Decision Support Tool Workshop, Ljubljana, 1st December 2017.

A stakeholder workshop was recently held in Ljubljana, Slovenia, which included representatives of the project and railway infrastructure managers from Irish Rail, Deutsche Bahn Netz, Croatian Railways and the Agency for the Management of Public Railway Infrastructure Investment in Slovenia.

The purpose of the workshop was to provide an update on project progress including a demonstration of the beta version of the Decision Support Tool (DST) with an opportunity for Infrastructure Managers to comment on progress and to suggest areas for improvement.

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Figure 1. An example of an interactive map used to visualise risks on networks.
The 4 work packages presented progress made with the project showing how each work package could provide an input into the DST (see figure 2).

Figure 2. Hazard analysis in terms of landslides which considers qualitative variables within a degradation factor.

The workshop provided the first demonstration of the beta version of the DST, using data from Irish Rail, with the objective of allowing the infrastructure managers and others present to ask questions to the development team. The demonstration prompted a number of questions, which the team responded to, together with some suggestions for improvements which the team has taken away for evaluation. Copies of the presentations can be found on the DESTinationRAIL website www.destinationrail.eu. The opportunity was also taken to hold meetings of the Consortium, Executive Board and Exploitation Sub Committee (see figure 3).

Figures 3. Presenters at the project meeting in Ljubljana.
Improving risk management for railway Infrastructure Managers.

In the DESTination RAIL project, a Decision Support Tool (DST) has been developed for Europe’s railway Infrastructure Managers. This has been developed using the FACT concept, which involves the four areas Find, Analyse, Classify, and Treat. The classify work package, i.e. WP3, contains the methodologies to be used to assess risk and plan risk reducing interventions for railway networks, i.e. tasks 3.2 and 3.3.

Risk assessment, as part of infrastructure management, is the identification, analysis and evaluation of the risk related to the infrastructure. Risk assessment involves estimating the probability of occurrence of future scenarios occurring and the consequences of this scenario if it occurs. Risk, i.e. the product of the probability and the consequences depends on:

• the likelihood of the infrastructure being affected by undesirable load events at all periods of time investigated, i.e. exposure, e.g. an earthquake, a flood, deterioration, heavy vehicle load,
• how the infrastructure will behave when affected, which is related to the state of infrastructure,
• how the network will be restored following the event, and
• how people are affected by the infrastructure not working as intended until it is once again restored to a point that it is providing an adequate level of service.

For example, if the probability of a particular switch failure (see figure 4) is 0.005 and the cost related to this failure, due to delay, replacement of the switch is €1,000,000, then the risk related to this switch failure is €5,000. Of course, this information can then be used to evaluate whether or not it is worthwhile to execute a risk reducing intervention. In this example, if it is possible to execute a risk reducing intervention on the switch before it fails, where the probability of failure would be reduced to 0.0001, then the risk would be reduced to €100, which means that the risk reduction achieved with a intervention would be €4,900. One should be able to pay up to, but not more than €4,900 then to execute the intervention.

Figure 4. An example of a set of motorised points showing the various component parts.
As railway networks consist of many different types of assets, e.g. bridges, switches, tracks, in order to make decisions network wide as to which risk reducing interventions should be executed, risk must be estimated consistently for all the assets of the network. For this purpose, within DESTination RAIL project, a risk assessment methodology (process) has been developed for railway networks. This process is presented in the Deliverable 3.2, which is available on the website of the project www.destinationrail.eu.

The risk methodology consists of four basic steps;

1. identify all things to be quantified per unit time in the estimation of risk, which includes the identification of who the stakeholders are that should be considered and how they are likely to be affected,

2. construct scenarios, i.e. of chains of events, from infrastructure related events, e.g. track differential settlement of 7% for 200m, to network use related events, e.g. reduction of speed down to 40km/h, to societal events, e.g. delay of 10min for 800 passengers and the execution of track maintenance interventions upon which values are placed, e.g. cost of delay per minute of passenger and cost of the track maintenance intervention. These scenarios are constructed for all assets, where generalisation is encouraged in cases where it cannot be done specifically for all assets.

3. estimate the risk due to each scenario, i.e. the probability of occurrence of each of the scenarios and the costs associated with each scenario, for each possible state of each of the assets of the infrastructure,

4. simulate the change of state of the infrastructure over the period of time of interest, estimating risk within each time step.

Figure 5. Details of a section of infrastructure used in the Risk Management Tool.
These steps enable the risk related to all assets to be estimated over the time period of interest in a way which makes them directly comparable. The comparability of the risk estimates ensures that the estimates can be used to prioritize risk-reducing interventions on the infrastructure in situations where it is not possible to execute all the desired interventions, i.e. when there are constraints on the optimization problem of net benefit maximization. It also enables clear explanation of potential problems to all people involved in the decision making process, without being forced to use proxies that often lead to vagueness, when not double counting of what matters. Figure 7 illustrates how maintenance can effect the condition of the asset over a period of time.

Figure 7. An intervention program is the list of the interventions to be executed on the assets in a network and the time periods in which they should be executed. The optimal intervention program is the one that results in the maximum net benefit, i.e. finding an appropriate balance between the costs associated with the failure of assets and the costs associated with the executing preventive risk-reducing interventions. The costs associated with failures are the risks estimated using the risk assessment methodology presented above. The net benefit of an intervention program is estimated as the difference between the risks and the costs of a reference intervention program, e.g. resulting from strategies to wait until the infrastructure is in an alarming state and then executing an intervention, and the risks and the costs incurred when the intervention program in focus, e.g. resulting from strategies to execute interventions before an alarming state is reached, is implemented.

Figure 7. A DST report on the modelled condition state for every year of the WLC analysis, simulating the effects of maintenance.
A challenge in the estimation of the net benefit, in addition to estimating the risks, is the consideration of the variations in the costs of executing interventions due to the possibilities of executing multiple interventions simultaneously.

For example, executing multiple interventions on one railway line at the same time is less expensive than executing the same two interventions two years in a row due to the reduced set-up costs but also due to the reduced costs in terms of interrupting service on the railway line. Another example is that executing multiple interventions at the same time may mean that some areas will lose railway service and result in high costs for users due to this loss of service.

The basic methodology to determine the optimal intervention program with constraints, e.g. a budget limitation, contains the following five steps: 1) identify possible intervention programs, 2) estimate the costs related to the execution of the risk-reducing interventions within the intervention programs, 3) estimate the risk reduction of each intervention program in respect to a reference intervention program, 4) estimate the net benefit of the intervention programs, and 5) select the intervention program with the highest net benefit. The mathematical model and algorithmic details have been included in the final deliverable of the DESTinationRAIL project. Figure 8 illustrates the type of output possible from the DST.

![Figure 8. Example output from the DST.](image-url)
As part of the DESTinationRAIL proposal, the project committed to support 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 to encourage more students to join this area of research. This is the fifth article and features Kangle Chen who is studying at The Technical University of Munich working on Work Package 1 Task 1.3 monitoring of Switches, Crossings and Track as well as Work Package 2 Task 2.5 Assessment of track.

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‘It is of great honour for me to join the Europa research project DESTination RAIL as a Ph.D. candidate. Under the instruction of my supervisor Dr. Bernhard Lechner, we are undertaking the tasks of track quality monitoring and evaluation.’

To achieve the objective of the project, which is to improve the safety, reliability and efficiency of rail infrastructure, a holistic management tool has been developed based on the FACT (Find, Analyse, Classify and Treat) principle. In Work package 1 Find and Work package 2 Analyse, novel techniques for identification, analysis and remediation on individual rail infrastructure assets including earthwork, structures and track itself have been developed. As railway superstructure engineers we are included in Work Package 1 Task 1.3 monitoring of Switches, Crossings and Track as well as Work Package 2 Task 2.5 Assessment of track. Our main task has been to choose methods of track monitoring and utilize the measurements to describe track quality with FEM-MBS co-simulation (see figure 9). Furthermore, the results of the simulation have also provided advice for identifying “hot spots” in railway infrastructure.

Figure 9. MBS for wheelset/track interaction
Traditionally track monitoring is performed by infrastructure managers using a track recording car, and track quality would then be evaluated by the measured track geometry quality. Considering the fact that the measured geometry of loaded track using a track recording car is a mixture of unloaded track geometry and track dynamic deflection under train run, such monitoring could only identify the existence of poor track quality locations, but could not further confirm the culprit to cause the problem. Then two further measurement equipment are introduced to improve the situation: the hand-pushed track recording trolley possess negligible self-weight and measures therefore the unloaded track geometry (see figure 10). Ground penetrating radar (GPR) measures the condition of track substructure, which provides information for track stiffness. The relationship among the measurement results from these three sources are studied by numerical simulation and validated by measurement at selected locations. Based on this a more detailed track quality monitoring approach is realised.

Figure 10. Measurement of unloaded track geometry.

With regard to my experience in this project until now, what impresses me most is the importance of team work in nowadays research activities. Firstly, with the development of science and technology, it is quite a common phenomenon that the processing of research in one area requires knowledge in other fields. For instance, to solve loads of problems I met in the project, it’s of great necessity for me to work together with experts in area of mechanical engineering, geotechnics, electronic engineering etc. Secondly, through the communication with other colleges in this project, I can have a deeper and wider understanding of railway engineering, not only confined to my research focus. Concept of risk analysis and assessment with respect to the whole network makes me begin to realize, that I should not only focus on the mechanical or mathematical details of the railway infrastructure itself, but also consider the feasibility and impact of a single research in view of the whole railway traffic system.
Future Events where you can see the results of the DESTinationRAIL project

As the project reaches its completion we are planning a number of events where the results of the project will be presented. These events include;

- The Railway Pro Technology and Service Forum, which is being held in Alba Lulia on 14th and 15th March, where 2 presentations are planned by Michael Robson and Andreas Schoebel. Further information can be found via the following link http://railwaypro.com/forum/programme/.

- The 7th European Transport Research Arena (TRA) which is being held at the Reed Messe Wien, Vienna/Austria from 16th to 19th April 2018. Currently 2 DESTinationRAIL papers have been accepted to be presented on the podium and will be published in the TRA 2018 Conference Proceedings. The first paper "Analysing the effect of rainfall on railway embankments using fragility curves" by Cormac Reale and the second paper "Evolution of Decision Support Systems for Railway Infrastructure Managers" by Allah Buhksh, Zaharah; Stipanovic, Irina; Gavin, Kenneth; Doree, Andre.

In addition to these papers it is planned to have a joint presentation with the Shift2Rail project. Further information can be found via the following link http://www.traconference.eu/

- The DESTinationRAIL final conference which is being held in Zagreb on 27th and 28th April will be an opportunity to showcase the work done over the 3 years of the project. The conference will consist of a key note address given by a Senior member of an Infrastructure Manager, a series of presentations by Work Stream Leaders describing the work of each package followed by a demonstration of the Decision Support Tool. Further information on these events my be found on the project website www.destinationrail.eu.