EPIS Thinktank

ARCTIC & SPACE

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# Arctic Satellite Infrastructure

## Dual-Use Dynamics, Infrastructure Bottlenecks and Governance Challenges in Arctic Satellite Systems

**About the Authors:**

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**About the publication:**

**3 Main Points:**

How does Arctic satellite infrastructure shape strategic, economic and security dynamics?

Polar-orbiting satellites and Arctic ground stations create vital data access but also introduce dual-use risks and infrastructure bottlenecks.

Expanding Arctic satellite infrastructure requires balancing resilience, security and sustainability through careful planning and governance.

**Highlight Sentence:**

*"Dual-use satellite infrastructure means systems built for civilian use that can also be used for military purposes, which increases both their importance and their vulnerability."*

**Definition:**

Polar-orbiting satellites are satellites that fly over the Earth from pole to pole, allowing them to gradually cover and observe the entire planet's surface.

## Polar-Orbit Satellite Infrastructure in the Arctic - Opportunities and Risks

### Introduction

Satellites have become indispensable for global communication, navigation, and Earth observation. From weather forecasting and climate change assessments to military applications, satellites have become the backbone of modern societies and economies.

In this context, the Arctic is gaining increasing importance. Polar-orbiting satellites can cover the entire Earth's surface, whereas geostationary satellites provide little or no coverage over the Earth's poles and other high-latitude regions. As activity in the Arctic intensifies –including increased shipping traffic, scientific research, resource exploration and extraction and strategic military operations– the demand for reliable data and real-time information rises significantly.

Arctic ground stations play a fundamental role in meeting this demand. By establishing frequent contact with polar-orbiting satellites, ground stations ensure the transmission of critical and precious data that would otherwise be delayed or even unavailable. This enhances capabilities in areas such as maritime domain awareness, environmental monitoring, emergency response, and scientific research, among others. However, while polar-orbiting satellites offer enormous data accessibility potential and thus create significant opportunities, it also introduces risks and bottlenecks. Since only a small number of ground stations can communicate with these satellites, any disruption -whether due to harsh weather conditions, technical failures or deliberate military attacks- can have serious civilian and military consequences.

The Arctic is therefore emerging as a strategic frontier in the space infrastructure and global data network. The expansion and strengthening of Arctic ground station infrastructure therefore gains dual importance: supporting civilian needs while reinforcing security in an increasingly contested frontier.

## Technical aspects of polar orbits and polar-orbiting satellites

Polar-orbiting satellites constitute the pillar of modern Earth observation systems. Their ability to provide high-resolution coverage both globally and, particularly, in high-latitude regions is what makes them unique and highly valuable for all their applications. Unlike satellites placed in geostationary orbits, which remain fixed above the Earth's equator at altitudes around 36,000 and 42,000 km, polar-orbiting satellites typically operate in the low Earth orbit (LEO) at a maximum altitude of around 1,000 km. Most importantly, however, is the fact that satellites in polar orbits follow near north-south trajectories, traveling close to both poles on each orbit, while the Earth keeps rotating. Since their inclination is close to ninety degrees to the equator, this means that not only does a polar-orbiting satellite consistently cover the

Earth’s poles, but it also gradually scans the entire surface of the planet. Indeed, a polar-orbiting satellite effectively covers more area than a satellite that continuously orbits over or near the equator, from side to side or from west to east.

This fundamental difference between orbits is what gives polar-orbiting satellites an edge when discussing operational advantages. While geostationary satellites provide continuous coverage over a fixed area (e.g. they allow antennas on Earth to constantly communicate with the satellite and therefore enable telecommunications, and they can be useful for monitoring the weather in a very specific region), their flaw is limited visibility at high latitudes, making them practically ineffective for Arctic monitoring. In contrast, polar-orbiting satellites provide almost complete global coverage, including the polar regions, and allow for high-resolution satellite imagery due to their lower altitude.

The usefulness of satellites depends entirely on ground infrastructure. Communication with satellites is only possible when a satellite passes within range of a ground station or, in other words, when the satellite is within line of sight. Therefore, in an orbital period, communication with a satellite can be established for a brief period of time due to the high orbital speeds at which satellites move. Commonly, contacts with satellites last no longer than 20 minutes, allowing for a short timeframe of data transmission and download. However, because polar orbits converge near the poles, polar-orbiting satellites can make contact with high-latitude ground stations on every orbital period.

Since satellites placed in low Earth orbit move at a speed of around 7.8 km per second, this means a full orbit is completed in around a hundred minutes. Therefore, polar ground stations can contact satellites around fourteen times a day, while ground stations located in equatorial regions can make contact approximately four times a day. Polar ground stations have an edge over other stations when it comes to satellite data accessibility, and this increased communication also reduces data latency and enhances operational efficiency.

Overall, it is evident that the inherent characteristics of polar orbits and its orbiting satellites allow for more frequent communication with polar ground stations, effectively contributing to higher data availability and an increase of these satellites' operational value.

## Arctic space infrastructure

The Arctic space infrastructure has grown into a network of bases that include ground stations and polar satellites launch facilities. With the aim of exploiting the benefits of polar orbits, Arctic states have been investing both in polar-orbiting satellites and infrastructure. The most prominent example is the Svalbard Satellite Station (SvalSat). Located in Norway's Svalbard, the facility has over 150 antennas which are covered with a radome to protect them from the Arctic's hostile environment. These antennas communicate with numerous polar-orbiting satellites, mostly operated by European states, NASA, Japan, South Korea, and India, making the station a global hub for scientific research, weather forecasting, commercial data services, Earth observation, and even defence-driven satellite data.

However, SvalSat is not the only ground station in the Arctic. The Esrange Space Center in Sweden also has a significant number of satellite antennas and ground services, as well as the capability of launching and testing rockets and satellites, positioning the station as key for Europe's space infrastructure and space autonomy. Similarly, Norway's Andøya space station serves as a satellite and rocket launch site, but also offers Earth observation services. Beyond Scandinavia, a new optical ground station that will use advanced laser technology to secure high-speed data transfers from polar-orbiting satellites is being built in Greenland through a partnership between the European Space Agency (ESA) and Astrolight, a Lithuanian space company. On the other side of the Atlantic, Eutelsat inaugurated, in 2024, a ground station in Yellowknife (Northwest Territories, Canada) to expand satellite services and accessibility across Canada and the Arctic. In the United States, Northrop Grumman was awarded, in 2024, a $ 4.1 billion contract for the development of two satellites intended to be placed on polar orbits.

Even though Arctic space infrastructure is ramping up, the usefulness of these facilities depend not only on their geographical location but also on their proper integration into an efficient digital connectivity network. As discussed during a past brief, the Arctic is becoming a global hub for data corridors and undersea optical fibre cables. In this context, the vast volumes of data obtained from communications with polar-orbiting satellites would greatly benefit from fast connectivity networks, effectively allowing rapid transmission from Arctic ground stations to users in Europe and other countries.

As mentioned earlier, the satellites' high orbital speeds allow for brief windows of communication to download data. Therefore, it is of utmost importance that Arctic ground stations are connected to fast digital connectivity networks to ensure the fastest possible data download and transfer. A fast digital infrastructure would ensure that isolated Arctic ground stations also serve as data hubs and enable near real-time transfer of satellite data, imagery and telemetry.

Taken together, these developments illustrate that the Arctic's space infrastructure is not limited to antennas in isolated sites, but it instead constitutes a complex ecosystem of ground stations, launch capabilities and high-speed digital connectivity networks.

## Strategic importance of the infrastructure

Polar-orbiting satellites support a wide range of applications that significantly increase the strategic importance of Arctic satellite infrastructure. Originally designed for civilian purposes, polar-orbiting satellites play key roles in observing changes in ice melting, ocean dynamics and atmospheric conditions on the Earth's poles.

Polar-orbiting satellites' missions are mostly civilian-driven. They make an important contribution to weather and climate observation and enable assessments of changes in environmental conditions such as the oceans, ice, and the atmosphere; all this information is critical for understanding climate change, mitigating the impacts derived from it, and for improving weather predicting models. Additionally, these satellites enable more reliable navigation, monitor the growing volume of Arctic shipping traffic, allow for the optimization of trade sea routes through satellite data, and support the detection of illegal activities at sea. These applications help Arctic maritime routes become more accessible, safe and predictable.

Beyond environmental and maritime applications, Arctic satellite infrastructure also contributes to the economic development of the region. Improved connectivity thanks to frequent contacts with polar-orbiting satellites helps bridge digital gaps in remote Arctic communities, effectively enabling broadband communication and access to internet services.

At the same time, the dual-use character of this infrastructure is becoming increasingly important. In addition to their primarily civilian functions, polar-orbiting satellites can also be leveraged for security- and military-relevant applications. They enable the monitoring of strategically sensitive areas with limited accessibility and strategically sensitive Arctic areas in the Arctic, thereby providing valuable information and intelligence for defense actors. In the context of increasing geopolitical competition in the Arctic, this satellite infrastructure is benefitting from increased attention by NATO and other security actors which rely on timely data to assess risks and make informed decisions.

Overall, the expansion of Arctic satellite infrastructure reflects its growing importance for both civilian and military purposes. Its dual-use condition allows for environmental monitoring, increased connectivity and security-driven data.

Data from polar-orbiting satellites enable improved monitoring of environmental conditions, Earth observation and overall enhancement of connectivity. At the same time, it enhances maritime situational awareness, supports early-risk detection and effectively enables informed decision-making based on real, satellite data. As reliance on satellite-derived data continues to grow across all sectors, the Arctic's space infrastructure is emerging as a critical node for sustainable development and military security.

## Challenges

However, the development and expansion of satellite infrastructure in the Arctic are also associated with a number of challenges.

First, the Arctic's extreme weather conditions significantly complicate both operations and data collection. Communication with satellites is highly sensitive to weather, meaning that signal reliability can be easily affected by atmospheric disturbances as common as a simple clouded sky. Extreme cold or temperature fluctuations can impair the functioning of technical components, accelerate material degradation, and increase energy demands. In addition, strong winds, ice formation and accumulation, and snow drifts can negatively impact the alignment of antennas used to communicate with satellites, potentially causing physical damage and signal disruptions. In addition, the polar night results in several months of little or no daylight, which limits optical Earth observation systems and complicates maintenance operations of facilities.

In addition to extreme weather conditions, the limited number of suitable sites for constructing ground stations also limits infrastructure development in the region. Large parts of the Arctic are permanently frozen or not easily accessible. This significantly increases the costs of construction, operation, and maintenance of ground stations. Furthermore, sustainability aspects must be considered in construction projects. The Arctic's fragile ecosystems, wildlife, plant life and the livelihoods of Indigenous communities can be negatively impacted by large-scale space infrastructure projects. When planning space infrastructure projects in the Arctic, a balance between technological expansion and environmental well-being must be found, therefore limiting the scope for action.

Further technical limitations exist. Snow and ice surfaces can affect radiation penetration, leading to distorted data reception and incomplete measurements. In addition, only a limited number of external reference values are available for validating the collected data.

Furthermore, the dual-use nature of satellite infrastructure also creates security risks. Since ground stations serve both civilian needs and military applications, they become potential targets for military attacks. The fact that an increasing number of satellites depend on only a very limited number of ground stations greatly increases dependency and vulnerability, turning these sites into bottlenecks.

In addition, legal frameworks must also be considered, which also may become problematic due to the dual-use nature of the infrastructure. International agreements, such as the Svalbard Treaty, regulate the use of certain Arctic regions and could restrict the expansion of satellite infrastructure. The Svalbard Treaty, for example, states that military use of the islands is prohibited. Since ground stations are primarily used for civilian purposes but can theoretically also fulfill military and security functions, the expansion of satellite infrastructure there could be interpreted by other treaty parties (particularly Russia) as a violation of existing agreements. This could further worsen already existing tensions.

Due to this wide range and diversity of challenges, careful planning and strategic site selection are of paramount importance. Reliance should not be placed solely on the few existing ground stations. The greater the dependence on limited infrastructure, the more severe the potential consequences of a technical failure or a military attack. At the same time, the already fragile ecosystem of the Arctic region, which is further burdened by infrastructure expansion, must not be overlooked. Therefore, decisions regarding expansion and investment must always balance probabilities, risks, and costs against each other.

## Conclusion

The satellite-derived benefits of polar orbits demonstrate the growing importance of Arctic satellite infrastructure. Combined with high-latitude ground stations, polar-orbiting satellites enable Earth observation globally, more frequent data transmission with ground stations, and enhanced monitoring capabilities that are increasingly essential in a constantly changing environmental and geopolitical landscape.

However, this growing reliance on Arctic space infrastructure also exposes significant vulnerabilities. First, the concentration of such critical infrastructure in a limited number of locations creates bottlenecks that can be disrupted by military attacks, technical failures or environmental conditions. At the same time, environmental sustainability and regional constraints must be considered when expanding space infrastructure in the Arctic.

Moving forward, resilient infrastructure and efficient connectivity in the Arctic will be the two key elements to maximizing the benefits derived from polar-orbiting satellites. This includes strengthening the digital infrastructure and identifying the most appropriate places for the construction of new ground stations.

Ultimately, the development and strengthening of the Arctic's satellite infrastructure is not only a technical necessity to maximize the effectiveness of polar-orbiting satellites, but also a strategic priority for any state whose dependence on Arctic-based satellite systems continues to grow.