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Cost benefit analysis of dynamic route planning at sea

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Abstract

Route optimization through dynamic route planning, where ships can shorten their routes taking other vessels movements into account through shared information, has a potential to make transportation at sea more efficient. Fuel and emissions can be saved through green steaming without increased cargo transit times, and without reducing safety. This study estimates the potential net benefits to society in major areas in the Baltic Sea and the North Sea. It is found plausible that routes can be shortened by one percent on average, which would reduce costs to society by 80 million euros per year, of which 35 percent are reduced fuel costs and 65 percent are reduced emission costs. Alternative unit values of emissions give an interval of 55 to 113 million euros in benefits. The project's costs are estimated at 15 million euros per year. With a growing world trade, the potential for more efficient and environmentally friendly sea transportation through dynamic route planning may be substantial.

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Keywords: sea transportation; cost benefit analysis; route optimization; emissions; environment; efficiency

1. Introduction

Rapidly growing international trade together with the intention to reduce global emissions leads to increasing needs to make transportation at sea more efficient. Lower fuel consumption and transportation emissions can be achieved by decreasing speed (Fagerholt et al., 2010, Chang and Chang, 2013, Maloni et al., 2013). A negative

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effect of slower speed is increased container transit time (Yin et al., 2014). The International Maritime Organization proposed larger vessels, reduced speed, and new technologies to reduce greenhouse gas emissions (Woo and Moon, 2014). However, such measures to lower emissions will come at the cost of increased capital expenditure (Hoffmann et al., 2012). Sea Traffic Management (STM) is a concept developed within the MONALISA project, which is aimed at increasing safety, environmental and operational efficiency for sea transportation. (Lind et al, 2014). One part of STM is Dynamic Route Planning (DRP) based on updated information about the intended routes of vessels in the area and shared information. This will create a potential for ships to take shorter routes, save fuel and reduce the impact on the environment without increasing the cargo transit time.

In this paper, the potential savings of fuel and emissions from route optimisation are analysed. We assume that safety remains unchanged, although another study in the project indicates positive effects also on safety through fewer possible conflicts between ships (SSPA, 2015). The availability of data from ships' AIS-transmitters provides new opportunities to quantify sea traffic and evaluate proposals aimed to make sea transportation more efficient. The volume of sea traffic for two major areas in the North Sea and in the Baltic Sea is calculated, based on complete AIS-data for three selected days. Then, the total costs of the traffic are estimated by using formulas for fuel consumption and emissions together with unit values for fuel and emissions. Together with AIS-data from passage lines and results from simulations made in other studies, this will provide a base for the estimation of the potential for savings by allowing sailing shorter routes.

The benefits will be compared to estimated costs for developing technology and investments in equipment as well as for training and for running the system. Monitoring and governance may be necessary. We analyse the potential net gains for society as a whole, by estimating the benefits and costs of implementing DRP using Cost--Benefit Analysis (Boardman et. al, 2010). By society, all parties that in one way or another are affected by sea transportation are included, i.e. both the buyers and sellers of the services and the rest of society.

2. Estimating costs for fuel and emissions of sea transportation

The fuel consumption by a ship is mainly affected by size, type, condition of ship, speed and load. Emissions are affected by fuel consumption as well as type of engine, presence of catalyser and fuel type (SEPA, 2010).

2.1. Fuel costs

The model for hull resistance in deep water (Larsson, Raven, 2010), applied by the Swedish maritime research institute SSPA (Holm, 2015), is used to estimate fuel consumption for the ships in the study. Fuel consumption for a specific journey by a ship is calculated as:

$$C = \frac{R_T * D}{E_{MGO} * \eta_T} \tag{1}$$

where
C = fuel consumption in kilogram
R_T = resistance
D = sailed distance in meters
E_{MGO} = MGO (Marine Gas Oil) energy density, 46200 is used
η_T = overall efficiency, 0.35 is used

$$R_T = \frac{1}{2} * \rho * V_S^2 * (B + 2d) * L * C_B * C_{TS} \tag{2}$$

where
ρ = water density, 1.25 is used
V_S = velocity (speed) in m/s
B = beam of vessel
DR = draught of vessel