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Towards safe and economic Arctic shipping

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Towards safe and economic Arctic shipping

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Abstract. We present a framework for safe and economic maritime operations of Arctic cargo ships. The framework comprises analyses from various perspectives and targets at safety and fuel efficiency of existing and future cargo vessels that are designed mainly for open water operations. International and national regulatory requirements regarding Northern Sea Route (NSR) transits were examined. The Arctic shipping status and challenges are analyzed using data collected by shipping companies. This article also proved that the Arctic routes save large percentage of sailing time and fuel costs.

1. Introduction

The Arctic is transforming into a navigable ocean due to the effects of global warming. On July 1st 1991, the Russian Federation opened up the Northern Sea Route (NSR) for foreign traffic and thereby opened a new sea route between Europe and Asia [1]. Substantial savings in voyage times and fuel consumption can be made using the NSR, compared via the Suez Canal Route (SCR) and the route around South Africa. However, NSR transits have serious safety implications for the ships operating in the region due to the Arctic extreme environment. On the other hand, the shorter distance via the NSR does not guarantee economic advantages in comparison with the traditional sea routes. This is mainly due to the following facts: 1) ice induces extra resistance resulting to increased fuel consumption; 2) extra maintenance and reparation costs related to ice-induced hull/propeller damages; 3) extra time due to voluntary and involuntary reduced ship speeds in ice-covered water as well as the waiting time for icebreaker assistance under severe ice conditions; 4) fees charged by the Russian authority for passing Russian territorial sea as well as fees for icebreaker assistance; 5) potential additional insurance costs. These costs, in addition to the higher risk levels related to Arctic transits make most ship-owners hesitated to take the NSR alternative.

Therefore, cross-disciplinary and dedicated research and innovative technologies are needed to ensure the economic benefits and to minimize risks of severe environmental catastrophes for commercial vessels sailing along the Arctic routes. In this study, the authors focus on Arctic sea routes between Europe and Asia, or the Northeast Passage, while the sea waterways across the Canadian Arctic Archipelago were not considered. Only cargo ships are taken into account, even though the Arctic cruise-shipping sector has seen a rapid increase in recent years. In addition, the operational scenarios are limited to "the summer season", which implies the encountered ice conditions are in general mild. The targeted ship types are accordingly commercial ships of lower ice-classes or are non-ice classed. Breaking ice by the commercial vessels themselves will not be discussed in this article.

2. Legal framework

A thorough understanding of the legal framework concerning sailing into ice-infested waters is fundamental for Arctic shipping related research. For the Northeast Passage, the legal framework is composed of the International Code for Ships Operating in Polar Waters (the Polar Code), and the Russian national NSR law. Canadian Arctic Shipping Pollution Prevention Regulations, which ships instead in the Canadian Arctic waters are to comply with, is outside the scope of this article.

2.1 IMO Polar Code

The Polar Code is a new convention adopted by the International Maritime Organization (IMO), marking an historic milestone to protect ships and people aboard them, as well as the environment of the waters surrounding the two poles [2]. The Polar Code entered into force very recently: 1 January 2017 for new ship; 1 January 2018 for existing ships; 1 July 2018 for manning and training requirements. The main requirements of this new international convention are related to safety, protection of the environment, and seafarer competence, and it is implemented through amendments to existing conventions of the International Convention for the Safety of Life at Sea (SOLAS), the International Convention for the Prevention of Pollution from Ships (MARPOL), and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).

The Polar Code classifies vessels into three categories: Category A ship - ships designed for operation in polar waters at least in medium first-year ice, which may include old ice inclusions; Category B ship - a ship not included in category A, designed for operation in polar waters in at least thin first-year ice, which may include old ice inclusions; or Category C ship - a ship designed to operate in open water or in ice conditions less severe than those included in Categories A and B. This classification of polar ships is a much broader indication of a ship's capability to navigate in ice, which differs from the Unified Requirements for Polar Class Ships developed by International Association of Classification Societies (IACS). The IACS rule has seven, PC 1 the highest to PC 7 the lowest, different Polar Class notations. In general, all IACS polar classes are above the Category C of the Polar Code [3].

The Polar Code requires ships intending to operate in the defined Arctic and Antarctic waters to apply for a Polar Ship Certificate (PSC). The Polar Code also requires Arctic sailing ships to carry a Polar Water Operational Manual (PWOM), to provide the owner, operator, and crew members with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process. It needs to be pointed out that according to the Polar Code, ships of Category C, i.e., ships designed mainly for open water operations, can also be allowed to sail in the Arctic waters, relying on icebreaker escort, or on an opportunistic basis where there is no ice or limited ice presence.

2.2The Russian NSR law

In practice, we do not distinguish the terms of the Northeast Passage and the Northern Sea Route, both refer to the Arctic routes connecting Europe and East Asia. However, strictly speaking, while the Northeast Passage includes all the East Arctic seas and connects the Atlantic and Pacific oceans, the NRS does not include the Barents Sea, and it therefore does not reach the Atlantic. In 2012, Russia adopted its Federal Law 132-FZ, often referred to as the Russian NSR Law [4]. This Russian national law introduces the new concept of the Northern Sea Route Water Area, illustrated in Figure 1.

In 2013, Russia approved the Rules of Navigation in the Water Area of the NSR, and established the federal state institution "Administration of the Northern Sea Route" (NSRA) to manage navigation in the NSR water area. Russia claims that the navigation through NSR water area must be authorized by NSRA [5]. In other words, foreign ships enter the NSR water area must apply for NSRAs permissions. Except for issuing permits, NSRA also manages ships for pilotage, ice pilotage, and icebreaker support, providing weather/ice conditions, and is responsible for search and rescue in the NSR water area. For commercial ships sailing along the NSR, both the Polar Code and the Russian NSR law are to comply with. It is noticeable that these two regulations are from two separate legal regulations. For example, the PSC and the PWOM required by the Polar Code are not in the list of documents to be submitted when applying for NSR navigation permission.

Figure 1. The NSR water area claimed by Russia (www.nsra.ru).

3. Practical Arctic experience of shipping companies

Even though Russia has been constantly encouraging international use of the NSR, it seems that most shipping companies by far take it as a less attractive sea route. The majority of the ships operated along the NSR are Russian domestic vessels. This is proved by the fact that a total of 250 vessels crossed the Arctic routes between Europe and East Asia from 2011 to 2017 according the NSRA, among which 137 vessels were Russia-flagged [6].

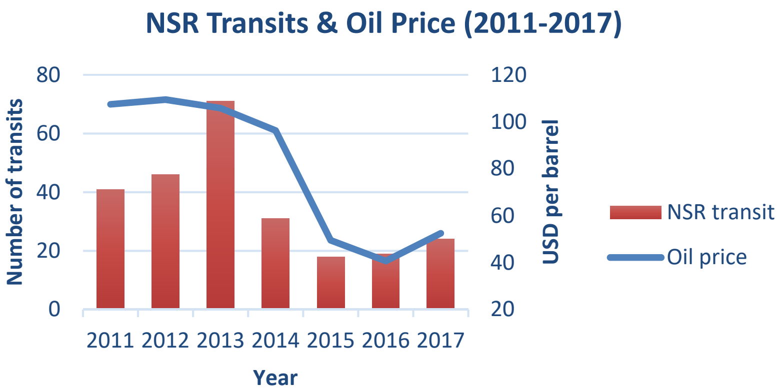

Figure 2. The number of transits through NSR and oil price 2011-2017 (sources: www.arctic-lio.com and www.statista.com).

The transit numbers vary significantly in recent years, topped by 71 vessels in 2013. In 2015, only 18 ships took the NSR. The transit numbers are believed to be a result of various factors. Conversions with ship-owners indicated that the oil price is a major impact factor behind the change of popularity of the NSR. Figure 2 illustrates the development of oil price in comparison of the NSR transit numbers from 2011 to 2017. In general, when oil price is high, the extensive fuel costs become a driving factor for shipping companies to choose the NSR. Another factor that influences the NSR transit frequency might be the international politics. The dramatic fall of the transit number in 2014 can be explained the by the western sanction on Russia after the Ukrainian crisis. For these reasons, we expect that a rising oil price will bring more shipping companies to the NSR in coming years, unless the Russian western relations continue to deteriorate.

Among the international shipping companies who have tried the Arctic routes, China COSCO Shipping Corporation Limited (COSCO) is reckoned as a consistent player. COSCO has now a fleet of 1114 vessels with a total of 85.3 million DWT, is thus one the largest shipping companies [7]. COSCO had its first NSR voyage in 2013, followed by a roundtrip transit in 2015. In 2016 six transits were completed by COSCO ships, inclusive the first transit without icebreaker escort. In 2017 COSCO sent five vessels through the NSR. None of the five vessels were ice-classed. The NSR has now become a commercial route for COSCO's North Europe voyages [8]. COSCO's NSR voyages proved the advantages of taking the Arctic routes. Taking the 2017 NSR transits as example, significant saving in terms of distance, time and fuel cost were achieved in comparison with the traditional SCR. Table 1 lists the five Arctic voyages and the savings achieved.

Table 1: the COSCO Arctic voyages in 2017 and the savings in comparison with via the SCR

Vessel name, IMO no. & Ship type	Departure date & place	Arrival date & place	Period in the NSR Waters	Distance-saving (nm)	Time-saving (day)	Fuel-saving (ton)
Lian Hua Song (IMO 9608829); General cargo	Aug. 3; Ulsan, South Korea	Aug. 31 Esbjerg, Denmark	Aug. 15-24	4779	15.5	372
Da An (IMO 9607825); General cargo	Aug. 22; Tian Jin, China	Sept. 14 Cuxhaven, Germany	Sept. 1-8	4872	15.0	390
Tian Le (IMO 9722730); General cargo	Aug. 29; Cuxhaven, Germany	Sept. 20 Tomakomai, Japan	Sept. 6-13	6104	19.5	490
Tian Jian (IMO 9722754); General cargo	Aug. 31; Lian Yun Gang, China	Sept. 23 Esbjerg, Denmark	Sept. 9-18	4589	15.3	383
Tian Fu (IMO 9704738); General cargo	Sept. 4; Grenaa, Denmark	Sept. 29 Shanghai, China	Sept.10-18	5226	16.1	425

Based on the fourteen NSR transits of vessels of various types and ice classes, COSCO has accumulated valuable experiences in practical operations in Arctic waters. These experiences were achieved under different environmental conditions, covering scenarios of independent ice-navigation, icebreaker escort, and icebreaker convey. COSCO's Arctic experience serves as a major contributor to end-user requirements for the authors' research on Arctic maritime operation. A few items summarized from COSCO's ice-navigation experiences are given here:

- Ice conditions vary significantly from year to year. It is difficult to predict the ice conditions from the encountered ice records of the same period of previous years. For example, in late August 2017 the entire NSR is almost ice-free, while in the same period of 2016 the ice conditions were much severer, particularly in the middle of the Laptev Sea and the East Serbia Sea. Figure 3 illustrates the ice concentration of the NSR in August 21st, 2016 and 2017, respectively.
- Ice thickness is a crucial parameter for decision support when sailing in ice-covered water. However, a typical weather/ice service only provide ice-concentration forecasts but not for ice thickness. Also, it is difficult to determine the encountered ice thickness with visual observation or with existing technologies.
- Strong North-east wind are often found in Laptev Sea, bringing in large amount of brass ice into Vilkitsky Straight, which to some extent blocks the straight. This ice accumulation however can hardly be predicted by the ice forecast.

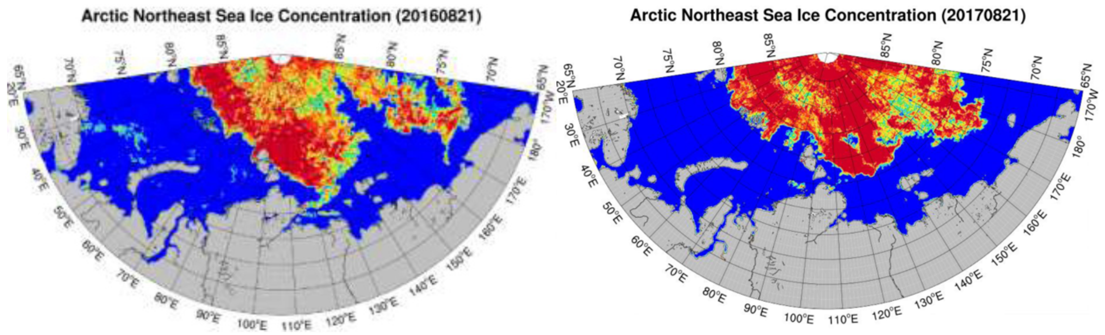

Figure 3. The comparison of ice extent along the NSR in the same period of 2016 (left) and 2017 (right).

4. Concluding remarks

This paper outlines a framework for safe and economic Arctic transit of cargo ships. The frame targets at enhancing safety and fuel efficiency of existing and future commercial ships that are designed mainly for open water operations for potential Arctic transits. The existing legal regulations related the Arctic shipping were examined and the practical Arctic transit experience from shipping companies were reflected. In general, the current regulatory framework leaves much responsibilities to national authorities of coastal countries as well as the flag states. It concludes from the practical experience of shipping companies that a safe Arctic transit can be achieved if caution and certain routines are followed, even for non-ice classed ships. It also proved that the Arctic routes save large percentage of sailing time and fuel costs.

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