Summary

Over the last four decades total seaborne container trade have quadrupled. During these decennia the handling of containers in ports has been more and more automated in order to handle the increased volume. The last step towards full automation of the handling of containers by Ship-To-Shore (STS) and Yard Cranes (YC) is the automatic pickup of containers from and landing containers on different chassis types as road trucks, trains, and AGVs.

The drivers for full automate the container handling by cranes are safer and more reliable operation, more efficient utilization of vehicle and terminal equipment and less wear and tear of equipment (and thus less downtime and lower maintenance costs) in comparison to semi-automated handling.

The research exists out of roughly two major parts; image acquisition & processing and a conceptual design of a system to auto-pickup and auto-land containers.

Object recognition and *position determination* of chassis, container and spreader during automatically pick-up and landing of containers by STS and YC is essential. This report presents several approaches in terms of measuring (scanning) and processing methods to generate the desired data for this recognition and position determination. A comparison between measuring methods (laser scanners and cameras) to generate the desired information in the form of range images is made. After the *image acquisition* a section about *image processing* algorithms for object recognition and position determination is carried out. With the generated insight in these sections a conceptual design for a system to automatically land and pick-up containers on/off chassis is formed. This conceptual design needs to meet the next general design criteria:

- Reliable operation in harbor environment (minimum maintenance);
- Fast (low processing time);
- Accurate automatic operation (high success rate);
- Flexibility (handling of various container as well vehicle types);
- Safe;
- Cost efficient.

A 3D camera mounted on the crane's portal beam, scanning per lane both chassis and spreader in one view is proposed as a conceptual design with great potential. In chapter 6 this conceptual design is described in detail. The choice to make use of a 3D camera as measuring device is based on the next points:

- Fast, real-time capturing of 3D images;
- Simple camera configuration (no rotating elements, robust, more or less maintenance free);
- The fast development of this type of measurement device (in terms of resolution and range);
- Cheaper than laser scanners and most other devices;

The specifications of the today available 3D cameras are not sufficient, in terms of range and resolution, to meet the requirements proposed by the presented conceptual design. But the concept

shows the attractiveness and potential for the usage of just one single 3D camera. Due to fast developments of 3D cameras which can measure longer ranges at higher resolutions this conceptual design can be practical implementable in the near future.

Part of the conceptual design is the approach for the development of image processing software to make the recognition and position determination of containers, chassis and spreaders out of the generated images possible. A lot of software solutions and algorithms are available as open-source material, which makes it possible to use in specifically designed image processing software for this automation task.

This report can be used to gain insight in the demands for auto-pickup containers from and auto-land containers on different chassis types in general and the use of 3D cameras for this task in particular. Further research, on both image acquisition by 3D cameras and processing software, is needed to design a system in detail which makes use of 3D cameras implementable in practice.