Summary

The Escher company is part of the oil and gas industry. Escher provides oil and gas treatment systems and flare systems. These systems have to be transported, because of their measurements and weight mostly exceptional transport is required. Escher hasn't got enough knowledge about their product transport. This is a disadvantage during contract negotiation, because unforeseen problems can occur during the execution of the project. Therefore the research goal is to have more insight in product(s) transport effects during contract negotiation. So an investigation has to be made in what range are the measurements and weight of Escher's products. Also research has to be done to find out, what factors are involved in Escher's product transports. Furthermore it has to be examined how the transport factors influence the transport effects and how the optimum is reached between the transport effects. The question is what optimization technique is required to find this optimum and how will be this optimum presented to the user.

As a start the past Escher projects are investigated to find out what the range is of product measurements and weights. After that a black box model is made to get a good understanding what factors influence product transport. The transport cost is also an important factor of the black box model. Therefore a literature study is made for finding transport cost models, which can optimize transport cost for multimodal transport. From the models found, the model of Kim is chosen with the use of a multi criteria analysis. This model is used as a start and adapted into a new model. The new model calculates cheapest route(s) for the 21 predefined options. These options are made with different combinations of road, rail and waterway transport. The model is programmed and uses the following inputs: origin, destination, Incoterms (contract terms with the client), product measurements and weight. With the product measurements and weights cranes and vehicles are selected. The vehicles minimum required quantity is determined with an algorithm, which fills the products into the vehicles. Also it checks if more products can be placed on one vehicle, so that fewer vehicles are required. As a first program input a vehicle is filled in for each modality. First this vehicle is selected on the lowest quantity and secondly on the smallest vehicle. If required the user can adapt this first input. The program proceeds with calculating the cheapest 21 options with the Sluimer algorithm. The Sluimer algorithm objective is to find the cheapest node to the origin (to be repeated for n = 1, 2, … until the nth cheapest node is the destination and the complete option is used. The output is the cheapest route(s) with the calculated transport time, the required vehicles between nodes and the cranes with their location. The program verification and validation has been done with the use of a test case, test runs and a real case.

The research goal is reached. Therefore Escher's past projects give more insight in their range of product measurements and weights and the used transport modes. Furthermore a black box model gives a better overview of which transport factors influence product transport. Also a decision support

program is made for the user to have a good insight in the transportation possibilities. Therein an adapted model of Kim is used. This adaption means that the minimum cost flow problem isn't used, but a special case from it named the Dijkstra algorithm. The reason is that Escher has to transport all products from an origin to a destination. That is why multiple supply- and demand nodes and arc capacities aren't required. Also the genetic algorithm heuristic method is removed from the Kim model. This algorithm reduces the calculation time of the problem. However, with a maximum of 5 products transported at the same time this isn't needed. Besides, the algorithm has a disadvantage that it finds nearly optimal solutions.

The Dijkstra algorithm is chosen, but needs to be adjusted. This because it can't handle multimodal transport and doesn't calculate the transport time wanted by Escher. Therefore the Sluimer algorithm is developed. This algorithm finds the minimum cost between origin and destination for each pre-defined modality combination. The minimum cost is calculated with the cheapest chosen crane per node and the chosen vehicle(s) per arc. Also the total travel time is calculated with travel time of the chosen vehicles.

In the decision support program not all transport factors are included. The following factors are included, which influence the transport cost and transport time: the origin and destination, products measurements and weights, vehicle quantity, Incoterms and the maximum transport time.

A verification of the program is done with a test case. In this test the results of hand calculations are compared with the program results. These results are identical, which shows the correctness of the program. Also the working of the program is tested with different inputs including wrong inputs. So it can be concluded that the program works well, because the program handles all inputs correctly.

After the verification the program is validated. A comparison is done between the program result and the result of a real project. In this comparison the results were almost similar, which confirms that Escher can use the program. Furthermore the program can be used for the calculation of a quick alternative when there are transportation problems. These problems can occur with connections between locations and the size and weight of the products. The program can also be used as a guideline during engineering. Besides, the program can calculate transport route with more than four nodes, but needs therefore multiple program runs. For Escher it's important to keep the databases up-to-date and add new arcs, vehicles and cranes.