Lead contractor

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Project Coordinator

University of Sheffield, USFD
Executive Summary

This deliverable describes the NeTIRail-INFRA final brochure which is summarising the main technical results achieved during the whole duration of NeTIRail-INFRA project.

The purpose of the final brochure is to disseminate the project results achieved within the NeTIRail-INFRA project in an easy way to a broad public via online media such as the project website and twitter, as well as in printed version.
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Abbreviations and acronyms

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1. INTRODUCTION

This deliverable describes the NeTIRail-INFRA final brochure which is summarising the main technical results achieved during the whole duration of NeTIRail-INFRA project.

The purpose of the final brochure is to disseminate the project results achieved within the NeTIRail-INFRA project in an easy way to a broad public via online media such as the project website, LinkedIn and twitter.

The final brochure consists of a thirty-two-page booklet covering all results achieved whole along the lifespan of the project. It has been printed in 150 copies in order to be distributed in several UIC events and also in our partners’ networks.

The colours and the layout have been selected on the basis of the project graphic identity in the continuity of all previous documents published for the NeTIRail-INFRA project.
2. STRUCTURE OF THE FINAL BROCHURE

The final brochure consists of a thirty-two-page booklet covering all results achieved whole along the lifespan of the project.

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Figure 1 – contents of the NeTIRail-INFRA Final Brochure

Figure 2 – Front page and Table of contents of NeTIRail-INFRA final brochure
Page 4 and 5 contain a summary of NeTIRail-INFRA background and general objectives. A figure showing the structure of the project has been included to guide the reader through the following pages focusing on each technical WP.

**Figure 3 – Overview and structure of the project**

Work package objectives and outstanding results of WP1 to WP6 are presented from page 5 to 23.

**Figure 4 – Example of Work Package page**
Some dissemination actions are briefly presented on pages 24 to 27. Interested readers are able to learn more about the project through the included links to several videos which include the presentations made during the final conference or the training workshops.
A list of all deliverables written by the project consortium has also been inserted to help the readers rapidly find the information they need.

The last three pages feature general information on the project consortium including the partners’ logos, the EU Countries represented, facts and figures and the main contact details allowing readers to obtain more information on NeTIRail-INFRA. This information has been used in all printed documents in line with NeTIRail graphic identity and for the complete information of the readers.

The website address http://netirail.eu is displayed on the back page in order to invite the reader to visit it and learn more on all results achieved by the NeTIRail-INFRA project.
3. DISTRIBUTION

The NeTIRail-INFRA final brochure is intended to be distributed at all major events attended by University of Sheffield and UIC as dissemination partners and upon request, by the other NeTIRail-INFRA partners when they participate in EU-level events relevant to the project.

The NeTIRail-INFRA final brochure is available for download on the NeTIRail-INFRA website at: http://netirail.eu/IMG/pdf/netirail_finalbrochure_fullpage.pdf.

It has also been announced on twitter to ensure the largest possible circulation.
4. APPENDIX

Following is the pdf version of the final brochure (32 pages).
This project has received funding from the European Union’s H2020 programme under grant agreement n°636237.
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Overview of the project aims and key statistics

The NeTIRail-INFRA project (Needs Tailored Interoperable Railway Infrastructure) is a three-year, 5.4m€ collaborative R&D project funded by the European Commission, sponsored by INEA within the Horizon 2020 programme. The project is coordinated by The University of Sheffield and has a total of 13 partners from eight different countries.

Background to NeTIRail-INFRA

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. And therefore, as well as identifying and developing new technologies, the project has also focused on the societal and economic benefits of marginal routes and the impact of the project’s innovations to society and the economy.

With this vision, the NeTIRail-INFRA main scope has been to:

► Identify the appropriate existing technologies for different line types and climate
► Develop new technologies for cost effective transition zones, low cost electrification and measurement and monitoring technologies
► Optimise S&C maintenance
► Assess the societal and economic benefits of lesser used lines and assess the impact of the technologies developed within the project
► Produce a GIS based decision support tool to aid asset managers in identifying the most appropriate technologies for their lines.

THE KEY ASPECTS OF THE PROJECT

Track infrastructure design and maintenance optimised for particular routes and track types
Tailored overhead line power supply infrastructure providing solutions for low cost electrification
Developing decision support software for rail system operators outside the project to apply the methods developed to their own lines
Low cost monitoring interfaced with railway technology to optimise operation, maintenance and renewal of the infrastructure
Assessment of economic and societal impact of rail transportation to examine costs, benefits and viability of lines and their investment decisions

4
FINAL BROCHURE
Structure of the project

WP1
Contrasting market needs, and business case
UNIVERSITY OF LEEDS

WP2
Tailored track infrastructure, design and maintenance
SLOVENSKÉ ŽELEZNIČNE, D.O.O.

WP3
Tailored overhead line power supply infrastructure
ADS ELECTRONIC RESEARCH SRL

WP4
Monitoring and Smart Technology
TU DELFT

WP5
Societal perspective
ALBERT LUDWIGS UNIVERSITAET FREIBURG

WP6
Evaluation and decision support tools
INTERNATIONAL UNION OF RAILWAYS

WP7
Dissemination, training needs and influence on guidelines and standards
INTERNATIONAL UNION OF RAILWAYS

WP8
Project coordination
THE UNIVERSITY OF SHEFFIELD
WP1 – Contrasting market needs, and business case

Work Package leader: University of Leeds

Objectives

Establish the business case for the proposed technical innovations as they apply to the three line categories under consideration in this project (busy capacity limited passenger railway; under-utilised secondary ("low density") line; and a freight dominated route) to demonstrate that the proposed technologies will generate an overall net benefit to society, and establish the financial case for each of the line categories, to demonstrate viability for the different parts of industry;

Propose changes needed to the (country-varying) incentive arrangements operating within the rail industry to facilitate the implementation of the proposed technologies

WP1 analysed the cost-benefits for all of the technical innovations within the NeTIRail-INFRA project, providing in most cases the net financial benefit either annually or over a 30 year or 25 year period, depending upon the asset. However, for some innovations, especially the monitoring solutions, it was difficult to quantify the benefits and value of the additional data from these devices, even though they will lead to better and more preventative maintenance practices and reduce service affecting failures. In these cases, the annualised cost of the WP4 solutions were calculated and this indicates the size of the benefits which would need to be achieved to obtain a positive benefit.

The analysis also identified the non-monetized benefits such as reduced delays, improved safety and comfort, which have been further analysed within WP5.

Cost benefit analysis methodology

WP1 has also studied the incentives for the rail industry to implement new innovations. This study comprised of a literature review, interviews in Britain (NR, TOCs, DfT, RDG, RSSB) as well as in Germany and Sweden, plus reports from partners in Sweden, France and Slovenia. Significant barriers to innovation were identified and the issues of fragmentation of the industry and short term time horizons for financial accounting were identified as significant barriers. Possible solutions were identified by looking at different structural models for the rail industry.
WP2 – Tailored track infrastructure, design and maintenance

Work Package leader: Slovenske železnice, d.o.o.

Objectives:

Based on data collection, research, testing and modelling WP2 will offer tailor made track infrastructure solutions for improved, cost efficient and sustainable rail track infrastructure. WP2 consists of 6 tasks, it’s objectives are to:

- **Reveal the real underlying drivers of cost and maintenance** for track though combining maintenance data with GIS mapping techniques.
- **Achieve track life extension** through prevention of rail corrugation.
- **Develop track specifications** suitable for busy passenger, low density rural/secondary line, and a freight dominated route.
- **Specify lubrication regimes** suited to route type and climate, taking into account environmental impact of lubricants.
- **Apply lean and automotive industry techniques** to railway S&C to achieve a step change in life and costs.
- **Design a new and more cost effective transition zone solution** to avoid sharp changes in track vertical stiffness that are known to drive dynamic loading leading to many track defects.

WP2 covers and addresses multiple aspects of the railway infrastructure, such as inspection technologies, renewal processes, materials, maintenance activities. The innovations of WP2 aim at improving the existing tracks to optimise the overall use of resources. Four innovations are considered within this work package:

- Lean techniques for S&C
- Tailoring track (clips and pads) to avoid corrugation
- Optimal lubrication techniques
- New design for transition zones

**Lean techniques for S&C (Task 2.3)**

The focus in this task is based on the techniques used when repairing or replacing existing switches & crossings (S&C). The concept of lean techniques derives from the automotive manufacturing field, the intention being to apply cost-efficient techniques in every dimension of the production process. In this application, it mainly refers to the reduction of track possession time and costs for implementing maintenance and investment activities, and to optimize the related effort. It is expected that lean techniques can (at little or no monetary cost) provide substantial productivity and efficiency gains to the railway.

Within the NeTiRail-INFRA project data was gathered from two switch installation case studies in Celje, Slovenia and Kayseri, Turkey. As part of the lean process the tasks were initially mapped, followed by on-site observations and the classification of tasks as either, value adding, necessary non-value adding or waste. The wastes were further sub-categorised. By observing and quantifying the waste tasks process improvements could be recommended, from principles as simple as additional marking to ensure that tasks are completed right first time, the use of additional lifting equipment, and the reordering of tasks to even out the utilisation of resources.
Tailoring track to avoid corrugation (Task 2.4)

This task aims at providing a theoretical understanding of what causes short pitch corrugation and suggesting changes in the rail track to reduce the problem, namely by looking at different clips and pads. The way in which clips and rail pads, i.e. the fastening system, functions may explain corrugation initiation. The engineering aim of this task is to provide a theoretical understanding of what causes (short pitch) corrugation. Identification of corrugation drivers opens the possibility to design the fastening system as well as tracks and sleepers in a way that reduces the need for maintenance. To develop the understanding of short pitch corrugation a 3D finite element model was used coupled with a dynamic model. This theoretical work was also supplemented by a corrugation catalogue which was created for corrugations in Turkey and a test where 3 different types of fastening were used on the Eskişehir- Afyon- Kütahya Line in Turkey and the impacts of the fastening systems were assessed for their impact on corrugation.

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**Schematic diagram of the model**

Parameters from typical Dutch network
Optimal lubrication techniques (Task 2.5)

An efficient lubrication of the wheel-rail interface can reduce rail and wheel wear as well as energy consumption, leading to substantial cost savings (Reddy et al., 2007). Correct and proper management of the rail–wheel interface helps the rail industry to reduce wear and fatigue, which results in enhancement of asset life, growing of rail industry’s business and improving reliability of service. In the case of railway curves, properly and efficiently applied lubricants decreases squeal on corners and reduce rail noise. Several issues have been addressed as part of the NeTIRail-INFRA project: When, how and how much lubrication should be used?; Which type of lubricant should be used for different traffic density and weather conditions?; Is it best to use a track based or an on-vehicle system? The resulting recommendations were based on the line type according to the UIC leaflet, UIC 714 – Classification of lines for the purpose of track maintenance and the Köppen-Geiger climate classification, based on these criteria an infrastructure manager is able to follow a simple flow chart to identify the lubrication most suited to their particular lines.

Examples of the Köppen-Geiger regions represented in the qGIS software, including maps for West Europe, Turkey, Slovenia and Romania

New design for transition zones (Task 2.6)

Maintenance in transition zones is more expensive than on plain lines, and to reengineering the transition zone is expensive and can require the removal of the track and substantial ground works. The purpose of this innovation is to reduce the track displacements that occurs in these zones. The NeTIRail-INFRA innovation for transition zones is concerned with changing the design features of transition zones. This relates to the position, shape and mass of sleepers, with the objective of reducing the displacement. Within NeTIRail-INFRA project, transition zones were modelled and validated against measurements taken over a transition zone in Portugal. The simulation results suggests that to use heavier sleepers in the transition zone will result in lower displacement, settlement and less maintenance (tamping and grinding) is required. Also, the life of the rail assets lasts longer (fewer renewals).
WP3 – Tailored overhead line power supply infrastructure

Work Package leader: ADS Electronics

Objectives

This is a technical work package developing technologies for the overhead line power system and supplying input about their costs and benefits to the business case being developed in WP1. It focuses on the challenges which lead to delay through unreliable performance of overhead line power supplies, the investment costs which make it difficult to install overhead power on low density lines, and on the ongoing operational cost of maintaining the system. Its objectives are to:

- Develop evidence based links between the grade of overhead line and components installed the traffic mix which uses it, and the life of the system.
- Specify tailored solutions for improving the quality and performance of overhead line power infrastructure.
- Develop technology for monitoring and minimising the life cycle costs of overhead line power infrastructure through the design of low cost solutions.

The work will support increased utilisation of capacity as well as a reduction in the recurrent costs of rail operations, and reduced power supply operational and maintenance costs.

Current and voltage monitoring, for the overhead contact line system

The on board current and voltage measurement system is designed for measuring the quality of the power from the overhead line, through on-board monitoring of current, voltage and power spikes.

The analysis, of historical data collected provide information about degree of wear of the photograph and contact wire and helps to identify problematic areas and defects where arcing is present. This therefore helps to optimise maintenance activities through early identification of these defects.

Experiments sessions were organized in SZ-Slovenia and AFER-Faurei, with success, and the results proved the TRL 6 level of the development.
Acceleration monitoring system for overhead contact line

Because of extreme conditions in which the system has to work, experiments were performed at two levels, more than for other systems developed.

The overhead line acceleration monitoring is expected to operate in the very difficult conditions of 25 kVac of the contact line in Romania, which causes concern that high levels of electromagnetic radiation would damage the sensors. Therefore, two levels of testing were performed:

1. Laboratory environment: ADS laboratory and USFD specialized laboratory
2. Real field conditions: AFER organized tests, at Faurei test ring

The main project requirement of the system is to acquire a large amount of data over a long time period, this has been solved by the total system’s power autonomy solution, using batteries and photovoltaic cells.

Another requirement for the system to be low cost this was achieved through design and development of the system, from the integrated circuits level, inside the project.

The desired final goal was to help changing to “on-demand” maintenance strategy.

Novel characteristics of the system include: total autonomy in terms of power supply; digital and precise sensors; wireless communication.

Tests results proved the system functionality and reliability. These demonstrate the system to TRL 6.
High speed video data gathering from pantograph and overhead line contact

The main objective of the video camera system is to register, for slow motion analysis, the dynamic behaviour of the overhead line, under action of the contact force.

High speed video filming from locomotive roof

High speed video filming from side of the track

The high speed video system consists of one high speed video camera and accessories. All data are visualized and recorded on Laptop connected to it.

The recordings were achieved with a high sampling rate (eq. 350 - 500 FPS).

Experiments were made: Romania (RCCF-Brasov and AFER-Faurei); TCDD-Turkey; SZ-Slovenia.

This high speed camera system and the overhead line accelerometers aim to increase the understanding of overhead line dynamic behaviour, leading eventually to better designed systems with lower maintenance requirements.
Trolley wire for lesser used, secondary lines

Trolley wire overhead line systems were modeled using LS-Dyna to investigate the potential for a low cost overhead line system with simpler construction. The LS-Dyna models were validated for speeds up to 200km/h for a conventional catenary wire system, but the trolley wire system was shown to be stable for speeds of up to 100km/h. The models were also used to investigate the impacts of varying wire tension on the dynamics of a catenary wire system, and the resulting impacts on the overhead line system life.

The University of Sheffield experimental test rig was also used to study the dynamic responses of the contact wire with varying tension and also to test and validate the overhead line accelerometers also developed within WP3.
WP4 – Monitoring and Smart Technology

Work Package leader: TU Delft

Objectives

The objective of this work package is to develop smart technology solutions for three major problems faced by lower density lines. It will develop:

Cost effective inspection and asset management to minimise maintenance interventions time/cost without dedicated inspection vehicles.

- Plain line and S&C track based system
- Train based system (axle box acceleration)
- Ultra low cost smartphone based

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 data into management information.

Acceleration monitoring system for plain line and S&C

The developed solution is suitable for plain lines and also for turnouts with S&C components. The system has also proven to be useful for curve sections. With this monitoring system, maintenance can be further improved by allowing the design of an “on-demand” strategy. Some interesting facts of this system:

- Total autonomy in terms of power supply. Digital and precise sensors. Wireless communication.
- Test sessions were completed at RCCF-Brasov in Romania, AFER-Faurei in Romania and TCDD railway line in Turkey.
- The system can acquire large amount of data over a long time period using the total system’s power autonomy solution, based on batteries and photovoltaic cells.
- The system is low cost and designed at an integrated circuits level and developed to be suitable for secondary lines and other railway lines.
- The system can be integrated with the monitoring system of accelerations from the overhead contact line in the same area, as an integrated system.
- After tests in the NeTIRail-INFRA project, the system can be considered to have reached TRL 6 development level.

Further details can be found in the related deliverables:

D4.1: Data collection equipment in the laboratory environment, and plan for field trials

D4.2: Low cost track based monitoring modules for plain line and S&C

D4.11: Validated monitoring equipment produced by testing of instrumentation in the real environment
Axle box acceleration monitoring system

The developed solution is suitable for the monitoring of rail, including also welds, S&C, insulated rail joints, among others. The system has proven being useful for detection or rail surface defects such as squats, corrugations, wheel-burns, etc. With this monitoring system, grinding operations can be further optimized by focusing into those segments of rail with high density of light defects. The system also allows the ranking of severe defects, so that replacement operations can be focused to the most urgent rail segments. Some interesting facts of this system:

► The detection of local defects with different severity levels is possible. Measurements conducted in the Netherlands and Romania prove the generalization capabilities of the ABA system, with the possibilities of implementation in railway networks in other countries.
► Detailed information of the defects can be used to optimize grinding plans, so to aim at areas with light defects (such as seed squats, light squats) where grinding is still effective.
► In the case of severe rail defects (such as moderate and severe squats), a ranking of these can be conducted based on the highest energy of the ABA signals, so that replacement operations are conducted first in the most severe locations.
► ABA measurements can be obtained during operation with a train while transporting passengers, as shown with the tests conducted in the railway line near Brasov, Bartolomeu-Zărnești in Romania.
► The ABA system can detect defects and responses at weld, S&C and insulated joints at both conventional and high speeds. From tests conducted in the Faurei testing ring, ABA proved efficient at a wide speed range from low to high speed (20 km/h up to 220 km/h), making the system suitable for metro, conventional and high speed railway.
► After tests in the NeTIRail-INFRA project, the system can be considered to have reached TRL 8 development level.

Further details can be found in the deliverables:

D4.3: Development of technology for track and ride quality monitoring
D4.4: Track and ride quality monitoring technology based on train-borne measurements in standard vehicles.
D4.7: Harmonised interface to transmit onboard monitoring data to the traffic control centre
D4.9: Interface definition for input of GNSS (or ground-based train odometry) location data to monitoring technology.
D4.11: Validated monitoring equipment produced by testing of instrumentation in the real environment

ABA measurements were performed in October 2017 in the test ring Faurei of AFER, Romania

ABA measurements where performed end of September 2016 in the line Bartolomeu-Zarnesti of RCCF in Romania
Dynamic measurements in Slovenia

In Slovenia rail track monitoring is performed with precise measuring trains and with portable equipment. Many different measuring methods are used, like measuring geometric parameters (Stability, Direction, Twist, Cant etc.), rail diagnostics (Ultrasonic control, Rail wear, Corrugation, Eddy current etc.), dynamic track parameters (vertical, lateral acceleration) and visual inspection.

Dynamic measurements are carried out with portable equipment, with sensors mounted on a bogie of a passenger train and connected with the measuring system in the cabin of a train. Vertical and longitudinal acceleration are measured with more sensors and from the data average vertical and average longitudinal accelerations are calculated.

Beside acceleration, kilometre position of a train is measured as well. The equipment consists of low frequency (Dewesoft) accelerometers with a frequency range of 80 Hz and high frequency (Dytran) accelerometers with frequency response 0-2500 Hz. The high frequency sensors were added within NeTIRail-INFRA project to upgrade the dynamic equipment and to research the difference in detection between different frequency vibrations. The difference is in amplitude of signals.

In the picture below both kinds of sensors are installed together on a bogie under the cabin of a train. Comparison of dynamic measurements with geometric and corrugation measurements showed the following results: correlation of vertical acceleration with stability and twist, correlation of lateral acceleration with direction and cant, correlation of corrugation with larger difference in vertical acceleration between high and low frequency sensors.

After comparison of different monitoring methods the conclusions can be that there is a great reliability on the correlation between dynamic and geometric parameters, but correlation for corrugation with a dynamic vertical parameter is not so pronounced. In case of corrugation, sensors should be placed closer to the formation of the corrugation and correlation in this case is more reliable.

Results of research measurement methods within NeTIRail-INFRA project prove that dynamic measuring equipment has a good potential of usability for “early diagnostics” purposes, such as detecting poor places where failures on rail lines appeared or can occur in the near future. With further research, testing of different sensors and improving of the measuring system we can develop a good dynamic monitoring method usable for detection of a wide spectrum of deviations on railway tracks.
Smartphone sensors application

The developed application is based on smartphone sensors technology, and it is used for infrastructure monitoring from within passenger vehicles. The smartphone application collects in real time the following information: Position of the acquisition point (latitude and longitude), timestamp, acceleration along three axes (x, y and z-axis, including gravity), speed, roll and pitch, and perception of ride comfort according to ISO-2631-1:1997 at the acquisition point.

- The solution includes crowd-sourced data collection, which helps to increase the volume of monitoring data and provide information about the regularity and granularity of monitoring track section.
- Data collected from busy capacity limited passenger railway, low density line and also freight dominated route help to increase knowledge of how track condition correlates with ride quality, and the effect of vehicle suspension on the vibration data.
- Several sessions of recordings and data collection were made with this application including: RCCF-Brasov, AFER-Faurei, TCDD-Turkey, and SZ-Slovenia. From this list, the session that allows the deepest analysis and post-processing is that one from RCCF-Brasov, due to ABA tests being carried out on the same railway line and it is possible to conduct a comparison from the two systems and prove that the same severe defects are detected by both systems in the same locations.

Further details can be found in the related deliverables:

- **D4.5**: Development status of smartphone technology for track and ride quality monitoring
- **D4.6**: Low cost smartphone based track and ride quality monitoring technology
- **D4.11**: Validated monitoring equipment produced by testing of instrumentation in the real environment
Upgrading old interlocking systems

Older CEM (Centralized Electro Mechanical) Interlocking Systems are still used for lower density lines, where shunting is a rare event. The main concerns are about safety deficiency: the information about CEM devices status are not usually available to the station operator. The solution developed in NeTIRail-INFRA is based on real time monitoring of the CEM status, for all in the field devices.

► The main advantage of the system is its completely autonomy and being non-invasive for existing CEM systems.
► The information about CEM status is entirely wireless transmitted.
► Increase the safety of interaction operator-installation through real time and reliable info.
► The system creates historical database of CEM operations and events and it will increase station operator responsibility.
► The tests for functionality validation were accomplished at RCCF-Brasov partner.

Further details can be found in the related deliverables:

D4.8: Functional, operational and technical specification for simplified interlocking of user autonomous switches in low density lines

D4.11: Validated monitoring equipment produced by testing of instrumentation in the real environment

Current situation: switch and signal

Sensor device and concentrator device for status monitoring
Tailored decision support through conversion of data to information

A data management framework that ensures a homogeneous and harmonized treatment of the various monitoring data produced was developed. Such a framework establishes a set of data structures that allow for encoding and integrating the various data produced, so as to generate valuable information for decision makers. Besides, the defined framework will serve as an input to the RailTopoModel (RTM) which is a generic railway infrastructure data model that aims to support current and future business usages and needs.

Further details can be found in the related deliverable:

**D4.10**: Tailored decision support for track and vehicle maintenance through conversion of data to information.

UML class diagram for monitoring data
WP5 – Societal perspective

Work Package leader: University of Freiburg

Objectives

The objective of WP 5 is to **assess and quantify possible societal effects caused by the decisions made about railway infrastructure**. The desired outcome is the interconnection of the results of the ethical and societal analysis with information on the NeTIRail-INFRA to be supplied to WP1 and WP6.

This is an important topic for the project in view of the great impact of rail travel on the mobility of the future. Currently there is a big need for individual traffic solutions (now addressed mostly with private cars or taxis) to get you to the nearest big railway station, yet a greater number of viable local lines could drastically improve this situation. Freight movement of consumer and industrial goods to and from major hubs has similar issues. Understanding the true societal impact of transport enables better choices of infrastructure and the train operations it can support.

Transport innovations have the potential to considerably impact on society. By improving connectivity, they can enable passengers to better reach destinations important for employment, education and health care. WP5 developed a methodology to assess the societal impact of railway innovations that can also be used beyond the scope of the NeTIRail-INFRA project. It also assessed the expected impact of the innovations developed by the technical work packages on the NeTIRail-INFRA case study lines in Romania, Slovenia and Turkey. The assessment was based, among others, on the results of a wide passengers’ survey carried out in the three countries, with more than 1,000 questionnaires collected and analysed. The survey results are presented in the NeTIRail-INFRA deliverable 5.2, available on the project’s website. WP5 also combined the societal impact assessment with the results of the cost-benefit analysis conducted in WP1 and provided input for the decision-support tool developed in WP6.

### Comparison use of train

<table>
<thead>
<tr>
<th>Location</th>
<th>Purpose: work, business, school, health care</th>
<th>Regular users: only employed people</th>
<th>only train</th>
<th>move house/give up work</th>
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<tr>
<td>RO Bartolomeu-Zărnești</td>
<td>83%</td>
<td>61.50%</td>
<td>93%</td>
<td>80,50%</td>
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<td>SLO Ljubljana-Kamnink</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>93%</td>
</tr>
<tr>
<td>SLO Pivka – Ilirska Bistrica</td>
<td>0%</td>
<td>52.80%</td>
<td>65%</td>
<td>50,80%</td>
</tr>
<tr>
<td>TU Sincan / Ankara – Kayaş</td>
<td>0%</td>
<td>8%</td>
<td>0%</td>
<td>84,60%</td>
</tr>
<tr>
<td>TU Divriği – Malatya</td>
<td>8%</td>
<td>25.25%</td>
<td>46%</td>
<td>32,30%</td>
</tr>
</tbody>
</table>

The NeTIRail-INFRA Passenger Survey
WP6 – Evaluation and decision support tools

Work Package leader: International Union of Railways

Objectives

WP6 has a threefold objective:

- **gather** the necessary, network-related technical and operational data;
- **expose these data via a web interface** that will be used by other WP for performing evaluations of potential infrastructure upgrades;
- **prepare the same tool and datasets** for further usage outside the Project.

Within WP6 a web based GIS decision support tool has been developed which allows the display of infrastructure data gathered from the RINF database, as well as additional user data and the creation of custom formula to demonstrate the cost impacts and societal assessment of the NeTIRail-INFRA innovations.

The cost impacts have had to be converted into a form that is accessible to web application. For this purpose the calculations have been simplified, and average maintenance costs used. The cost impacts are calculated using a log-log functional form with:

- **Variables**: selected line parameters provided by RINF or by the user, and
- **Coefficients**: derived from various public sources
- **Function which can be re-written** on the fly by advanced users

And this data is stored within the web application.

For the social impact analysis, there are six relevant criteria identified from WP5, these are:

- Personal experience: Crowding, Comfort, Safety
- Service quality: Punctuality, Frequency, Journey time

The impacts of the innovations are not monetarized, and as the customer satisfaction data is based on questionnaire results, it is specific to particular routes and lines and cannot be generalized, for new routes (not included in the NeTIRail-INFRA project) these criteria must be based on factors which are inputted by user based on either surveys related to these new routes, or from expert opinion. The results of the social impact are compounded and displayed on selected lines using a colour coding system.

To allow for these functions the WP6 tool has two interfaces, the “Regular User Interface” and the “Administrator Interface”. The Regular User Interface allows for lines to be selected and data related to those lines and operational points to be viewed, sorted and searched. The Administrator Interface has been developed to allow the user to input custom data, this can be related to the cost and societal evaluations, or related to further functions developed by end users for their customized use of the tool. The Administrator Interface also allows for the input and editing of equations, these are used within the project for the calculation of financial and societal benefits, and these existing equations can also be customized by the user. Or the user may also add completely new functions to the tool to create their own custom calculations for whatever purposes they require.
Existing RINF XML files

Uploading XML file from local repository

Local files
The Final Conference of NeTIRail-INFRA, co-organised by UIC (dissemination leader) and SŽ, opened on May 24 at the Prometni Institut within Slovenian Railways (SŽ), in Ljubljana.

The conference, attended by around 40 participants from across Europe’s rail infrastructure industry and academia, was opened on the morning of 24 May by Mr. Blaz Jemensek on behalf of Mr. Peter Verlič, Director of the Prometni Institut within Slovenian Railways, and Dr. David Fletcher, Project Coordinator, University of Sheffield. The day’s sessions were moderated by Mr. Jonathan Paragreen, Project Manager, University of Sheffield.

Mr. Blaz Jemensek on behalf of Mr. Peter Verlič, welcomed the participants and highlighted the importance of projects such as NeTIRail-INFRA. He said: “NeTIRail-INFRA is an important project for infrastructure managers as it enables them to make cost savings through the maintenance of infrastructure. It is a project that connects Europe – from the UK to Turkey – and represents an excellent opportunity for us.”

Dr. David Fletcher, Project Coordinator, University of Sheffield, gave a final overview of the project’s aims and objectives. He explained the economic viability and the societal impact of the innovations: “Many projects are quite technically-focused, and so we wanted to bring in the economic and societal impacts.”

The sessions then featured presentations by the various work packages on the results, innovations and impacts of the experiments and activities conducted throughout the project.

Highlights of the conference included:

► Presentation of all of the technologies developed within the NeTIRail-INFRA project
► Demonstrations of sensor technologies and the decision support tools
► Visit of the Slovenia railway museum

All presentations given during the final conference are available for download at: http://netirail.eu/-News-and-Events-3-

Videos of the presentations are available on YouTube at: https://www.youtube.com/playlist?list=PL8AlkKGU64W_cB6h-hC0EBelEMgo-u2Ui
NeTIRail-INFRA videos

Several videos have been made to present the project and its main achievements. These videos cover the following fields:

- Overview of the NeTIRail-INFRA project
- NeTIRail-INFRA WP4 demonstrations
- Overview of NeTIRail-INFRA WP4 - Monitoring and Smart Technologies
- NeTIRail-INFRA Track and Overhead line accelerations monitoring
- NeTIRail-INFRA Smartphone monitoring of train accelerations and passenger comfort
- NeTIRail-INFRA ABA Axle Box Acceleration System
- NeTIRail-INFRA Interlocking devices
- NeTIRail-INFRA High speed video camera analysis of overhead line dynamics
- NeTIRail-INFRA Switch and Crossing monitoring

All these videos are available on the NeTIRail-INFRA website at: http://netirail.eu/Documents-and-Downloads#Videos.
WP4 Training workshop

A training workshop has been organised at UIC in Paris on 31 May 2018 to present all of the technologies developed within WP4 (Track monitoring innovations and results).

This training workshop is now available at: https://youtu.be/Blg6lSdbzAc

NeTIRail-INFRA workshop in Ankara, Turkey

After the final conference organized in Slovenia, the dissemination impact of the NeTIRail-INFRA project was extended by a workshop in Ankara, Turkey. A two half-day workshop was organised on May 29th and May 30th. The workshop was performed in Turkish to get more attendance in the Turkish railway sector. As expected, most participants came from the Turkish State Railways (TCDD) and Raysimas Co. (private sector). There were more than thirty participants.

The workshop was organised to explain the general concepts of NeTIRail-INFRA and the presentations prepared for the final conference were translated into Turkish. The first day of the workshop was dedicated at explaining the NeTIRail-INFRA project and presenting the results of the project. The second day of the workshop was more specialised on activities performed by TCDD and INTADER. During the workshop, NeTIRail-INFRA website, published reports and contact details were amply shown to enable participants to learn more about the project.

The presentations of the project in Turkish are available for download on the website at: http://netirail.eu/-News-and-Events-3-
TEN-T Days

NetIRail-INFRA was presented at TEN-T Days 2018 in Ljubljana, 25-27 April

TEN-T Days 2018 was held in Ljubljana from 25 to 27 April. With over 2,000 registered participants and 26 Ministers of Transport in attendance and with around 100 exhibition booths, TEN-T Days offered an excellent opportunity for transport industry stakeholders to meet and exchange innovative ideas. NetIRail-INFRA was one of the indoor exhibitors, and TEN-T days provided an excellent opportunity to announce the final project conference and to present the project results.

Ms. Christine Hassoun, UIC Senior Advisor, Project Dissemination and Ms. Violeta Bulc, EU Commissioner for Transport

Mr. Jon Paragreen, Netirail Project Manager, Ms. Christine Hassoun, UIC Senior Advisor, Project dissemination, with Ms. Vlasta Miklavžin and Mr. Jakob Klofutar from Slovenske železnice
List of Deliverables

Once they are approved, all NeTIRail-INFRA deliverables are made available at: http://netirail.eu/Documents-and-Downloads#Deliverables

WP1: Contrasting market needs, and business case

D1.1 Report on selection of case studies.
D1.2 Database of economic data on case study lines, with accompanying meta-data report to document structure.
D1.3 Cost model development report.
D1.4 Cost and User benefit report.
D1.5 Wider economic benefits intermediate report.
D1.6 Wider economic benefits final report.
D1.7 Incentives final report.
D1.8 Final business case synthesis final report.

WP2: Tailored track infrastructure, design and maintenance

D2.1 Analysis of "big data": geospatial analysis of costs, drivers of failure and life of track infrastructure.
D2.2 Practices and track technology tailored to particular lines.
D2.3 Cost/benefit data and application methodology for lean in railway S&C.
D2.4 Application of lean and automotive industry techniques to produce a step change in railway S&C life and costs.
D2.5 Corrugation reduction strategies for NeTIRail-INFRA track types, with estimates of costs and benefits.
D2.6 Tailoring track to avoid corrugations: Traffic dependent selection of rail cross-section, clips and pads to avoid or delay corrugation.
D2.7 Lubrication systems and data available, with estimates of costs and benefits.
D2.8 Tailoring lubrication to duty and climate: Safe, effective and eco-friendly avoidance of track wear and damage.
D2.9 Preliminary transition zone model and detailed modelling plan.
D2.10 Cost effective transition zone design tailored to line type and traffic.
WP3: Tailored overhead line power supply infrastructure

D3.1 Power supply technologies and practices of low and high-density railways, identifying learning points and future opportunities.
D3.2 Analysis of "big data": tailoring overhead line infrastructure specification and needs through geospatial analysis of duty and life of equipment.
D3.3 Model to support increasing the resilience of power supply infrastructure to changing climate.
D3.4 Modular packages of component grades and design specifications for new installations of power infrastructure tailored to traffic and operational needs.
D3.5 Tailored combinations of wire tension, pantograph collector strip material and upload force for optimum performance.
D3.6 Data on system damage for different combinations of wire tension, pantograph collector strip material and upload force.

WP4: Monitoring and Smart Technology

D4.1 Data collection equipment in the laboratory environment, and plan for field trials.
D4.2 Low cost track based monitoring modules for plain line and S&C.
D4.3 Development of technology for track and ride quality monitoring.
D4.4 Track and ride quality monitoring technology based on train-borne measurements in standard vehicles.
D4.5 Development status of smartphone technology for track and ride quality monitoring.
D4.6 Low cost smartphone based track and ride quality monitoring technology.
D4.7 Harmonised interface to transmit on-board monitoring data to the traffic control centre.
D4.8 Functional, operational and technical specification for simplified interlocking of user autonomous switches in low density lines.
D4.9 Interface definition for input of GNSS (or ground-based train odometry) location data to monitoring technology.
D4.10 Tailored decision support for track and vehicle maintenance through conversion of data to information.
D4.11 Validated monitoring equipment produced by testing of instrumentation in the real environment.

WP5: Societal perspective

D5.1 Societal and legal effects of transport decision: Stakeholder analysis.
D5.2 Perception of different service options: User study and data analysis
D5.3 Balancing societal effects and cost-benefit of different infrastructure decisions.

WP6: Evaluation and decision support tools

D6.1 Confidentiality policy and agreements.
D6.2 Data report on network-related technical and operational data.
D6.3 GIS-based web application
D6.4 Decision support tools for implementation of technologies.
D6.5 Case study line data scenarios playable in the web application.
D6.6 Cost-benefit and societal analysis report illustrated by case Study line data.
D6.7 Status report on current design & maintenance criteria relative to needs, static illustration for case study lines.

WP7: Dissemination, training needs and influence on guidelines and standards

D7.1 Project Flyer.
D7.2 Project Website (public and private).
D7.3 NeTIRail-INFRA Newsletters (3 issues).
D7.4 NeTIRail-INFRA Final brochure.
D7.5 Overview of technical developments and innovation with direct or possible future expected impact on existing guidelines.
D7.6 Overview of project related recommended future development needs.

WP8: Project coordination

D8.1 Project Management Plan.
D8.2 Project Quality Plan.
## Consortium

**COORDINATOR:**

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<th>Code</th>
<th>Country</th>
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Conclusion

The NeTIRail-INFRA project has delivered the aims which were conceived at the grant preparation stage. This project has successfully demonstrated a range of technologies through simulations and modelling, experimental work, on track demonstrations and through the delivery of the decision support tool. The NeTIRail-INFRA has developed the project innovations specifically to suit different line categories and geographical locations, and the final technology readiness of each innovation and recommendations for their future development can be found in deliverable D7.6, Overview of project related recommended future development needs.
Consortium

Co-ordinator

Partners

UNIVERSITY OF LEEDS

uic

Digital Systems

SAFER

TUDelft

Slovakia

IFSTTAR

TU Delft

TCDD

IntaDer

vti

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