based indicators.

Partners: amag SBB CFF FFS SIEMENS

CSFM