Whilst it is hard to believe that the 1st of May 2016 marked the first anniversary of the start of the project many activities have been completed by the consortium partners. The first meeting of the project took place at the Inchicore Works of Irish Rail in Dublin on 19th and 20th May 2015 with the most recent series of project meetings being held in Zagreb on 26th and 27th May 2016, with details of some of the key outputs from this series of meetings to be found in this issue. This newsletter features a detailed article showing the progress of one of the work packages, in this case work package 2. In order to stress the importance of developing the future researchers there is an article by one of our Ph.D. students on what working on the project means to her.

As the project moves to deliver some important milestones in the next 6 months, Risk Ranking and Risk Assessment reports for Bridges, beta versions of the Traffic Flow and Whole Life Cost models will be presented at workshops, there will be a lot going on. Information on all of these developments along with information on the project can be found on our website at www.destinationrail.eu.

What has been achieved in the second 6 months of the DESTinationRAIL project?

The project team held their third plenary meeting at the Faculty of Engineering, Zagreb University on the 26th and 27th May 2016, to review progress with the project. The agenda for the two days included meetings of the Exploitation Sub Committee, Executive Board, Advisory Board and Work Package Groups. The second day concluded with a plenary session involving the Advisory Board, during which presentations on the progress of individual work packages, including forthcoming actions were presented and discussed with feedback being received from the Advisory Board members.
Presentations included
- Probabilistic assessment of structure based data from the Boyne viaduct in Ireland
- The use of drones in Croatia for detecting landslides
- Modelling of track stiffness
- The use of geophysical techniques for locating “hot spots” on rail tracks
- Risk assessment and risk ranking methodologies
- Examples of the use of novel materials/treatments in transition zones and embankments e.g. high pressure expansion polyurethane resins
- Progress with the development of a traffic flow model with an application based on the collapse of the Malahide viaduct
- Data structure for the Life Cycle Cost model
- Details of the presentations and briefing carried out to support the dissemination and exploitation activities.

Conference presentations in Brno on the left and on the right at TRA in Warsaw

**Work Package 2: Progress to Date**

A key input for a decision support tool for optimisation of infrastructure is quantification of the probability of failure of individual elements. The methodologies developed within WP2 will provide Owners/Managers with the facility to optimise budgets/resources from the perspective of minimisation of the cost for the lowest failure probability. The Work Package is divided into five sub-tasks. The first task aims to develop a Probabilistic Basis for Multi Criteria Performance Optimisation of Railway Infrastructure. An extensive document is being produced which considers not just railway structures (bridges) but all aspects of railway infrastructure including earth slopes (natural and man-made) and tracks. The progression of the document to date has included guidelines for system analysis of the structures and earthwork as well as the performance of probability-based fatigue assessment of railway infrastructure.

The second task aims to show how information from remote monitoring installations can be incorporated into the probabilistic assessment framework. A Bayesian probability based updating algorithm has been developed which can update basic “a priori” probability distributions based on a likelihood function derived from some site specific information from monitoring / testing. The result is a refined “posterior” distribution for the input variable (see Figure 1)

![Figure 1: Bayesian updating from measurement](image-url)
The third task is concerned with assessment of structures. The central span of the Boyne Viaduct (Figure 2) was selected as a case study bridge. A probabilistic assessment was carried out on the structure based on the guidelines being developed. The assessment was used to identify stress hot-spots for instrumentation. Four rosette strain gauges were installed on the structure along with 4 triaxial accelerometers (Figure 3). Measurement is currently available for 35 days with 724 train passage events being recorded.

The data has been used to perform calibration of a Finite Element (FE) model of the structure, giving an excellent agreement at the monitored locations. This allows a much more accurate assessment of the structure to be carried out. The data was also used to calculate an accurate dynamic allowance for the critical elements in the context of both probabilistic and deterministic assessment. It has been shown that the dynamics on the structure are very low. Software has been developed to perform a probability-based fatigue analysis at the monitored locations to calculate the reliability index on a yearly basis.
As part of assessment of structures, the complex task of soil-structure interaction modelling will be addressed. Pile foundation elements are commonly modelled using a Winkler model (Figure 5) whereby the foundation structure and the surrounding soil are modelled as a beam supported by mutually independent and closely spaced springs. Excitation of the bridge structure (by traffic loading) allows monitoring of the natural frequency over time. The variation in the natural frequency can then be used to monitor the effect of bridge scour. Signal noise and vehicle speed have been investigated and it has been noted that there is little or no effect on the calculated natural frequency. In the coming months, the effect of dynamic cyclic loading will be investigated as well as non-linearities in the soil matrix.
The fourth task is concerned with assessment of earthworks. Engineered slopes fail in many different ways depending on which triggering mechanism presents itself first. For example heavy prolonged rainfall is likely to instigate a shallow landslide while an increase in external loading is more likely to cause a deep seated failure. Therefore to ensure that a slope has adequate capacity, current practice requires that both planar and rotational failure mechanisms are checked. To circumvent this, a slope stability model was developed which is able to locate multiple critical probabilistic failure surfaces simultaneously, regardless of slip surface shape. It accomplishes this by combining a particle swarm based multi-modal search algorithm with a first order reliability method and a fully adaptable non-circular slip surface. This allows end users to rigorously assess the stability of an existing cutting or embankment and find all areas of concern, thereby ensuring that remediation works are carried out in the most effective manner possible.

Given that loading demands from both climate and traffic are increasing and the majority of Western Europe’s railway cuttings and embankments are aged, it is imperative that we can quantify the effect of increased rainfall on slope stability. A series of fragility curves have been developed to describe the vulnerability of engineered slopes to rainfall of various intensities and durations. By interrogating these curves it is possible to determine how likely existing infrastructure is to fail for various different climate scenarios (See Figure 7).
A major maintenance issue for railway infrastructure is the track itself. As part of the fifth task, a pilot section of track has been selected near the city of Munich to perform field measurements and develop numerical models for further data processing and research. The section chosen is an old, conventional ballasted track which is globally straight and homogeneous (see Figure 7). Ground penetrating radar and track geometry measurements have been carried out for both loaded and unloaded scenarios. Significant differences have been noted in the longitudinal level measurements (Figure 8) between loaded and unloaded scenarios, which suggests that the track stiffness quality along the pilot section may play an important role. To model the effect of track stiffness, simulation combining FE Methods and Multi-Body Simulation (MBS) was performed. The track stiffness is represented in FEM, while the unloaded track geometry is represented in the MBS model as track excitation. The track geometry under the loaded scenario will be investigated with the dynamic response of the vehicle as it passes the track.

Figure 7 Pilot Track Section, near Munich

Figure 8: Comparison of the longitudinal rail level measurement results by RailLab (DB), loaded track and TUM, unloaded track
How Ph.D. Students are contributing to the project

As part of the DESTinationRAIL proposal, the project committed to taking on a number of Ph.D. students in order to develop research capabilities. With this in mind a number of students have prepared articles describing how they are working with the project to try and encourage more students to join this area of research. This is the second article and features Natalia Papathanasiou who is studying at ETH Zurich, Switzerland and who is working on task 3.2. Risk Assessment Methodology.

The DESTinationRAIL project aims in developing a decision support tool for the Europe’s Railway Infrastructure Managers. This is addressed through the FACT concept, which involves four areas Find, Analyse, Classify and Treat. Classify is the third process of the FACT concept and refers to the implementation of risk management for railway networks. Within the context of risk management, my task is to develop a structured and systematic methodology for risk assessment. In particular, my work addresses the question of how failures of individual assets of the railway infrastructure, e.g. bridge collapse or geometrical track defects, can affect the performance of the network, e.g. cause delays or accidents, and which is the methodology that will allow the computation of those risks.

Two of the main components in the computation of risk are; the probability of a scenario to occur and the consequences of this scenario. The probability depends on the level of exposure, in time and space, of the infrastructure to different events, e.g. earthquake, flooding, deterioration, vandalism. On the other hand, the consequences depend on the intensity and the way these events progress in the network. The analysis of this complex relationship results in essential benefits for the infrastructure’s management.

When infrastructure managers adopt a risk approach to assess the railway network, important performance requirements, such as safety and reliability, can be met through intervention planning. Therefore, the purpose is to create a method that can be used as an input for intervention prioritisation. The key idea is that if we know what elements, objects or sections are exposed to higher risks regarding the performance of the network, we can increase their reliability through cohesive intervention planning. Consequently, the approach against the risk becomes preventative, rather than responding to failures when they occur.
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This risk management process will be part of the decision support tool to ensure the optimum balance of cost and risk reduction for the European railway network. I expect to grow as railway engineer through the challenges of the project. Certainly by participating in this project, I gain experience and knowledge in the field of railway. It is an invaluable opportunity to collaborate with partners, from a variety of backgrounds, countries and from a range of disciplines, but with one common aim: to improve the European railway network.

My involvement in this environment helps me to improve myself as an asset in the field of railway infrastructure management. I believe that this is an area with many prospects for research and improvement. My goal is to contribute in bridging the gap between risk management and railway engineering. Hence, I hope that the outcome of my research will allow railway infrastructure managers to optimize the maintenance of the European railway network.

During this first part of the project I have already developed different perspectives regarding the railway infrastructure. I am now aware of different innovative techniques to monitor, analyse and improve the maintenance of the railway, for example drones. Also, I continuously deepen my knowledge in the different challenges faced by the European railways in maintaining an adequate level of transport service.

In particular, concerning my task, I conduct research on the opportunities and challenges of risk management for railways. I learn how to utilize the technical knowledge in railway infrastructure, in the process of developing a structured methodology for risk assessment. This task requires that I expand my understanding from how the railway infrastructure works, to what happens when the railway infrastructure does not work. This process requires me to be familiar with a variety of tools and methods, for example probabilistic tools, reliability and risk assessment methodologies.

Update on Work Packages 1 and 3 to 5

Work Package 1 has been involved in trials using GPR to locate hot spots and work has continued with trials using Drones and geophysical techniques to detect hot spots including potential rock falls. Track measurement work is progressing using off the shelf monitoring equipment, work has also continued on bridge scour modelling and collecting data from the Boyne bridge.

Work Package 3 has developed a Risk Assessment Methodology framework which will be used in the Decision Support Tool. A review of published literature has also been carried out to identify any Risk Ranking literature which would be applicable in addition to establishing rules on when the optimum time to carry out work on the network.
Work Package 4 has identified test sites for its work on construction techniques for track and earthworks, including bridge abutments. Data is being collected on traffic flows and infrastructure for the traffic flow model based on a section of the rail network in Ireland. Work is continuing to build the Whole Life Cycle Analyse model as both of these models are due to be demonstrated at workshops in the autumn.

Work Package 5 has moved to presenting progress, as opposed to raising awareness, with the project with 6 presentations carried out since January. Meetings have also taken place with Infrastructure Managers to assess possible exploitation opportunities.

Future Events and Planned Presentations

DestinationRAIL partners will be giving presentations on the progress of the project at the following events:

- Railway Pro Investment Summit on 11/12 October in Bucharest.
- Global Infrastructure Conference 24/25 November in Frankfurt

In addition to the above events, a number of the team members will be at Innotrans in Berlin from 21 to 23 September and would be happy to discuss the project with you. In addition to the above, articles are planned for a number of railway magazines.

Do not forget that you can always download this newsletter along with any other published material, including presentations, from our website www.destinationrail.eu

You can also keep up to date with DESTinationRAIL activities by joining our LinkedIn group.

www.linkedin.com/groups/8428750

Above. GPR mounted on a Robel vehicle for field tests in Norway. Below an example of induced wet spots on JBV. The red circle shows where water was poured into the track.