Advanced Monitoring

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SP4 – Advanced Monitoring

Agenda

- Overview Work packages 4 “Advanced Monitoring”, Objectives
- Monitoring – Diagnosis – Self-Inspection
- Where is monitoring useful?
- Identification of structures and components for monitoring
- Technical & economical assessment within the infrastructure
- Requirements for smart solutions
- Demonstrators
Overview of the Work packages

Work packages and content

SP 4 - Advanced Monitoring

WP 4.1 Monitoring Strategies and evaluation, Algorithms
  - Mechanical Analysis, Data handling, mathematics, „Customer needs“

WP 4.2 Monitoring Technologies & Sensor
  - Measurement technologies, overview and experiences in other industries

WP 4.3 Implementation in new structures
  - Civil engineering & monitoring technologies

WP 4.4 Migration of innovative technologies to existing structures
  - Infrastructure Knowledge and maintenance problems; measurement tech.

Demonstrators
Objectives in SP4 Advanced Monitoring

➢ Identifying components and systems critical for operation/deterioration of the railway infrastructure that should be monitored. Technical & economical assessment

➢ Identifying key operational parameters that govern deterioration of selected key components, translation of measured data to deterioration predictions for these systems

➢ Identifying and evaluating of sensor and energy harvesting technologies, communications. Development of smart solutions: small, energy independent, accurate, intelligent, Wifi

➢ Translation of the innovative measurement technologies into railway-tailored solutions for predictive maintenance, decision support, operational support and safety. Plug&Play. Retro-fit.
Important differences

- **Monitoring**

  Measuring of direct or indirect values to identify unusual product behaviour. (Switches → measurement of the current)

- **Diagnosis**

  Automatic assessment of measured values. Repeatability ensured by statistic. Clear Knowledge about the behaviour of components or products.

- **Inspection (Self-inspection)**

  Measurement or visual assessment of safety relevant behaviours. The measurement accuracy must be at least 10-times better than the value in the specification. (1.0 mm → 0.01 mm)

**Note:** Proprietary point diagnostic system reports no error.
## Where is monitoring useful?

<table>
<thead>
<tr>
<th>Cost per damage</th>
<th>Frequency of failure per time slice</th>
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<tr>
<td>high</td>
<td>low</td>
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<td>moderate</td>
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<td>moderate</td>
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<tr>
<td>low</td>
<td>high</td>
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- **Root cause analysis**
- **Early warning**
- **Act**
- **Monitoring**
- **Do nothing**

- **Cost per damage:**
  - high
  - moderate
  - low

- **Frequency of failure per time slice:**
  - low
  - moderate
  - high
The main objective is to reduce the number of technical disruptions and delay minutes as well as reducing the related life cycle costs of the e.g. switches. In detail, the defined tasks to achieve the objectives are:

- Establishment of simple key performance indicators related to the availability for controlling substantial production means (performance measurement, analysis and monitoring system).
- Classification of all switches on availability criteria
- Definition of equipment standard for the complete system, e.g. switch (which switch category gets e.g. a heating system or closure compartment cover) or diagnostic to fulfill performance requirements
- Development of a strategy for the preventive maintenance and implementation concept
- Target-actual comparison regarding the equipment standard sharply outlined on the component/system
Advanced Monitoring – Guidelines for decision support

Diagram of decision tree for monitoring recommendations

1. Type of asset
2. Asset register, hierarchy
3. Key Performance Indicators
4. Requirements of the Asset Manager and Strategists
5. Historic data of the concerned asset
6. Operation & Maintenance data
7. Cost data

- Trade-off decision between costs and benefits (≈ CBA)
  - Benefits and added values
  - Associated Costs and risks
    - Operational & placement strategies; data collection & analysis
      - Spider charts
      - Recommendation based on technical-economic evaluation

- Analysis of cause and effect relationship
  - Operationally relevant components
  - Identification of the key operational parameters
    - Impact of the key operational parameters
    - Ranking of the key operational parameters

- Is there currently any monitoring strategy/practice?
  - if not
    - General feasibility of monitoring
      - Recommendations based on technical-economic evaluation

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Monitoring technologies must fulfill requirements of

- Ballasted track
- In-service slab track
- New structures & track constructions
Technologies to be used to develop integrated solutions for next generation railway monitoring and inspection

• Specification, identification and evaluation

Scope

• Sensing, energy harvesting, communications, processing and data integration

Expectations

• Low cost, robust, intelligent, and low power

Near-horizon technologies or technology transfer from other domains

• Not the development of entirely new approaches
Evaluation at multiple levels

High level requirements
- Integration
- Standardisation

Mid level requirements
- Data aggregation, fusion and storage
- Fault detection (defect recognition)
- Diagnosis (evaluation algorithms)
- Prognosis (degradation algorithms)

Low level requirements
- Sensors (data acquisition)
- Energy harvesting (generation/storage)
- Communications
Requirements for smart solutions
- Technology Identification Framework

Requirement types within a level are grouped

Scores in different requirement categories are collated
Requirements for smart solutions
- Technology changes processes

• Energy harvesting technologies
  – Identification
  – Evaluation

• Sensors

• Retro-fitting in existing railway, Demonstration

  Process analysis & Learning by doing

• Migration strategy for individual infrastructure
  - Maintenance process change
  - Work planning, assets, teams
• A first evaluation of an „FOS“- fingerprint of a high-speed line was done and compared with acoustic measurements
• Second evaluation of sensing wear in switches is in progress
Full Size Demonstrators

- Transition zone monitoring

New Sado river crossing
• Transition zone site – Rio Sado
Full Size Demonstrators

Switches W873 & W874, aprox. 7 km north of Hbf Würzburg, Line 1733

Rail expansion joints, ballasted track, bridge

Tunnel entrance Tunnel Neuberg,

Direction to Würzburg

Stellplatz
Switch type W874 & W873, km 321,2:
EWR 60-1200-1..., concrete sleeper, movable frog,
$V_{\text{max}} = 250 \text{ km/h}, \text{typ. 230 km/h}$

Test site advantages:

- Track geometry by wayside monitoring (tilt-sensors)
- Sleeper voids by accelerometer
- Measurements by regular inspection by measurement train all 3 month
- Weekly monitoring by equipped ICE-2 train
- Acoustic monitoring of the switch (class-1 standard)
...any questions?

Thank you for your attention!