

# **Increasing rail capacity utilization in port of Hamburg by early provision of information for import containers**

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## **Problem definition**

Various actors are involved in hinterland transportation of incoming rail containers along the maritime transport chain. To coordinate each actor's logistics processes, and therefore to improve utilization of existing transport capacity, the early provision of information, e.g. in form of estimated time of arrival (ETA), is inevitable. The port of Hamburg is selected for two main reasons. First, this port belongs to those ports that are historically based in urbanized areas. Therefore, its capacity is not expendable due to shortages in space with the consequence that utilization of capacity is particularly important. Second, the port of Hamburg and its hinterland connection by rail are important location factors for German and European economies. Our investigation covers all relevant transportation and information processes as well as interfaces between a deep sea carrier, a terminal operator, a railway operator and a railway company in the case of the port of Hamburg. The objective was to measure impacts of these information flows on capacity utilization by means of a simulation based approach.

## **Solution**

To simulate the effect of ETA container from vessel to hinterland transport mode rail, a system dynamic simulation model was developed based on the case study about import containers at the port of Hamburg. As result the amount of hinterland container on rail was compared with and without ETA for different container import volumes using a monte carlo experiment containing multiple simulation runs – each with individual generated distribution functions – for every input volume. The data, which are used by the simulation model, are real-world data of each actor and include the import container flow for hinterland transportation by rail. The basic simulation framework are table functions representing a data set, linked on container ID level. The data set connects the container import data of the involved actors with referential integrity within a database system for the two – with and without early provision of information in form of containers' ETA – different periods of three months each. In total 261,361 data tuples were gathered. Based on the data, a container based distribution function was built and adjusted to simulation time and a total probability of occurrence of 1.0. A further deductive evaluation of the data in form of mediation analysis led to a outliers stable triangular representation of the functions by using the interquartile range. The three values first quartile (Q1),

median (M) and third quartile (Q3) represent the middle fifty percent of all containers. This function was used for simulation of a general period with and without ETA container by randomized function access at each simulation run as depicted in Figure 1.

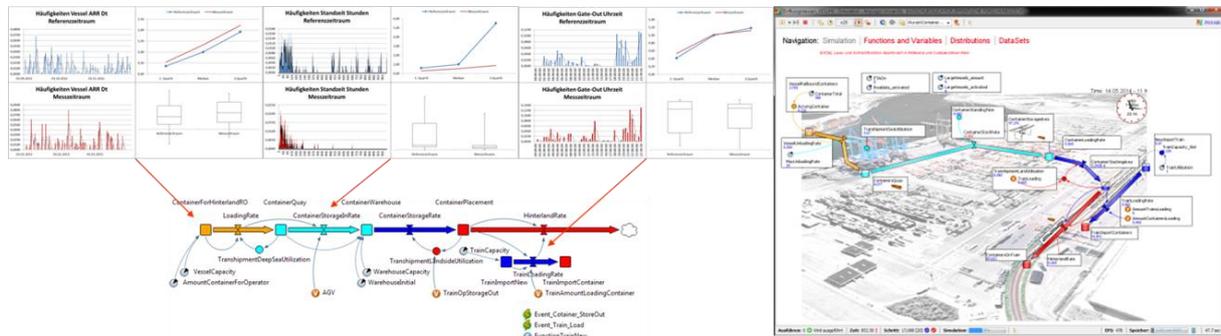


Figure 1: Basic simulation model using System Dynamics with table functions (left) and final simulation view (right)

## Output

The experiment was conducted as follows: For both periods – with and without containerized ETA information – one experiment, each with five simulation runs containing ascending container input volume was carried out. The output of containers on train in relation to the varying input of import containers will be saved in a two-dimensional array at the end of each simulation run. Each simulation run within the experiment represents a period of ninety days. The runs are executed without further variation of other parameters. As experiments shall represent a general time period, the triangular representation of real distributions are used. Each experiment runs multiple simulations with increasing container input amounts. For statistically robust results, monte carlo is used for a five time replication of all simulation runs. By the multiple reproduction of simulation runs with same input parameters and the comparison of input and output volumes, the sensitivity of the model relating to the parameters and the individual computed triangular distributions can be analyzed. Sensitivity analysis compares the parameters and their trustworthy influence on the model output and their standard deviations for both  $ETA_{Off}$  and  $ETA_{On}$ . Each simulation of five replication runs for 28 different input container amounts, which equals a total of 140 simulation runs per experiment, lasts about 1,940 seconds. By connecting real actors inter-related data, all relevant processes from transshipment from the container vessel to the seaport terminals warehouse and further transshipment on hinterland mode rail are covered in one simulation.

Results show, that managing provision of information in form of containerized ETA in maritime transport chains is a valuable approach for increasing existing utilization. Disposition strategies show an even larger effect, if this information was extended to all hinterland containers. When comparing real actor's distribution functions with  $ETA_{Off}$  and  $ETA_{On}$ , an improvement with a containerized ETA by 14.3 percent more containers per time unit on the hinterland mode rail could be reported. Furthermore the simulation model is capable to include effects of large container vessels

with less arrivals, longer birthing windows and larger container volumes within the experimental setup. Here monte carlo results show, containerized ETA stabilizes the output for hinterland mode rail.