FFI Norwegian Defence Research Establishment

EXTENDED SUMMARY

The future Arctic operating environment

Extended summary of FFI report 24/00993

By 2050, trends in geopolitics, environment, military systems, doctrines, and society will have altered the operating environment in the Arctic. This will have significant implications for the Norwegian Armed Forces.

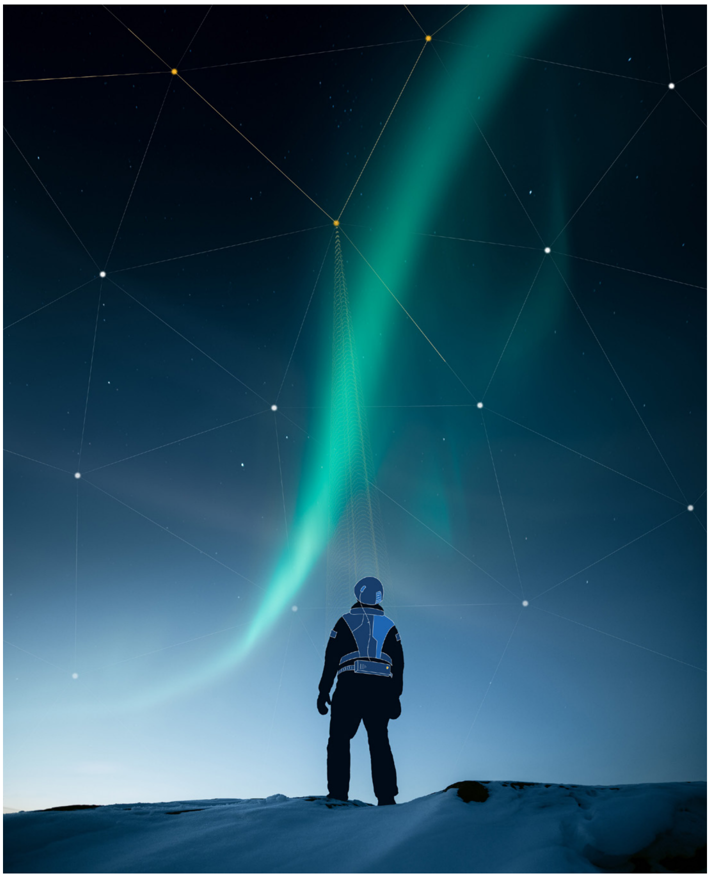


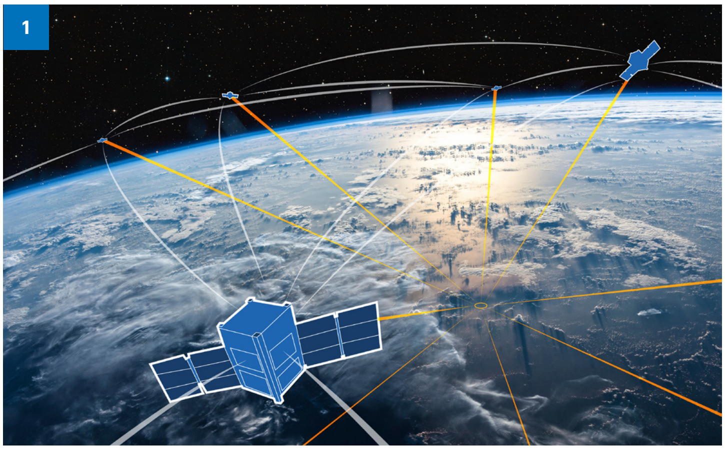
Illustration: Halogen

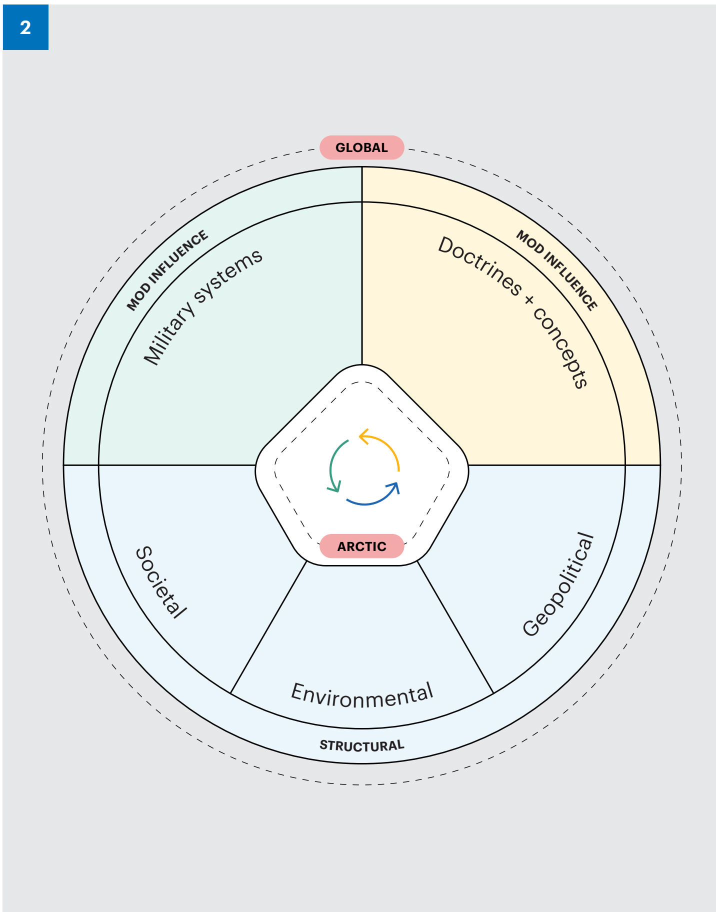
Many aspects of the Arctic operating environment will have changed by 2050, but central characteristics will remain, such as vast distances, polar nights, the midnight sun, and transmission disturbances from the northern lights.

Imagine conducting a military operation in the Arctic during the late 2040s. Consider how different many of the important aspects of the operating environment will be. There may be less sea ice, more commercial activity, increased population, and expanded civilian infrastructure both on land and in space. Modern military forces have leveraged autonomy, artificial intelligence, advanced sensors, and digital networks to enhance situational awareness and boost lethality. Even in the cold expanses of the Arctic, these technologies have been wedded to well-established tactics, techniques, and procedures to improve survival and operational effectiveness in the inhospitable and distant region. Although we cannot accurately predict the details of the future Arctic battlefield, we can nevertheless learn from exploring the possible features of a potential *future operating environment (FOE)*. We define this as the combination of factors that provide context within which military operations are conducted.

Defense planning decisions often have far-reaching consequences, and these decisions may be improved by considering future trends. The Norwegian Defence Research Establishment (FFI) therefore launched the *Tekno* project in 2019, a project tasked with analyzing the consequences of emerging and potentially disruptive technologies on future Norwegian military operations. With this latest report, we have combined the results of our earlier research to create a holistic picture of the future operating environment. We selected a simplified set of five variables that have historically influenced how military operations are conducted and might therefore capture potential shifts in the character of warfare: *geopolitics*, *environment*, *society*, *military systems*, and *doctrines*.

Illustration: Halogen Photo: Forsvaret





1. Arctic actors can expect comprehensive satellite coverage from constellations providing high-capacity broadband, reliable PNT and detailed ISR capabilities. 2. Relevant aspects of the future operating environment include geopolitical, environmental, and societal factors that are more structural in nature, while military systems and doctrines can be more easily influenced by defense ministries. 3. By 2050, the Arctic Ocean will likely be ice-free during the summer.

For each factor, we began by looking at relevant global trends and assessed how they would impact the Arctic region, paying particular attention to cross-cutting effects, synergies, and feedback loops among the variables. We then combined these factors to create three distinct possible futures and consider how the conduct of military operations might be affected as viewed through the lens of the joint functions (command and control, mobility and maneuver, intelligence and information, fires, sustainment, and protection).

The unique Arctic environment

The Arctic has several unique and enduring features. It is remote, scarcely populated, and dominated by a maritime domain that is often covered by sea ice. Weather conditions can be severe, ranging from extreme cold to the frequent mixed precipitation that occurs along many Arctic coastlines and poses challenges for both personnel and equipment. Low-lying vegetation such as grasses, small shrubs and moss cover much of the landscape. The poorly draining soil beneath the tundra creates muddy conditions during the summer months.

There are extreme variations in light conditions throughout the year. The highest latitudes experience constant summer daylight and the constant darkness of wintertime polar nights. Nevertheless, most locations in the Arctic see some daylight during the winter, even if the sun remains below the horizon, and some twilight during the late spring and early autumn months. Another well-known Arctic phenomenon is the aurora borealis, or northern lights, which generate colorful fluorescent displays during the dark winter months but are highly disruptive to GPS signals and radio communications.

The Arctic climate in 2050

Many aspects of the Arctic environment are changing rapidly. The principal reason for the growing interest in the Arctic is climate change, which is already having a dramatic effect on a region that is warming several times faster than the rest of the globe. By 2050, summer sea ice will likely have completely disappeared. Coastal erosion will be severe without the sea ice to protect it, and foggy conditions that previously were a rarity in the Arctic will become more common. Certain fish stocks will migrate northward in search of colder water, while other species may simply disappear. The Greenland glaciers will retreat significantly, contributing to rising global sea levels and revealing land that had previously been covered by ice for thousands of years. Precipitation will increase but fall more often as rain instead of snow, and the snow season will be shortened by several months.

On land, smaller streams and rivers are likely to be more susceptible to flooding from the frequent extreme weather. Permafrost melting across the Arctic will make the land more unstable, and the tree line will move northward and upward along the mountain slopes, encroaching on areas that previously were open landscapes.

The receding ice is expected to lead to increased economic activity, such as shipping, fisheries, and mining. Population growth resulting from these commercial enterprises will expand transportation and

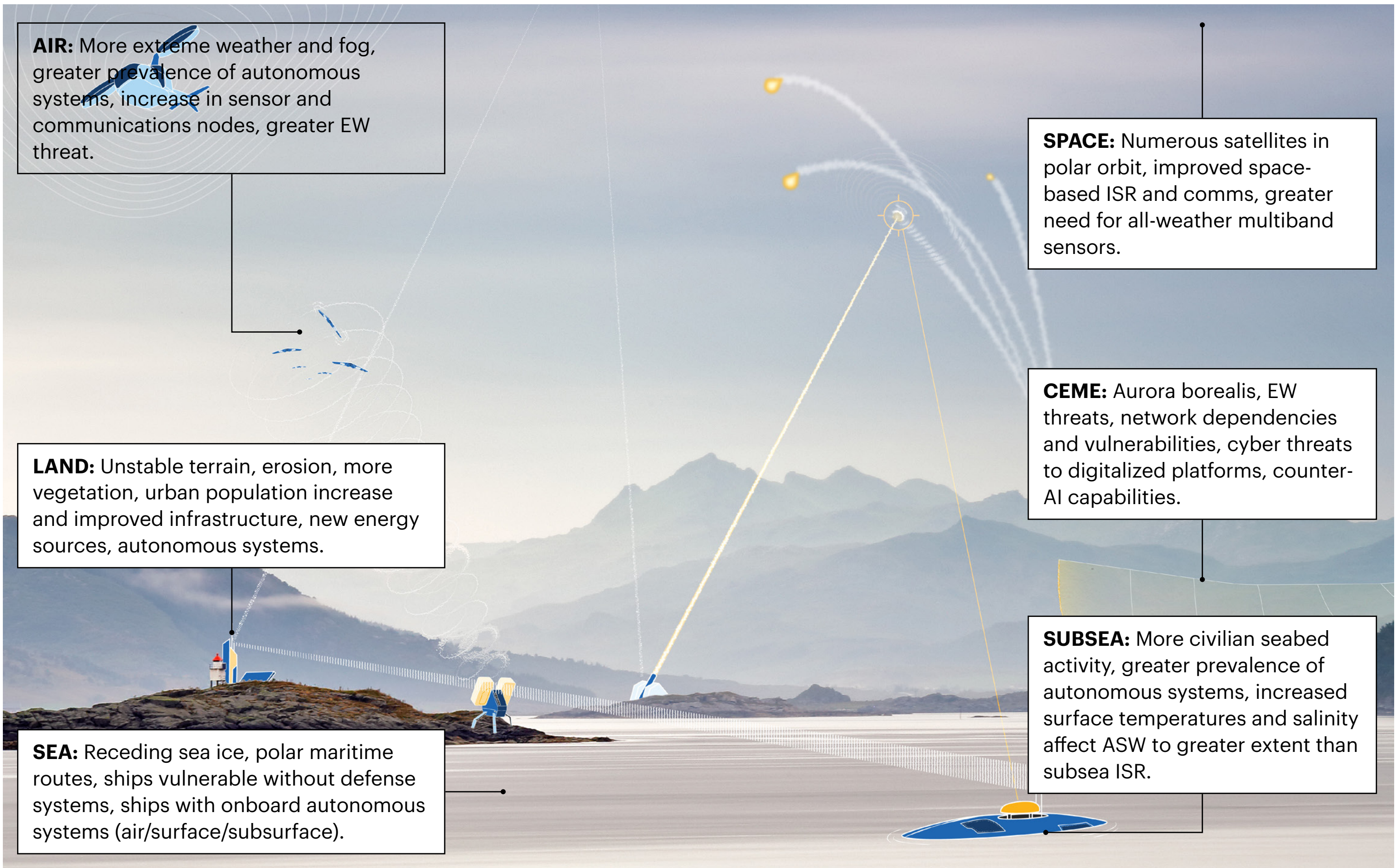


Illustration: Halogen

The specific characteristics of the future Arctic battlefield will depend on how each of the five factors develops, but some general conclusions can be made for subsea, sea, land, air, space, and cyber and electromagnetic effects (CEME).

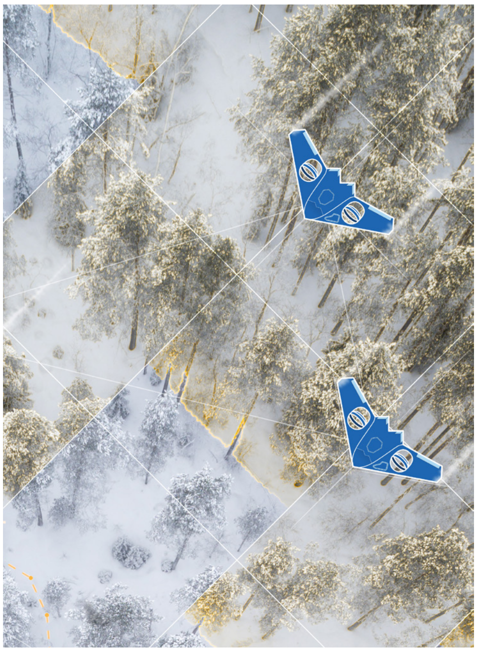
communication infrastructure, as well as increase the geostrategic value of the region. By 2050, we are also likely to see new geopolitical developments, significant advances in many civilian technologies and potentially disruptive military technologies. How these factors evolve and interact will influence the future operating environment in different ways. To explore and illustrate different combinations of factors, we created three possible futures.

The future battlefields

In the first *chaotic* future, Russia is an active but technologically inferior Arctic actor among a mix of state and non-state actors. Notably, this does not include the United States, which lacks the interest or ability to fully engage in the region. Competition over resources strains international laws, treaties, and respect for exclusive economic zones in the Arctic. Networks of sensors in all domains ensure robust situational awareness in a region experiencing expansive economic activity fueled by seabed mining, oil extraction, maritime transport, and fisheries. Concealment and maneuver are challenging, but smaller units with reduced signatures may be less detectable. The region's vast distances favor range and speed for stand-off engagements. Large platforms depend on enhanced defenses against long-range and swarming threats for survival, while underwater concealment and maneuver are challenged by receding sea ice. Increased commercial activity ranging from subsea to space-based assets creates the need for extensive intelligence, surveillance, and reconnaissance (ISR) from the seabed to space. The battlefield is transparent, connected, autonomous, and remote.

In our second future, the Arctic is an arena for *geopolitical competition*. China has become a bona fide Arctic actor through its close military partnership with Russia, thus ensuring US engagement in the region. The battlefield is congested, competitive, and sensitive as intense commercial activity blends together with the high-tech military systems of China, Russia, the US, and the Nordic countries. The operating environment is crowded with advanced sensors, long-range weapons, and capable air and missile defenses. The electromagnetic spectrum is highly competitive and connectivity disruptions due to adversary actions are common. The risk of unintentional military escalation, either from kinetic engagements between autonomous systems or between militaries and private proxy forces protecting economic installations, creates a tense and cautious atmosphere among Arctic state actors.

The third potential Arctic future is *quiet and uncontested*. Dramatic advances in civilian technology and absent geopolitical tensions have led to an Arctic that is peaceful and dominated by uncontested remote sensing. Beneath the tranquility, however, Russia resembles a failing state, with the associated risk of rogue armed factions, uncontrolled migration into the Nordic countries, and CBRNE accidents from ageing military systems carrying nuclear warheads or atomic reactors. Due to its weakened position, Russia prioritizes asymmetrical approaches against its adversaries. In the technologically advanced Western societies, much of the social, economic and political activity has become a mix of the physical and digital spheres of immersive metaverses and human-robotic interactions, Illustrasjon: Halogen



By 2050, easily deployable autonomous swarms can swiftly cover large areas and provide unprecedented ISR.

SELECTED RECOMMENDATIONS

- Investing in greater intelligence, surveillance, and reconnaissance capabilities (ISR), particularly in emerging domains such as space and the maritime seabed environment. Ensuring that changes to the Arctic Ocean (salinity, temperature, sea ice coverage) and the impact on anti-submarine warfare (ASW) are well understood.
- Developing new methodologies and technologies to detect an adversary's deceptive or covert use of civilian activities or vessels.
- Conducting multi-sector whole-of-government exercises and wargames based on potential confrontations with new and therefore less familiar Arctic actors to better understand escalation risks and potential de-escalatory options.
- Exploring ways to better leverage new technologies such as additive manufacturing or energy storage technologies to increase self-sustainment in austere Arctic environments.
- Developing plans for securing new critical infrastructure resulting from emerging commercial and military activities in the Arctic from kinetic and non-kinetic threats, ranging from seabed activities to space-based assets.

providing Russian actors with many avenues for influencing and disrupting democracies. NATO countries, having invested in force structures for high intensity interstate warfare, are less equipped to address these threats emerging from Russia.

Implications

The implications for defense planners naturally depend on which of the futures comes to pass, but some aspects of the Arctic in 2050 are more likely to emerge than others. Due to the current interest in space-based and terrestrial infrastructure, communication options in the Arctic are likely to be more robust and reliable by 2050. Natural disruptions from the aurora borealis will persist, but disruptions from potential adversaries are far more relevant.

Adversarial sensor networks make mobility far more challenging and dangerous as any movement leads to rapid detection, targeting, and potential engagement. Technologies for countering an adversary's sensors (and anticipating adversarial counters to friendly sensors) will continue to be characterized by constant competition, either through electromagnetic measures or advances in materials sciences that create coatings, camouflage, and techniques that mimic cloaking functions. In general, sensor density and the prevalence of civilian activity will likely lead to more covert activities. Anti-submarine warfare may become more complicated due to ambient noise from civilian maritime traffic and altered underwater sensor characteristics resulting from lower salinity and higher surface temperatures.

Mobility on land and at sea will be affected by more intense storms, precipitation, erosion, coastal fog, and unstable terrain. Sustainment may be even more challenging from the impact of erosion, shorter frost seasons, and higher precipitation levels. Exploring options for maintaining compatibility with civilian infrastructure may create an extra level of redundancy in remote locations.

These and many other aspects of future operations in the Arctic need further analysis, particularly as many current or planned military systems are expected to still be in operation by 2050. Understanding the trends and their potential effects on the FOE will better prepare military forces for the future.

Read the full report on FFI's website:
ffi.no/en/publications-archive/the-future-arctic-operating-environment

Authors:
Michael Mayer and Ingunn Helene Landsend Monsen

Questions? Please contact:

André Pettersen, Director of Research
andre.pettersen@ffi.no

FFI's Communications unit:
info@ffi.no

Learn more about FFI and our research at ffi.no

December 2024