English summary

This research assignment has tried to answer several questions concerning the realistic modeling of a container terminal. To answer these questions a new model is derived from existing work of Alessandri et al. [2007] and [2008]. Their models are designed to reduce the lay times of carriers, by optimizing the allocation of resources. This improves efficiency of the container handling at the port which results in higher throughput and increase of economic benefit. The optimization of resources is done by maximizing the handling rate of the equipment in the terminal. A maximum handling rate, results in minimum costs, which is calculated according a cost function. The outcome of these cost functions are simulated over a prediction horizon therefore the the optimum is determined for a future moment in time, using the receding horizon principle.

Within the assignment description, there were three main questions. During the work on this assignment these three question where reformulated into two main research questions:

- How valid is this model, as a representation of a container terminal?
- How does the modal split influence the number of containers handled?

The first question is about the validation of the presented model. In general every model, that is computed is an simplification of reality. To validate the simplification, it is necessary to compare the results of the model, with data from the real world. The model, that is presented in Chapter 3 is called the complex non-linear complete intermodal model. The model is derived from the Alessandri model as mentioned before. Because of the fact that the model was a combination of these two models, the complex non-linear model is validated according data of an Italian port case that is presented in the Alessandri paper as well. The new model has proven to be valid for the Italian case. Hand calculations with respect to the constraints and input have given proof of a realistic representation of the reality. However the results have been analyzed for only one specific case and further research needs to be done in order to quantify the deviation from real world data. Therefore more data has to be gathered about incoming and outgoing traffic of current ports in the world.

The second question is about the impact of the modal split on the number of containers handled. In this case, the modal split determines the destination of the arriving containers. The arriving containers will be distributed according a ratio [A B C] meaning containers with label 'A' are destined for the vessel, B for the truck and C for the train. The quest for an answer on this question was raised by first, the assignment description that implies that component/dynamics could be added to obtain a more accurate representation of reality and second because of the changing modal split [www.portofrotterdam.com]. To elaborate on the first reasoning behind the question, in current ports all the three major modalities, vessel, truck and train interact with each other. Therefore in order to make a realistic representation of reality, the model needs to facilitate intermodal container movement. Concerning the second reasoning, the change of the modal split, is founded by the specific case of Port of Rotterdam. In the Port of Rotterdam, the second 'maasvlakte' is currently under construction. This new addition to the port's infras-

tructure will increase the throughput capacity. Currently the transport of containers arriving by ocean vessels into the hinterland is dominated by truck transport. Because of the increase in capacity at the inlet, logically the capacity has to increase at the output as well. This lead to the problem were the road infrastructure at the outlet of the port, can not deal with the increase as expected in Port of Rotterdam.

As the results show in Chapter 4, there is a significant impact of the implementation of the modal split. Changing the modal split within the scenarios had the consequence of fewer containers handled at the terminal, given the same capacity. This was the result of the vessel handling capacity that was insufficient and dominant. For the modalities of truck and train the capacity was enough but as the modal split was changed more in favor of the vessel, more container got stuck at the stacking yard awaiting transfer to vessel. The stacking yard was the interchanging point for the three separate container flows, as shown in Figure 2.8.

However within the context of this subject there are a lot of improvements that could result in more realistic and founded results. Within this assignment only three minor varying scenarios are run where there are fare more options possible. Parameters like simulation time, departure functions, arrival functions, handling rates, yard capacity, modal split, cost factors, length of prediction horizon and time steps could be changed at analyzed on impact.

Apart from changing and examine of the complex non-linear complete intermodal model, the model in itself could be further extended. More constraints and equations could be derived form other papers or resources in order to come closer to reality. In addition to that it would be interesting to optimize not only on the reducing the cost function of the model, but also minimizing on the handling rate, in order to determine the minimum capacity for a given throughput. Or trying to implement other optimization function that could present different results with fewer computer time.

All in all, it can be concluded that the complex non-linear complete intermodal model, is valid for the scenarios and data used within the context of this assignment. The model has shown the relation between the intermodal flow of container within a terminal and has therefore answered both the questions stated above. However this model is far from perfect, the method, model and scenarios can be further improved to quantify the deviation of reality and try to approach reality even more.