

Ice Automatic Routing: Analysis of Simulation Testing Based on Voyages of Arc7 Class Vessels in the Arctic

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The Arctic and Antarctic Research Institute (AARI) has long-term experience in hydrometeorological support and selecting optimal routes of navigation along the Northern Sea Route. One of the key challenges for hydrometeorological support and safe and cost-efficient navigation is developing an automatic method for selecting the optimal ship route in ice. In this study, we present results of testing AARI auto-routing and discuss its perspectives.

INTRODUCTION

In the middle of the 20th century, extensive studies began along the Northern Sea Route (NSR) and in the Arctic Basin. Upgrading cargo and icebreaking fleets caused changes in ice navigation tactics. It has become necessary to navigate in fast ice, extend the length of the navigation period, increase the speed of a ship with icebreaker assistance, and increase the capacity of the NSR. As a result, new requirements for navigation support have been developed. Specialized ice information on ice conditions directly along the ship lines has become a necessity. These tasks require the study of the ice cover as a navigational environment and development of algorithms to assess quantitatively the impact of sea ice on navigation in ice-covered waters. Analysis of field observations reveals differences between ice conditions along a ship route and those determined over a sea region or entire sea area. In 1961, the Department of Ice Navigation Study was established in the Arctic and Antarctic Research Institute (AARI) to study ice cover as a navigational environment and identify quantitative indicators of ice impact on the difficulty of shipping. Since then, AARI experts have accumulated great experience in providing specialized hydrometeorological information to vessels operating along the NSR, including practical and methodical experience of optimal ship routing in particular.

The safety and efficiency of navigation along the NSR depend not only on total sea ice cover and duration of ice season. A sig-

nificant effect of sea ice on shipping is due to dangerous ice phenomena and ice formations—that is, abnormally early ice formation, the presence of compacted and very thick ice along the shipping lines, ice compressions, ridging, the density of icebergs, and grounded hummocks (Mironov, 2010). Ice conditions are general characteristics within a given localized or large sea region. Ice navigation conditions identify ice conditions along a ship route. Therefore, difficult ice navigation conditions may occur against light sea ice conditions, and vice versa (Mironov et al., 2021).

The need to automate operational processes has also involved the automation of ship route optimization in ice-covered waters. A number of methods for automated optimal ship routing in ice conditions (auto-routings) have been developed, as represented in studies by, for example, Kotovrita et al. (2009), May et al. (2018, 2020), Lehtola et al. (2019), and Topaj et al. (2019).

However, even well-developed automated methods of route optimization in ice-covered waters are limited by the development of input data (i.e., actual ice charts and forecasts). Automatic interpretation of satellite images is still unable to provide a prompt, accurate, and detailed ice chart; therefore, ice charts are prepared by an ice expert who visually interprets satellite images. The interpretation includes identifying homogeneous ice zones: from the one side, a homogeneous ice zone serves as a general characteristic of a given localized or large sea region; from the other side, it contains only part of the required ice parameters and thus is unable to provide the complete performance of ice navigation conditions and represent an actual model of ice cover, which is required for application tasks.

Automatic routing systems should be developed together with methods of ice cover interpretation by satellite imagery; this will effectively assist in planning maritime operations. Until recently, it was not evident whether the results of auto-routings could serve as an independent tool for supporting safe and efficient navigation along the NSR without involving an ice expert.

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