PUBLISHABLE EXECUTIVE SUMMARY

LIST OF PARTNERS

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<tr>
<th>Co-ordinator</th>
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<th>D2S</th>
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OBJECTIVE

The objective of this project is to improve the vehicle-track interaction in the turnout systems for urban rail transit, and therefore improve their efficiency, enhance their safety levels, reduce the required maintenance, and restrain the emitted noise.

These objectives are to be reached by reducing the loads and stresses in the frog and in the switch point/stock rail sections in comparison with a conventional turnout. The modern conventional turnout is of tangential geometry design and equipped with clothoidal transition curves. These eliminate the steady state flange contact-based form of curving condition in the diversion curve.

The following turnout systems will be considered: turnouts with cast manganese and welded frogs, turnouts on concrete slab and on sleepers in ballast, turnouts with grooved rail and with vignol (T) rail, embedded turnouts (tram) and free surface turnouts.

Mathematical models will be established in order to quantify the loads and stresses. The modelling procedures will be validated by means of measurement results on existing turnouts. The mathematical simulation of turnout negotiation poses three major problems: the rail profiles vary along the track, the track flexibility varies along the track, and the dynamic forces are complex: a horizontal force during curve negotiation and a vertical loading caused by gapping of the wheel at the flangeway gap. The forces
depend on the geometry of the turnout, the stiffness and damping of the turnout fixations and of the foundation, and the dynamic properties of the vehicle. Two different simulation approaches will be compared.

The first approach is based on a multi body dynamics model, which includes rails, fixation systems, foundation, and vehicle. Some bodies are described using 3D finite elements and other bodies using lumped parameters. A numerical procedure will be used to reproduce vehicle-track interaction whereby the equations of motion of track and vehicle are integrated simultaneously evidencing wheel-rail contact forces. This numerical simulation includes all non-linear effects and transient phenomena, which are relevant to turnout negotiation.

The second approach is based on a non-linear 3D finite element analysis of the turnout system where the performance of the turnout (without vehicle) is calculated through a non-linear transient dynamic analysis. The input forces and finite element model parameters are derived from lumped parameter models, which are updated using experimental measurement results (static and dynamic).

The objective is to obtain models capable of predicting the input forces within a margin of 3 dB considering known input data such as new or used wheels treads, track geometry, fixation characteristics, etc. The models will then be used to evaluate the effect of some important parameters on the impact forces: inertia of the frog section, wear of wheel tread, stiffness of the elastic components.

**WORK PERFORMED**

POLIMI has completed the development of the multi-body dynamics model and NTUA has completed its 3D finite element model. Both models have achieved the desired accuracy of predicting accelerations of rail and soil to within 3 dB.

The industrial partners and operators have pooled their knowledge and experience to produce a list of possible measures to reduce impact forces. The following selection of measures has progressed into the conceptual design phase for testing in the models and conversion into prototypes. The conceptual designs are generally the result of intense collaboration between a manufacturer and an operator and often combine a few design measures:

1. RATP development of a methodology for re-profiling of existing turnouts (measuring, grinding and welding).
2. BFM optimisation of the welding procedure focusing on shortening the intermediate material between the frog and the running rail (shorter welds, improved alignment, timing of force and heat during flash but welding).
3. JEZ development of a moveable nose frog for installation in the roadbed and a new standard frog for embedded installation on concrete.
De LIJN in co-operation with D2S and FDP studies the foundation damping and the integration of the standard JEZ turnout and its ancillaries in the concrete roadbed.

4. FDP development of an industrial turnout

5. COGI development of two low profile turnouts (one standard and one deep groove) for prefabricated embedded installation

   STIB contributes the development and specifications for the jacket material to incorporate the turnout into prefabricated panels.

6. D2S development of an under sleeper pad in combination with ballast mat for the reduction of soil accelerations on an embedded turnout.

The above concepts were matched with specific turnouts and locations and modelled to perform a sensitivity analysis to determine the most beneficial solution for each case. The retained concepts were fine tuned and brought to detailed analysis in order to enable the manufacturing of the turnouts aimed at a specific location. The materials used for vibration isolation, foundation damping and mechanical isolation between road and track have been tested to determine their characteristics for the modelling. A number of concepts have actually been produced and some of them are under installation.

RESULTS ACHIEVED SO FAR AND EXPECTED END RESULTS

POLIMI and NTUA have validated their modelling technique with the help of additional measurements by D2S on a turnout at De LIJN in Antwerp.

The consortium has made a selection of conceptual design measures to reduce impact forces. The validated modelling techniques have assisted in performing a sensitivity analysis to select the most appropriate measures for the different turnout types in their specific locations. The materials involved have been laboratory tested. Based on these properties, detailed designs have been developed that are also modelled to predict their outcome in terms of rail and soil accelerations. The detailed designs are production and/or installation ready. Two concepts have already been installed in the field.

INTENTIONS FOR USE AND IMPACT

The proposed concepts are reviewed for their functionality at the locations for which they are intended and their performance is predicted using the previously developed models.

In general, the development of these new turnout systems combined with new production and installation techniques will provide the industrial partners with a major
competitive advantage. The operators are expected to benefit from the new designs through cost savings from reduced construction and maintenance cost. For example, the reduction in impact forces will reduce wear, turnout renewals and maintenance, and increase the life expectancy of the crossing, thus providing a significant reduction in life cycle costs. In addition, the low profile turnout, which can be installed on a thinner concrete slab, is now more compatible with the concept of pre-fabricated track elements. The thinner slab is easier to transport and to manipulate and thus opens new perspectives for reducing construction times.

Reducing the impact forces in turnouts has a direct beneficial impact in the environment through the reduction of radiated noise along the tracks. The quality of life, health and safety of the citizens, and their working conditions will be improved through the reduction in ground borne vibrations. The improved rail profiles will reduce or eliminate rail grinding; a noisy process that is disturbing when carried out at night and dangerous when carried out during the day under normal traffic conditions.

The improved designs will also contribute to a reduction of the risk of derailment, a major risk for casualties in urban transport.

Overall, advanced technology trackwork concepts will be applied in the design to provide high technical reliability, accurate component reproduction capability, minimised maintenance and increased operational speed through the turnout. This will contribute to maintaining Europe's scientific and technological advance in rail transport technology. Offering new and better solutions to the problem of turnouts reinforces the technological advantage necessary to sustain and increase employment in this highly technological field.

RESULTS AND DISSEMINATION

The installation of the turnouts is a first step towards dissemination. By securing the cooperation of operators that are eager to implement the new concepts, the project is guaranteed to have high visibility in the urban transport community. Further dissemination will occur through technical papers, presentations at conferences, scientific journals, as well as in workshops and seminars.