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USING THE GENSYS SOFTWARE FOR RAILWAY VEHICLE MODELING

В Швеции и Скандинавии с 1971 года успешно проводится компьютерное моделирование динамики рельсовых экипажей. Для этого используется программный комплекс GENSYS и его предшественники. GENSYS – очень гибкая и легко управляемая программа, к которой легко добавляются новые модули, написанные на языке C или Fortran. Для подготовки исходных данных используется язык высокого уровня, на котором пользователь описывает свою задачу.

History

In Sweden modeling of railway vehicles in computers started at ASEA in 1971 with a linear program in the frequency domain. In 1973 the development of the first nonlinear time integration program started. The program was a code with specific-generic-structure. The program consists of two parts; one taking lateral motions into account, and the other taking vertical motions into account. These programs were developed together with the first high speed test train, the X15, in Sweden. The Rc4-locomotive was designed in 1975 for the Swedish State Railways, and was the first project in which ASEA used the above mentioned computer programs. Since then every new vehicle delivered by ASEA, and later Adtranz, has been designed by using these programs, including the tilting high speed train, the X2000.

The first official presentation of our tool was made by Evert Andersson in Graz 1977. The name of the presentation was "Simulation von Spurkräften und Laufeigenschaften", ZEV-Glasers Annalen 101 (1977) Nr 8/9, p.339-347. Evert Andersson is today the professor in Stockholm at the Royal Institute of Technology, Department of Railway Technology. Development of the simulation programs continued with several releases through the whole 1980s, but in 1992 the development of a new three-dimensional calculation program started. At the same time the development of the dynamic package moved into a new company called DEsolver, which has the only task to develop and support the program package. This new three-dimensional, general computer code, together with all earlier pre- and post-programs became in 1993 the new railway vehicle analysis tool called GENSYS.

Flow chart

On the top of next page a flow chart shows how the different programs in GENSYS communicate with each other. Dark gray boxes indicate data files, and light gray boxes indicate executable programs. Communication between programs and data files are marked with arrows, the direction of the arrows indicates the direction of the communication.

Preprocessors

GENSYS consists of several preprocessors, in order to generate safe and simple input data for the main calculations programs. The preprocessors are divided into the following parts:

TRACK. A group of preprocessors generating designed track geometry and track irregularity files. The program group can translate track data between many different formats. The Trac-format is the native format used in GENSYS. The track data format used in different track recording vehicles are also understood, for example: Mauzin, Matisa, Strix and Plasser & Theurer. Track irregularities can also be given in the frequency domain in Fourier- or PSD-spectras.

KPF. A group of preprocessors generating functions of the wheel/rail geometrical properties. The wheel and rail profiles can be measured profiles from “miniprof”, “spak”, or similar profile measuring devices. The wheel and rail profiles can also be taken from a drawing, where the profiles usually are described by strait lines and arcs.

MISC. A group of miscellaneous programs:

- FTRANS Fourier transformation and filtering of curves read from ASCII-files.
- FUNC Algebraic operation on curves read from ASCII-files.
- MTABLE Collecting results in tables from many calculations.
- RUNF_INFO Input data checking tool.

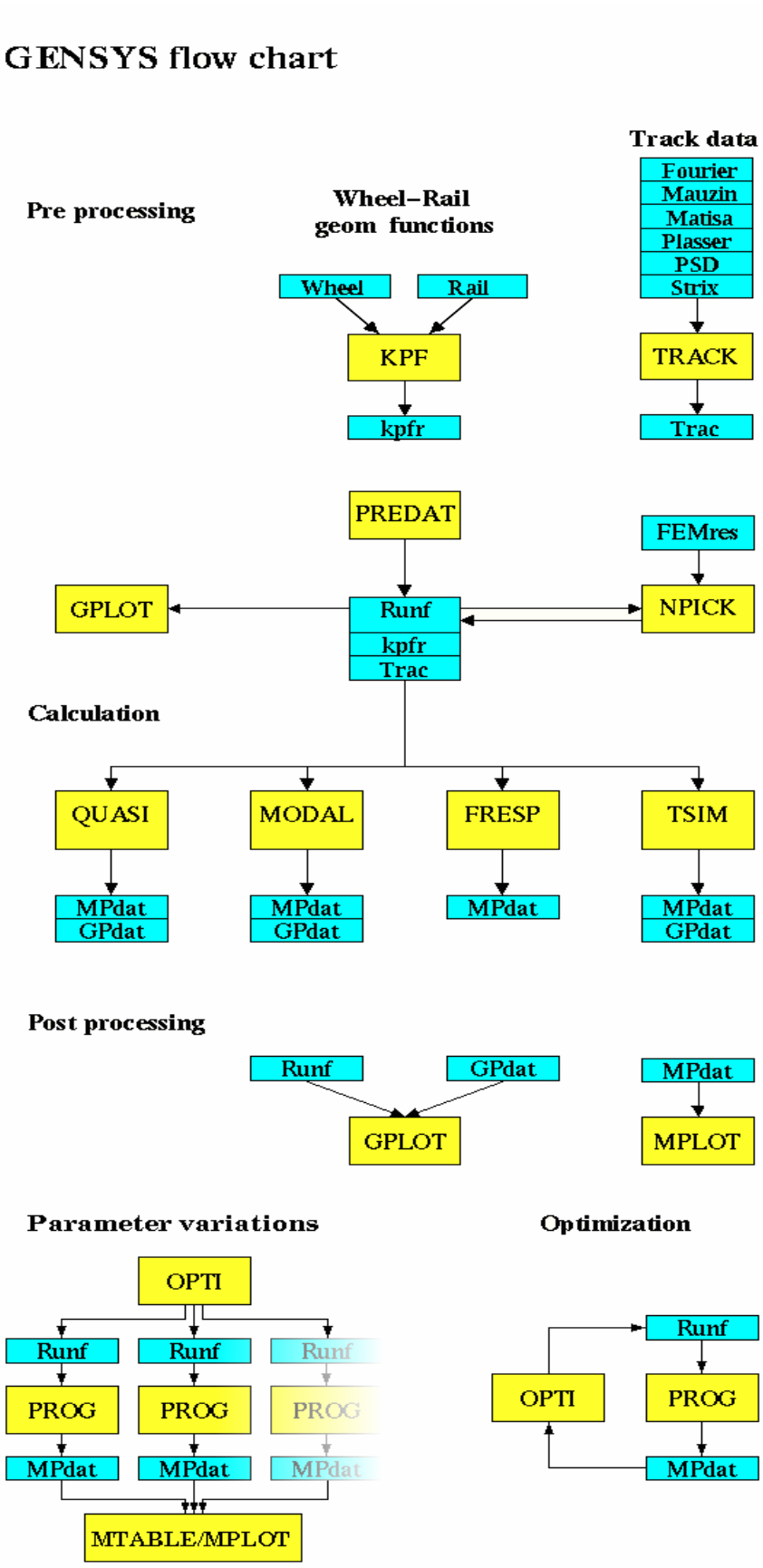

Fig. 1. Flow chart over the different modules in GENSYS

NPICK. Program NPICK reads the runf-file plus results from a modal analysis in a FEM program. Program NPICK then adds information in the runf-file which changes the rigid masses into flexible masses.

PREDAT. Program PREDAT is a fast input data generator to the main calculation programs in GENSYS. As input data to PREDAT the user gives three types of input data: 1) Known data, fixed distances, fixed weights, , , etc. 2) Requirements, wheel unloading on twisted track, max. roll coefficient, , , etc. 3) Preferred data, eigenvalues, damping in different eigenmodes. From these input data program PREDAT tries to create a vehicle model that at least fulfills input data of type 1) and 2), plus some of the data according to 3). If too many data has been defined according to 1) and 2), maybe PREDAT will fail to create a vehicle modal.

The main calculation programs

The main calculation programs in GENSYS are: QUASI, MODAL, FRESP and TSIM. Where: Program QUASI performs quasistatical analysis, program MODAL performs modal analysis, program FRESP performs frequency-response analysis and finally program TSIM performs time integration.

All the four major calculation programs are very general in their basic concepts. All information describing the problem is stored in one big array, in order to give the user access to all data during the calculation phase. Every variable in this big array has an unique name, which makes it easy for the user to create own active suspension components, where the user has an interest in reading arbitrary variables in the vehicle data model. The coupling between wheel and rail is described in a user-defined element where the creep-forces between wheel and rail depends on creep, spin, contact force and shape of the contact surface.

The two programs TSIM and QUASI operates in the time domain and are both fully non-linear. The other two programs MODAL and FRESP operates in the frequency domain, therefore must the non-linear equations be linearized. In the initial stage of the programs MODAL and FRESP a linearization process takes place. Every degree of freedom is moved a small distance and the responses in the derivatives in all other degrees of freedom are measured, in order to create a linear Jacobian of the non-linear mechanical system. When the Jacobian has been calculated the created Jacobian will replace the fully non-linear model. This linearization process is done fully automatically, and the input data files to the four different programs are all the same independent of analysis type.

Postprocessors

In the GENSYS package two powerful postprocessors are included, GPLOT and MPLOT.

The GPLOT program is a 3-D program viewing the vehicle from a point chosen by the user. GPLOT can be used as both pre- and post-processor. As preprocessor GPLOT can be used for checking the input data of the vehicle model. Every coupling have a hot-spot on which the user can click on in order to inspect the data for the coupling. As postprocessor GPLOT can be used for visualizing the complex eigen modes calculated by MODAL, or animate a simulation by TSIM. A screen shot of the GPLOT program can be found on next page

The MPLOT program performs postprocessing and diagram plotting of the results produced by the main calculation programs. The postprocessing part of MPLOT includes the most necessary tools for making different evaluations according to different standards: ISO, CEN, UIC, BS,,,etc. If any functionality is missing the user can add new modules written in C or Fortran. MPLOT can handle results from several results simultaneously. A screen shot of the MPLOT program can be found on next page

Parameter variations and Optimization

Program OPTI runs a subprogram in a loop. Program OPTI can be run in manual- or automatic-mode. In manual mode all cases are from the beginning known, in this case the user lists the different cases he or she wants to be carried out, and OPTI just executes the tasks according to the list. In automatic mode the user formulates a penalty index to be minimized, and which of input data to the subprogram that program OPTI is allowed to change.

Validation and development

The program package has continuously been validated by ASEA, later Adtranz now Bombardier transportation, for different kinds of railway vehicles. Validation of the program package has also been carried out for the following benchmarks: IAVSD Benchmark #1, IAVSD Benchmark #2, ERRI B 176/DT 290 and the Manchester Benchmarks. The results from the Manchester Benchmarks can be read in the

supplement of Journal of Vehicle System Dynamics, April 1999. The development of GENSYS is carried out by DEsolver in cooperation with the Technical University of Stockholm (KTH) and Gothenburg (Chalmers).

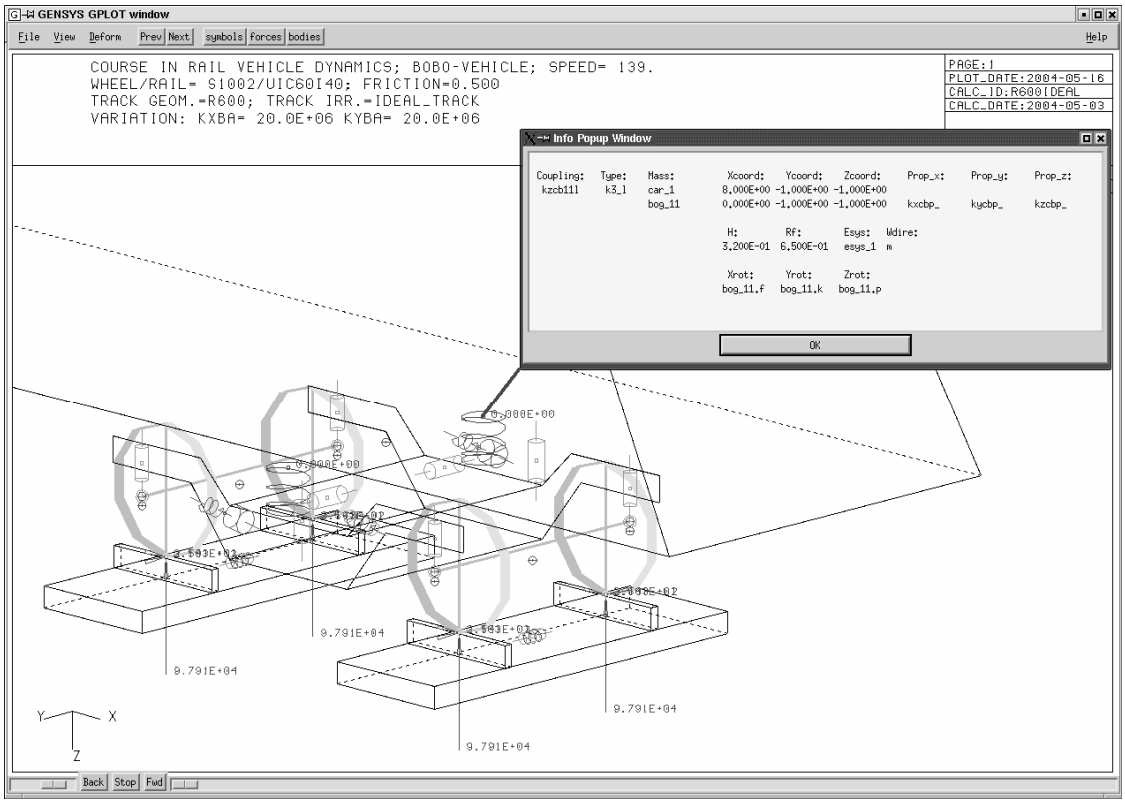

Fig. 2. A screen shot of the GPLOT window

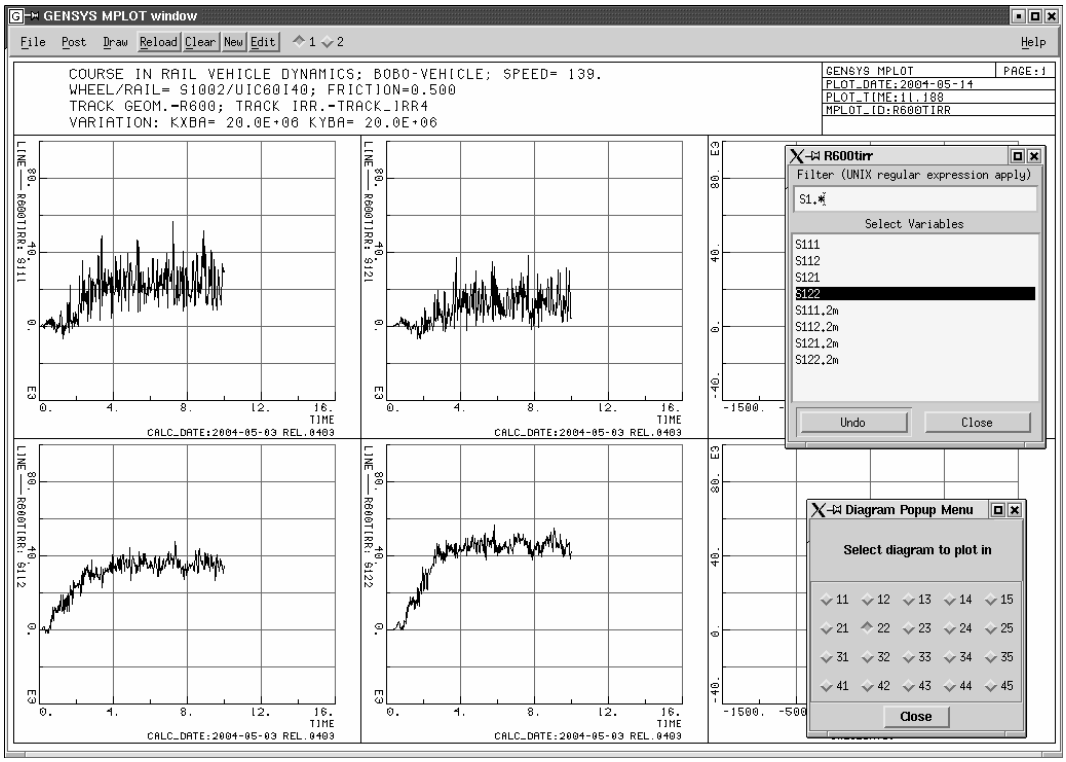

Fig. 3. A screen shot of the MPLOT window

Availability

GENSYS is available from DEsolver under a license agreement. The annual license fee of the package includes full telephone support, access to the GENSYS USER GROUP, an introduction course, maintenance and updates. Installations exist on the following platforms: HP workstations running under HP-UX, IBM workstations running under AIX, Sun workstations running under Sun_OS and Solaris, Silicon Graphics INDIGO workstation and PC-computers with Intel and Alpha processors running under Linux.