A case study from an emergency operation in the Arctic Seas

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ABSTRACT: The objective of this paper is to highlight the needs for improved access to high quality maritime data and information in the Arctic, and the need to develop maritime communication infrastructure with at least the same quality, in terms of availability and integrity, as in other more central places at sea. The foreseen Arctic ice melt down will lead to new maritime transport corridors within relatively few years, and there is an urgent need to prepare for this, to ensure safe sailings and to protect the vulnerable Arctic environment.

This paper points out some of these needs by presenting a case from a former accident in the Arctic sea. The case shows how the lack of proper information and data complicates the emergency operation. Some possible solutions to the challenges are discussed, and finally the paper briefly discusses the IMO e-Navigation concept in light of the Arctic challenges.

1 INTRODUCTION

Emergency operations are always critical, regardless of the position on earth. The need for high quality data at the right time is essential, and the need is present within all phases of an emergency operation. On some places on earth it is, however, more difficult to manage emergency operations due to harsh environment and long distances, lack of suitable communication means and poorly developed SAR facilities and services. Such is the case for the Arctic areas.

It is foreseen that within this century the Northeast and Northwest passages will become the alternative transport corridors between the Eastern and Western parts of the world, and that the maritime traffic will increase significantly in the area (Orheim, 2008). A consequence of this will be increased number of accidents that could have fatal impact on people and the vulnerable Arctic environment. Also, new requirements to meet the navigational challenges will appear, such as e.g. requirements for real time meteorological data updates and prognoses to be used in the planning of a voyage.

To illustrate some of the challenges connected to emergency operations in the Arctic seas, a case from an earlier accident is described. The focus is on the availability of information, data and communication means, and it includes all elements participating in an emergency operation (emergency team, SAR vessel, ship in distress, passengers, operation centre ashore).

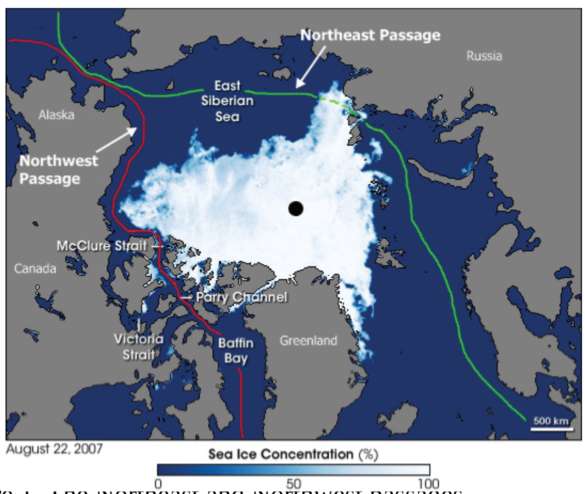

Figure 1. The Northeast and Northwest passages

1.1 *MS Maxim Gorkij*

At 00.40 on the 17th of September 1989, the Captain on board the Norwegian Coast Guard vessel KV Senja received a message from Svalbard radio that a vessel positioned 60 nm West of Isfjorden required assistance. The ship in distress was a Russian vessel chartered by a German tour operator; it had 953 people on board, whereof 575 passengers and 378 crew. It was on its way to the Magdalena fjord at Svalbard when the crew discovered ice and took the vessel closer to it to show the passengers. The weather conditions were good, a bit hazy, but no wind and only 2-3 meter swell. At 23.05 Maxim Gorkij collided with the ice. A crucial maneuver resulted in a 10 meter long rip in the hull in addition to some smaller rips in the bow. At 00.05 the Captain on board Maxim Gorkij sent an emergency message on the 500 MHz frequency and requested assistance.

When KV Senja received the message from Svalbard radio she finished her inspections in the area around Isfjord radio and went by 22 knots to the position of Maxim Gorkij. Estimated time of arrival was 04.00, 5 hours after the exact time of accident. They did not have any information on what had happened, what type vessel or the extent of the emergency. The only available information was that a vessel was in distress and the position of the vessel.

At 01.00 KV Senja received a message via a poor VHF link from Maxim Gorkij that she took in water, but she was stable. At 01.30 KV Senja received a message that passengers and crew went into the lifeboats. On basis of this information the crew on KV Senja started to plan the rescue operation. The resources they had on board were 53 people, a medical treatment capacity of 110 persons, medical personnel, divers and various equipments such as cranes and smaller boats. However, when they arrived at the scene of accident, almost nothing was possible to perform as planned.

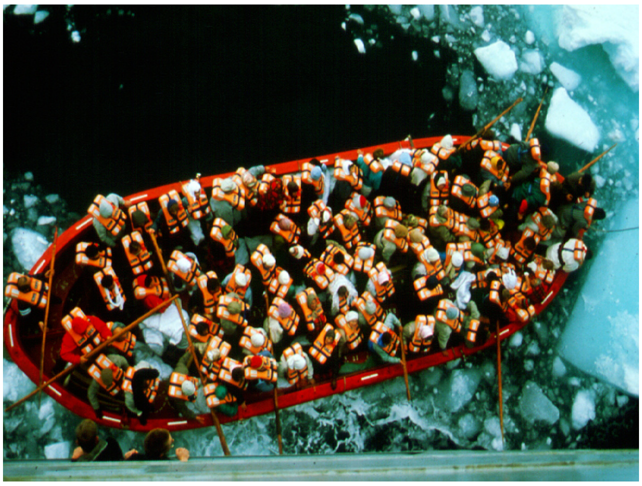

Figure 3. MS Maxim Gorkij passengers in lifeboat. Photo: Odd Mydland

First, a 1.5 nautical mile thick belt of ice made it impossible to get close to Maxim Gorkij. Second, the cultural and language differences between Russian and Norwegian crew made communication difficult, including the communication with the Master on board the Maxim Gorkij. Third, the passengers were mostly elderly people that needed rapid and extra assistance to get out of the lifeboats and on board KV Senja.

Another complicating issue was that the requested rescue helicopters had to refuel in the air, and they had to land on KV Senja with passengers, even though the helicopter was too large to be using the ship as landing place.

On board the bridge on KV Senja some of the main challenges were: Managing requests from the press and worried relatives, poor support from decision makers on the main land and few available resources.

Figure 2. MS Maxim Gorkij passengers. Photo: Odd Mydland.

After some critical moments and huge efforts from the emergency team, KV Senja finally could go to Longyearbyen at Svalbard with crew and passengers from Maxim Gorkij. The Russians were able to save their ship with assistance from KV Senjas divers. Luckily no one died or was seriously injured. There were only a few minor injuries among the emergency team.

The Maxim Gorkij is not the only accident of its kind. A more recent accident is the MS Explorer which was tragically lost in 2007. This accident happened in Antarctica, but the scenario was generally the same: The vessel collided with ice, rescue assistance were far away, the vessel MS Nord Norge just accidentally happened to be in the area and were able to assist MS Explorer.

Also, in 2008 there were 4 ship incidents in the sea areas near Svalbard, and already by January 2009 there were two accidents with fishing vessels in the area, where the Captain on board one of them tragically lost his life. (Svalbardposten, 2009a) (Svalbardposten, 2009b).

2 CHALLENGES

The case study of Maxim Gorkij reveals several gaps in information availability, both in the planning- and execution phases of the rescue operation. The following sections points out the main challenges, divided in the themes of information and data, and communication.

2.1 *Information and data*

In the planning phase, which started the moment when KV Senja received a message from Svalbard radio that a vessel needed assistance at 60 nm West of Isfjorden, the lack of information and data was striking. The only information available was: A vessel was in distress at this position. This made it close to impossible to plan the rescue operation. Information that should have been available at KV Senja was:

- What type of vessel was in distress? Was it a smaller fishing vessel with few persons on board, was it a tanker that could leak oil or was it a cruise ship with lots of crew and passengers?
- How was the weather and ice condition? Was the vessel trapped in ice? Was it windy? Difficult waves?
- Were other vessels in the area and could possibly assist?

On the way to the emergency scene, two messages were received from Maxim Gorkij, via a poor VHF channel. One of the messages contained information that the vessel was stable, and the next informed that passengers were transferred to the lifeboats. A question to be raised is whether Maxim Gorkij had tried to contact other vessels at an earlier point of time, but was not able to reach anyone due to the poor communication link?

The initial operation phase started when KV Senja finally arrived at the emergency scene. The rescuers recognised that almost nothing of the initial planning could be used; they were not prepared at all on the real situation. The first surprise was the thick ice belt, the second was the condition of the passengers that had gone out of the lifeboats and stood on ice floes, waiting to be rescued. They were mostly elderly people, in their nightwear and coats. The new goal of the rescuers on KV Senja was immediately changed to: Rescue as many people as possible. It is easy to imagine what huge benefit better access to information could have on the emergency operation:

- An overview of the emergency scene in terms of ice and weather conditions would help them to plan an alternative route to the emergency scene
- By getting information on the type of vessel, number of passengers and the condition of the passengers they could have prepared for a reception adjusted to this information.

In the next stage of the operation phase, one of the challenges was the lack of information and support from operation centres and decision makers ashore. One example is the usage of helicopters. The helicopters were, according to laws and regulations, too large to land on KV Senja. However, if they did not land the helicopters, they would use more time to rescue the passengers. Having in mind that they were out there in relatively thin clothing in the harsh environment, the rescuers had to make fast decisions. The decision and responsibility on overruling the laws and regulations was put on the shoulders of the Captain on board KV Senja and the helicopter pilot. If they had online contact with an operation centre ashore, which again had continuously contact with necessary decision makers, they could have received a temporary allowance to perform the operation. In such way they would not have to use time to worry on the personal consequences on breaking the rules. Luckily the Captain and the helicopter pilot were willing to take personal risks to save the lives of the Maxim Gorkij passengers. What if they had not?

Another issue, which probably had to do with cultural differences in addition to lack of information, was the Russian helicopters that suddenly appeared at the emergency scene dropping packages on the deck of Maxim Gorkij. The people on board the KV Senja had no information on how many Russian helicopters to expect or what they were doing. An operation centre ashore could probably assist in finding out what they were doing by taking contact with Russian colleagues, and then providing KV Senja with this information.

2.2 *Communication*

The relation between getting access to high quality data and information and the availability of communication channels are of course obvious. Without the communication link, it is not possible to distribute the information. Different possible communication technology solutions will be discussed in the next section. The communication challenges in the Maxim Gorkij accident were:

- Limited or almost no possibilities to communicate with the vessel in distress
- No online communication link between an operation centre and the emergency operation team (KV Senja and the helicopters)
- No communication link for weather and ice updates, and other information to raise situational awareness
- The available communication link (Isfjord radio) were also occupied by worried relatives and the press

Even if the Maxim Gorkij accident happened 20 years ago, the above challenges regarding communication infrastructure and access to high quality data and information has remained almost unchanged in the Arctic areas. This accident ended without loss of lives and hazardous consequences for the environment thanks to dedicated rescuers and nice weather conditions. The question to be raised is: What will happen when the traffic increases and hence the emergency rates increases? Are we willing to take a chance on the weather conditions and rescuers that are accidentally in the area? There is an immediate need to address the issues of communication, information and data, and the following sections will discuss a few possible solutions.

3 POSSIBLE SOLUTIONS

3.1 *Information and data*

On basis of the challenges described in the above sections, the following information and data is considered useful and necessary during an emergency operation:

– Metrological- and hydrological ocean data (weather-, wave- and ice data)
– Information to increase situational awareness (type of ship, number of passengers, condition of passengers, condition of ship, surrounding traffic)
– Improved Electronic Navigation Charts (ENC's)
– Improved emergency preparedness tools
– Status on and from fairway objects (lighthouses, buoys, sensors to monitor stream, temperature, wind, etc.)

Some of these information and data sources are further described in the following sub-sections.

3.1.1 *Metrological- and hydrological ocean data*

Today there exist several maritime services that broadcast information on weather and sea conditions via radio channels and on the Internet. To offer such services in the Arctic areas, enough observation and measurement sites are required, and a communication link for distribution of the data. This is a challenge due to the long distances over open sea and harsh weather conditions. Another challenge however is the information on ice conditions. The solutions available for this today are satellite images from Synthetic Aperture Radars (SAR) and near ship ice monitoring by using cameras on the bow of ice breakers. Investigations have been and are being conducted to test out how the satellite images can be used by vessels sailing through ice infested areas. One of the challenges is to understand and read the images without having enough knowledge or experience of reading ice surfaces from satellite pictures.

This type of information can be useful especially within voyage planning. By using this type of data the planners are able to set up routes outside ice infested areas, or possibly through openings in the ice. What these satellite images can not be used for however is real time monitoring of ice conditions near the ship. It can not provide any information on rapid changes in ice conditions and thickness.

A study performed at the University Centre in Svalbard (Marchenko, 2009) shows that it is possible, by advanced techniques, to calculate velocities on ice, ice compactness and the effect on ships sailing in this ice. Compactness means the surface concentration of ice on sea surface. For example, if half of sea surface is covered by ice and another half is ice free, the compactness is equal to 0.5. These calculated parameters can be used to show ice compactness on ice maps, and it is one of parameters characterizing ice structure in numerous numerical models of sea ice cover dynamics. The conclusions from the study are:

1 Velocities of spatial evolution of compacted ice regions depend on the compactness of surrounding rare ice. Their representative values can reach few meters per second when rare ice compactness is bigger 0.6.
2 The ship resistance caused by rare ice can be of the order of water resistance when rare ice compactness is bigger 0.5 and floes diameter is about ship width.
3 When ice compactness is closed to critical value 0.78 the performance of small ships, which maximal speed in open water is about 10 knots, is very pure in ice conditions. Practically they will be captured by the ice in this case.

By combining and using these parameters, it could be possible to develop an advanced and accurate real time decision tool for sailings in ice infested areas. This could also be used within an emergency operation, as a decision support tool. In the Maxim Gorkij case, such tools could be used to assist the Captain onboard KV Senja to decide whether or not to move trough the ice belt.

3.1.2 *Situational awareness*

Information that would increase the situational awareness both in the planning- and execution phase of an emergency operation, is information about the ship in distress. Examples of such information are vessel type, size, condition of vessel, number of passengers, condition of passengers, information on surrounding traffic and available resources.

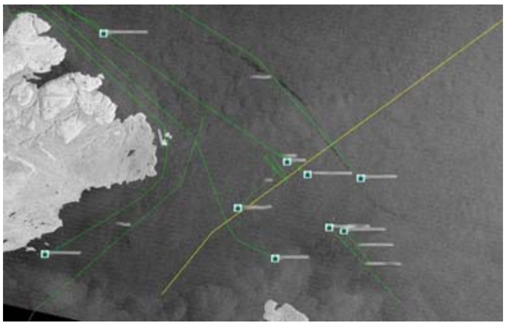

Figure 5. Combination of satellite images and AIS data. Photo: Kongsberg Satellite Services (KSAT).

One possible solution to this is to combine data from several sources, e.g. images from surveillance satellites and ship information from AIS or LRIT. The picture above shows an example of this. The Coastal Administration in Norway has used satellite images from surveillance satellites to detect oil spills in Norwegian waters. From these satellite images it is impossible to see which ship is responsible for this. However, if a layer of AIS data is put on top of the images, the ship can be identified. In areas outside coverage of land based AIS base stations, other sources can be used to identify the ship, e.g. LRIT or in the future; space based AIS.

This way of combining data could also be used within surveillance of emergency operations. Today the time delay on data from satellite is to large, but future development of the communication infrastructure might solve that problem.

3.1.3 *ENC's and preparedness tools*

The existing Electronic Navigation Charts (ENC's) for the Arctic seas are not very mature. So far it has been difficult to develop these charts due to the ice covering the sea and land. This work needs to be started as soon as the landscape is visible. Good charts are a very important factor to increase the safety of navigation.

Preparedness tools are also something that needs to be developed. In Norway work is ongoing to develop such tools and also work is started to investigate possible areas to be used as port of refuge.

3.2 *Maritime communication technology*

The previous sections clearly illustrate the need for high quality maritime communication technology in Arctic areas. High quality means enough bandwidth and it means reliability. Shut downs of the communication link from time to time can not be accepted. To be able to implement the possible solutions depicted in section 3 of this paper, stable communication channels are needed between land and sea, and also ad-hoc networks at the emergency site. The maritime communication technology can roughly be divided into three domains:

- Satellite communication, consisting of so called Low Earth Orbit (LEO) satellites, Geostationary (GEO) satellites and High Earth Orbit (HEO) satellites
- Terrestrial wireless communication
- Ad hoc communication networks

As can be seen from the figure on the next page, the situation today for satellite communication in Arctic areas is not good. Only the system Iridium has truly global coverage. The newly launched Iridium service OpenPort can offer up to 128 kbps capacity. This might be sufficient for transmitting operational messages during and emergency operation. However, if video and images shall be transmitted to land stations for real time monitoring of the operation, even this service will be insufficient.

Another challenge for Iridium is the time delay due to data relaying, hence Iridium can not be used within time critical applications.

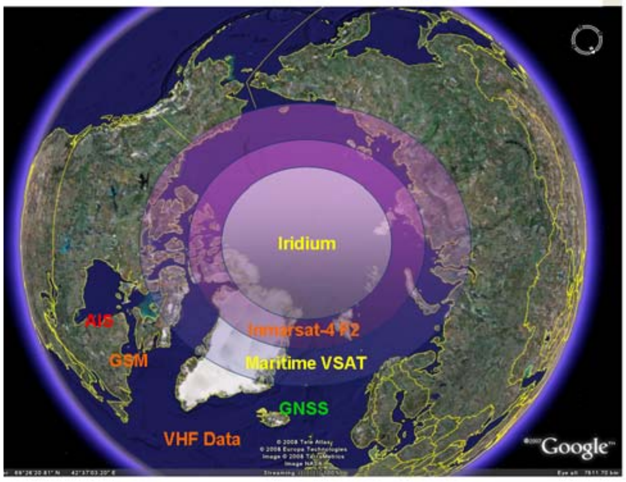

Figure 6. Maritime communication systems coverage areas

The challenges regarding GEO satellites are:

- They are invisible at latitudes above 80°N and it is difficult to achieve a stable communication link above 76°N.
- Very good (and expensive) antennas are required at these latitudes, so in practice, the GEO satellites are usable only below 70°N for moving targets.

A study performed in the MarCom project (Bekkadal, unpubl.) states that 'the only adequate SatCom alternative for the High North is to be based on HEO satellites'. This is due to the convenient satellite orbits of the HEO's. They cover the northern hemisphere for a large time of day, and a 3-satellite constellation could be sufficient to cover this area 24 hours a day. However, this needs to be further analysed both in terms of technology and cost/performance. Such a development would require cooperation with other countries with borders towards the Arctic areas, such as Russia, Canada, Finland, Iceland, Denmark, Sweden and the USA. It could very well be organised under the auspices of the Arctic Council.

The coastal areas (including the Northeast and Northwest passages) are judged to be adequately covered by terrestrial systems (Bekkadal, unpubl.) WiMAX and enhanced Digital VHF are considered the most promising future alternatives. However, the cost and complexity of such systems would require a detailed study of i.e. the area's topography.

Ad hoc networks are in use today by both SAR teams and in military operations. Ad hoc networks do not really depend on the position on earth because the network comprises only the nodes within a limited area. However, it would be very convenient if the ad hoc network could be monitored from operational centres ashore. Then there is a need for a satellite or terrestrial link with sufficient bandwidth and high integrity. Integrity means that the link is trustable.

3.3 *Applications*

The Wikipedia definition of an application is: “Application software is any tool that functions and is operated by means of a computer”. Some applications could be developed to meet the challenges in emergency operations in the Arctic areas. These applications could be used both in the planning and execution phases of the operation. An example of a planning tool is the contingency plan. This tool includes features such as optimal selection of rescue resources. Examples of such resources are tugs and right oil recovery equipment specific for operations in Arctic areas.

The need for enhanced equipment and applications on board vessels should also be considered, and by that be able to improve the process of emergency operations. Often it is a “normal” vessel that reaches the emergency scene first, and it does obviously not have the same equipment and applications on board as a SAR vessel. New requirements for a minimum set of Arctic SAR applications and equipment on board vessels could be considered. This needs of course to be combined with classification of vessels. A sailboat does not need the same equipment as a fishing vessel. By introducing such requirements all vessels can sufficiently assist vessels in distress until the arrival of the SAR team.

Another issue that should be investigated is prioritising mechanisms on communication channels. This is especially important in the time of period before the communication infrastructure is fully developed in the Arctic areas, which may take some years. The prioritising mechanisms should automatically provide necessary number of communication channels and sufficient bandwidth to ensure high availability and integrity of channels used by all partners involved in the emergency operation.

Ice related applications are of course also very important in the Arctic areas. This is the case both during normal sailing in the Arctic areas, and during emergency operations. Possible applications are:

- Calculations and visualisation on ship performance in different ice conditions, this could be used both during normal sailings to avoid dangerous situations, and for analysis during emergency operations.
- Recognition of sea ice characteristics (compactness, thickness, icebergs) by satellite images. This is already to a certain extent used by navigators on vessels sailing in ice infested areas.
- Features of rare ice drift around Svalbard and in fjords. This could also be used to enhance the safety of a sailing in ice infested areas, and for analysis during emergency operations.

4 E-NAVIGATION IN THE HIGH NORTH

Some of the proposed possible solutions on applications and communication in the above sections should also be considered during the development of the IMO e-Navigation concept. The IMO has adopted the IALA definition of e-Navigation, and it says (NAV sub-committee, 53rd session, 2007):
“e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information on board and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment”.

In remote areas, and especially in the Arctic sea, this concept has special challenges. It is e.g. difficult to collect, integrate and exchange maritime information if there are no available communication channels. Also, the need for special purpose e-Navigation services for Arctic areas should also be considered. The extreme navigational conditions due to low temperatures, ice and harsh weather requires more specialised services than other more central positions at sea. E-navigation can be an important part in a future safety and security concept for Arctic areas.

5 CONCLUSIONS

It is important to not forget the experiences from the Maxim Gorkij and other similar accidents that have happened in the Arctic areas. They can help provide a clear view on what type of information, data, communication infrastructure and SAR resources that needs to be developed. The main lessons to be learned from the Maxim Gorkij accident is that to be able to conduct more efficient and safer emergency operations, more information needs to be available. This could be in terms of supporting decision tools and information from operation centres ashore. Nothing of this is however possible without a maritime communication infrastructure with sufficient bandwidth and integrity. This important task should be immediately addressed within the maritime community.

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