The rail vehicle approval process today is costly and time-consuming. “Virtual testing” using multi-body simulations is one approach to reduce these costs. During the European research project DynoTRAIN, one of the main activities in work package 5 was the comparison of simulations and measurements from on-track tests to develop the process and criteria for model validation. The on-track measurements were carried out with a measurement train in Germany, France, Switzerland and Italy. This article describes some selected simulations with the Bim 547.5 coach and the simulation tool SIMPACK, which have been carried out by Bombardier Transportation.

INTRODUCTION

For the past two decades, Europe has increased its cross-border transport of freight and passengers. The European Union is aware that this makes cross-border rail transport a viable alternative to road transport. Historically, every country in Europe developed its own railway system with different national rules for testing the acceptability of railway vehicles’ running characteristics. Today, it is necessary for cross-border rail transport to be interoperable with various railway systems. The European approach to interoperability led to two European Commission (EC) Council Directives: 96/48/EC on July 23, 1996 on the interoperability of trans-European high-speed rail systems and 2001/16/EC on March 19, 2001 on the interoperability of the conventional rail systems. At both of these councils, processes to determine standard rail vehicle approval were established. Today, testing vehicle running characteristics is a costly and time-consuming process since the vehicle certification against European standards (EN), like EN 14363 [1], requires multiple field tests. Unexpected environmental or other boundary conditions influence the results so that field tests have to be repeated several times in order to cover the possible range of circumstances, increasing costs and duration of vehicle approval. One approach to reduce this effort could be “virtual testing” using numerical multi-body simulations (MBS). For the application of this methodology, the validation of the simulation model is essential.

THE DYNOTRAIN PROJECT

In 2007, the European Commission (EC) initialized the Seventh Framework Programme (FP7) for research and technological development. DynoTRAIN was one of three projects in the TrioTRAIN cluster (Total Regulatory Acceptance Interoperable Network), started in June 2009 (scheduled project duration: 48 months, extended to 52 months) with funding by the EC under FP7 (Grant Agreement no. 234079) with a budget of € 3.3 million. DynoTRAIN included the following objectives: closing of open points in the high speed (HS) and conventional rail (CR) technical specifications for interoperability (TSI) related to vehicle dynamics, harmonize European and national standards on railway dynamics, and reduce costs of certification and development of an innovative certification process using computer simulations. The research work was divided into seven work packages (WP):

- WP1: Measurement of track geometry quality and virtual certification
- WP2: Track geometry quality
- WP3: Contact geometry
- WP4: Track loading limits related to network access
- WP5: Model building and validation
- WP6: Virtual certification of modified vehicles and vehicles running in other conditions
- WP7: Regulatory acceptance

The DynoTRAIN project team is a unique international consortium co-ordinated by UNIFE, the European Rail Industry. In WPs, 14 partners from industry (Bombardier, Siemens, Alstom, CAF, AnsaldoBreda), universities, public research institutes (TU Berlin, KTH, POLIMI, IFSTTAR, CEIT, RISSB) and transport companies (DB, Trenitalia, SNCF) collaborate. For more information, see www.triotrain.eu.

DYNOTRAIN MEASUREMENT CAMPAIGN

In October 2010, the German transport company Deutscher Bahn (DB) compiled a 325 m long measurement train. Over a four-week period, on-track measurements were carried out with slightly different train configurations over a 5000 km distance through Germany, France, Switzerland and Italy. The measurement train consisted of 13 different rail vehicles:

- One electric locomotive DB series 120.1 (normal operation mode, with measuring equipment)
- One inter-city passenger coach series Bim 547.5 (normal operation mode, empty, with measuring equipment)
- Two flat freight wagons with Y25 bogies for containers and swap bodies series 5475 (one wagon empty, one wagon laden, wheel set load of 22.5 t, both with measuring equipment)
- Freight wagon unit consisting of two flat wagons with stakes series LAs (one wagon empty, one wagon laden, wheel set load of 20.0 t, both with measuring equipment)
The simulation model fulfils the validation limits and can therefore be regarded as validated. The vehicle model is ready to use for virtual vehicle approval. The following conclusions can be drawn regarding the comparisons between simulation and measurements:

- Measured track irregularities as well as measured rail and wheel profiles are used for the accuracy of simulation results compared to on-track measurements.
- Stationary tests can be used for model improvements if there are uncertain vehicle parameters. Due to a good data basis for the Bim 547.5 coach, the vehicle model improvement by comparisons with stationary tests was only marginal; the main improvement was achieved by comparisons with on-track test measurements.

**REFERENCES**


**CONCLUSION**

The complete analysis of the simulation results of all vehicles and the proposed process and criteria for model validation has been published in the final WPS deliverable and at conferences IA VSD 2013 in Qingdao, China [3] and Bogie ‘13 in Budapest, Hungary [4]. Based on the proposed validation methodology in WPS, the Bim 547.5 vehicle model fulfils the validation limits and can therefore be regarded as validated. The vehicle model is ready to use for virtual vehicle approval. The following conclusions can be drawn regarding the comparisons between simulation and measurements:

- Measured track irregularities as well as measured rail and wheel profiles are used for the accuracy of simulation results compared to on-track measurements.
- Stationary tests can be used for model improvements if there are uncertain vehicle parameters. Due to a good data basis for the Bim 547.5 coach, the vehicle model improvement by comparisons with stationary tests was only marginal; the main improvement was achieved by comparisons with on-track test measurements.

**REFERENCES**