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Towards Understanding Maximum Expected Time Of Rescue In Canadian Arctic Waters By Maritime Assets

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To mitigate risks of Arctic shipping, the International Maritime Organization (IMO) has developed the Polar Code, which sets regulations for ships operating in polar waters. Such vessels and their crew require certification to show compliance with the Code. A critical requirement for safety of life at sea is ensuring that ships are equipped and prepared to effectively handle emergencies. A key aspect of this is determining the 'Maximum Expected Time of Rescue' (METR) for the intended operations, which should be included on the vessel's Polar Ship Certificate. The METR specifies the minimum duration that a ship should be prepared to sustain the people on board in the harsh polar environment without external assistance, which sets a basis for the type and amount of survival equipment to be carried on board. Only Piercey et al. (2019) have proposed a method, using a relatively simple set of equations. This method has not yet been extensively validated.

This research presents a new approach to determine the METR in Canadian Arctic waters, accounting only for the response by marine assets (Coast Guard and vessels of opportunity). As shown in Fig. 1, the approach uses various data sources, a transit time calculation method, and algorithms to analyze the transit times of all vessels operating in the area, from which finally the METR value in the Canadian Arctic is derived.

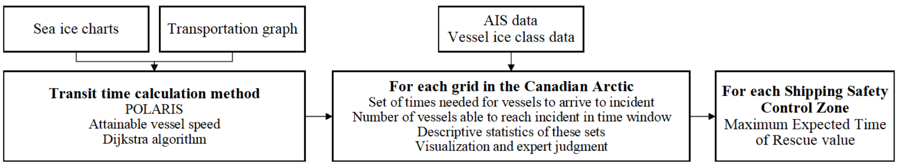

Fig. 1. Overview of the method to determine the METR in the Canadian Arctic.

As a basis of the work, 20 years of weekly historical sea ice charts are used, as well as two years' data from the Automatic Identification System (AIS), augmented with information about a responding vessel's ice class.

The transit time calculation method is used to determine the time for responding vessels to reach a given incident location. This method is based on a transportation graph for the Canadian Arctic area, which is overlayed with historical sea ice charts, so that its spatiotemporal attributes are joined to ice conditions at the nodes in the graph. Furthermore, the Polar Operational Limits Assessment Risk Indexing System (POLARIS) (IMO 2016) is used to calculate a Risk Index Outcome (RIO) for each node. These nodal RIO values are subsequently assigned an attainable operational speed for vessels with different ice classes based on empirical work by Stoddard et al. (2024a). The transit time between all adjacent nodes in the graph are then determined based on the distances between nodes and the attainable speed for the given vessel type, as explained in Stoddard et al. (2024b). Finally, the transit time calculation method implements Dijkstra's algorithm (Dijkstra, 1959) to obtain the minimum time for a vessel to reach the incident ('end location') from its location when the incident occurs ('start location').

The trajectories of the vessels operating in and near the Canadian Arctic area are sampled based on AIS data, for a set of two-week periods (selected as representative of sea ice conditions and traffic patterns over the span of a year). For these sampled vessel locations, the transit time calculation method is applied. For each cell, this results in a set of time values representing how long it takes for a marine response vessel to arrive at the incident. Through descriptive statistics, this information is then visually represented to various maritime experts, following which the METR values are determined for each cell. Finally, cells are grouped according to Shipping Safety Control Zones (SSCZ), which lay at the basis of operational restrictions to ensure navigational safety and facilitate environmental protection, as defined in the Arctic Waters Pollution Prevention Act (SSCZO, 2024). These transit time calculations lay at the basis of the resulting METR values for different areas of the Canadian Arctic, for different periods in the year, further accounting for additional factors such as the response notification delay and operational on-scene rescue time, taking an approach similar as in Piercey et al. (2019). Fig. 2(a) shows an example transit analysis for a response for a given vessel to a given incident location, for ice conditions representative of late July. Fig. 2(b) shows an example of results of transit time calculations from ship traffic to grid cells in a selected SSCZ.

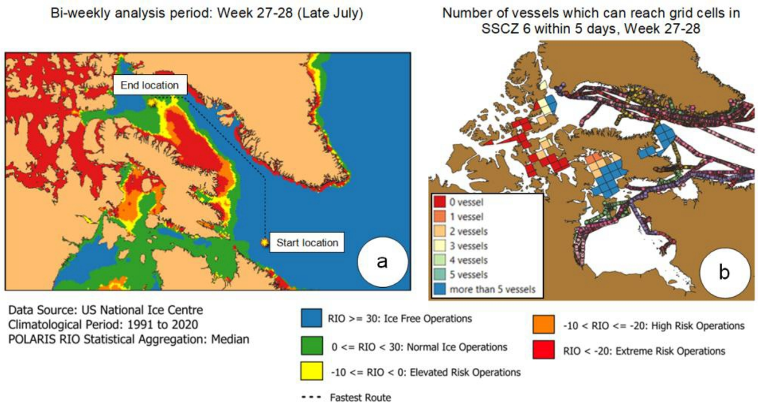

Fig. 2. Results of the METR calculation process: (a) transit time for a given ship; (b) number of vessels able to reach grid cells within 5 days.

Future research is recommended to analyze in detail the time needed for on-scene rescue, which is not considered in the here presented results. The method also should be further validated, e.g. by comparing the calculated transit times with observed ship tracks from AIS data, through systematic sensitivity analyses. A benchmark validation, as in Goerlandt et al. (2017), is also recommended, comparing the results with those by Piercey et al. (2019). The method should also be applied using a longer period of historical ship traffic data. Future research can focus on extending a model for helicopter SAR response (Zarrin Mehr et al., 2023) to provide insights into the capability of air assets in Canadian Arctic areas, and how this response affects the METR value.

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