Challenges and Trends in Ship Routing and Scheduling

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1 Introduction

The demand for maritime transport services is increasing consistently, and there are no signs that the world economy will rely less heavily on maritime transport in the future. In this presentation, we discuss some challenges and trends in ocean shipping that will probably influence both the need for optimization-based decision support systems for maritime applications, and the shipping industry's acceptance of and benefits from such systems. We also wish to point out challenges and trends that result in a need for researchers to pay attention to new problem areas for this sector.

Maritime transportation is the major transportation mode of international trade. The world fleet has experienced continuous growth during the last few decades with a total capacity of more than 800 million deadweight tons in 2002 (see Figure 1). The fleet consists of more than 39 000 ships over 300 gross tons (ISL Bremen, 2001).

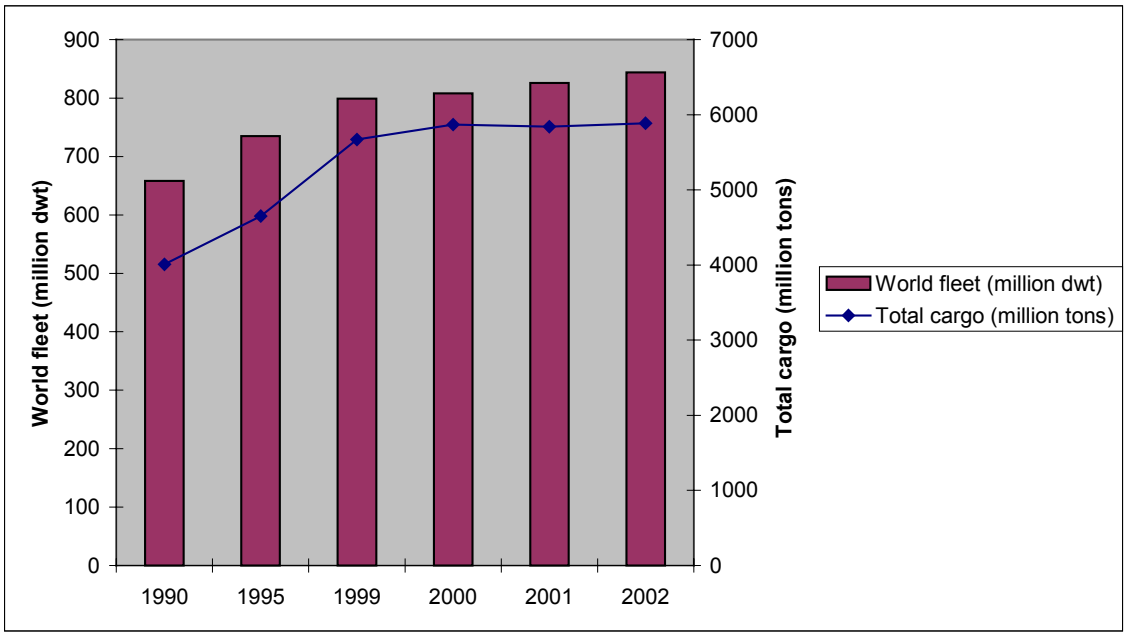

Figure 1: World fleet and world seaborne trade development 1990-2002 (UNCTAD, 2003)

The world's seaborne trade has experienced a similar increase to that of the world fleet capacity. The world trade in 2002 was nearly 6 000 million tons representing almost a 50 % increase compared with 1990 (UNCTAD, 2003).

The ocean shipping industry has a monopoly on transportation of large volumes between continents. This activity will probably increase in the future with the continuous growth in the world population, the rising standard of living, increased globalization resulting in international groups of companies collaborating and merging, greater product specialization, and, finally, the depletion of local resources. With an increase in these deep-sea activities we also need feeder systems for so-called short-sea shipping. Consequently, such regional shipping activity is expected to increase as well. In addition, we will probably see growth in the area of short-sea shipping due to heavy pressure on road networks and air corridors.

Seaborne activities are heavily dependent on the services that the world's fleet can offer. Usually, we distinguish between three general modes of operation in shipping: *industrial, tramp* and *liner*. In industrial shipping, the cargo owner or shipper also controls the ships. Industrial operators try to ship all their cargoes at minimal cost. Tramp ships follow the available cargoes, like a taxi. A tramp shipping company may have a certain amount of contract cargoes that it is committed to carry, and tries to maximize the profit from optional cargoes. Liners operate according to a published itinerary and schedule similar to a bus line. These three modes are not mutually

exclusive. A ship may be easily transferred from one mode to another, and a shipping company may operate its fleet in different modes simultaneously.

The fleet size of shipping companies may change over time, and the fleet may contain various types of ships, ships of different sizes, ships with different cost structures and with different other ship-specific characteristics. Although the fleet size and mix of shipping companies may differ considerably, they have one main objective in common, namely to utilize their fleets (fixed or variable) optimally. Consequently, shipping companies have many similar complex, extensive planning problems, ranging from the strategic to the tactical/operational levels.

A ship involves a major capital investment (usually millions of US dollars), and the daily operating costs of a ship can be tens of thousands of dollars. This means that improving fleet utilization can be translated into significant improvements in financial results. Another positive result of increasing fleet utilization can be reduced damage to the environment due to reductions in transport operations.

It is clear from the above that there is a considerable need for, and potential benefits from, decision support systems in ship scheduling. The first survey in ship routing and scheduling dates back to 1983 (Ronen, 1983). Ten years later, Ronen published a second review on ship scheduling and related areas for the decade 1982-1992 (Ronen, 1993). The increasing interest in maritime transportation is reflected in some recent publications, see for instance the survey by Christiansen, Fagerholt and Ronen (2004). However, the attention to maritime transportation planning problems has been low compared to other transportation modes, and we will briefly give a few reasons for this in the presentation.

Ship routing and scheduling problems are different from those of other transportation modes because ships operate under different conditions. We will mention some of the differences between ships and other transportation modes in the presentation.

The rest of the presentation will be dedicated to the challenges and trends in this area and the use of optimization-based decision support systems within the shipping industry.

2 Mergers, Acquisitions and collaborations

During the last couple of decades we have witnessed consolidation in the manufacturing sector resulting in bigger actors on the demand side for maritime transport services. This has given the

shippers increased market power compared to the shipping companies, resulting in squeezed profit margins for the shipping companies. In order to reduce this imbalance, there have been many mergers among shipping companies in the last decade. Many shipping companies have entered into pooling and collaboration efforts in order to increase their market power and gain flexibility in the services that can be offered.

Traditionally, scheduling in maritime transportation has been done manually by pencil and paper, based on the planners' knowledge and experience. The above trends of mergers and pooling collaborations result in larger controlled fleets. This means that it becomes much harder to determine a fleet schedule only by manual planning methods. Therefore, the need for optimization-based decision support systems has increased and will probably continue to increase in the future.

3 New generation of planners

Decision-makers and planners in the shipping industry are traditionally experienced, often with a sea-going background. As the fleets become larger, their ship routing and scheduling problems become much harder to handle by manual methods. Despite this, planners are often very skeptical of computers in general and of optimization-based decision support systems in particular. However, in recent years we have seen that shipping companies have started employing planners with less practical but more academic background. This new generation of planners is more used to computers and software, and therefore is often much more open to new ideas such as using optimization-based decision support systems for the different applications in maritime transportation.

4 Developments in software and hardware

The fast technological development in computers and communications also weighs heavily for the introduction of optimization-based decision support systems in shipping companies as in other business areas. Many earlier attempts failed due to restricted computer power, making it hard to model all the important problem characteristics and to facilitate a good user interface. However, today's computers enable an intuitive user interface to be implemented, something that

is crucial for acceptance by the planners. In addition, there have been significant algorithmic developments. This, together with advances in computing power, has made it feasible to find good solutions to hard problems in a reasonable amount of time.

5 Shift from industrial to tramp shipping

Looking at the literature review presented by Christiansen, Fagerholt and Ronen (2004), we observe that most contributions are in industrial shipping, while only a few are in the tramp market. In industrial shipping the shipper controls the cargo and the fleet of ships. The purpose of an industrial operation is usually to provide the required transportation services for the organization's cargo requests at minimum cost. Industrial shipping is practiced by large extracting and manufacturing companies that have their own division controlling a number of ships for the transportation of their own cargoes. However, in recent years this has changed. Many such companies are now focusing on their core business and have outsourced other activities like transportation to independent shipping companies. Therefore, the emphasis has shifted somewhat from industrial to tramp shipping. Increasing global competition results in shifting industrial shipping operations from being considered "cost centers" into "profit centers" and compels them to become more involved in the spot market. This also brings new opportunities for optimization-based decision support systems for maritime transportation planners.

6 Focus on supply chains

In most ship scheduling studies reported in the literature, the supply chain perspective is missing. Recently we see an increasing competition between supply chains even more than between shipping companies. Shipping companies must consider themselves as total logistics providers, or at least as a part of a total logistics provider, instead of only a provider of sea transport services.

We expect an increasing emphasis on integrating maritime transportation into the supply chain. This will also bring new interesting challenges to the research community in routing and scheduling, such as inventory routing, collaboration, and cost and/or profit sharing along the supply chain.

7 Summary

Ship routing and scheduling is an interesting area with high potential for improvement by optimizing fleet utilization. We have pointed to some of the trends in the shipping industry that will probably influence both the need for optimization based decision-support systems for ship scheduling and the shipping industry's acceptance of and benefits from such systems. These trends lead to several challenges for the researchers and decision support developers. In the presentation, we will discuss the related challenges and present some own experiences from developing such systems for the shipping industry.

References

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