Using Advanced Networks and Technology for Improved Management, Preservation and Exploration of the Planet's Arctic Region

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Abstract—Satellites play a key role in today's modern society. From navigation and research of endangered species to wide television distribution and high-speed intercontinental communications, satellites are used for a wide variety of services that benefit humanity. Nowadays advanced sensor and communications networks have already been widely implemented in highly civilized areas. This proposal illustrates possible implementations on the ground that utilize existing and upcoming satellite networks to improve management, preservation and exploration of the Planet's Arctic region.

Index Terms—Arctic, IEEE, Satellites, communications.

1 Introduction

Life today is highly augmented by satellites and space programmes. From the unique vantage point of space, satellites can be used to provide a whole range of services to the Arctic territories. Many of these innovative satellite networks exist today, but require an efficient implementation on the ground. Initially, problems such as communications and environmental monitoring will be discussed and a suitable solution proposed. Afterwards, more advanced problems such as maritime safety and preservation of marine resources will be covered and solutions brought forward.

2 Development

Machine to Machine (M2M) communications via satellite have rapidly gained in popularity since their introduction. Various satellite operators offer tracking and data services but there is currently little attention being put towards the Polar regions since they are economically less interesting due to less users. However the urge for better preservation of the planet's polar regions has satellite operators pushing for a higher availability of polar services, as is evident by ORBCOMM's decision to put satellites in orbits with higher inclinations, allowing polar coverage [1]. Besides ORBCOMM, Iridium also operates a constellation of satellites in Low Earth Orbit (LEO), but with a higher orbital inclination of 86.4° offering excellent polar coverage [2]. How these satellites can service the Arctic is described in the following paragraphs combined with several use-cases and the corresponding implementations on the ground.

3 Exemplary implementation

3.1 Communications

VHF (Very High Frequency) and HF (High-Frequency) are most suitable for respectively short and medium range voice communications. However for reliable beyond LOS (line-of-sight) voice and data communications, satellite networks must be utilized. On the edges of the Arctic region, geostationary satellites are sufficiently above the horizon to allow reliable communications. Operators such as Inmarsat and Intelsat provide high-speed data and direct telephony services via geostationary satellites [3], [4]. For in-the-field voice communications over long distances, the Iridium PTT service can be used. Iridium PTT provides a real-time simplex voice link between two or more users anywhere on the globe using hand held devices [5].

3.2 Buoy-based Environmental Surveillance

Environmental surveillance on the ground is performed via solar-powered autonomous sensing buoys. Data Collection Platforms (DCPs) are widely used around the planet for the monitoring of coastal waters with the intent of global ocean level monitoring and tsunami early warning. The International Arctic Buoy Programme (IABP) is a joint-programme between several international meteorological agencies to maintain and monitor a widespread network of electronic sensing buoys in the Arctic [6]. Figure 1 illustrates the buoys deployed by the IABP.

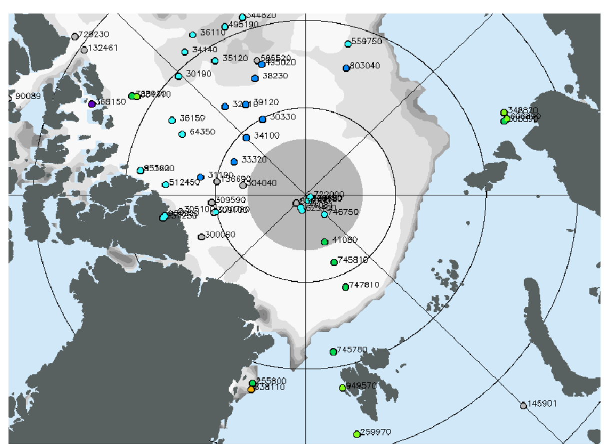

Fig. 1: Buoys in the Arctic deployed by the IABP [7]

As can be seen on figure 1 the buoys are concentrated towards the US side of the Arctic, leaving vast regions unmonitored. IABP buoys measure surface air pressure, temperature, sea level pressure, and ice movement [6]. With additional sensors for measuring atmospherical composition, CO_2 levels and water pollution, these buoys could be used for environmental monitoring and alerting. Additional well marked and visible buoys can be placed near the Arctic shipping lanes to act as channel markers but also monitor the pollution from passing tankers and freight vessels. When elevated levels of pollution are being detected, the buoy will relay the last received AIS (Automatic Identification System) packets from the closest ships along with it's exceeding environmental readings via satellite. This principle is illustrated in figure 2.

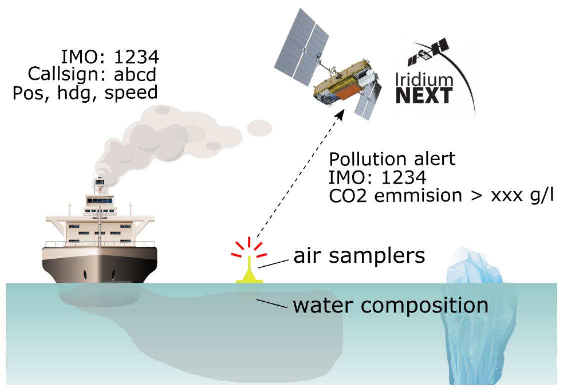

Fig. 2: Working principle of pollution detection by smart buoys along shipping lanes and AIS ship information relay via Iridium

This allows further measures to be taken against the ship's operator to ensure compliance with the International Maritime Organization (IMO) and to mitigate the occurrence in the future. Data from the buoys is relayed via the Iridium LEO satellite network that has recently began upgrading towards Iridium NEXT, ensuring even better coverage and communication bandwidths [8].

3.3 Maritime Navigation and Safety

Major shipping lanes run through the Arctic region making this a critical area where smart monitoring resources could be deployed to improve safety and efficiency. Figure 3 illustrates three major shipping lanes in the Arctic.

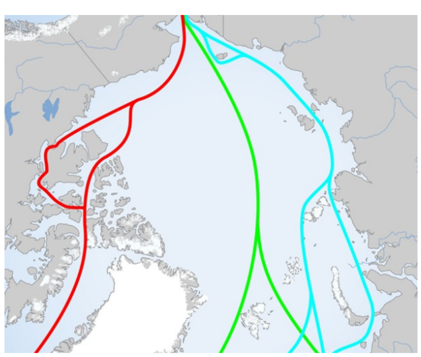

Fig. 3: Major shipping lanes in the Arctic [9]

3.3.1 Navigational Safety

Generic channel marking buoys can be used to indicate shipping lanes, however it is beneficial if a fraction of the channel marking buoys also double as sensing buoys elaborated in 3.2 in order to monitor marine pollution by the passing vessels. Short range identification and collision avoidance is provided by existing AIS equipment on board vessels. Vessel tracking and fleet monitoring via satellite is a relatively new but promising technology. M2M satellite operator ORBCOMM already has a number of OG2 satellites in-orbit equipped with AIS receivers providing daily tracking of over 150.000 unique vessels [1].

3.3.2 Search and Rescue Operations

COSPAS-SARSAT is a system that relays distress signals from EPIRBs (Emergency Position Indicating Radio Beacon) to MR-CCs (Marine Rescue Coordination Centre). Recently, the system has began upgrading to an all-MEO system (MEOSAR), primarily with repeater payloads on US GPS, Russian GLONASS and European GALILEO satellites because of the global, and therefore also polar, coverage. This will improve alerting latency and increase the chances of survival [10].

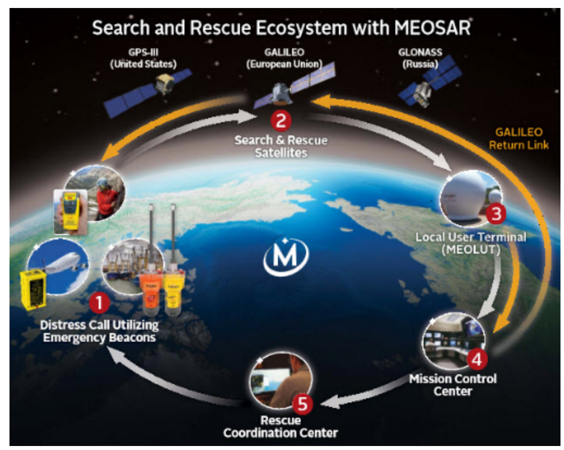

Fig. 4: MEOSAR, the future of global search and rescue operations [10]

3.4 Management of Marine Resources

Marine vessels are required to have an active AIS-system on board. Local designated authorities are responsible to make sure domestic regulations are enforced with regard to fishery quota for certain species. Reports indicate that arctic fishery is highly regional and confined to the territorial waters and exclusive economic zones [11, p. 77]. AIS receiver instruments on ORBCOMM OG2 satellites can detect if certain fishing vessels are operating outside of these zones and the corresponding duration of out-of-zone activities, allowing further measures to be taken.

4 Conclusion

Communications possibilities in the Arctic have been illustrated that provide reliable beyond LOS capabilities. Furthermore an expansion of the existing network of the International Arctic Buoy Programme with smart sensing buoys has been proposed. The smart sensing buoys provide both navigational aid as well as a novel environmental monitoring and alerting system. Furthermore the upcoming MEOSAR network has been illustrated and the role it will play in future Arctic Search and Rescue activities. Finally, a method has been proposed that allows fishing vessel fleet tracking which ensures regional and international fishing regulations are adhered to.

REFERENCES

[1] ORBCOMM, "ORBCOMM Announces Commercial Service for Its Final 11 OG2 Satellites," available at https://www.orbcomm.com/en/company-investors/news/2016/orbcomm-announces-commercial-service-for-its-final-11-og2-satellites.

[2] Earth Observation Portal - Sharing Earth Observation Resources, "Iridium NEXT (Hosting Payloads on a Communications Constellation)," available at https://directory.eoportal.org/web/eoportal/satellite-missions/i/iridium-next.

[3] Intelsat, "Intelsat Fleet Maps," available at http://www.intelsat.com/fleetmaps/.

[4] Inmarsat, "Our coverage," available at https://www.inmarsat.com/about-us/our-satellites/our-coverage/.

[5] Iridium Communications LLC, "Iridium Extreme PTT," available at https://www.iridium.com/products/iridium-extreme-ptt/.

[6] NOAA - National Oceanic and Atmospheric Administration, "IABP - International Arctic Buoy Programme," available at https://www.arctic.noaa.gov/Arctic-News/ArtMID/5556/ArticleID/387/International-Arctic-Buoy-Programme.

[7] Polar Science Center Applied Physics Laboratory University of Washington, "International Arctic Buoy Programme," available at http://iabp.apl.washington.edu/maps_daily_map.html.

[8] Iridium Communications LLC, "Iridium NEXT - The Bold Future of Satellite Communications," available at https://www.iridium.com/network/iridium-next/.

[9] The Arctic Institute - Center for Circumpolar Security Studies, "The Future of Arctic Shipping," available at https://www.thearcticinstitute.org/future-arctic-shipping/.

[10] McMurdo, "MEOSAR - The Future of Search and Rescue," available at https://www.mcmurdogroup.com/meosar-knowledge-center-2/.

[11] Arctic Council, "Arctic Marine Shipping Assessment 2009 Report," *Arctic*, pp. 39–55, 2009.

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