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Unmanned Arctic

Unmanned Systems in the Arctic

This article explores the importance of unmanned systems in carrying out operations in the Arctic's harsh environment

"The Arctic region is often characterised as risky and highly complex due to its remoteness and long physical distances to civilisation, low temperatures, uncertainty in terms of ice and weather, icing, lack of infrastructure, and vulnerable environment," reads the 'Arctic Search and Rescue Capabilities Survey' published by the Finnish Border Guard in 2017. Yet, as temperatures rise and the length of the ice season continues to reduce year by year, the amount of maritime traffic (commercial, tourism, defence and security) is slowly increasing. Similarly, resources are becoming progressively more available for exploitation in the region, drawing significant interests from regional and non-regional powers (e.g. China).

These changes are bringing to the fore the necessity to develop capabilities that can safely operate in very harsh environments to support a likely increase in Search and Rescue (SAR) operations, enhance the security of the growing extractive industry, and ensure the security of new, attractive Sea Lanes of Communications (SLOCs). Unmanned systems play a significant role in this scenario, presenting a number of advantages in support to manned aerial and maritime platforms; however, a number of technical engineering challenges persist, both limiting (currently) certain operations and opening a whole new area of technological development opportunities.

When the Going Gets Tough

The Arctic environment is one of the harshest environments in the world to operate in, both physically and technologically. The extreme weather conditions considerably affect the ability of people to work outdoors (whether on an oil platform, at an operating station on land or on a platform at sea), thus presenting certain operational limitations. A number of studies have also recently emerged providing evidence that the melting sea ice is contributing to increasing wave heights, especially in the Beaufort and Chukchi Seas off the coasts of Canada and Alaska, as noted by the article 'Wind and Wave Climate in the Arctic Ocean as Observed by Altimeters', published in 2016 in the *American Meteorological Society* journal. Incidentally, these seas are on the Northwest Passage, a route that will continue to see increasing traffic.

The use of unmanned systems in the region therefore "reduces the chances of confronting any potential health or safety issues while at sea," James Cowles, Technical Sales Manager for L3 Unmanned Maritime Systems, told NAVAL FORCES. "Operators can be stationed on land, as opposed to being exposed to the elements at sea, and unmanned vehicles can be more tolerant to extreme, cold weather conditions, which provides a higher degree of operational flexibility." Operational flexibility also means that unmanned systems can be used to analyse a situation before deciding whether or not a manned aircraft should be sent. For instance, in certain regions fishing vessels may disappear behind cliffs, which run interference with their Automatic Identification System (AIS); in such cases, sending an unmanned system out would allow authorities to assert whether there is a problem or not, thus limiting the risks for manned aircraft crew.

Unmanned systems also present a distinct advantage in terms of increasing situational awareness, whether on board a ship during a mission or ahead of time to determine weather conditions. "Having an unmanned aircraft on board a ship that you can launch ahead offers the ability to determine what route will allow you to break the least amount of ice, giving you the smoothest passage," Dr Catherine Cahill, Director of the Alaska Centre for Unmanned Aircraft Systems Integration (ACUASI) at the University of Alaska Fairbanks, told NAVAL FORCES. They are also a key capability in terms of gathering data needed to build climate models used to predict where it is possible to operate and under what conditions. Indeed, the sensors that can be mounted on board unmanned aircraft, such as the synthetic aperture radar, can help build a digital elevation model of the sea ice in the region, thus facilitating the planning of missions and routes.

More specifically, Unmanned Aerial Vehicles (UAV) undoubtedly remain the preferred unmanned systems to operate in the Arctic at present. Unmanned Surface Vehicles (USV) would only be able to operate where and when there is no ice, whereas communication links with Unmanned Underwater Systems (UUV) would be quite challenging under sea ice (at least at present). These UAVs provide an extended range compared to manned aircraft, extending up to 200km for UAVs such as UMS Skeldar's V-200 and Schiebel's Camcopter

Textron's Aerosonde Small UAS includes a synthetic aperture radar and various meteorological sensors including pressure temperature, humidity, icing, dropsondes, solar radiation, and sea surface roughness. Here flying over Antarctica.
(Photo: Textron)

ACUASI's Griffon Aerospace Sea Hunter has a range of up to 695km. Seen here flying north on its way off the coast of Alaska in October 2018. (Photo: Jordan W. Murdock and Robert J. Edison)

S-100 and up to 695km for ACUASI's Griffon Aerospace Sea Hunter, for an acquisition and operational price that is generally much lower than that of a manned aircraft.

As David Willems, Head of Business Development for UMS Skeldar, told NAVAL FORCES: "Unmanned systems can embark several payloads and are capable of operating in extremely harsh environments, making them cost effective and safe to operate in these extreme locations." However, a number of challenges persist.

Communication

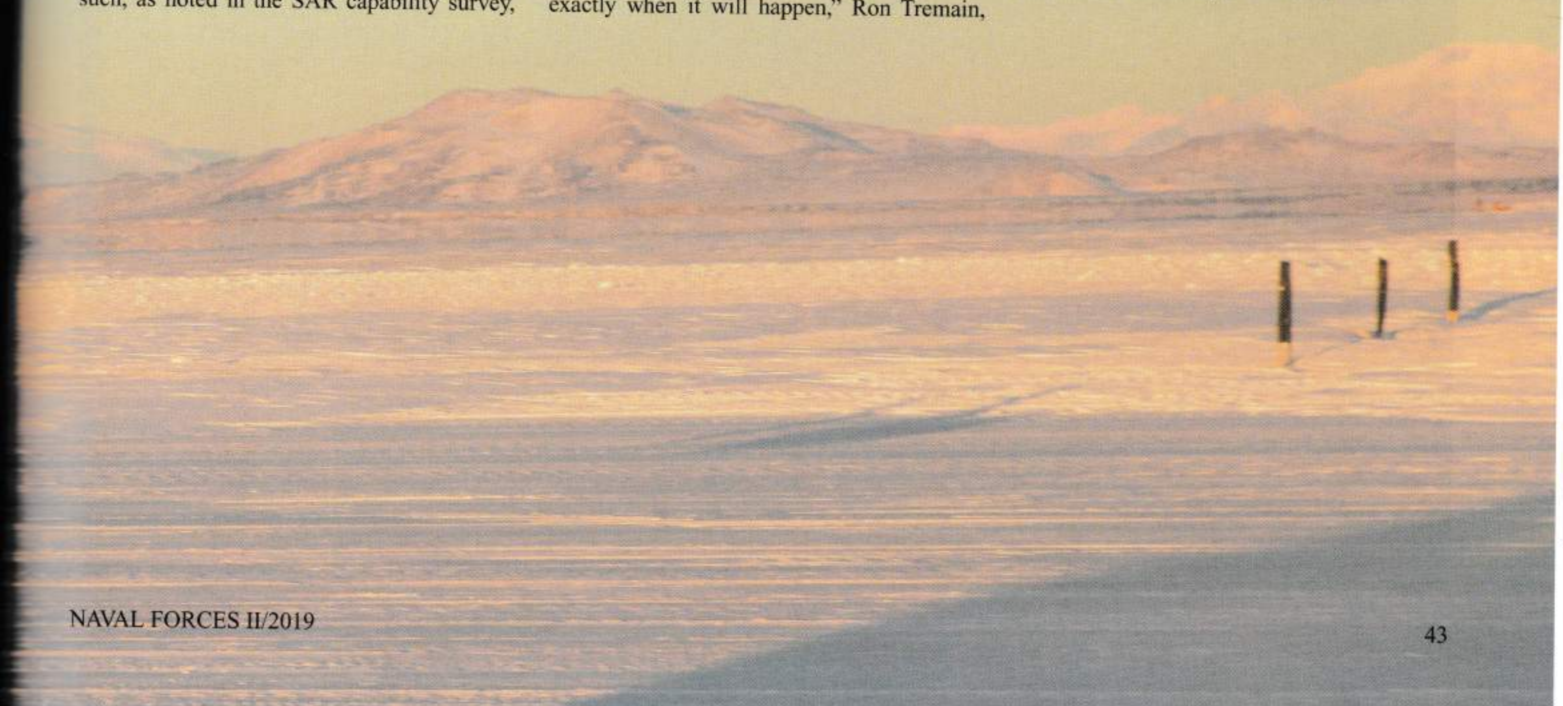
Communication infrastructure in the Arctic is very scarce. Current communications satellites operating in geostationary Earth orbit tend to be closer to the Equator and are therefore low on the horizon of the poles. As such, as noted in the SAR capability survey, "satellite-based broadband in the Arctic can encounter latencies, and bandwidth tends to be limited and expensive throughout the region."

Similarly, the peculiar atmosphere of the region also regularly affects radio coverage. High Frequency (HF) radio signals are very dependent on the ionosphere through which they travel and propagate. The ionosphere is the layer of the Earth's atmosphere ionised by solar and cosmic radiation, according to the Stanford Solar Centre, and the higher the levels of radiation received from the sun the greater the levels of ionisation, thus increasing propagation of HF radio signals. However, the sunspots that regularly affect the region, and which cause the Northern Lights, interfere with radio signal propagation, making communication patchy. "You can determine what time of year sunspots are going to be most problematic, but you can never determine exactly when it will happen," Ron Tremain, Business Development Executive for Civil and Maritime Industries at Insitu, told NAVAL FORCES.

A patchy SATCOM and HF radio link with limited bandwidth means that receiving live information from the UAVs as they fly over and gather information on areas of interest is challenging. To address this issue, a number of UAV systems and software manufacturers have developed on board data processing systems for the UAVs. This is the case for Insitu's ScanEagle, for instance, and for the Norwegian research institute NORCE as well as ACUASI in Alaska. Simply put, on board processing means that all the data gathered by the UAV is constantly being processed and sorted to be able to transmit live only what is relevant. "You slice the data down to what you can send over the poor link when you are back online," said Nils Håheim-Saers, Flight Operations Manager at NORCE. This circumvents the issue of limited bandwidth during the mission, while all the information is stored in the system to be carefully analysed as a whole once the UAV returns to base.

At L3 ASV, the issue has been addressed by integrating the company's unmanned maritime systems division into the broader Communications & Networked Systems (C&NS) segment within L3. "The C&NS segment has world-class expertise in connecting space, airborne, ground and sea-based platforms with secure, real-time data," said Mr Cowles.

Other options are also available, such as the Iridium satellite constellation, which provides L-band voice and data coverage to satellite phones, pagers and integrated transceivers over the entire surface of the Earth. But generally speaking, these systems remain expensive to use. Furthermore, at present, the SAR capability survey notes: "Cold temperatures also contribute to a short construction season for the infrastructure necessary for broadband technologies, and large amounts of snow and ice make the maintenance and development of broadband technologies difficult."



Navigation

The same issues affecting communications also affect navigation in the Arctic. As the GPS is a satellite-based radio navigation system, the sunspots mean that the GPS signal can be limited or patchy in certain areas, creating issues for the navigation of UAVs during their missions in certain areas.

To address these, for instance, NORCE has chosen to fuse radio navigation with optical navigation. "If the radio link is temporarily interrupted, thus creating a loss of GPS signal, the UAV is programmed to switch to optical navigation," said Mr Håheim-Saers. "Optical navigation processes the data gathered from the camera sensors on board to give the UAV coordinates calculated on the basis of its current direction and speed, effectively helping it navigate until connection is regained."

Similarly, Boeing's Insitu has built a lost communication link into its software, "so that in the event that the UAV runs into a sunspot situation or simply loses communication links, it will continue to work autonomously until the signal is regained," said Mr Tremain. In such circumstances, the system is programmed to detect the position of the UAV and calculate, on the basis of its direction of travel and the Earth movement, where it is supposed to be, thus allowing it to continue navigating until signal is regained. "If, for some reason, the signal is never regained, the plane already has logic built into it so that it will automatically return to a pre-determined point of landing," continued Mr Tremain.

Icing

Given the extreme temperatures the region is prone to (as low as -50°C in the winter over large parts of the Arctic), another main challenge to operating manned and unmanned aircraft in the Arctic is the risk of airframe icing. "Airframe icing occurs when an ice layer builds on the airframe, making it difficult for the aircraft to remain aloft," David Phillips, Senior Vice President and General Manager at Textron Systems. "Airframe icing also negatively impacts aerodynamic performance, the dynamic airspeed sensors, as well as the pilot tube and static, which are system critical for control of flight, airspeed and altitude."

Addressing the issue of icing, however, requires UAV engineers to find a fine balance between de-icing/anti-icing capabilities and adding as little weight as possible to the system. There are therefore currently a number of different approaches that could easily complement each other.

For its ScanEagle, Insitu is experimenting with higher-grade materials with insulating properties that hold-up better in the region's harsh environment. To avoid issues of thickening engine oil or fuel gelling, both likely to result in engine failure or damaged propulsion, Insitu crew also warm the equipment as much as possible before launching, so that once it is in the air it does not have to draw too much power to warm itself. "Prior to operating the engines in the Arctic, we wrap the ScanEagle in a thermal blanket and turn the heater on," said Mr Tremain. Typically, once warmed-up the system can operate for 12 to 24 hours in -37°C.

ACUASI is also working on de-icing/anti-icing. In partnership with the National Oceanic and Atmospheric Administration and the Department of Energy, ACUASI will be testing this year different solutions using the icing research tunnel of the NASA Glenn Research Centre.

Mr Willems noted that for the UMS Skeldar's V-200, a system designed and built in the harsh environment of Sweden, harsh conditions were at the heart of the system's architecture from the start. "The architecture of platforms and the location of sealed, weather resistant boxes, is critical for these systems; for the V-200, the boxes with all the sensors are made of carbon and aluminium, and are located in well insulated parts of the airframe to prevent direct air from coming into the compartment."

But tackling issues related to de-icing/anti-icing need not be limited to protection of the systems; they can also entail taking an active approach to assessing real time weather conditions, such as relative humidity, dew point and temperature, as well as the UAV system performance, according to Mr Phillips. "Our UAV platforms provide a multitude of sensor readings to our operators, and we have developed the tools and training to help operators recognise the symptoms of degraded performance due to adverse weather." The Aerosonde Small UAS includes a synthetic aperture radar and various meteorological sensors including pressure temperature, humidity, icing, dropsondes,

Powered by a heavy-fuel engine – and therefore better suited to the corrosive marine environment – is the Skeldar V-200 developed by Swiss-Swedish enterprise UMS Skeldar, a joint venture of UMS Aero Group AG and Saab AB. In addition to hyperspectral sensors, high-definition optics can be carried to understand, identify, and assist in a variety of missions. (Photo: UMS Skeldar)

Arctic Operations

L3 completed several operations off the coast of Alaska, successfully demonstrating the benefit of using an ASV in extreme environments. Over the past four years, L3 has carried out almost 15,000km of survey lines in the Bering Sea region. In operations that marked an industry first, L3's **C-Worker 5** ran alongside **TerraSond**'s Q105 survey vessel doubling the survey coverage and reducing time on-site. ASVs such as the C-Worker 5 are ideal for precision line following and acting as a force multiplier, allowing maximisation of weather windows. Other vessels such as the C-Enduro offer a slightly different capability of long endurance operations, which can be used to gather information such as environmental data.
Insitu's ScanEagle regularly flies off US Coast Guard and Navy ships, as well as Royal Canadian ships off the coasts of Alaska and Canada.
UMS Skeldar's V-200 was built in Sweden and designed for very harsh environments. It has an ability to carry multiple payloads with high endurance levels, and includes a Hirth Engines heavy fuel engine. There is a high probability that the system will be flying soon in the Arctic, although Mr Willems was unable to reveal the details of the programmes at this stage.

solar radiation and sea surface roughness. Similarly, ACUASI is flying on its UAVs the PEMDAS airborne sensing and prediction system, which allows UAV operators to have real-time information on whether the system is in a cloud or icing conditions, or whether there is a potential for either. "When we fly our UAVs, unless we have such systems on board, it is very difficult for us to know what is happening to our system, so this information is vital," Dr Cahill told NAVAL FORCES.

Finally, the fact that, as indicated previously, the waves in the Arctic are getting bigger as a consequence of the decreasing ice in regional waters, only adds to a set of already harsh environment conditions at sea. Strong winds, choppy waters and icing all combine to render launching and recovering of UAVs from naval platforms rather complicated. "On station, a UAV will fly well above weather but during take-off and landing it will have to fly through at times very bad weather conditions, especially in winter," Harald Håvoll, Senior Adviser and Military Analyst at the Centre for International and Strategic Analysis in Norway told NAVAL FORCES. One possible solution to this challenge is General Atomics Aeronautical Systems' MQ-9B which, amongst many other things, is also capable of self-deploying through SATCOM-controlled Automatic Take-off and Landing Capability.

Technological Opportunities

"The difficulties crew face when operating UAVs in the Arctic are actually technology motivators," says Mr Håheim-Saers. The need for unmanned airplanes to perform the same level of situational awareness as manned airplanes have provided so far, pushes industry and researchers to find solutions that can overcome these challenges.

"UAV technology is constantly evolving in support of operating in extreme conditions, such as the Arctic, and we expect to see the emergence of new payloads with increased capability," noted Mr Phillips. The emphasis on the importance of payloads to gather data that will facilitate the functioning of the UAVs in such harsh conditions was also reflected in contributions to this article from General Atomics, NORCE, Insitu, Schiebel, UMS Skeldar, and ACUASI. Chris Day, CTO Schiebel, told NAVAL FORCES: "Ice detectors can be used to improve operation at temperatures where icing is a challenge."

Challenges in finding the right trade-off between de-icing/anti-icing and weight/power will also drive research for lighter material that prevents icing on the airframe and the systems of the UAVs. Similarly, the debate on the best type of propulsion system will continue to yield interesting results. Batteries are probably the least favourite system, as their life is significantly reduced in harsh temperatures, thus diminishing the systems' endurance. Heavy fuel is considered a good option, as it is resistant to the temperatures encountered in the Arctic, but there are also talks of hybrid propulsion systems with hydrogen fuel cells providing electric power for an electric motor. For instance, Insitu is exploring the use of fuel-cell-based hybrid electric propulsion systems, which eliminates concerns associated with managing fossil fuels. All-electric UAVs can run inside a building or shelter prior to launch because there are no toxic emissions, and energy generated by the fuel cell stack can be electrically routed or recirculated in the aircraft to maintain the system's operating temperatures in flight.

Ultimately, as the Arctic continues to gather importance on the world stage, with the Northwest passage opening up and military operations increasing in the region, it is easy to predict that unmanned systems will become central to operations in Arctic waters. "They have a tremendous potential in terms of piloting ships and for Arctic domain awareness," said Dr Cahill, providing support to ships as they navigate, indicating the thickness of ice and signalling the presence of icebergs. "In case of medical emergencies, they might also become a key capability for delivering emergency supplies," she continued. "The smaller environmental footprint of unmanned systems is also an important factor for operations in the Arctic region," added Mr Day. "We are only at the beginning of the use of unmanned systems in the Arctic," concluded Mr Willems, and technology will grow and mature to support customers' changing needs. NAFO

Schiebel's Camcopter S-100 has a range of up to 200km. (Photo: Schiebel)