

# **Optimization for Container Logistics: Freight Containerization and Berth Allocation with Transshipment Handling**

## **Project Description**

Container logistics rely on an extensive sequence of operations to flow cargo over long distances. Planning the execution of these operations, whichever we consider, is usually a challenging task due to the high volumes of goods that are shipped using container in our modern economies.

As one of the major global companies in container logistics, Maersk is regularly facing such planning challenges. To help its planners make sound choices, it often relies on decision-support systems to receive recommendations. These systems use analytical approaches to find optimal or near-optimal solutions to complex decision problems.

This project focused on developing or improving such decision-support systems for two distinct decision problems commonly encountered in the industry.

The first problem deals with the placement of packages into containers at a warehouse: there, the goal is to find the set of various size containers with minimum cost that can accommodate all the freight, and where multiple constraints on the mixing of packages exist.

The second problem revolves around the allocation of berthing slots and times to vessels at container terminals, as well as the assignment of quay cranes to process the load and discharge operations, over a time horizon of one week. When designing berth plans, a particular focus needs to be placed on the handling of transshipments, which are operations where containers are transferred from one vessel to another. When

## **Research Outcome**

Mathematical models of the first problem were formulated, but generic resolution methods proved to be too limited to provide quality solutions for test cases resembling those encountered in the industry. Therefore, custom algorithms (heuristics and metaheuristics) were developed with the hope to obtain better results. The most advanced of these algorithms showed a

significantly better performance than the generic methods. Using the generated plans could lead to potential costs saving of up to over 50%, compared to those designed by the less sophisticated approaches commonly used in the industry.

Mathematical models were also developed for the second problem, which was approached both from the perspective of a liner shipping company (which gives berth plan suggestions to a terminal for its own vessels) and from that of a terminal (which tries to meet the liner shipping companies' requests as closely as possible while satisfying its operational constraints). With the shipping line angle, the models focus on optimizing multiple Key Performance Indicators (KPIs) at once. Those KPIs related to vessel schedule reliability, container on-time delivery at destination, and operational costs such as fuel cost. The research showed how such a modelling approach, using a weighted sum objective function, can lead to find the right balance between the KPIs, in alignment with shipping line's requirements.

Tackling the problem from the terminal's side is computationally more challenging. Indeed, if a liner shipping company suggests plans where only its own vessels can be moved in time or space, a terminal needs to plan for all the vessels of all the shipping lines that call it. Therefore, generic resolution methods struggle at scaling when trying to solve industrial cases. As for the first problem, a heuristic method was developed to overcome this issue. The algorithm can successfully generate berth plans when 80 vessels are calling the terminal within a week, when a generic approach starts failing at 40 vessels.

Overall, our research demonstrated how tailored optimization models can support more efficient decision-making in container logistics, improving the quality of operational plans for both freight containerization and berth allocation.