Summary

Unloading systems, used in agri-bulk terminals, can be divided in two main categories: continuous (screw, chain and pneumatic unloaders) and discontinuous ship unloading systems (slewing and gantry cranes). The investment, operating and maintenance costs of these alternatives show much variety. The decisions made when purchasing terminal equipment determines to a large extent the future running costs of the terminal. To reduce costs and increase cost-effectiveness, there is need for a better financial comparison of different types of unloading equipments. A small increase of the initial investment for example, can result in major savings on maintenance and consequently in a significant decrease of whole life-cycle costs.

During the last decades much research has been performed into Asset Management Control strategies, including Life-Cycle Cost Analysis (LCCA). LCCA is mainly applied in the preliminary design phase of an asset. The decisions made during that initial phase will have influence on the total life time of the asset. LCCA turns alternative solutions, new technology opportunities, maintenance strategies, design changes or asset replacement decisions into business or economic language. The method involves estimating the total cost of an asset throughout its entire life. It is about identifying future costs and referring them to present day costs using standard accounting techniques.
It is a quantitative method to determine or to assess how well an investment will perform financially in the longer term. This is expressed in the Net Present Value and the Internal Rate of Return of the investment.
LCCA seems to be the only available approach for option evaluation, assessing the impact of design, operation, support and disposal decisions on the total program. The method has lots of benefits and in spite most principles of LCCA are well developed in theory, it has not received a wide practical application yet. Nowadays purchasing decisions in port engineering are mainly based on investment costs and a global estimation of the annual operating and maintenance costs.

A literature search resulted in some 20 partly overlapping LCCA methods. The method described by Barringer has been modified and serves as backbone for the developed Decision-Support model for agri-bulk unloaders. With the use of the Decision-Support model different types of quay equipment and configurations can be analyzed based on life cycle costing. The first step of the model is the definition of the project. Based on e.g. annual throughputs, product type, vessel sizes and working times, the model will generate a minimum required unloading capacity. Secondly, alternative quay unloading setup solutions are made, which can handle the required capacity and provide the required terminal service. The third step is forecasting future values for several (financial) parameters, like inflation, interest rates, energy prices and labour costs. These input variables for the LCCA should be chosen carefully as they have great impact on the sensitivity and risk of the investment.
In the LCCA calculation, predictions of the energy price and labour costs will be based on historical trends, extrapolated for inflation and adjusted for possible extra percentage of increase or decrease. The cost breakdown structure of the unloading equipment is generated; investigation of the

investment, operating, maintenance and disposal costs of all alternatives is performed. This will result in the yearly costs profiles, which determines the future costs of the different unloading solutions.
If finally, for the multiple unloading solutions the financial calculations are performed, break-even graphs and comparable cost diagrams are generated and sensitivity analysis and risk assessments have been completed, a final judgment will take place. The selection criteria are the Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), investment and annual operating costs and the outcome of sensitivity and risk analysis.
In addition to the financial comparison (LCCA), the Decision-Support model distinguishes two qualitative criteria; operation and environment, which also are decisive factors in selecting the most appropriate unloading equipment. In case of unloading agri-bulk, qualitative operational aspects like flexibility, safety, reliability, wear and tear, and cleaning-up rate need to be considered when purchasing new unloading equipment. Qualitative environmental criteria are among others noise, dust, spillage and energy usage.

In conclusion, the challenge in decision-making is to find the balance between human concerns (e.g., cost, health, comfort) and environmental concerns (e.g., resource use, ecological degradation). Very often, however, LCCA points to solutions that are environmentally and operationally desirable. Careful design choices that result in efficient use of energy do yield long-term cost savings.

The Decision-Support model has been applied on two case studies, a barge terminal (350,000 tons/yr) and an import sea terminal (3,000,000 tons/yr), handling free-flowing wheat and non free-flowing tapioca. In case of the barge terminal labour is responsible for 70 percent of the costs during 30 years of operation. This contribution is equal for all different unloading alternatives. Energy costs conversely, are low due to the small terminal throughput. It seems that in case of free flowing products a cheap but power consuming 300 t.p.h. pneumatic unloader or a 300 t.p.h. chain unloader with high annual maintenance costs are preferred over the sustainable, low maintenance requiring grab crane. The high initial investment for the grab crane seems to reduce profitability. The lower overall costs during life time can't compete with the higher required investment.
The case study also shows that fluctuations of discount rate, inflation and the expected throughput may have strong impact on the outcome measures.
In the second case study on the import sea terminal, energy cost is a high cost driver together with labour and maintenance. In case of free-flowing wheat, purchasing two chain unloaders with a nominal capacity of 800 t.p.h. showed the best financial results. Furthermore, the chain unloader is less influenced by high energy prices compared to the pneumatic and screw unloaders. For non free-flowing tapioca, the pneumatic and chain unloader are unattractive due to high costs caused by the required unloading assistance. The best alternative would be purchasing two 800 t.p.h. screw unloaders or two 1000 t.p.h. slewing cranes. Local environmental regulations could be a final decisive factor when spillage and dust would not be tolerated. In that case the grab crane would not be allowed and the best alternative would become the more power consuming screw unloader.

In conclusion, the Decision-Support model including LCCA is an effective tool to compare different unloading equipment and to evaluate their sensitivity for future price fluctuations and risks. It provides insight in "what if" questions with respect to consequences for investment, energy, labour and maintenance costs. Unfortunately, the NPV does stimulate low budget investments, which on the longer term requires higher costs. This is a disadvantage, because it discourages innovation and automation. Moreover, there is no guarantee of future profits because of the assumptions made in forecasting of variables and prices.