Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

RailSys, a system to plan future railway needs

J-P. Bendfeldt, U. Mohr, L. Müller
Institute of Transport, Railway Construction and –operation (IVE), University of Hannover, Germany

Abstract

The article describes a new infrastructure and timetable optimisation environment developed at IVE to enable railways to undertake a wide range of railway management tasks. The microscopic system supports the user from the beginning of railway planning like running time calculation via the exact timetable and infrastructure construction to the roster planning for locomotives and trains. The impact of different scenarios can be evaluated and alternatives can be determined. The computer aided railway planning, which was developed for several examinations in order to enable the planner to work within an integrated approach on complex tasks, will be described and advantages will be demonstrated.

1 Introduction

To plan future system requirements and to evaluate the impact of these requirements for the railway system, efficient computer aided tools are needed. The complexness of the railway system, combined with the number of to be considered boundary conditions, results in a very large number of possible variations. Therefore, a lot of alternatives has to be investigated which extends the duration of the whole planning process. Additionally the costs for e.g. infrastructure extensions of the network are very high and the accurate planning is the key to prevent investment mistakes.

The uncertain estimation of future development of public transport traffic rises the number of to be considered variables. The intensity of train services can change between two timetables while the building of infrastructure takes several years.

To enable the detailed planning of both, infrastructure and timetable for several variants and alternatives the system **RailSys** was developed. It includes accurate tools for running time calculation, infrastructure mapping, timetable-construction and -evaluation and the planning of vehicle rosters.

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

2 The system architecture

To fulfil the demands of customers, railways need to optimise their timetables and their capacity of tracks and stations. This implements an optimised infrastructure. The planning of railway infrastructure or future timetables bases on the existing network and the to be realised running times. To calculate the number of needed vehicles and to consider empty train runs a vehicle roster plan has to be determined. The completed timetable is simulated to demonstrate its robustness and stability in case of disruptions. Finally the results have to be evaluated to obtain a ranking of the alternatives. Figure 1 shows the system architecture and data flow.

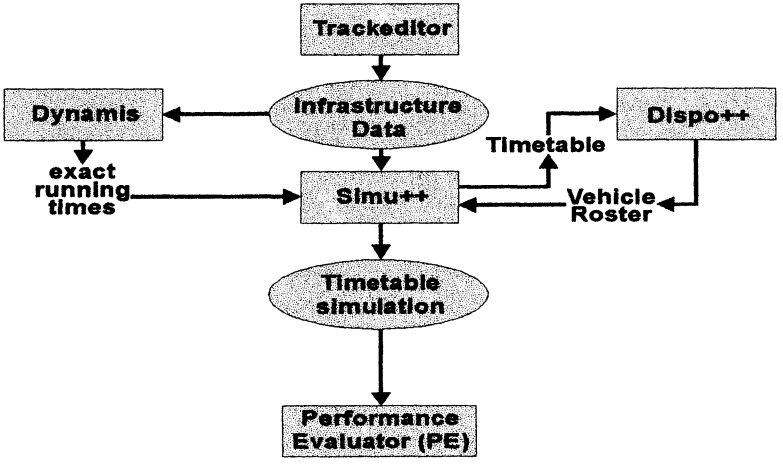


Figure 1: Architecture of the planning environment **RailSys**

2.1 Infrastructure mapping

To map the existing infrastructure and to build up infrastructure variants, the **RailSys** System includes an infrastructure editor called **Sted**. The editor allows the user to model the whole network in the computer with the accuracy of one meter. The mapped infrastructure contains information about track parameters like gradient, max. speed, etc.. The location of points, signals, stations, stopping point, speed indicators platforms and tracks are considered. Signalling systems like ETCS (European Train Control System), radio controlled operation or ATC/ATO (Automatic Train Control / Operation) can be edited and simulated.

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

2.2 Train run computation

The exact calculation of running times is done with **DYNAMIS,** a tool to simulate train runs of all train types on the existing or to be planned infrastructure.

DYNAMIS considers the traction force vs. speed diagram of the locomotives/EMU, weight and length of each vehicle. It includes an interactive tool to get an exact overview of the calculated train run and to modify all input data interactively. Additionally, energy saving driving strategies, the computation of signalling infrastructure locations or the check of the alignment of the track can be undertaken.

DYNAMIS is used by several European railway companies to solve the above mentioned tasks and to assist in the timetable construction. Software interfaces ensure the

2.3 Timetable construction and simulation

The results of the running time calculations can be transferred into the timetable construction phase done with **Simu++** .A screenshot of **Simu++** is shown in figure 2.

Simu++ includes all necessary information on the infrastructure such as gradient, speed restrictions, block signals (various signalling systems), platforms, points and stations. The infrastructure data is created and edited with a graphic tool. Alternatively, data can be imported from other data sources.

The handling of large railway networks consisting of many lines and stations is supported by a modular set up of the railway network. Every line in a large scale network can be planned and simulated independently. Lines can be joined to a network at any time during the planning process and can be separated again afterwards . For example, the network of a railway company can be separated into several local areas (i.e. suburban areas and the lines between these areas). Trains running on more than one line can be scheduled by supervising planners. **Simu++** indicates inconsistencies such as connection times and transit tracks in stations for these trains.

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

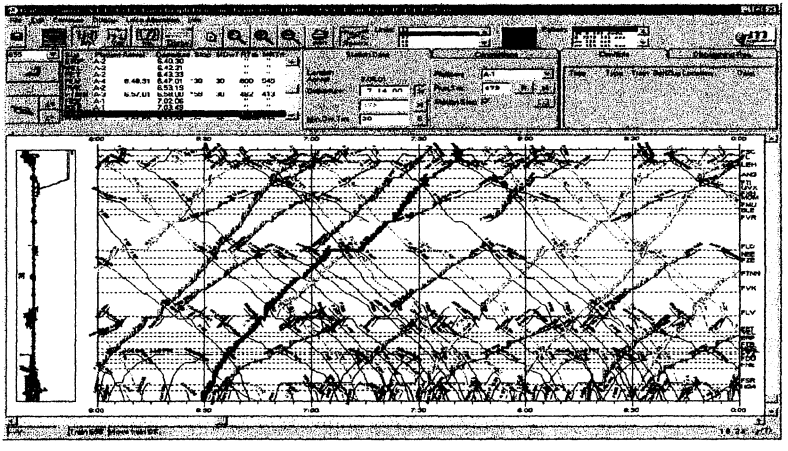


Figure 2: example of the timetable construction with **Simu++**

The new signalling system moving block (specified by the ETCS standard) is implemented. The model supports the principles of the running in absolute or relative braking distance. Trains using this system can be mixed with trains using traditional signalling systems. This is supported throughout the whole program system i.e. timetable construction and simulation.

2.4 Vehicle roster planning

The main task of the program is the optimal disposition of locomotives in large networks. Typical applications are the roster planning of more than a hundred locomotives according to given boundary conditions (e.g. reversing times, compulsary connections or track slot prices). The main target is to minimise the number of locomotives and to reduce the number and length of empty train runs. Additional parameters, for example the prices of track slots, can be used for the disposition.

2.5 Performance Evaluation

To evaluate the impact of infrastructure and/or timetable alternatives the Performance Evaluator **PE** was created.

This tool serves for the evaluation of the performance of the simulated operational program. The main base for this task are the delays which are statistically prepared and analysed. The results of the simulation can be displayed as performance of the whole network, for lines only or in stations.

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

It can be separated into average delays of each defined train type, e.g. freight or suburban services. Further possibilities are for example added delays in stations or delay vs. percentages diagrams.

3 Planning Process

For most questions concerning railway operation and railway infrastructure it is possible to use a standardised planning process working with **RailSys**. A standardised planning process is shown in figure 3. The planning process is mainly characterised by taking into account concrete assumptions for variants, which usually lead to an increased number of variants. Different expectation values for infrastructure or service measures can be determined by the iterative procedures of variant definition, simulation and evaluation.

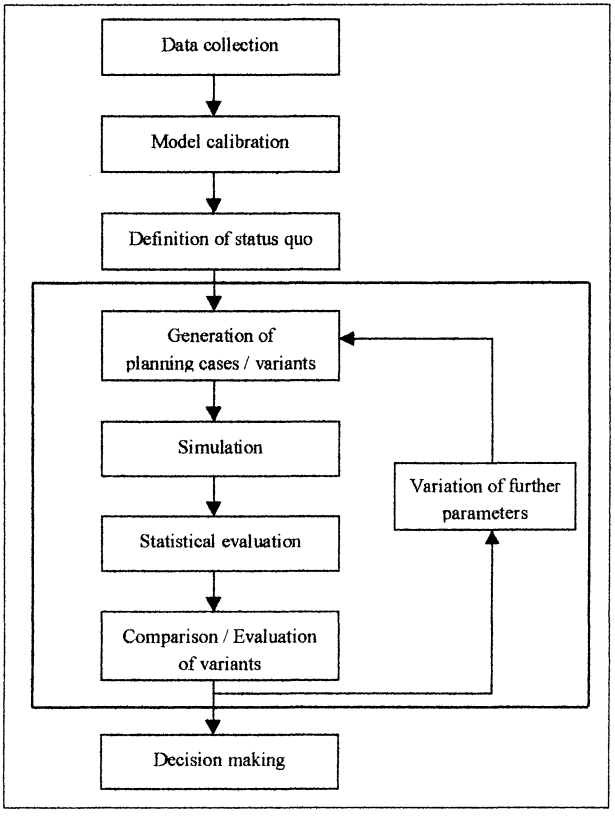


Figure 3: Standardised planning process

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

3.1 Data collection

In a first step, the original data for the examination is collected. It includes the necessary details concerning the infrastructure (tracks, turnouts, positioning of signals, speeds, gradient ratios etc.) and the operational program (timetable). The operational program, consisting of a multitude of train types, is undertaken a reduction through the projection into the model by a summary of train types with the same or similar dynamical characteristics to model train types. Furthermore, delay reference values are to be registered or determined as basic values for the simulation. The determined basic values are further computed by the referring modules of the program system **RailSys**

3.2 · Model calibration

When all relevant data is taken over into the model, the model calibration takes place. In general, two approaches for the calibration are possible, that derive from the planning task. For examinations that base on an existing infrastructure or an existing operational program, a model calibration can be made referring to the current service situation. For examinations that base on a planned infrastructure or a planned operational program, usually a calibration can only be made by controls of likelihood or by comparisons with other, independent calculations (e. g. running times).

3.3 Status quo definition

After having calibrated the model, a zero-variant, the status quo, is projected. In case of further use of existing infrastructure or existing operational program, the variant for calibrating the model can be used as the zero-variant. For other starting parameters, zero- variants can be defined in any way. The statistical characteristics of the zero-variants serve as an evaluation basis for other variants in the remaining planning process.

3.4 Development of alternatives

The further variants derive from the variation of the examined infrastructure or service parameter. The number of variants usually depends upon the complexity of the examined area. In an ideal case, a matrix can be derived that consists of the different combinations of infrastructure- and operational program-constituents.

3.5 Simulation of alternatives

After the definition and construction of examination variants, a simulation takes place. Here, two simulation approaches have to be distinguished. On one hand, a multiple simulation can be applied, in which a predefined number of time tables with different reception delays are simulated. On the other, it is possible to com-

Computers in Railways VII, C.A. Brebbia J.Allan, R.J. Hill, G. Sciutto & S. Sone (Editors)
© 2000 WIT Press, www.witpress.com, ISBN 1-85312-826-0

pute single simulations in frames of case studies without the influence of any appearing input delays. In both cases, delay developments can be disposed as the simulation's result.

3.6 Statistical evaluation

The from the simulation resulting delay developments can be determined either train-exact or model train type-exact at any cross-section. Furthermore, the delay developments can be summarised by statistical characteristics and thereby be compared.

3.7 Comparison and rating

By the help of statistical characteristics and delay spreadings, a comparison among the single measures' effectiveness can be made. Usually, the zero-variant is taken as a reference basis, so that a relative comparison of variants can be made. If the examined measures base upon known starting parameters and within the model calibration it is proofed that the model delivers safe results, the results can also be considered and evaluated as absolute sizes.

3.8 Decision

The last step of the presented planning process is the decision making on the basis of the computed variants. Therefore, the weighting of each variant has to be made by the planner, concerning to their own notion. If the simulated variants should not lead to a pleasing result, further variants can be defined and later be simulated, until optimised results are approached by means of an iterative process.

4 Applications

In the past, the program system **RailSys** has already been applied for a multitude of projects at the IVE. The examinations included long distance railways as well as urban and city railways. Thus, **RailSys** was applied succesfully in the following projects:

- High Speed Line Köln-Rhein/Main
- High Speed Line Sydney Canberra, Australia
- City railway Munich
- City railway Cologne
- City railway Saarbrücken

The exceptional challenge within each project was mainly to analyse the often different and special frame conditions of national and international railway systems and to integrate them into the program system **RailSys**.