Overview of the DLR RailwayDynamics Library

Andreas Heckmann[1] Marc Ehret[1] Gustav Grether[1] Alexander Keck[1] Daniel Lüdicke[1]
Christoph Schwarz[1]

[1]Institute of System Dynamics and Control, German Aerospace Center (DLR), Germany,
andreas.heckmann@dlr.de

Keywords: railway vehicle dynamics, wheel-rail contact, multi-domain vehicle modeling

Background and Motivation

Railway vehicles are complex multibody systems running at high speed along a given track. The particular contact between steel wheels and rails carries the payload, provides lateral guidance and submits traction forces. The running gears and their suspensions ensure track-holding and control the vibration comfort, which the passengers perceive.

However, railway vehicles also employ multiphysical subsystems such as pneumatic friction brakes and air suspensions, electrical engines to provide propulsion and to regenerate energy, Diesel-electric or Diesel-hydraulic drive trains and so on.

With this background, the newly released commercial DLR RailwayDynamics Library is supposed to support holistic system design, optimization and hardware or software in-the-loop testing by provision of vehicle dynamics models. Since these models may be scaled and adapted with respect to the required modeling level, the library proposes a sound modeling framework to support multidisciplinary engineering tasks.

Railway Modeling Particularities

Besides library structure and templates to assemble vehicle models from substructures, the paper presents some modeling particularities that are tailored for railway dynamics simulations:

- the track, which is the path as a function of the path length parameter s, i.e. the 3D curve $\boldsymbol{r} = \boldsymbol{r}(s)$, the vehicle is intended to move along,
- the track joint that defines one mechanical degree of freedom and presents the capability to move along the 3D path $\boldsymbol{r}$,
- the track panel, which is used to introduce the flexibility of the rail and the subgrade structure,
- the wheelset, that reproduces inertia properties and contains two translatoric and three revolute degrees of freedom of the wheels in addition to the longitudinal motion already presented by a track joint,
- and the wheel-rail contact model, which includes the consideration of non-linearities in normal and in tangential direction in view of the wheel and rail profile geometry.

Example Applications

The paper contains elaborate example applications, which in parts are shown in Fig. 1:

- Traction analysis investigates in-train forces as well as longitudinal oscillations of coupled vehicles during acceleration and braking maneuvers.
- Comfort studies examine and assess the level of vibrations that the passengers perceive and which are initiated by track lay-out and irregularities.
- Roller rig models reproduce the capabilities of test rigs that are used for research and development in industry and research institutes.

Conclusions and Outlook

The consideration of vehicle dynamics issues in multidomain engineering tasks is a specific focus of the RailwayDynamics Library. Therefore, the paper also includes two proposals in order to organize multidomain modeling, on which the authors intend to initiate a discussion. Additional future applications of the library concern the synthesis of advanced observer and control lay-outs and refined assessment scenarios for crosswind stability of railway vehicles.

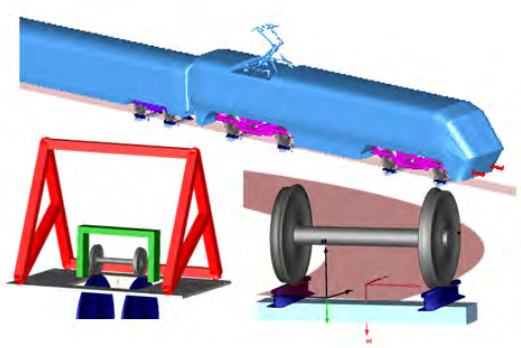

Figure 1. Animations from example applications of the DLR RailwayDynamics Library