MAIN LINE

Workshop targeted to Central and Eastern Europe

Budapest, 15 May 2014

Degradation monitoring: gaps & opportunities

SEVENTH FRAMEWORK PROGRAMME

This project is co-funded by the European Commission with the FP7

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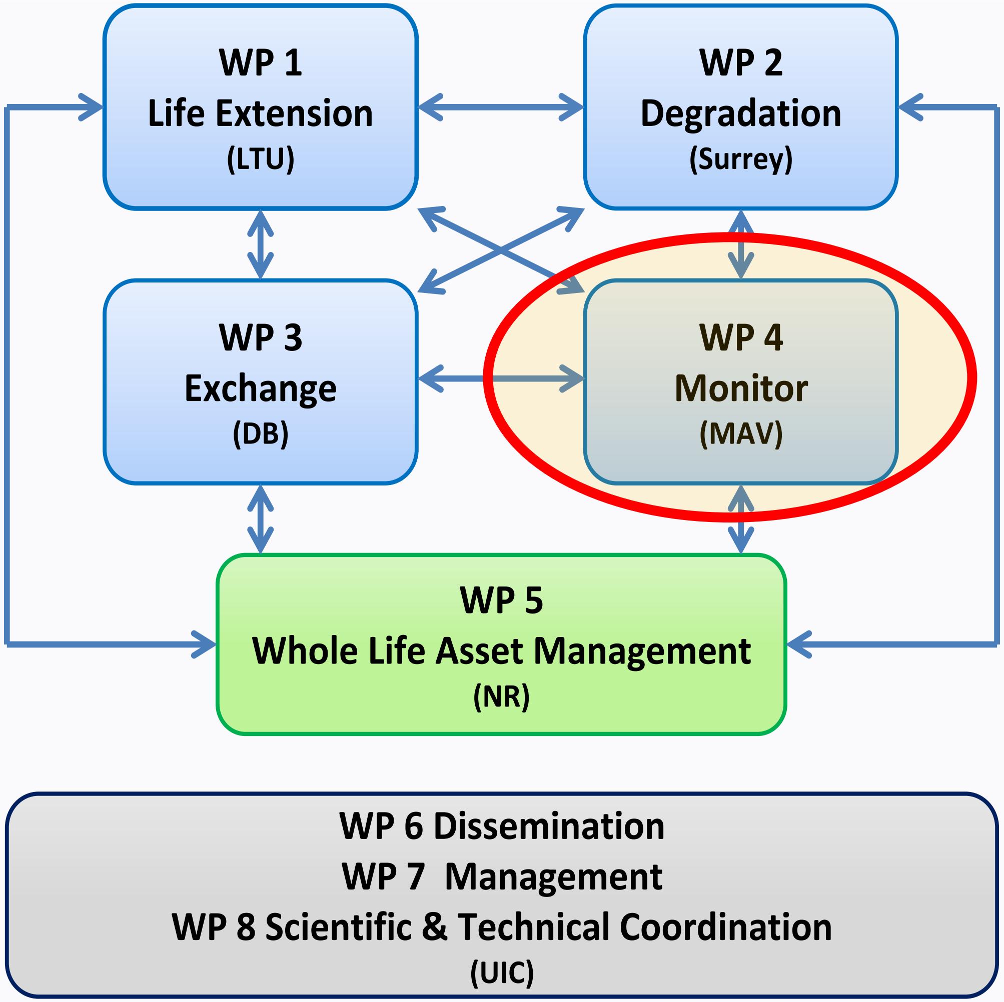
Outline of MAINLINE



Important work items

- The main objectives of WP4 are:

  - ❑to clarify what inputs the degradation models require from advanced monitoring and examination systems,

  - ❑to investigate their use and identify how these can operate in the most cost-effective and reliable way to complement or replace existing examination techniques for elderly infrastructure (part of an effective/efficient whole life asset management system), and

  - ❑to provide case study/validation evidence so as to promote take-up of the proposed approaches by IMs.

Progress made towards objectives

- Task 4.1 – (M1 – M12): completed, D4.1

  Assessment of current monitoring and examination practices in relation to the degradation models

- Task 4.2 – (M12 – M24): completed, D4.2

  Compatibility in data interpretation for optimum performance

- Task 4.3 – (M24 – M36): on-going, D4.3

  Case study/validation

MONITORING & EXAMINATION PRACTICES

Task 4.1 (completed) – overview

- Task 4.1: Assessment of current M&E practices in relation to DMs
  - M1-M12
  - 6 partners: **MAV**, TWI, UIC, SKM, NR, DAMILL
  - Capture current experience and research on M&E
  - 5 different assets: cuttings, metallic bridges, tunnels, plain line S&C, retaining walls
- D4.1 report
  - Pros and cons of different approaches in use in the rail sector and other relevant sectors.
  - Summary tables combining selected Railway Assets and M&E

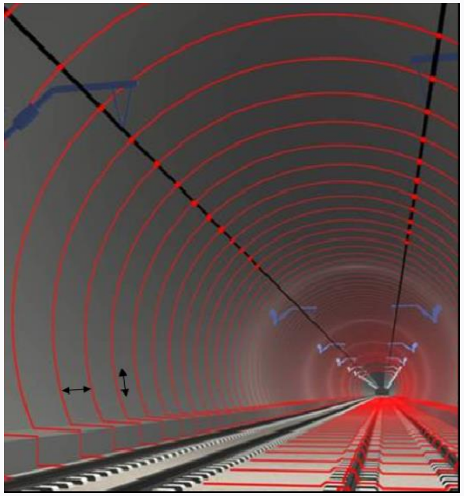
Task 4.1 – report structure

- Publicly available
- 84 pages
- 9 Chapters
- All 5 assets included
- Example: bridges →
- Summary tables (Assets/M&E)

Task 4.1 – M&E techniques

Most widely applied M&E techniques:

- Visual Inspection
- Strain gauges
- Inclinometers
- Radiography
- Ultrasonic testing
- Eddy current testing
- Thermography
- Laser scanning (range finder)
- Ground penetrating radar
- Automated vision monitoring
- Acoustic emission testing
- Optical fibres etc.



Task 4.1 – lessons learnt

What to take away:

- Visual inspection widely applied
- Visual inspection Vs advanced techniques
- NDT do offer solutions but still on-going work
- How is the output used is a key issue
- Cost efficiency factor
- Gaps/difficulties in accessing output

Related work:

- Innotrack, Sustainable Bridges, Smartrail, Interail, Acem-Rail, Monitorail, Railect etc.
- CIRIA documents

DATA COMPATIBILITY GAPS AND SOLUTIONS

Task 4.2 (completed) – overview

- Task 4.2: Compatibility in Data Interpretation for Optimum Performance
  - M12-M24 (M26)
  - 7 partners: **TWI**, MAV, SKM, LTU, NR, DAMILL, UIC
  - Examine type of data captured from M&E techniques
  - Identify and propose optimal solutions to address gaps with regard to M&E + DMs data (Link to Task 4.3)

- D4.2 report
  - Identified gaps and compatibility issues
  - Potential solutions to address gaps in most cost effective way
  - Summary tables per section (Assets, M&E, DMs, Gaps, Solutions)

Task 4.2 – report structure

- Publicly available
- 106 pages
- 9 Chapters
- All 5 assets included
- Example: tunnels
- Summary tables

  (M&E/DMs/Gaps/Solutions)

Task 4.2 – framework/approach

- T4.2 work approach

  - Current M&E practices inputs
  - Degradation and Intervention Modelling Techniques inputs
  - Good examples of data compatibility (frameworks or quantitative)
  - Identified gaps and compatibility issues (e.g. data precision/accuracy not feasible)
  - Potential solutions to address gaps (e.g. additional info, replacing technique etc.)
  - Guidance for optimum performance (SWOT, feasibility, KPIs etc.)
  - Summary results (M&E/DMs/Gaps/Solutions)

Task 4.2 – framework/approach

- Compatibility gaps examples
  - Reliability and sensitivity of detection
  - Inspection coverage
  - Inspection effectiveness
  - Cost efficiency
  - Time factor
  - Practicality
  - Expertise needed
  - Accessibility issues etc.

- SWOT analysis to identify gaps and propose optimal solutions to address these

Task 4.2 – Example: metallic bridges

- Model types and inputs:
  - For corrosion
    - Empirical or based on simulations
    - Material and exposure properties & conditions
  - For coating deterioration
    - Empirical or based on simulations
    - Material and exposure properties & conditions
  - For fatigue
    - Load effect
    - Resistance and accumulated damage
    - Prediction of length
  - Combined corrosion/fatigue?

- M&E Techniques:
  - For corrosion
    - Visual inspection
    - Optical fibre
    - UT
  - For coating deterioration
    - Visual inspection
  - For fatigue
    - Visual inspection
    - Optical Fibre monitoring
    - Fatigue sensors
    - UT
    - MPI etc.
    - Full scale/fracture tests for resistance

Task 4.2 – Example: metallic bridges – gaps and solutions

Summary of compatibility gaps and suggested solutions in metallic bridges

Linkages with other Tasks / Asset Type	D2.1 Degradation Mechanism	D.2.2 Model Type and Input	D4.1 Monitoring & Examination Technique and Output	D4.1 - D4.2 Compatibility Gap	D4.2 Potential Solutions
Metallic bridges: (1) Beams (2) Riveted joints (3) Welded joints	Corrosion	Empirical or Based on simulations Material and Exposure properties & conditions	Visual inspection Optical fibre Ultrasonic testing	No monitoring available for exposure parameters	Monitoring procedures for exposure
	Coating deterioration	Empirical or based on Simulations Material and Exposure properties & conditions	Visual inspection	No monitoring available for exposure parameters and the coating performance	Better monitoring procedures Probability-based modelling
	Fatigue	Load Effect	Visual Inspection Optical Fibre Monitoring Ultrasonic testing Radiography Fatigue sensors MPI etc.	To measure at points with maximum damage	Optical sensors
		Resistance Accumulated damage (Palmgren-Miner sum)	Test of details Fracture mechanics Full scale tests		
		Prediction of life length	As above	Existing models lack relevant data and give results with large spreads	Reliability based models More full-scale tests of old structures to calibrate models
	Combined corrosion and fatigue	Combinations of above	Combinations of above	Models for combined effects	New or refined models

Task 4.2 – Example: tunnels

- Models
  - Material deterioration in concrete lined tunnels:
    - Corrosion of steel in concrete
    - Sulphate attack
    - Frost attack
    - Alkali-aggregate reactions – no models
  - Modelling of masonry lined tunnels: very few models ➡ use field inspection data to develop empirical models

- M&E Techniques used
  - Visual Inspection (or remote)
  - Hammer-tapping
  - Laser scanning
  - Ultrasonic Testing
  - Thermal imaging
  - Ground Penetrating Radar
  - Optical fibre sensors etc.

Table 6-5 The interface between degradation model inputs and inspection output in concrete-lined tunnels

	Degradation Mechanism	Model Type	Model Input	M&E Technique	M&E Output
Concrete lined tunnels	Steel corrosion	Numerical models from experimental observations (f_y^D)	A_{pit}, pit area i_{cor}, corrosion rate	Half-cell mapping, electrical resistivity (4 electrodes), sensors, corrosion coupons	E_{corr} (corrosion potential) i_{cor} (corrosion rate)
	Sulphate attack	Mechanistic model for degradation rate (R)	X_{spall}, spalled layer thickness	VI + Hammer test, Impact Echo, UT, Core testing	Photographic, wave speed, crack depth, sulphate content
	Freeze/thaw attack	Stress-strain models (not time dependent)	Plastic strain caused by frost Temperature	VI, UT, resistance test, laboratory tests	Visual output, wave transit time, Stress-strain lab results
	Alkali-aggregate reactions (ARR)	x	x	VI, laboratory tests	Visual (cracking), flexural and compressive strength, porosity

Task 4.2 – Example: tunnels – gaps and solutions

Summary of compatibility gaps and suggested solutions in tunnels

Identified Gap	Potential Solutions
Lack of consistent and reliable inspection data across Europe	Standardisation of the inspection assessment through a commonly accepted framework
Lack of models for masonry linings	Use of field inspection data to develop empirical models
High cost of continuous monitoring and limitations of periodic inspection.	Monitor specific input parameters and avoid excess amount of data
Effect of environmental conditions on inspection	Incorporating environmental data into the deterioration models
Combining monitoring data (quantitative) with examination information (qualitative)	Develop decision support tools to bridge the data interface gap

Task 4.2 – lessons learnt

Main gaps and challenges:

- Lack of data for validation purposes across Europe (e.g. tunnels, cuttings etc.)
- Effect of climate change (e.g. earthwork stability)
- Lack of combined effect of fatigue and corrosion (e.g. bridges)
- Lack of models for particular assets (e.g. masonry lined tunnels, track super-structure and S&C, retaining walls)
- Need for generalised and standardised framework/DSS tool
- Lack of sufficient inspection data (e.g. retaining walls)
- High short-term cost of laser and sensor technologies

Task 4.2 – lessons learnt

Potential solutions to overcome these gaps:

- Development and implementation of generalised algorithm (framework) across Europe
- Incorporation of monitored data into deterioration models
- Inputting climatic region-specific data
- Focus of measurements at points with maximum damage (e.g. fatigue in bridges); optical sensors/photographic strain monitoring?
- Use of field inspection data to develop empirical models (e.g. masonry lined tunnels)
- Monitoring specific required parameters; use DSS tools for data/control management
- Vehicle-based inspection (e.g. S&C and super-structure)

CASE STUDIES/VALIDATION

Task 4.3 (on-going) – overview

- Task 4.3: Case Study/Validation

  - M24-M36; Participants: **SKM**, MAV, TWI
  - Perform validation exercise on at least one rail bridge and one earthworks asset chosen by the consortium
  - To quantify the benefits of optimum M&E Systems in order to promote their uptake

- D4.2 report

  - Report on the Case Studies (at least 2 according to DoW)
  - To provide evidence on how improved monitoring and examination can support cost-effective risk-based asset management

Task 4.3 – Case Studies selection

- Selection methodology:
  - M&E technologies arising from D4.1
  - Solutions to gaps identified through D4.2
  - Variables measured / degradation mechanisms
  - Equivalent traditional approach
  - Expected benefit over traditional technique (use, cost etc.)
  - Potential for Case Study (sources etc.)

- Proposed solutions for Bridges: → Case Study 1
  - ✓ Computerised digital displacement monitoring (Retszilas bridge)
  - ✓ Photographic strain monitoring (Aby bridge) → Case Study 2

- Proposed solutions for Earthworks:
  - ✓ Compare results using 2 methods → Case Study 3
    - Generalised examination sheet (SKMA model)
    - Use of SMARTRAIL technique (GASSA model)

Task 4.3 – Case Studies

- 3 Case Studies selected by the Consortium
- Bridges:
  - Retszilas bridge (Hungary) – Case Study 1
  - Åby bridge (Sweden) – Case Study 2
- Earthworks:
  - Sligo Line cutting (Ireland) – Case Study 3

Case Study 1

Case Study 2

Case Study 3

Deliverables

Publicly available:

- D4.1: ‘Report on assessment of current monitoring and examination practices in relation to the degradation’ – MAV/TWI, M12

- D4.2: ‘Solutions to gaps in compatibility between monitoring and examination systems and degradation models’ – TWI, M24 (M26)

To be submitted:

- D4.3: ‘Report on case studies’ – SKM, M36 (M35)

Deliverables and Milestones

D4.3: 'Report on Case Studies'

SKM, MAV, TWI

Delivery date: M36
Aim: M35

Table of Contents

Thank you for your attention!

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