

AngelStow: A Commercial Optimization-Based Decision Support Tool for Stowage Planning

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Nowadays a considerable part of trade goods are seaborne, with around 90% of all non-bulk cargo carried by container vessels. These vessels follow specific routes loading and unloading containers at different ports. A Stowage Plan (SP) assigns containers to load in a port to vessel slots. Good SPs save port fees, optimize use of vessel capacity, and reduce bunker consumption. Stowage Coordinators (SCs) produce these plans manually with the help of graphical tools (e.g., [4,3]), but high-quality SPs are hard to generate with the limited support they provide. Plans for deep-sea vessels with capacities up to 15.000 TEUs (Twenty-foot Equivalent Units) are made just hours before the vessel calls the port, and it is difficult to satisfy stacking rules, stress limits, and stability requirements, while optimizing the use of resources e.g., port cranes and vessel capacity. Moreover, the SP for the current port affects SPs in downstream ports.

Liner shipping companies are in their infancy on using optimization-based decision support tools for this task. Moreover, most of the research on stowage planning during the past twenty years has focused on algorithms to automatically generate stowage plans (e.g., [2,1,6,5]), limiting the role of expert users to result validation. Though some of these approaches generate good quality SPs, difficulties arise using them in practice. Stowage planning is full of corner cases disregarded in the models solved by automatic approaches. SCs need to be able to adapt automatic generated plans to specific situations, or be directly involved in the generation of the plans, such that SPs can be successfully used in practice.

In this abstract, we introduce AngelStow which is a commercial optimization-based decision support tool for stowing container vessels developed in a collaboration between Ange Optimization and The IT University of Copenhagen. The tool assists SCs in the process of generating SPs interactively, focusing on satisfying and optimizing constraints and objectives that are tedious to deal with for humans, while letting the SCs use their expertise to deal with hard combinatorial objectives and corner cases. Our approach divides the process of generating SPs into two major phases as depicted in left figure of Figure 1. In the first phase, the SC selects the discharge port of containers to be stowed and a weight capacity for each longitudinal section of the vessel (*Bays*). Containers can also be manually placed in specific slots at will by the SCs in order to address corner cases. In the second phase, following the layout proposed by the SC, containers from the load list are stowed automatically in slots by an approach combining an LP model and a placement heuristic, fulfilling low level stacking constraints and minimizing the capacity wasted. The algorithm stows each port on the vessel's route independently, and the results are propagated to downstream ports.

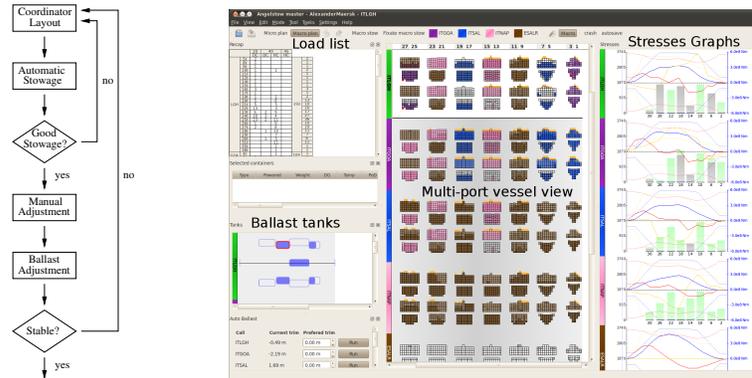


Fig. 1. Left: flow diagram for generating SPs with AngelStow. Right: screen shot of AngelStow stowing a vessel calling 5 ports. Labels indicate load list of containers and status of the ballast tanks for the current call, and multi-port vessel view of 5 different calls (current call highlighted) with their corresponding stresses graphs.

Plans produced in the second phase are easily modified by SCs to cover corner cases. Once a satisfactory SP is generated, a decision support tool for adjusting ballast water can be run to stabilize the vessel. This tool solves an LP model minimizing the amount of water filled into the tanks such that all main stresses are within limits (torsion, bending, shear force), a desired trim is achieved, and the vessel is not tilted. The layout defined by the SC can be modified at any time, and the generation process starts over. For a good level of interaction with SCs, execution time for the decision support tools is kept sub-second. Right figure of Figure 1 depicts AngelStow being used for stowing a vessel.

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