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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 centralized areas. The foreseen Arctic ice meltdown is expected to provide new maritime transport corridors within relatively short time, and there is an urgent need to prepare for this, to ensure safe operations at sea 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 proposed, 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 crucial in all phases of an emergency operation. In some places on earth it is, however, more difficult to manage emergency operations due to harsh environments and long distances, lack of suitable communication means and poorly developed search and rescue (SAR) facilities and services, which is most definitely the case for Arctic areas.

It is foreseen that within this century the Northeast and Northwest passages may well become alternative transport corridors between the Eastern and Western parts of the world, and that the maritime traffic will increase significantly in these areas (Orheim, 2008). A consequence of this will most certainly be an increased number of accidents that could have fatal impact on people and the vulnerable Arctic environments. 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 pertaining to emergency operations in the Arctic waters, 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 in an emergency operation (emergency team, SAR vessel, ship in distress, passengers, operation centre ashore etc.).

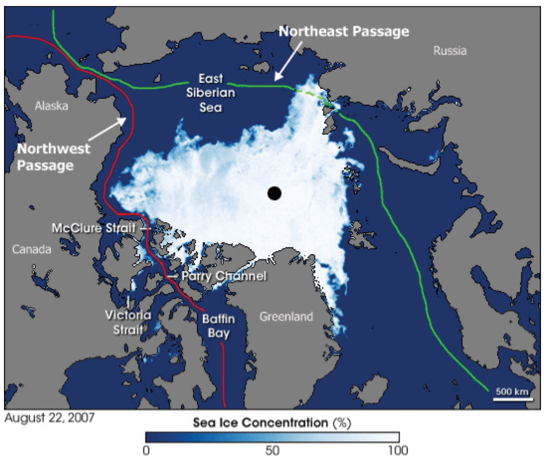

Figure 1. The Northeast and Northwest passages

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; having 953 people on board, whereof 575 passengers and 378 crew members. 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 m swell. At 23.05 Maxim Gorkij collided with the ice. A crucial maneuver resulted in a 10 m long rip in the hull in addition to some smaller rips in the bow. At 00.05 Maxim Gorkij's Captain sent an emergency message on the distress frequency 500 kHz requesting assistance.

When KV Senja received the message from Svalbard radio the vessel finished it's 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 time of the accident. KV Senja 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 this vessel.

At 01.00 KV Senja received a message via a poor VHF link from Maxim Gorkij that the vessel took in water, but remained 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 the accident, almost nothing was possible to perform as planned, since:

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

- A 1.5 nautical mile (nm) deep ice-belt of about 1m thickness was separating KV Senja from Maxim Gorkij.
- The cultural and language differences between Russian and Norwegian crew made communication difficult, including the communication with the Master on board the Maxim Gorkij.
- 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 helicopters were too large to be using the ship as landing place.

At the bridge of KV Senja some of the main challenges were to accommodate requests from the press and worried relatives, coping with poor support from decision makers on the mainland 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 could finally leave for Longyearbyen (at Svalbard) with the crew and passengers from Maxim Gorkij. The Russians were able to save their ship with assistance from KV Senja's divers. Luckily no one died or was seriously injured. There were only a few minor injuries among the emergency team.

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

Also, in 2008 there were 4 ship incidents in the waters near Svalbard, and in January 2009 there were two accidents with fishing vessels in this 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 deficiencies in information availability, both for the planning- and the execution phases of the rescue operation. In the following sections the main challenges are identified and categorized to information and data, and communications.

2.1 *Information and data*

In the planning phase, which started at the moment 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 is striking. The only information available was: A vessel was in distress at this position, making it virtually 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 but a 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 conditions? Was the vessel trapped in ice? Was it windy? Difficult waves?
- Were other vessels in the area that 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 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 ice belt, the second was the condition of the passengers having left 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 therefore immediately changed to: 'Rescue as many people as possible'. It is easy to imagine what benefit better access to information could have added to the emergency operation:

- An overview of the emergency scene in terms of ice and weather conditions would assist them in planning 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 use 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 harsh environments, 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 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 had to waste time worrying about the personal consequences of 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 most probably have assisted in finding out what they were doing by making contact with Russian colleagues, and then providing KV Senja with this information.

2.2 *Communications*

The relation between getting access to high quality data and information and the availability of communication channels is obvious. Without a proper communication link it is impossible to distribute the information. Different potential communication technology solutions are discussed in the next section. The communication challenges pertaining to the Maxim Gorkij accident were:

- Limited or almost no possibilities to communicate with the vessel in distress.

- No on-line 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 enhance situational awareness.
- The communication link (Isfjord radio) was 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 rate increases? Are we willing to take a chance on the weather conditions and rescuers that are in the area by coincidence? There is an immediate need to address the issues of communications, information and data, and in the following sections possible solutions are proposed and assessed.

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:

- Meteorological- 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 this information and data sources are further described in the following sub-sections.

3.1.1 *Meteorological- and hydrological ocean data*

Today several maritime services are broadcasting information on weather and sea conditions via radio channels and on the Internet. To offer such services in the Arctic areas, sufficient observation and measurement sites are required, along with an adequate communication link for data distribution. This challenge is due to the long distances over open sea and harsh weather conditions. Another challenge is the information on ice conditions. The solutions available for such information are presently satellite images from Synthetic Aperture Radars (SAR) and near ship ice monitoring by the use of 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 icecovered waters. 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 particularly useful for voyage planning. By using this type of data the planners are able to set up routes outside ice-covered waters, or possibly through openings in the ice. However, these satellite images can not be used for 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 meaning the concentration of ice on the 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 maps, and it is one of parameters characterizing ice structure in numerous numerical models of sea ice coverage dynamics. The conclusions from the study are:

1. Spatial evolution velocities of compacted ice regions depend on the compactness of surrounding rare ice, with typical values reaching a few meters per second when rare ice compactness is larger than 0.6.
2. The ship resistance caused by rare ice can be in the order of the water resistance when rare ice compactness is larger than 0.5 and floe diameters are about the ship width.
3. When ice compactness is close to the critical value of 0.78, the performance of small ships with maximum speed of about 10 knots in open waters, is very poor. 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 voyages in ice-covered waters infested. This could also be used in an emergency operation as a decision support tool. In the Maxim Gorkij case, such tools could have been 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 pertaining to 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.

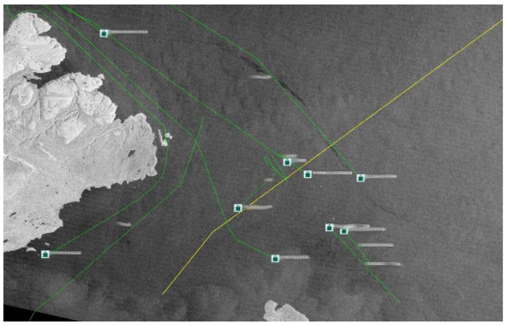

Figure 5. Combination of satellite images and AIS data. Photo: Kongsberg Satellite Services (KSAT).

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, as exemplified by the picture in Figure 3. The Norwegian Coastal Administration has utilized 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 beyond coverage from land-based AIS base stations, future space-based AIS or other sources can be used to identify the ship, e.g. the evolving LRIT system.

This way of combining data could also be used for surveillance of emergency operations. Today the time delay of data from satellite is to large, but future developments 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 far from mature, since it has been difficult to develop these charts due to the ice covering sea and land. This work needs to be started as soon as the landscape is visible. Satisfactory charts represent a crucial factor to increase the safety of navigation.

Preparedness tools are also something that need 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 technologies*

The previous sections clearly illustrate the need for high quality maritime communication technology in Arctic areas. High quality means primarily sufficient bandwidth and adequate 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 pertinent maritime communication technologies can roughly be divided into three domains:

- Satellite communications (SatCom), comprising so called Low Earth Orbit (LEO) satellites, Geostationary (GEO) satellites and High Elliptical Orbit (HEO) satellites
- Terrestrial wireless communications
- Ad hoc communication networks

As can be seen from the Figure 6 the present situation for satellite communication in Arctic areas is far from satisfactory. Only the LEO-based Iridium system has allegedly 'true' global coverage. The newly launched Iridium service OpenPort can offer up to 128 kbps capacity, which might be sufficient for transmitting operational messages during and emergency operation. However, if video and images shall be conveyed to land stations for real-time monitoring of the operation, this service is also rendered useless.

Another problem with Iridium is its dubious latency (the time delay due to data relay), and hence being doubtful for time-critical applications.

The limitations of GEO satellites in Arctic areas are:

- They are invisible at latitudes beyond 80°N (grazing incidence), and it is challenging to achieve a stable communication link beyond about 76°N (5° elevation).

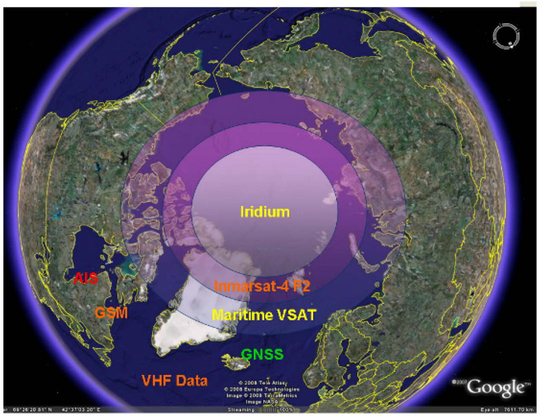

Figure 6. Maritime communication systems coverage areas

- Complex (and expensive) antenna platforms are required at these latitudes, so in practice the GEO satellites are usable only up to about 70°N for moving vessels.

A preliminary study performed in the MarCom project states that 'the only adequate SatCom alternative for the High North is apparently to be based on HEO satellites' (Bekkadal, 2009). This is due to the convenient satellite orbits of the HEO's, covering the northern hemisphere for a large time of the day, and a 3-satellite constellation would be sufficient to provide this area with a 24/7 service. However, this needs to be further analysed both in terms of technology and cost/performance. Such a development would require cooperation with other countries bordering the Arctic areas, such as Russia, Canada, Finland, Iceland, Denmark (Greenland), Sweden and the USA, which 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 deploying terrestrial systems along the coast - WiMAX and enhanced Digital VHF being considered the most promising future alternatives. However, the cost and complexity of such systems would require a detailed study of a.o. the area's topography (Bekkadal, unpublished).

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, which would require a satellite or terrestrial link with sufficient bandwidth and high integrity - integrity meaning the link being trustworthy.

3.3 *Application software (SW) tools*

The Wikipedia definition of an application SW 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 posed by emergency operations in Arctic areas. These applications could be used both in planning and execution phases of the operation. An example of a planning tool is the contingency plan, including features such as optimum selection of rescue resources. Examples of such resources are tugs and oil recovery equipment specially designed for operations in Arctic areas.

The need for enhanced equipment and applications on board vessels should also be considered in facilitating improvements to the process of emergency operations. Often it is a "normal" vessel that reaches the emergency scene first, obviously not having the same on-board equipment and applications as a SAR vessel. New requirements for a minimum set of Arctic SAR applications and equipment on board vessels should be considered, which needs of course to be combined with classification of vessels. By introducing such requirements all vessels could amply assist other vessels in distress until the SAR team arrives.

Another issue that should be investigated is prioritising mechanisms on communication channels usage. This is especially important in the time to come before the communication infrastructure is fully developed in the Arctic areas, which may take some years. The prioritising mechanisms should automatically provide exclusive access to sufficient communication capacity 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 of ship performance in different ice conditions, which could be used both to avoid dangerous situations during normal seafaring, 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-covered waters.
- Features of rare ice drift around e.g. Svalbard and in fjords. This could also be used to enhance the safety of a voyages in ice-covered waters, and for analysis during emergency operations.

4 E-NAVIGATION IN THE HIGH NORTH

Some of the solutions on applications and communications proposed 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 subcommittee, 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 Arctic waters, this concept faces extraordinary 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 in Arctic areas should be considered. The extreme navigational challenges due to low temperatures, ice and harsh weather conditions require more specialised services than in other more centralized areas. E-navigation can become an important part in a future safety and security concept for Arctic areas if these requirements are fulfilled.

5 CONCLUSIONS

It is important not to forget the experiences from the Maxim Gorkij and other similar accidents having occurred in the Arctic and Antarctic areas. They can help in providing a clear view on what type of information, data, communication infrastructure and SAR resources required to be developed. The main lessons to be learned from the Maxim Gorkij accident is that in order to be able to conduct efficient and safe emergency operations, more crucial information needs to be available to all parties involved. This could be in terms of supporting decision tools and information from operation centres ashore. However, nothing of this is possible without a maritime communication infrastructure with sufficient bandwidth and adequate integrity. This important task should consequently be immediately addressed within the maritime community.

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