CONROCAPS – MODELLING INTERMODAL TERMINALS TO CALCULATE THEIR CAPACITY

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ABSTRACT
The worldwide increase in transportation leads to capacity problems on seaside as well as hinterland terminals. Based on the rough layout, productivity figures and realistic traffic schedules the capacity of a terminal will be calculated by ConRoCAPS. The system handles Containers as well as RoRo (Roll on, Roll off) cargo. The capacity of each interface (quayside, road, rail) is calculated in a similar manner, based on the facility structure, the carrier mix and available resource types and the annual turnover regarding shift schedules and terminal processes. The results show figures concerning utilization and productivity as well as operation, idle and waiting times. This tool enables the planner to detect bottlenecks in very early phases and dimension the interfaces of the terminal in a balanced way.

Keywords: capacity, terminal planning, productivity

1. INTRODUCTION

Actual studies predict a continuing growth in seaborne trade and especially the worldwide container flow (Heideloff et al. 2007, Stenvert et al. 2007). Multimodal hinterland terminals as well as seaport terminals have to cope with these demands. For the planning of new terminals as well as for the reconstruction existing ones the calculation of terminals capacity is based on the layout, the equipment needed and facility parameters.

Various authors have developed container terminal simulation systems to estimate the capacity. Boll (2002) presented a tool to calculate maritime terminal's capacity and also presented an example (Boll 2005). Gronalt (2006) developed SimConT, a tool for hinterland terminals. Schütt (2006) presented a similar tool for intermodal rail terminals, developed for the demands of the US market. Further papers are listed by Steenken et al. (2004) and Stahlbock et al. (2007).

2. CONROCAPS

ConRoCAPS is a simulation system for capacity investigation regarding the various terminal facilities. The system is able to simulate combined terminals, i.e. RoRo (Roll on – Roll off) and LoLo (Lift on – Lift off) handling. Both kinds of operation can be simulated separately and also combined. The simulation model considers the quay (vessel service), the railway tracks (train services) and the gate operation (truck handling) of a combined terminal.

Out of this layout information and a given throughput the required quay length, the number and length of railway tracks and the number of lanes for the in-gate/out-gate can be determined. Furthermore the model gives information about service time and waiting queues at these interfaces as well as information about the yard space needed. It is possible to analyse various strategies with their pros and cons (e.g. consequences of elimination of processes, parallelisation and aggregation of processes, different berthing strategies of vessels, shunting of railroading, optimal productivity in terms of volume utilisation of trains, trucks and vessels).

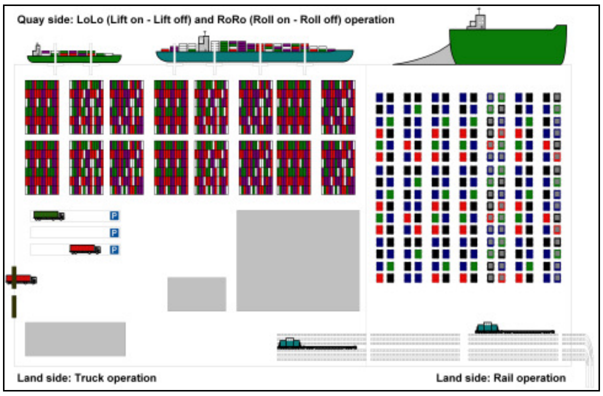


Figure 1: Terminal Interfaces which can be Analysed by ConRoCAPS

2.1. The structure of ConRoCAPS

Each interface is developed as an individual and independent simulation systems. Each simulation system consists out of an input module, the simulation module itself and the output part. Global parameters which have relevance for all three interfaces, e. g. type of cargos to be handled on the terminal, can be defined as global parameters.

Each interface is identically structured as shown in figure 2:

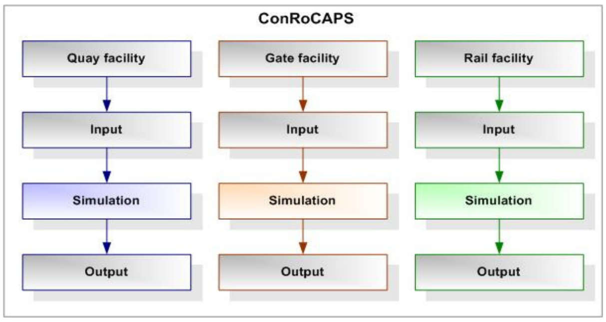


Figure 2: Interface Structure

Besides others the following questions can be analysed by this simulation model:

- Influence of changes in the modal split (vessel : rail, vessel : road, road : rail etc)
- Influence of different vessel types and types of trains (more big vessels or more small vessels, length and utilization of trains)
- Test of different process chains
  - Elimination of processes
  - Parallelisation of processes
  - Aggregation of processes.

The simulation course of the interfaces is executed in the following manner:

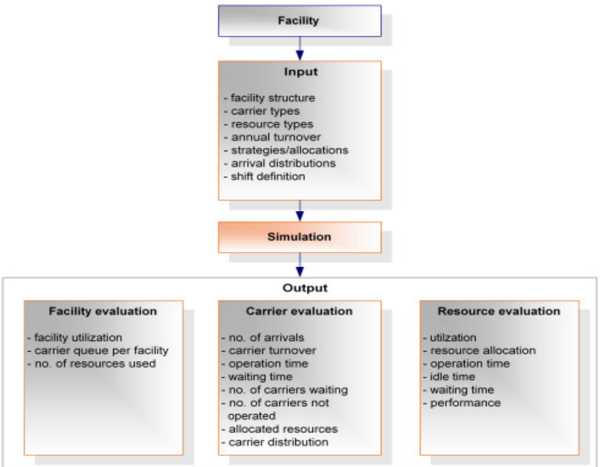


Figure 3: Interface Simulation Course

On the basis of the annual turnover, the carrier volume and weekly as well as annual arrival distributions the system calculates an arrival pattern for each carrier type which is executed during simulation.

Adapted from restrictions, allocations and strategies, which are part of the data input, the system simulates the operation of the carriers and saves continuously variable data which are aggregated after the simulation time of one year and prepared for three kinds of evaluation (fig 3):

- facility evaluation
- carrier evaluation
- resource evaluation

2.2. Types of cargo

The definition of different types of cargo is essential for the ConRoCAPS as shown in figure 4. Typical cargo types are container, cars, chassis, break bulk and other.

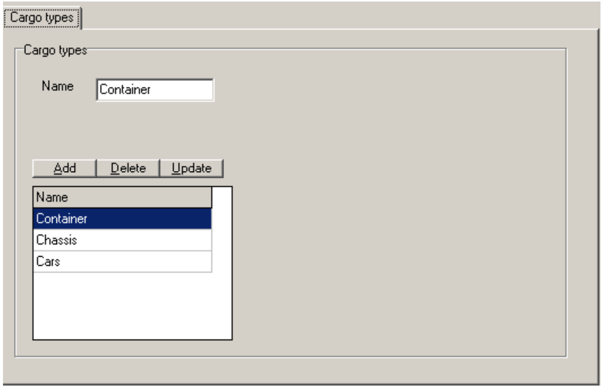


Figure 4: Screenshot of Cargo Type Definition

Each carrier and resource type will depend on the cargo types in behaviour and productivity.

2.3. Rail facility

The rail facility will be taken to demonstrate the input, simulation and animation as well as the output of the system.

First the annual throughput and seasonal distributions have to be entered (fig. 5). These information are dependent on the cargo type. The number of moves is split up to the cargo types and the distribution may differ between the types.

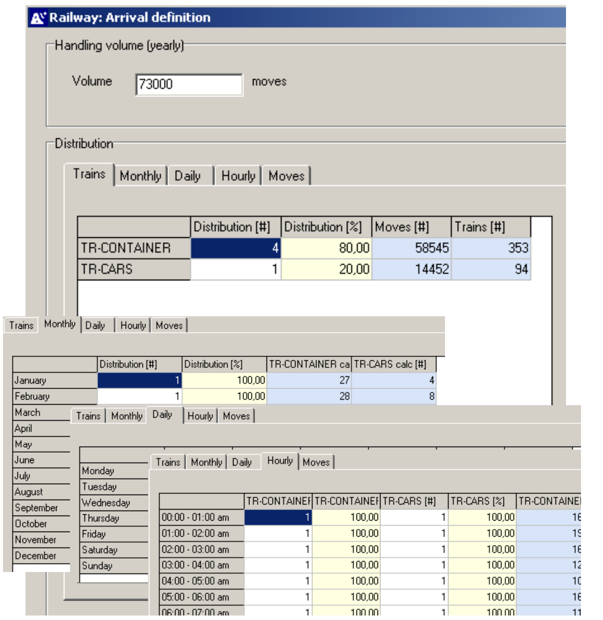


Figure 5: Input of Annual Turnover and Seasonal Distributions

On the other hand the carrier types (i.e. the trains) have to be defined (fig 6). In a first step the wagon types have to be entered. Each wagon type may carry different types and amount of cargo. The train definition is based on these wagon types and includes additional information about the utilization and the cargo split.

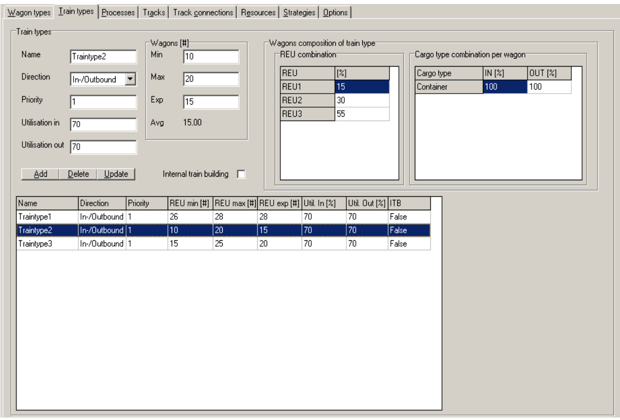


Figure 6: Train Definition

Based on these information (throughput and train types) the system generates train schedules automatically.

In the next step the operation has to be defined. First the resources for the service (i. e. equipment, e.g. cranes, fork lift trucks, terminal tractors) are entered (together with a shift schedule) regarding different productivities (moves/hour) for the various cargo types (fig. 7). They are used for the loading and unloading of the cargo. Besides these default processes other ones may be defined by the user (e.g. for air testing, cargo checking).

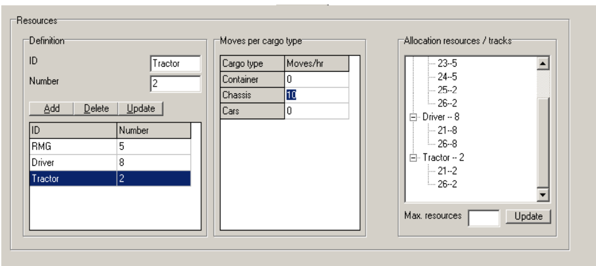


Figure 7: Resource Definition

The description of railway facilities (length and number of tracks) defines the layout of the terminal. And last but not least the strategies of the operation (i.e. allocation of processes to train types, allocation of tracks to train types, allocation of trains and resources to tracks)

With these information the simulation (fig. 8) may be started. The simulation system is based on a discrete event manager. After generating the train schedule the trains are generated in a hub (interface to the external railway system). They enter the assigned track if the connection and the track itself is ready for them. The attached processes start their work, whereas the assigned resources are split to all trains in a FIFO (first in first out) sequence regarding tracks productivity and the shift schedule.

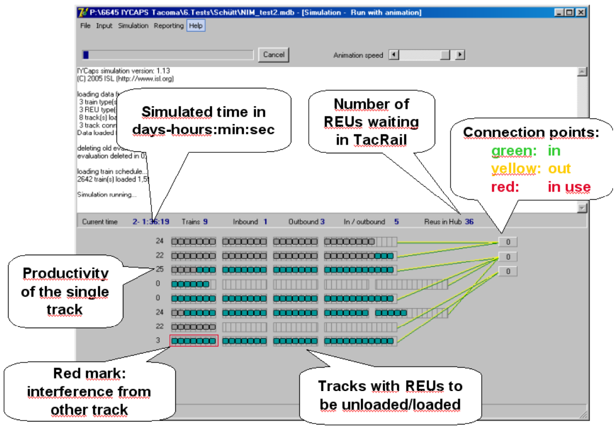


Figure 8: Simulation and Animation

Nearly all events are saved in a database for further evaluations. In this way the user may define his own queries besides the standard evaluations of ConRoCAPS. These are throughput, productivity and utilisation analysis of trains, tracks, and resources.

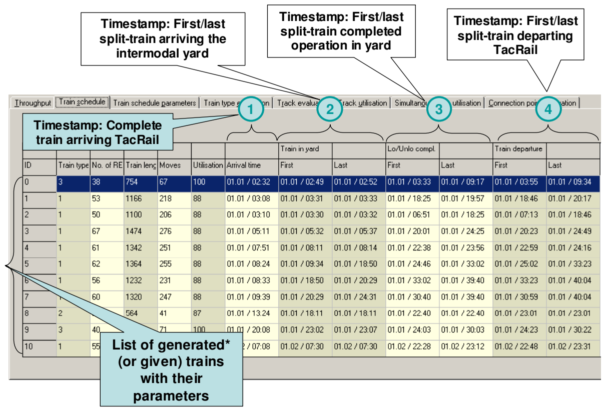
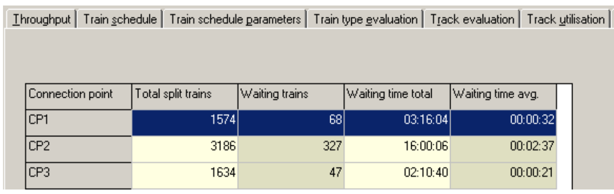


Figure 9: Generated Train Schedule with Event Timestamps

The train schedule (fig. 9) is enhanced by various times of operation (train in yard, start of operation, load/unload complete, train departure). Furthermore information about operation time, time for waiting for equipment, and average as well as max. productivity are available.



Throughput | Train schedule | Train schedule parameters | Train type evaluation | Track evaluation | Track utilisation

Connection point	Total split trains	Waiting trains	Waiting time total	Waiting time avg.
CP1	1574	68	03:16:04	00:00:32
CP2	3186	327	16:00:06	00:02:37
CP3	1634	47	02:10:40	00:00:21

Figure 10: Layout Analysis

The available facilities may be analysed using figures about the utilisation of tracks and/or the connection points (fig. 10). The main figure in analysing the simulated operation is the *staying in terminal* evaluation as shown in Figure 11.

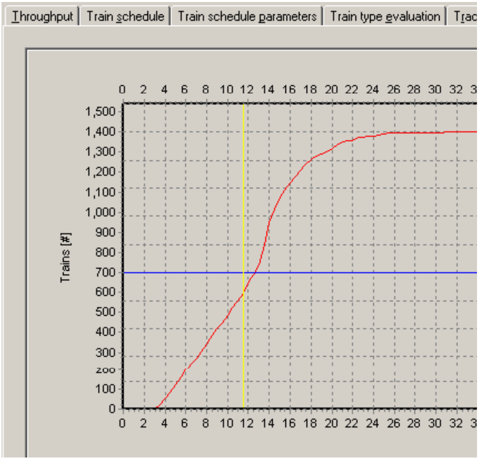


Figure 11: Staying in Terminal Analysis

The diagram shows the total time of each train in the terminal (sorted by duration). In this case 100% of all trains (1.400 trains) left the terminal at the latest after 31 hours. No train was faster than 3 hours, more than 1.250 trains (90%) left within 18 hours. This figure may be used as a service figure within contracts (i.e. *we guarantee 90% of your trains will be operated within 18 hours*).

2.4. Quay facility

The simulation of the quay facility is very similar to the train simulation. Mostly the layout definition varies (of course). As to be seen in Figure 12 the quay is split up into various quay segments.

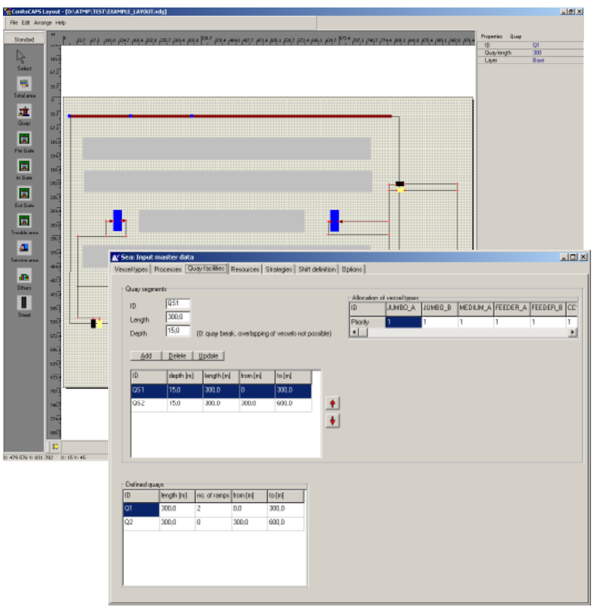


Figure 12: Staying in Terminal Analysis

The definition of vessels, of the throughput, of processes and within these also the schedule generation is nearly the same as used by the rail module.

The main analysis figure in the quayside module is the number of cranes used in parallel.

no. of StSC	Share of time	Availability
1	0.64%	0.64%
2	12.20%	12.83%
3	3.84%	16.67%
4	11.57%	28.24%
5	9.32%	37.57%
6	10.10%	47.66%
7	8.19%	55.85%
8	9.12%	64.98%
9	7.95%	72.93%
10	7.22%	80.15%
11	6.40%	86.55%
12	3.54%	90.09%
13	2.07%	92.16%
14	2.84%	95.00%
15	2.53%	97.53%
16	1.35%	98.87%
17	0.31%	99.18%
18	0.56%	99.74%
19	0.26%	100.00%

Figure 13: Crane Analysis

As to be seen in Figure 13, 15 cranes or less were simultaneous used in 97.5 % of the time. The other four cranes may not be needed for operation, without loss of productivity. Another simulation with a reduced amount of cranes will answer this question.

2.5. Gate facility

The main difference of the Gate facility module (regarding quay and rail module) is the additional usage of a traffic network on the terminal.

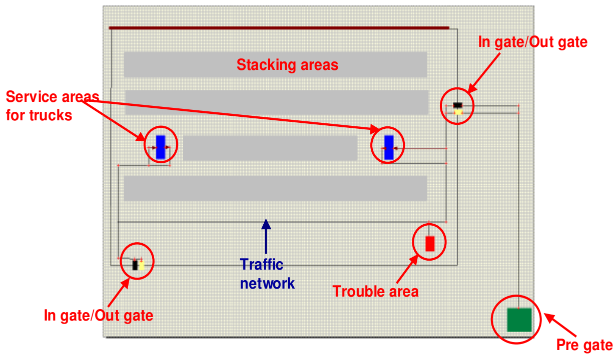


Figure 14: Truck Traffic Network

The network (fig. 14) contains the pregate, the in/outgate, trouble areas and the service areas for trucks as well as the roads to be used by the trucks. In this way the *staying in terminal analysis* includes also driving and waiting times at these service points.

3. CONCLUSION AND OUTLOOK

ConRoCAPS allows the planner of seaport as well as hinterland terminals to calculate terminals capacity and some other key data in the beginning of the planning phase. The results are based on few input parameters and may be detailed in the planning progress step by step.

The tool (and its preceding versions) has been used for terminal planning in various projects. Various terminal operators calculated their quay side capacity, so done by the JadeWeserPort Realisation Company in a very early project state. The Port of Tacoma (US) uses it for planning their intermodal yard facilities including double stack container trains. The project MOSES (Motorways Of the Sea European Style, supported by the European Commission) will use it for analysing RoRo facilities.

The next step in development will be a yard analysis module, which will calculate the needed space for given throughput scenarios.

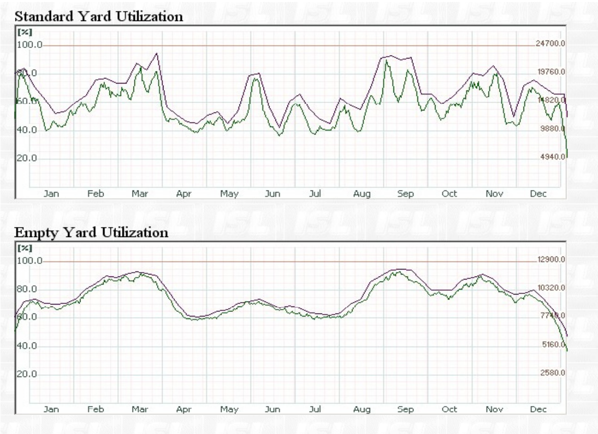


Figure 15: Yard Utilisation of Different Cargo Types

Figure 14 shows the result of a yard analysis module, where the utilisation of all defined cargo types max be shown in the diagram.

With this extension ConRoCAPS will be a simulation based tool supporting the planner of seaside as well as hinterland terminals by analysing the quay, the rail, gate and the yard facilities. It may be used in a very early state of planning to calculate terminals capacity. Furthermore it may be detailed simultaneously to the planning and allows dimensioning the facilities (e.g. number of tracks, amount of resources) as well as test operation processes and strategies.

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Dr.-Ing. Holger Schütt is the head of the section Optimisation and Simulation within ISL's Information Logistics department. The focal point of his work is the simulation and optimisation of business processes as well as material flow in logistic systems. In former times he worked as a computer scientist and project manager at the biggest harbour and logistic provider in Hamburg. He was responsible for the development of various administrative and planning systems (e.g. dangerous goods information system, berth planning system) as well as for the simulation based consultancy of the new fully automated container terminal Hamburg Altenwerder.