

## Summary

VolkerRail, a head contractor in the rail sector performs large rail renewal projects. During the execution of these large projects, mistakes and obscurities in the operational planning can cause deviations. Also disturbances during execution can effect deviations between the schedule and the execution.

Planning with simulation and visualisation is a possible instrument to minimize these deviations. In this report, the correctness of this statement becomes examined. The three most important objectives for a simulation model are: the correctness analysis, the robustness analysis and the visualisation.

The developed simulation model is based on a modular structure. These structure consists of a number of basic modules and a number of extensions. The realized prototype of this simulation model consists of four modules: the simulation module, the visualisation module, the import-track-layout-module and the import-schedule-module. For the realization of this prototype Tomas/Delphi is used.

In the prototype the simulation and the management of the activities is based on an adjusted network planning method. For recognizing and avoiding the collision of activities, the prototype uses an autonomous-cell-approach (Cellular Automata).

There are three experiments accomplished by the developed prototype of the simulation model. For all three the experiments a fictive case is used in which renewal of the ballast track takes place. A conflict-free concept schedule of this project has been made already with help of a time-way diagram.

In the first experiment, the concept schedule is judged on correctness. The correctness of the schedule is determined as the difference between the calculated project duration and the simulated project duration. The presumption in this experiment is that the duration of the activities equals to the duration following from the schedule. In this experiment no disturbance of the activities occur. From the results of this first experiment becomes known that the project duration of the simulated project approximately 1% deviates from the calculated one. This deviation can be declared by the difference in the minimal distance between two activities being larger in the prototype then in the time-way diagram. The conflict-avoidance-module changes the schedule by slowing down one or more activities.

In the second experiment, by which the robustness of the schedule is judged, a simulation with disturbances is used. The duration of the disturbances is originated from a certain distribution. For this experiment is a normal distribution and an Erlang-K distribution used. By simulating many times with different disturbances, a distribution from the resulting project durations can be made. In the results, two things show off.

The first thing is the difference between the average project duration in this experiment and the scheduled project duration. Beyond of expectation, the average duration is lower than the scheduled duration. This phenomena is declared by a design choice in the prototype: the number of acting disturbances is limited by the number of tracks in the route.

The second point is the fact that there's no difference between the results of the experiments with the two used distributions. This can be explained by the very high K-factor in the Erlang-K distribution. Thereby the two distributions are almost equal. Therefore a third experiment with a low K-factor is done.

The third experiment equals the second experiment excepted the used Erlang-K distribution. In this distribution the form factor equated at 4 ( $K=4$ ). From this experiment appeared a larger dispersal of the project duration by using this adjusted distribution.

### *Conclusions*

In this investigation the following is proved:

- The incorrectness of the planning can be minimized by using a simulation model to indicate and solve logistic mistakes and conflicts in the project schedule.
- With a simulation model an optimal balance can be found between the robustness and the project duration.
- Progress registration in a simulation model contribute to a more flexible project schedule during project execution.
- Visualisation with a simulation model provided more understanding in the scheduling and execution of complex projects.

From above conclusions follows that time and expenses can be saved by using simulation technique in the scheduling and execution of railroad renewal activities.