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# Green approaches at sea – The benefits of adjusting speed instead of anchoring

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ABSTRACT

In this paper, the concept 'green approaches' already used in aviation is applied to cargo transportation at sea. Instead of anchoring outside a port waiting for berth, ships can adjust their speed to arrive just in time for berthing. With improved incentives for reducing speed and shared information about berthing times, green approaches instead of anchoring can be a way to reduce fuel consumption and emissions without increasing the transit times of goods. The present study estimates the benefits to society as a whole for the EU ports in the Baltic Sea with Automatic Identification System data applying a new method using data collected in real time. Data consists of all anchored ships awaiting berth on 40 different occasions in 2015 and are subsequently extrapolated to a year. Fuel consumption by the individual ships, emissions and values are calculated from the detailed data with established models and estimates of unit values. The potential benefits are estimated at 27 million euros per year in the scenario where the near 15,000 anchorings by ships annually awaiting berth may instead start a green approach 12 h prior to arrival and may reduce speed by 25%, using the middle unit values for fuel and emissions. The methodology used in the paper can be applied to estimate the benefits of green approaches in other areas with anchored vessels.



## 1. Introduction

Transportation at sea needs to be more efficient to make it possible to combine increased international trade with reduced global emissions. Decreasing speed is a way to achieve lower fuel consumption and emissions (Chang and Chang, 2013; Fagerholt et al., 2010; Maloni et al., 2013). Because fuel consumption increases progressively with speed, even small reductions can contribute to significant benefits both for ship owners and for the environment. Larger vessels, reduced speed and new technologies are proposed by the International Maritime Organization with the aim of reducing greenhouse gas emissions (Woo and Moon, 2014), but lower speed will increase transit times of goods (Yin et al., 2014).

The concept 'green approach' (or Continuous Descent Approach), is being applied in aviation. To economise on fuel and emissions, airport approaches begin earlier during the flight. Aeroplanes adjust speed to the estimated time for landing to avoid holding in the air when airports are congested and descend in a more even pattern instead of the common stair-like decent, reducing fuel consumption, emissions and noise (Sarkar, 2012; Brussels Airport, 2012; Schiphol, 2011; Swedavia, 2015). In this paper the concept is applied to sea transportation and means that when a ship cannot enter the port upon arrival, it adjusts its speed to arrive just in time for berthing instead of 'holding' by anchoring outside the port. Ships

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may have to anchor before entering a port because the berth is occupied, the cargo is not ready, the berth time needs to be adjusted to accommodate tides or channel operations and so forth.

Today ships have imperfect incentives to adjust speed to arrive just in time for berthing. Contracts often stipulate that ships should arrive as soon as possible, whether or not a berth is available – a 'hurry up and wait' principle. If the ship arrives later than stipulated in the contract, the owner may lose revenue in the form of 'demurrage' they receive when waiting. This loss serves as a penalty for arriving late. If the demurrage is greater than the savings on fuel from sailing slower, the incentive is to arrive early and anchor. The saved emissions are external effects that would benefit society as a whole, not specifically the ships slowing down. Furthermore, many major ports apply a first-come, first-served principle (Alvarez et al., 2010). Ships thus have little incentives to reduce speed before the port approach (Rematulla and Smith, 2015). Contracts that allow for adjustment of speed, so-called virtual arrival, are being introduced as a way to reduce this problem, particularly for tankers (IMO, 2016; Yiantselis, 2015). This means that decisions about which ship is to be first served can be based on a calculated instead of actual Expected Time of Arrival (ETA), and ships can adjust speed without losing demurrage.

Ships also have imperfect information regarding when the ship can enter the port. Different stakeholders in the port are involved in the process of making the berth and other resources available without anyone necessarily having the overview or incentives to make approaching ships adjust their approach to arrive just in time, taking early decisions about who is to be served first and informing other ships about expected berthing times. Information sharing as part of Sea Traffic Management (STM) was developed in the MONALISA project (Lind et al., 2014).

The benefits of making green approaches at sea depend on the present number and the anchored time for the ships. Watson et al. (2015) studied the extent of anchoring in the port of Gothenburg based on stored Automatic Identification System (AIS) data for anchorage in designated areas outside the port with the aim of estimating the possible savings by improving information sharing by applying STM. To study the anchoring at one port, this method can be applied.

To estimate the total volume of anchoring in the entire Baltic Sea area, however, that method is difficult to apply. To not exclude any relevant ships, it is necessary to know every single area where anchoring might occur and then combine the data of anchorings with data of berthing ships to not include ships anchoring for other reasons than waiting for berth. In a pilot study by Andersson and Ivehammar (2016a) a different approach was tested. In that study the extent of anchoring outside ports in the Baltic Sea was quantified by samples of occasions when AIS data from the Internet site Marine Traffic (2013, 2014) were collected. In the present study this approach is further developed by studying the extent of anchoring outside all ports in the EU countries of the Baltic Sea from the Internet site Marine Traffic (2015), using individual data for the calculations. Compared to the pilot study four times as many observation occasions are included, collecting more information about each individual ship, and fuel consumption is estimated for each individual ship with current fuel prices instead of only using standard values for different ship types, and unit values for emissions are updated.

The aim of this paper is to estimate the potential benefits to society as a whole of applying green approaches to the EU ports in the Baltic Sea instead of anchoring and to discuss the possibilities and incentives to achieve these benefits. Another aim is to develop a methodology for how AIS data can be collected for estimating the total extent (numbers and anchored time) of anchoring and make it possible for others to use a similar approach. The study is confined to the European Union because it is considered a suitable cooperation body for starting to improve incentives and information at sea. Port capacity and the efficiency in port handling are factors that affect the extent of anchoring. In this study they are treated as exogenously given.

## 2. Method

Welfare theory intends to achieve as much benefit (or as little cost) as possible with the scarce resources available in society (Boardman et al., 2010). The main costs of sea transportation for society as a whole are fuel costs, staffing costs, capital costs (Stopford, 2010), and in addition, the external costs for emissions and accidents caused by ships. Using green approaches instead of anchoring awaiting berth will save fuel costs and emission costs. The potential benefits depend on the total volume of anchored ships, the possible fuel and emissions savings for the different ships, and the unit values for fuel and emissions.

### 2.1. Data collection: A real time study

Since 2007 it is mandatory for commercial ships to have an AIS transmitter that continuously sends a signal with information about the ship's position and other data (EU Directive 2013/52/EU, 2013). This offers new opportunities to collect large amounts of data. AIS data for the Baltic Sea are stored by organisations in the HELCOM network.

The data were collected in real time from Marine Traffic on forty occasions during two time periods to estimate the extent of anchoring awaiting berth outside all ports in the EU part of the Baltic Sea. The first time period included twenty occasions in April and May 2015, and the second included twenty occasions in August and September 2015. Data were collected for Estonia, Finland, Latvia, Lithuania, Poland, Sweden and the Baltic Sea ports in Denmark and Germany.

All ships anchored waiting to enter a port at a specific moment were registered. The registered ships were then followed up to find out for how long each one anchored before berthing and to verify that the ship actually entered a port. Thus, ships