SECOND PERIODIC REPORT

PUBLISHABLE SUMMARY

DEVELOPMENT OF A SMART FRAMEWORK BASED ON KNOWLEDGE TO SUPPORT INFRASTRUCTURE MAINTENANCE DECISIONS IN RAILWAY CORRIDORS

Grant Agreement number: 314031

This project has received funding from the European Union’s Seventh Programme for research, technological development and demonstration under grant agreement No 314031
Grant Agreement number: 314031

Project acronym: OPTIRAIL

Project title: DEVELOPMENT OF A SMART FRAMEWORK BASED ON KNOWLEDGE TO SUPPORT INFRASTRUCTURE MAINTENANCE DECISIONS IN RAILWAY CORRIDORS

Funding Scheme: COLLABORATIVE PROJECT

Date of latest version of Annex I against which the assessment will be made: 21ST JUNE 2012

Periodic report: 1st [] 2nd [X]

Period covered: From 1st April 2014 to 30th September 2015

PROJECT COORDINATOR¹
VIAS Y CONSTRUCCIONES, S.A.
CARLOS MARTINEZ BERTRAND (carlos.martinez@vias.es)
Tel: (+34) 914179800
Fax: (+34) 914179833

Project website² address: http://www.optirail.eu/optirail/

¹ Usually the contact person of the coordinator as specified in Art. 8.1. of the grant agreement.
² The home page of the website should contain the generic European flag which is available in electronic format at the Europa website (logo of the European flag: http://europa.eu/about-eu/basic-information/symbols/flag/index_en.htm). The area of activity of the project should also be mentioned.
## Document Approvers

<table>
<thead>
<tr>
<th>Partners</th>
<th>Approvers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VIAS</td>
<td>Manuel Menéndez</td>
</tr>
<tr>
<td>2. CARTIF</td>
<td>Marta Galende, Gregorio Sainz</td>
</tr>
<tr>
<td>3. LTU</td>
<td>Diego Galar, Roberto Villajero, Carl-Anders Johansson</td>
</tr>
<tr>
<td>4. UGR</td>
<td>José Manuel Benítez</td>
</tr>
<tr>
<td>5. OSFTALIA</td>
<td>Frank Klawonn</td>
</tr>
<tr>
<td>6. SINTEF</td>
<td>Andreas Seim</td>
</tr>
<tr>
<td>7. MERMEC</td>
<td>Francois Defossez</td>
</tr>
<tr>
<td>8. EVOLEO</td>
<td>Pedro Ribeiro</td>
</tr>
<tr>
<td>9. ADIF</td>
<td>Diana Alonso</td>
</tr>
</tbody>
</table>
CONTENT

1. PUBLISHABLE SUMMARY ................................................................. 5
   1.1 PROJECT AND OBJECTIVES ...................................................... 5
   1.2 WORK CARRIED OUT WITHIN THE PROJECT ............................. 6
   1.3 RESULTS AND POTENTIAL IMPACTS ....................................... 7
DECLARATION BY THE SCIENTIFIC REPRESENTATIVE OF THE PROJECT COORDINATOR

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;

- The project (tick as appropriate):
  - [ ] has fully achieved its objectives and technical goals for the period;
  - [ ] has achieved most of its objectives and technical goals for the period with relatively minor deviations;
  - [ ] has failed to achieve critical objectives and/or is not at all on schedule.

- The public website is up to date, if applicable.
  - [x] is up to date
  - [ ] is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 6) and if applicable with the certificate on financial statement.

- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 5 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Carlos Martínez

VIAS Y CONSTRUCCIONES, S.A.

Date: 27 / November / 2015

Signature of scientific representative of the Coordinator:

3 If either of these boxes is ticked, the report should reflect these and any remedial actions taken.

4 If either of these boxes is ticked, the report should reflect these and any remedial actions taken.
1. PUBLISHABLE SUMMARY

1.1 PROJECT AND OBJECTIVES

The main objective targeted by the OPTIRAIL project aims at developing a new tool, based on Fuzzy and Computational Intelligence techniques and validated through two case studies, that will enable the better cross-border coordination for decision making of railway infrastructure maintenance across the European railway corridors.

The project is led by the Spanish construction firm VIAS Y CONSTRUCCIONES (VIAS) specialised in the maintenance of railway corridors, and includes a series of universities, technology centres and specialised companies from 6 European countries with complementary skills and expertise. The 9 partners participating in the project are: VIAS, the Spanish research and technology centre CARTIF, Luleå University of Technology (LTU), University of Granada (UGR), Ostfalia University of Applied Sciences (OSTFALIA), the Norwegian research organisation SINTEF, the companies MER MEC and EVOLEO TECHNOLOGIES, and the public Spanish Railway Infrastructure Manager ADIF. Furthermore, non-participant railway administrators have shown their interest and commitment to the project as part of the Advisory Board such as: TRAFIKVERKET (Sweden), JERNBANEVERKET (Norway), REFER (Portugal), NETWORK RAIL (United Kingdom), INSTYTUT KOLEJNICTWA (Poland).

The work package (WP) overview to reach the objectives is shown below:

FIGURE 1. WORK PACKAGES STRUCTURE.
WP1 “Specifications & Requirements”, WP2 “Analysis of transferability of tools”, WP3 “Tool conceptual design”, WP4 “Fuzzy & CI models” and WP5 “Integration and usability validation” are the different RTD activities of the project, developing the different solutions that will be demonstrated in two case studies (WP6). Moreover, WP7 “Dissemination and Networking” and WP8 “Project Management and Coordination” are transversal WPs.

Finally, it has to be remarked that OPTIRAIL started in October 2012 and it has been finished in September 2015. Further information about the project can be found on the project website, http://www.optirail.eu.

1.2 WORK CARRIED OUT WITHIN THE PROJECT

The activity on WP1 was to analyse the requirements and needs (regulations, procedures, etc.) for the development of the smart railway maintenance decision support system. This analysis shows a complete picture about how the tracks are, how they are managed among the different countries in Europe, and how the railway domain (tracks, networks, corridors...) can be improved.

In WP 2, we have summarized maintenance practices in four high criticality infrastructures: Electricity networks, gas (subsea) distribution infrastructure, water infrastructure, and airports. The purpose of these case studies was to identify practices that could be implemented in OPTIRAIL tools and contribute to the improvement of rail infrastructure maintenance.

As OPTIRAIL tool is based on Computational Intelligence (CI) and fuzzy techniques and these ones are based on data and expert knowledge, WP1 contributed towards establishing the foundations for the conceptual design of the smart framework, WP3, and the development of the different degradation models, WP4, mainly, through the description of the relevant elements, aspects and operations of the railway maintenance areas as the description of the main ICT systems, and the data stored in them, used by different railway managers, highlighting the difference between them in order to improve the corridors interoperability.

The work in WP3 was focused on developing a general conceptual framework for OPTIRAIL initiative. The SOA (Services Oriented Architecture) client-server architecture is based on three layers: user
interface, business logic and data & knowledge acquisition. The final objective was to obtain an optimized railway maintenance plan to be applied in all scenarios in the cross-border freight corridor. The framework has been designed with an open concept, so new data issues and alternative solutions can be added on each level of the OPTIRAIL framework, to update and/or improve the OPTIRAIL performance at any moment through the possible best solutions for each issue.

WP4 aims at building fuzzy and Computational Intelligence models for predictive maintenance, which are then included in a multi-objective optimization framework. Condition data is aligned and dynamic segmentation is used to get time series of the condition data for homogeneous sections of the track. These can then be used to predict the need of maintenance operations. Then, using historical condition data and work orders, fuzzy and CI models can be used to learn a relationship between these two. The resulting models can then be used on predicted condition data to forecast and propose necessary maintenance operations, in a decision support system. Finally, this knowledge can be included in a multi-objective optimization framework to make maintenance decisions, optimized for various objectives.

Within WP5 (Integration and usability validation) a partial implementation and integration of the conceptual framework (defined in WP3) has been carried out based on an existing platform that will validate from ICT and CI points of view.

Finally, once the proposed solutions were integrated and tested on a commercial platform, WP6 (Pilot tests) has carried out the final tests of the integrated system. Two pilot tests have been selected out in Spain and other in Sweden in order to validate the use of the developed technology in the railway infrastructure.

1.3 RESULTS AND POTENTIAL IMPACTS

OPTIRAIL project results main impact will be to contribute to easing common EU maintenance routines and coordination techniques, to improve the railways interoperability in the European Union in order to promote a single European rail market. In addition, the project will also bring new information systems to support maintenance decisions, using smart controls, which will increase the competitiveness of the different states and of the whole Union.
Regarding to the specific results obtained in each WP, WP1 has highlighted the differences between how the maintenance operations/systems are planning by railway managers and the main differences in track elements and its characteristics. This information will be used to define common practices and the standardization of criteria and needs for interoperability purposes.

On the other hand, WP2 has identified several practices from four different industries, which would likely reduce the cost and improve the effectiveness of railway infrastructure maintenance.

WP3 has proposed an open conceptual design. This framework can work with both data and expert knowledge, and allows obtaining the maximum benefits to manage simultaneously both sources of information in the models developed in WP4. European Standards have been taken into account, so all the available information can be considered in order to obtain an optimized maintenance plan. Thus, WP3 presents some ideas about the cross-border coordination in order to improve the current situation, where the cooperation between countries does not seem to be a common practice.

In addition, WP4 will contribute to a more effective and standardized maintenance with a standard methodology for the use of condition data. Such a standard can be seen as the base for cross-border maintenance, as standardization yields interoperability and facilitates collaboration. OPTIRAIL has identified the need for data standardization on all types of data but geometrical auscultation data, where there exists the standard EN-13848-5. Besides, WP4 has developed methodologies for predictive deterioration and effect models of maintenance.

All the developments carried out within WP4, have been validated and its integrability has been tested into commercial maintenance platforms (RAMSYS Platform) within WPS. As a consequence, a validation guideline has been provided for the full or partial implementations of the OPTIRAIL framework that ensures the key points and performances of the OPTIRAIL framework functionality and usability.

Finally, the most relevant designs and models have been validated within two case studies (Spain and Sweden). In this way, OPTIRAIL proposes viable solutions to improve railway infrastructure maintenance routines to ensure a higher availability of this infrastructure along corridors.