Needs Tailored Interoperable Railway Infrastructure

Foreword

The NeTIRail-INFRA project is now entering its third and final year; within this newsletter we present some of the highlights from the first two years of the project and the close collaboration which has been this time. Throughout the project we have seen trials of the developed technologies tested on track, and this will continue in the last year of the project, demonstrating the robustness and applicability of the research carried out within the NeTIRail-INFRA project.

The mid-term conference that was held on November 4th, 2016 in Brussels has shown the considerable achievements made so far, all of the public deliverables which have been submitted during this period available for all on the public website at: www.netirail.eu. Further workshops, training events and a final conference will be held over the next year where participants will have the opportunity to learn more about the technologies developed and to discuss the research and development in detail with the consortium, as the dates for these events are fixed they will be available on the NeTIRail-INFRA website or please follow the project’s twitter feed, @netirail.

Jon Paragreen – NeTIRail-INFRA Project Manager

Background to NeTIRail-INFRA

The principles behind the NeTIRail-INFRA project were conceived in early 2014 in response to the topic MG2.1 “Intelligent Infrastructure” in the 2014-2015 Mobility for Growth Horizon 2020 call. The NeTIRail-INFRA concept was based on designing railway infrastructure and monitoring tailored to the needs of specific lines to ensure the most cost effective and sustainable solution for different line types and geographical locations.

There is particular emphasis in the project on lesser used lines which are marginally economical and at risk of closure or require substantial public subsidies. As well as the lesser used lines the project also considers capacity constrained and freight dominated lines.
WP1 - Contrasting market needs, and business case

Leading partner: University of Leeds – Institute of Transport Studies

Business Case for the Innovations

During the consortium meeting in Leeds in March 2017, each of the technical innovations was discussed in detail by a multi-disciplinary team including transport economists from WP1. The purpose was to identify the likely economic costs and benefits for each of the innovations as a starting point for setting out data needs for the base case and “with innovation” scenarios. This data, once collected, will enable a business case to be established.

An example of the way in which the engineering underlying the innovations will be utilised to derive cost changes for one innovation – transition zones is set out in the diagram below.

Since the March meeting in Leeds the WP1 team has developed a specific data requirements list for each innovation based on the discussions held to be discussed and finalised at the June meeting in Delft.

Wider Economic Benefits Deliverable

In May the final report of the Wider Economic Benefits deliverable was completed (internal review completed in the week ending 26th May with final revisions to be completed by 31st May).

This deliverable sets out the methods to quantify and value the wider economic impacts of the NeTIRail-INFRA interventions which form the basis of the business case in task 1.6.

Wider Economic Impacts are the economic impacts of transport (e.g. on labour, product and land markets) that are additional to the transport user benefits (e.g. travel time savings). Under conditions of perfect competition for both the transport and transport-using sectors, a properly specified appraisal of a transport scheme would accurately estimate all welfare impacts through the first order effects (i.e. user benefits as measured by consumer surplus). These first order effects are estimated in Task 1.3.2. In practice, most markets are not perfectly competitive. If only direct user impacts are appraised, some economic impacts would be missing. In some contexts, these impacts can be a large part of the overall appraisal of a rail scheme.
Before wider economic impacts can be valued in a cost benefit analysis it is necessary to predict the scale of the impacts on the economy – e.g. in terms of productivity, employment and output. This is the **quantification stage**. As part of this process we identify the market failures that are relevant to the analysis, as this determines the scope of the wider impact analysis to be employed in the NeTIRail-INFRA case studies.

This deliverable also addresses one of the main evidence gaps in the quantification of wider economic benefits – that of quantifying the employment effects. Within this deliverable new evidence is presented on the relationship between rail infrastructure and employment. Whilst we were unable to identify suitable historic investments within the NeTIRail-INFRA area of interest, we proceeded with a detailed examination of four historic rail investments: Murska Sobota- Hodos (Slovenia), Mansfield to Nottingham - the Robin Hood line (UK), Manchester metro (UK) and Stirling to Alloa (UK).

Our analysis of these case studies in this deliverable has given interesting but mixed results. We do find evidence of employment impacts in certain contexts. This deliverable sets out the principles based on existing evidence and guidance necessary to estimate such effects where relevant for the innovations in the project, utilising the general evidence from the literature as well as the new econometric work undertaken.

In terms of the **valuation stage**, we show how economy impacts are only included in a cost benefit analysis in addition to user benefits if market failures exist. We identify that the impacts of relevance in the NeTIRail-INFRA business case studies are agglomeration externalities affecting productivity; differences between prices and marginal costs of products arising from monopsonistic power; and income taxes that create high levels of unemployment that affect changes in employment.

In both the quantification and valuation stages we have transferred models used elsewhere to capture the agglomeration impacts and imperfect competition effects. Suggested model parameters pertinent to Eastern Europe have been drawn from the literature and presented to give a set of models that can be used to estimate the wider economic impacts of the NeTIRail-INFRA innovations when tested in the case studies.

Demand. It can also be used for forecasting the impact on demand as well as estimating the benefits of service improvements.
WP2 – Tailored track infrastructure, design and maintenance

Leading Partner: SZ – Prometni institut Ljubljana d.o.o.

Progress update

WP2 consists of six tasks. Progress (in last months of work) was made within four tasks T2.3, T2.4, T2.5 and T2.6. First two tasks were completed after first six months of the project.

Task T2.3 has been carried out from two aspects, namely the state of the art and data collection. The main progress within this task represents collecting data from various sources, considering the application of railML, providing source of climatic data, filling in questionnaires regarding the replacement of S&Cs and researching layout of S&Cs at stations. The main output is the deliverable D2.3 entitled “Cost/benefit data and application methodology for lean in railway S&C”. The methodology for the lean optimisation was developed and the first technical site visit to assess the replacement of a switch and crossing took place in Kayseri, Turkey in May 2017.

The main progress of the task T2.4 is related to researching forces, feasibility and reliability of ABA in detection of rail corrugation, corrugation initiation and damage mechanisms. For this task some documents were prepared, deliverable D2.7 “Corrugation reduction strategies for NeTIRail-INFRA track types, with estimates of costs and benefits” and two journal papers about railpads and initiation of corrugation, further data collection from the partner countries is planned during the final year of the NeTIRail-INFRA project to further develop the case studies.

Task 2.5 has developed questionnaires for details about lubrication system (track based, on board), lubricators and lubricants, costs, traffic and climatic conditions with fuel consumption and cost benefits of lubrication. Special attention was paid to the lubrication of curves. This lubrication data has been collected and analysed for strengths and weaknesses of different systems and the result of this task is presented in the deliverable D2.7 “Lubrication Systems And Data Available, With Estimates Of Costs And Benefits”.

The progress within the task T2.6 is on building the model of transition zones which includes studying the resonance in the rails, the impact loads and wearing effects on the rails, rail-wheel contact with effect on corrugation, the dynamic loads effect on track deformation and ground responding, the climate and soil temperature effects on the rail behaviour. Final deliverable of this task is D2.9 “Preliminary transition zone model and detailed modelling plan”.

Images from D2.3, D2.5, D2.7, D2.9.

ABA measurement system and diagnosis system
Example of the data

Elpa On-board lubrication system and working regime of the system

Elpa On-Board Lubrication System

Full extrude version of the whole transition zone
WP 3: Tailored overhead line power supply infrastructure

Leading Partner: ADS-Electronic Research SRL

The main objectives of the WP 3 are presented synthetically in the figure below.

The objectives of the WP 3 over the duration of the project are the following:

» Identify correlations between the grade and quality of overhead line components installed versus the life of the system;
» Develop technologies for monitoring and minimising the life cycle costs of overhead line power infrastructure. These technologies will help models, created for optimising the controllable factors, to be validated and improved;
» Specify tailored solutions for improving the quality and performances of overhead line power infrastructure.

Development work is ongoing and in track testing of the following solutions will begin autumn 2017.

On-board monitoring of voltage, power spikes, other electrical properties

» Designed for monitoring the electricity supply of the locomotive;
» Measures the voltage at the entrance to the train, from the pantograph; will be used the instrumentation transformer already available for metering of electricity consumed and for informing the locomotive driver.
» First solution aborted: collecting data from the main transformer is not possible because of electrical high noise from engines.
» The second solution which is to be implemented measure is the current absorbed through the main transformer.
» ECVM is placed into the driver cab and connected to the laptop, using an USB interface, for control and data storage.
» Installation and construction details are presented for EA060, Romanian locomotive for the testing but can be adapted for other locos.
Instrumentation to measure accelerations and displacement of the overhead line.

The system contains the next three types of devices:

» WSDO (Wireless Sensor Device for Overhead Lines)
» WCDO (Wireless Concentrator Device for Overhead Lines)
» WLRCD (Wireless Long Range Communication Device)

These devices have been tested in the laboratory and on track testing is planned for autumn 2017.
General Considerations of the System:

» **Objective:** to collect vibrations and displacement data at the contact point; these data will feed into the modeling work

» **Electrical restrictions:** electrostatic discharge and electromagnetic field intensity

» **Mechanical restrictions:** difficulty of installing and maintenance of WSDO devices on the contact wire

**Technical requirements:**

**WSDO - Wireless Sensor Device for Overhead lines**

» Function - Collect data from accelerometer sensor. There are used: three axis accelerometer (±2g/±4g/±8g/±16g selectable full scales; 1 Hz to 5.3 kHz selectable SPS) and temperature sensor.

» Sensor device is mounted on the grooves of the contact wire, using a metal clamp and is powered by a battery and photovoltaic cells.

» Data is transmitted over a short distance to WCDO type device, using IEEE 802.15.4 RF standard as ISM 868MHz.

**WCDO - Wireless Concentrator Device for Overhead lines**

Collects data from WSDO’s and relays the sensor data to the WLRCD, which has data logger function and long-range communication capability.

**WLRCD - Wireless Long Range Communication Device**

» Receive data from WCDO device, provides data logger function when long-range communication is not available.

**High speed video camera system**

» The high speed video camera systems are used for measuring the dynamic behavior of the contact point, between pantograph and overhead line and the monitoring of electrical arcing.

» Current status: Testing and calibration are ongoing in laboratory, with field trials planned for autumn 2017.

Using the systems and data from the above solutions, models will be created to explore the relation between controllable factors (line tension, contact line materials, and upload force) and power system wearing rate and damages. The solutions proposed will be validated by testing in one dedicated task of this work package.
In WP4 of the NeTIRail-INFRA project we develop smart technology solutions for three major problems faced especially by lower density lines:

- Cost effective inspection and asset management to minimise maintenance interventions time/cost without dedicated inspection vehicles.
- New methods of interfacing equipment specific to lower density lines with existing systems of data communication, location information and interlocking.
- Data mining and interpretation capability to convert monitoring information into management information.

The highlights of the main results achieved so far:

- For understanding dynamic loading for plain and S&C, versatile and reusable low cost track side based monitoring modules were developed. The proposed hardware system includes three devices: Wireless Sensor Device for Rail, Wireless Concentrator Device for Rail and Wireless Long Range Communication Device. Additionally, the experimental equipment for data collecting has been designed. This equipment was used by partner RCCF for testing range of rails vibrations. Other tests will follow this year.

- Regarding the high precision infrastructure monitoring using standard vehicles, testing was conducted in the Dutch railways and in the Romanian railways. The paper “Robust and predictive fuzzy key performance indicators for condition-based treatment of squats in railway infrastructures” was accepted in the Journal of Infrastructure Systems.

- The software for a smartphone was developed based on technology for vehicle and infrastructure monitoring from within passenger vehicles, i.e. crowd-sourced data collection, to increase the regularity and granularity of monitoring data available. The proposed system architecture consist of 2 systems: at rail unit level the application for low cost smartphone, and at Control Centre the application for crowd-data server.

- In the task about smart technology interfaces, regarding the data transmission, actions have been taken with data service provider Vodafone so to make the data traffic used by the SATLOC compatible. Regarding interlocking for lower density lines, technical solutions were established after system analyses stage; acquisitioned the components and materials necessary for the system development and designed, manufactured and assembled the hardware devices of the system. Additionally, last experimenting of the ABA system in Romania provided the frame of interactions with SATLOC systems, so the laptop used by ABA system also collects and integrates short messages from SATLOC on board equipment (GPS positioning data, odometer data, in field tag codes).

- In the task about processing and tailoring the monitoring for specific needs, the definition of the harmonized and standardized interface through which monitoring data can be delivered has started. This includes the definition of suitable data structures that allow harmonized data management. The final goal is to improve the process and utilization of monitoring data in infrastructure management.

- Finally, measurements campaigns were already conducted for the three tasks 4.1, 4.2 and 4.3 in the AFER and RCCF tracks where the application of the data acquisition systems could be proved. Additional validation measurements will be done during 2017.
Task 4.3 Low cost smartphone sensors for vehicle and infrastructure monitoring

In the last 12 months, the work in Task 4.3 concentrated on the development and testing of application for smartphone based technology for vehicle and infrastructure and comfort monitoring from within passenger vehicles.

Expected results of this task are:

- Developing an app to gather data from the smartphone GPS sensor and its accelerometer. This will consider conservation of battery life as a priority to ensure viability of the app.
- Developing a gateway to which the data is transmitted using the phone 3G or WiFi connection.
- Developing an interface for querying of available data (e.g. relational database structure).

Research activities carried out under phase 2 of the Task 4.3 focused on the development, deployment and testing of the Low-Cost Smartphone system and of dynamic Web services platform support for data collection in order to measure ride comfort and to obtain the track inputs.

The development of the systems was accomplished by carrying out three activities namely:

- Development of relational databases based on reference model, data model consolidated designed on first phase of Task 4.3
- Development of mobile application according to specifications involving demarcation of functional and technical requirements of the system in concrete terms (functions, processing, interfaces, etc.) identified in first phase of Task 4.3

Deployment activity has mainly focused on the following actions:

- Deployment of the mobile terminal application;
- Deployment of the system Web services;
- Deployment of the database of the system;
- Deployment of the components (business logic) of the reporting web interface.

Systems testing was conducted in three sub activities, namely:

- Defining of the test plan according to the technical specifications
- Unit Tests and Component Tests
- Prototype test in real conditions

The deliverable D4.6 “Low cost smartphone based track and ride quality monitoring technology” made during this period contains the following main sections:

- Working Methodology
- Standards, technologies and techniques for evaluation of ride comfort
- Requirements for system for track and ride quality monitoring
- System for track and ride quality monitoring based on Low Cost Smartphone
  - Development framework for smartphone application
  - Layout of smartphone application
  - Functionality description of smartphone application
    - Activity for real-time data display and data collection
  - Activities for setting application
  - Activities for navigation logs
  - Activities for graphical display of logs
- Testing of for track and ride quality monitoring based on Low Cost Smartphone
  - Unit Tests and Component Tests
  - Prototype test in real conditions
Some print screen of mobile interface are presented opposite:
WP5 – Societal perspective

Leading Partner: Albert-Ludwigs-Universität Freiburg

The NeTIRail-INFRA Passenger Survey: selected results on use of train and passengers’ perceptions of railway services

In the last 12 months, the work in WP5 concentrated on the planning and realisation of a Passenger Survey on the case-study lines and on the analysis of its results. WP5 also developed a methodology for quantifying the survey results and the expected changes due to the innovations planned in NeTIRail-INFRA in order to carry out the social impact assessment. Both the survey results and the methodology are presented and discussed in the NeTIRail-INFRA Deliverable 5.2 “Perception of different service options: user study and data analysis” (May 2017).

Between June and December 2016 NeTIRail-INFRA project partners in Romania, Slovenia and Turkey carried out the Passenger Survey. A total number of 1,087 questionnaires has been collected; 1,074 interviews could be included in the analysis.

In the context of WP5, the results of the Passenger Survey are critical for understanding, among others, railway use characteristics, how passenger value different travel aspects that can be affected by the planned innovations and how satisfied they are with the current state of affairs. This information provide the basis for assessing the social impact of the innovations planned in NeTIRail-INFRA, in particular changes in terms of passengers’ accessibility to basic goods, i.e. on their opportunity to reach destinations or activities related to employment, education and health care.

The Survey results highlight the high importance that several of the NeTIRail case-study lines have for passengers’ accessibility. In particular, on the lines Bartolomeu-Zărnești (Romania), Ljubljana-Kamnik (Slovenia) and Sincan / Ankara – Kayaş (Turkey) the percentage of passengers travelling to reach destinations important for work, education or health care are very high: 83% on the Romanian line; 93% on the Slovenian line Ljubljana-Kamnik and 77% on the Turkish line Sincan / Ankara – Kayaş.

The Survey results also provide important information regarding the percentage of regular users among employed respondents, the share of passengers who rely only on train to reach the destination of the trip during which the survey took place and the percentage of respondents who would move house or completely give up work if they could not travel to their destination by train anymore. These further findings, together with the ones regarding the journey purpose, are reported in the graphic below:
The results regarding passengers’ perceptions of current services led to interesting findings as well. On the Romanian and Slovenian lines, all travel aspects related to time (punctuality, journey time and frequency of trains) are considered to be the most important ones, with the only exception of the Slovenian route Pivka – Ilirska Bistrica, where safety is ranked by passengers as the most important travel aspect, followed by travel time and punctuality. By contrast, on the Turkish lines aspects regarding the quality of travel such as comfort and safety gain priority, even if aspects related to time still remain important.

Concerning passengers’ satisfaction, the survey respondents mostly expressed dissatisfaction on aspects that they did not rank as the most important ones, thus pointing at a relatively good level of satisfaction with current services. There are nevertheless areas in which, according to the survey findings, service improvements are expected to produce important consequences in terms of social impact.

These are:
- punctuality on the Bartolomeu-Zărnești line (Romania);
- travel time and frequency for the route Ljubljana-Kamnik (Slovenia);
- travel time on the Pivka – Ilirska Bistrica line (Slovenia);
- crowding on the Sincan / Ankara – Kayas route (Turkey) and
- travel time, punctuality and frequency on the Divriği – Malatya (Turkey).

This preliminary assessment will be refined and combined with details regarding the technical innovations planned on each line in the upcoming tasks of WP5.
WP6 – Evaluation and decision support tools

LEADING PARTNER: UIC

Work Package 6 focusses on the IT tools to allow a geographic presentation of the network under scrutiny, and to support scenario analysis when introducing innovations.

The overall architecture of the application has been defined in view of it becoming an open source application: platform-independence (on user side) and the consistent use of widespread technologies are of paramount importance.

Current works focus on the database and on the application server. A database mockup has been supplied by UIC, complete with sample data for internal testing purposes. The database rests on PostgreSQL, in view of developing geographic features. The database structure strictly adheres to UIC RailTopoModel (IRS30100), to ensure future compatibility with external data sources such as the European Register of Infrastructure (RINF) managed by the European Agency for Railways.

ADS electronics has added a geographic layer to the database, and is currently developing the CRUD tools (create, read, update, delete) to manipulate data, in order to integrate project-related subnetworks and line characteristics. An algorithm to associate database elements, such as line sections, with geographic elements will provide a flexible coupling between railway and geographic data.
Facts and figures

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