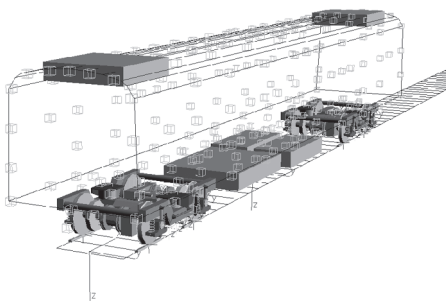


# Modeling and Simulation of the New Metro Train for Vienna with SIMPACK Wheel/Rail Using Flexible Car Bodies

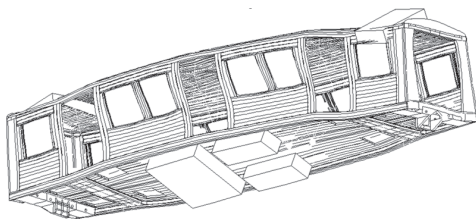
Designing the Metro for Vienna, combined both multi-body and finite element modelling in the entire development process. The car body models were imported from ABAQUS into SIMPACK, taking advantage of SIMPACK's ability to accurately tune the FE model for use within a multi-body system, with the use of frequency response modes. SIMPACK's use of substructuring a complete railway model allows an efficient way of investigating the behaviour of different vehicle designs, reducing model set-up time. The project was carried out with the help of INTEC's consultancy branch.



New Metro Train for Vienna\*



The Virtual Intermediate Car\*



The Diagonal Distortion\*

Due to the increasing demand for urban transport systems manufacturers are continually working to optimise passenger capacity and comfort and to increase travelling speeds. Virtual testing systems which minimise development time and enable optimisation, not only significantly reduce costs, but also quicken the time to market - advantages necessary in today's competitive market.

The role of structural dynamics in connection with vehicle running dynamics is increasingly important due to the ever more common use of lightweight materials and constructions. A virtual testing system must also therefore be able to accurately simulate elastic behaviour.

Work has been carried out by SIEMENS in order to optimise the ride comfort of future metro trains by numerical simulation using SIMPACK. Additionally, the software tools I-DEAS and ABAQUS have been used. A database has been built in order to simplify and speed up the development process.

SIMPACK's database structure enables quick and easy assembly of different train configurations for virtual test-

ing. The database follows a modular concept, which consists of all the components necessary for accurate simulations to be selected and pulled together into a main model for virtual testing. Alterations made to any components (i.e. substructures like rigid or as flexible modelled car bodies, couplers, driving bogies, trailing bogies, etc.), automatically transfer and thus update the train-models of interest. Each component has been tested and validated before being entered into the database.

This concept allows a large number of different vehicle configurations to be easily handled.

The car body shells of the metro train for Vienna are made out of large aluminium extrusions welded together and has been modelled using finite element software. The ceiling frame, floor structure, windows and seats have also been modelled as elastic components. The car body of the intermediate car consists of approximately 369 000 degrees of freedom. These degrees of freedom have been reduced using the Guyan condensation method. To enable short computation times all mode shapes

above 30 Hz have been neglected. In order to improve the accuracy of the particular modes, which describe local deflections, the SIMPACK pre-processor FEMBS allows to select frequency response modes which are significant to the coupled movement and frequency range of interest. Time consuming modifications to the FEM model and unnecessary constraint modelling are not required. The entire elastic body has been reduced to 12 eigenmodes and 27 frequency response modes to accurately describe the flexibility up to 30 Hz.

Elastically mounted equipment attached to the car body has been modelled with rigid bodies connected using force elements. In order to ensure the validity of the model for the flexible structure, a comparison was made between an ABAQUS FEM model (i.e. including flexibly mounted equipment) and the SIMPACK model using the reduced FEM model.

The results from the SIMPACK simulation correlate well with those obtained from the measurements taken from the prototype vehicle for both the lateral and vertical accelerations (rms). The accelerations were measured on the floor at the car centre close to the side wall. Having developed the database and having validated the entire virtual train, different configurations can now be assembled quickly and easily for use in dynamic analyses and optimisation studies.

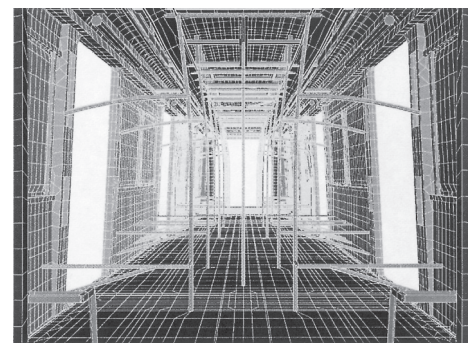
Not only can development costs be dramatically reduced, but the company's expertise and know-how can be continually collected and stored in

an ever expanding database, on hand for the current and next generation of products.

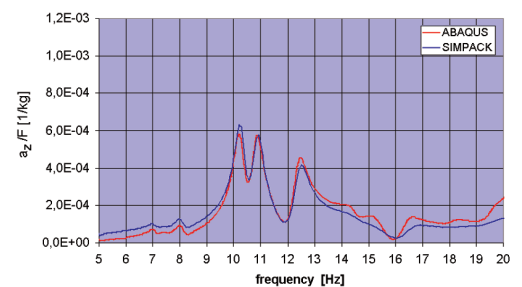
A similar article, which points out additional aspects of this project can be obtained from INTEC: Structural Dynamics of Rail Vehicle Systems: A Virtual Systems Approach, Civil Comp Ltd., Edinburgh, Scotland 2000. All the figures on page 6 and 7 are taken with the kind permission of Civil Comp Ltd.



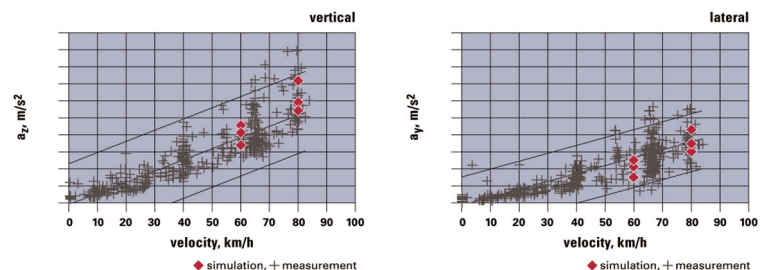
Interior Design of the Metro Vehicle\*



Finite Element Model of the Metro Vehicle\*



Comparison Between ABAQUS FEM Model and Reduced SIMPACK Model\*



Comparison of Simulated and Measured Accelerations \*

\* all figures are from the article "Structural Dynamics of Rail Vehicle Systems. A Virtual Systems Approach" by A. Stribersky, F. Moser and W. Rulka, published as pages 29 to 36 inclusive in "Developments in Engineering Computational Technology", edited by B.H.V. Topping (CIVIL-COMP LTD)

