PROJECT

PANTOTRAIN

PANTOgraph and catenary interaction: Total Regulatory Acceptance for the Interoperable Network

Funding: European (7th RTD Framework Programme)
Duration: Jun 2009 - May 2012
Status: Complete with results
Total project cost: €3,534,167
EU contribution: €2,166,370

Call for proposal: FP7-SST-2008-RTD-1
CORDIS RCN: 93087

Background & policy context:

The current interoperability approval process for new High Speed and Conventional railway vehicles in Europe is a very long and costly process. The European Railway Agency (ERA) is charged with the development of new and future Technical Specifications for Interoperability (TSIs), which provide common regulations for the authorisation of placing new vehicles into service. TSIs will provide a safe and technically-compatible railway system for Europe by specifying requirements for all the different relevant technical aspects. However, they will not directly eliminate the burdens that currently affect the railway industry and the railway undertakings regarding new vehicle approval on each European network.

TSIs are a set of common minimum requirements and therefore, not optimal for each network administrator and/or railway undertaking. Placing a new vehicle in service, even if compliant with TSIs, still requires network approval by each National Safety Authority (NSA) responsible for the Member State in which the vehicle is to be operated.

In addition to the handicaps mentioned above, it is important to take into account the lack of compatibility of the national assessment methods. Therefore, it is often requested by the Member States to repeat specific tests for homologation that are, as a matter of fact, analogous to those tests already performed in other countries. At present a full harmonisation of the assessment methods required does not exist, although the evolution of new and expanded European standards is helping to close the gap.

The Technical Specifications for Interoperability provide common regulations for the certification of new rolling stock but do not directly eliminate the current burdens regarding new vehicle approval on each network. In this context, the pantograph/catenary system represents one of the major barriers to rolling stock interoperability. Indeed, each country has developed its own overhead line equipment leading to different catenary designs with variations in mechanical properties.

A unified approval method is a key subject that must be addressed to provide a competitive railway system. Hence, PANTOTRAIN proposes to transfer the pantograph/catenary certification from current line testing towards laboratory testing and simulation. This will improve pantograph interoperability, increase train performances on the existing infrastructure and achieve considerable costs and time savings for the certification of new pantographs.

The PANTOTRAIN project

Objectives:

The high level objectives of the PANTOTRAIN project included the following goals:

- To introduce new procedures based on numerical simulations and Hardware-in-the-Loop testing and to reduce migration time for the implementation of new interoperable solutions in the current
certification process of the pantograph/catenary system;

- To use the numerical and physical simulation to extend pantograph certification to different catenary systems, thereby enhancing the interoperable use of existing infrastructure and the development of new interoperable pantographs;
- To foster the use of innovative and mechatronic pantographs, by understanding how the certification process needs these systems and by revising the limits provided by the TSIs;
- To use the simulated behaviour of new/modified pantographs or catenaries "close" to those already certified by line tests, thereby, avoiding to repeat certification tests on the new/modified designs and allowing the saving of a large portion of the associated costs;
- To foster the use of "Hardware-in-the-Loop"(HIL) testing as a more objective and less expensive alternative to line tests.

The technical objectives were:

1. Modelling and simulation tools:
   - To establish criteria to define and validate pantograph/catenary numerical simulation tools for use in the virtual certification process;
   - To investigate the effect of uncertainty parameters involved in pantograph/catenary modelling (their knowledge, as combined with simulation, will significantly improve the reduction of uncertainties in the certification process).

2. Advanced testing tools:
   - To develop and validate techniques based on the concept of "Hardware-in-the-Loop" simulation, tailored to the specific case of pantograph/catenary interaction, to shift part of the physical testing from the line to a laboratory.

3. Virtual certification for interoperability:
   - To collect a data-base of European catenary systems, to be used in combination with the simulation tools addressed by the project (this will significantly enhance the range of catenaries and pantographs to be potentially simulated, increase the efficiency of the combined test and simulation process, allow more extensive coverage of operational conditions and enable the assessment of pantograph performances in view of interoperability since the early stage of the design process);

Methodology:

The PANTOTRAIN project aimed at developing and introducing a computer-aided certification process to allow the reduction of the time and cost of pantograph certification against European norms (EN) and TSI by transferring current physical track tests to laboratory testing and numerical simulation. The same procedure was also envisaged to greatly improve the interoperability of pantograph systems across EU Nations, since virtual certification techniques would be applied to extend pantograph homologation across different National railway networks. The collection of the pantograph and catenary database at European level would be an essential step towards this ambitious goal.

The project was organised according to the following groups of activities:

1. Criteria to build and validate pantograph/catenary numerical simulation tools. The following tasks would be performed:
   - Analysis of key parameters affecting the accuracy of pantograph/catenary numerical models;
   - Procedure to build pantograph models based on laboratory tests;
   - Criteria to validate pantograph/catenary simulation tools.

2. "Hardware-in-the-Loop" testing of pantographs. The following tasks will be performed:
   - "Open loop" HIL testing;
   - "Closed loop" HIL testing.

3. Virtual certification for interoperability. The following tasks will be performed:
   - Collection of pantograph and catenary data base at European level;
• Procedure to extend pantograph certification to different catenary systems by numerical simulation;
• Procedure to extend pantograph certification to different catenary systems by HIL testing.
• Virtual extension of certification for a pantograph that presents minor changes from an already certified one. The following tasks would be performed:
  • Sensitivity analysis to assess the effect of variations in pantograph parameters for virtual extension of certification;
  • Analysis of aerodynamic properties via Computational Fluid Dynamics (CFD).
• New innovative pantograph designs with control functionalities. The following tasks would be performed:
  • Pantograph structural optimisation;
  • Certification of a mechatronic pantograph.
• Assessment of virtual certification procedures and Regulatory Acceptance. The following tasks would be performed.

**Parent Programmes:**
**FP7-SST - Sustainable Surface Transport**

**Institute type:** Public institution  
**Institute name:** European Commission  
**Funding type:** Public (EU)

**Lead Organisation:**

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<th>European Union Road Federation</th>
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| **Address:** Avenue Louise 106  
1050 BRUXELLES  
Belgium |
| **Organisation Website:** [http://www.unife.org](http://www.unife.org) |
| **EU Contribution:** €137,079 |

**Partner Organisations:**

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| **Address:** Avenida Del Partenón  
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<td>Rue Sarah Bernhardt 12/14/16</td>
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<td>92600 Asnieres Sur Seine</td>
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**EU Contribution:** €40,391

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**EU Contribution:** €18,388

**Rail Safety And Standards Board Limited**

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<td>Bombardier Transportation GmbH</td>
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Key Results:

The PANTOTRAIN team developed innovative tools, as well as novel pantograph designs which employed advanced systems combining mechanical and electronic systems with supporting software. PANTOTRAIN selected an appropriate computational fluid dynamics (CFD) simulation of the aerodynamic component including contact force, uplift of the catenary wire at the supports and vertical movement of the contact point from several algorithms. Simulation results were compared to test rig measurements and line test runs with excellent agreement amongst all three approaches.

Team members furthermore, developed an extremely accurate multi body model of a pantograph simulating the non-ideal behaviour of the joints by including realistic bushings in the model. Two prototypes of pantographs with active or smart control that adapts automatically via incorporation of sensors and actuators, were produced and tested with simulations and a test rig.

Assisted by its partners, PANTOTRAIN then optimised the models for use in field conformity assessments. Researchers proposed a homologation map providing mean and standard deviation of contact force and uplift, as well as a measure of the safety margin achieved by the conformity assessment.

Innovation aspects

The main innovative aspect of the project is the proposition of transferring the pantograph/catenary certification from current line testing towards laboratory testing and simulation. This will improve pantograph interoperability, increase train performances on the existing infrastructure and achieve considerable costs and time savings for the homologation of new pantographs.

Technical Implications

- Enhancement of the interoperability on existing infrastructure and development of new interoperable rail equipment;
- Reduction of the migration time for the implementation of new interoperable solutions;
- Development and implementation of TSI;
- Impact on the operational and technical integration of the different national railway systems in the EU and accession countries.

Policy implications

- Impact on competitiveness;
- Saving costs improves the overall competitiveness of the European Rail sector, encourages modal shift and protects the environment;
- Strategic impact of virtual certification on the rolling stock manufacturing industry;
- Strategic impact of virtual certification on railway undertakings;
- Addressing community societal needs;
- Health and quality of life: Higher safety and availability at lower costs for the users;
- Environmental issues.
Other results

The project will lead to updating the Current Technical Specifications for Interoperability (TSI) within five years. PANTOTRAIN expects to contribute knowledge vital to appropriate changes in TSI and European standards, leading to decreased certification costs, enhanced interoperability and safer train travel.

Strategy targets

Innovating for the future: Promoting more sustainable development.

**STRIA Roadmaps:** Network and traffic management systems
**Transport mode:** Rail transport
**Transport sectors:** Passenger transport, Freight transport
**Geo-spatial type:** Other