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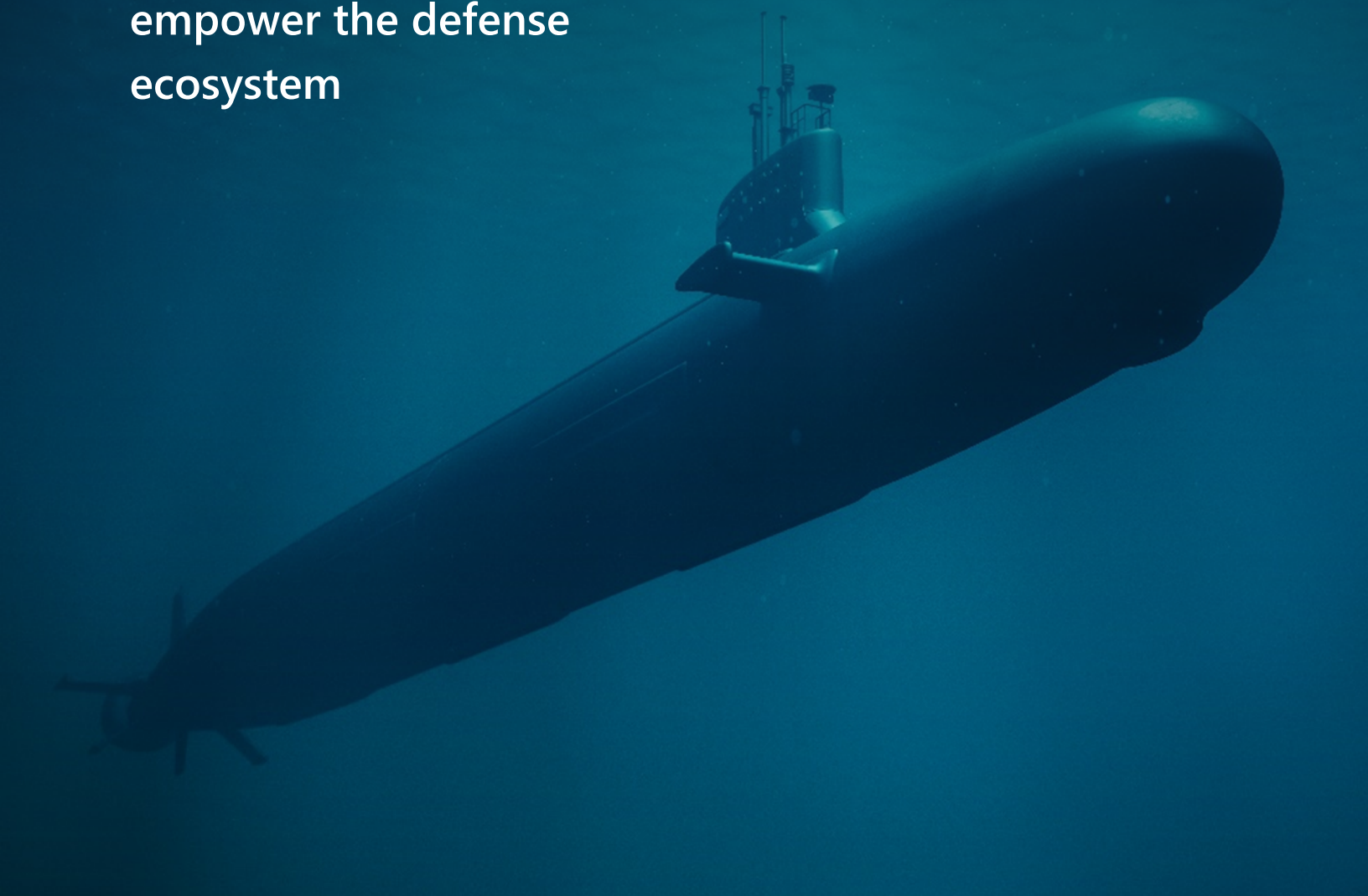
# Transforming sub-surface operations with data-driven decision support

Leveraging the power of data and artificial intelligence to empower the defense ecosystem



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# Introduction: Powering the future environment through data driven decision support

As the future of military operations changes, defense organizations must embrace emerging technologies that can provide crucial battlespace advantage. This paper identifies how those technologies can be deployed in the maritime domain.

Defense and intelligence organizations contribute to national security and protect their respective country's interests. The changing nature of the global security environment is shaping military capability development. Great power competition, terrorism, and regional posturing remain prevalent, as well as ever increasing threats in the cyber and space domains.

Subsurface operations, typically involving submarines or other underwater vehicles, is an increasingly important component of naval operations and has been a significant focus area for many countries' defense strategies. In 2021, Australia announced a strategic partnership with the United Stated and United Kingdom that included the procurement of nuclear-powered submarines, increasing its strategic influence in the Indo-Pacific region.[1] The maritime domain, particularly the subsurface domain, is complex and challenging, but modern technology offers solutions to many of these challenges.

Maintaining battlespace advantage in this environment, with limited resources, requires a clearer, more connected understanding of the full spectrum of maritime domain scenarios and situations. This in turn requires new technologies and approaches. A key technology that will be instrumental in this transformation is Artificial Intelligence (AI).

# The right technology to augment Navies' strengths

The use of data and AI in mission planning is rapidly evolving. Advances in technology are driving new capabilities and opportunities. The analysis of data from the electromagnetic spectrum is an area where there is significant potential for improvement. Sub-surface equipment and technology are particularly poised to improve their analysis of electronic intelligence (ELINT), communications intelligence (COMINT), and acoustical intelligence (ACINT) because the current sensors, processes and pipelines are readily available for the application of advanced AI tools.

AI algorithms can be used to process and analyze this data, enabling assets to detect, track, and classify potential threats more quickly and accurately. In the sub-surface domain, submarines, anti-submarine warfare (ASW) frigates and other sensors, such as maritime patrol aircraft, collect significant amounts of acoustic data. This requires labor-intensive processing using highly skilled individuals who must reference against large bodies of historical data to extract value.  Furthermore, the collection and point of processing of that data is often at the extreme tactical edge in disconnected environments, where access to the cloud or to high power computing with current legacy infrastructure is limited or infeasible.

With the advent of modern computing technologies, advanced analytical techniques are being used to deal with these types of scenarios; in AI application, this includes machine learning (ML) and deep learning (DL) intelligence. These technologies provide notable advancement in the complementing and enhancing (or replacement) of traditional signal processing techniques. The advantage of these technologies is wide, but they've proven most beneficial in the analysis of extremely large data sets against recognizable features.

It is important to note that AI technology is not meant to replace, but rather augment, the human element in military operations and serve as a 'co-pilot' in providing computational decision-assist capabilities that are data-driven and transparent. This allows defense forces and the defense industry to optimize operations, improve readiness, gain information superiority, and accelerate the observe-decide-act cycle – all critical to a successful defense posture.

A primary desired outcome of these advanced analytical techniques is the ability to rapidly search, identify and classify features within data sets, which can then be applied to a broad range of use cases.

ML and DL enable automated collection and labeling of large data sets, identifying, and classifying feature groupings. Traditional implementation of these technologies, e.g., within autonomous driving development, involves three key aspects:

1. Workflow for the collection, identification and labelling of data.
2. Development of models which can be applied to assets for inference monitoring.
3. Deployment of assets for sensor identification and use in decision making.

Accordingly, the current pipeline and process in defense forces' acoustic data collection, analysis, and dissemination, including the provision of highly qualified personnel to provide reinforcement learning from human feedback (RLHF), is already firmly established. This makes this area of application the potential 'gold standard' for development of high performing AI systems.

## Canadian military position: The importance of sub-surface operations

An example of the importance of sub-surface operations is typified by Canada's military strategic circumstances, which are shaped by its geography, history, and the current global security environment. Today, Canada faces a range of challenges, including terrorism, cyber threats, and the resurgence of great power competition. It is also facing increased pressure from Russia in the Arctic region and is working to strengthen its defense capabilities in this area.

Canada has a vast geography that occupies much of the continent of North America, stretching from the Atlantic Ocean in the east to the Pacific Ocean in the west, and to the north lies the Arctic Ocean. To defend this significant coastline, Canada requires a two-ocean navy, maintaining a presence in both the Atlantic and Pacific oceans and the Arctic. This presents a serious dilemma for a medium-scale power with limited resources. Like other militaries experiencing the same challenges, Department of National Defense (DND) is looking to exploit modern technology as a force multiplier.

Furthermore, with Five Eyes nations ramping up their collective submarine capabilities and the Royal Canadian Navy recently announcing their intent to purchase a replacement submarine, attention will naturally swing towards sub-surface warfare, and maritime domain awareness more broadly. This will play a vital role in protecting Canadian sovereignty and interests at sea, at home, and abroad. Accordingly, it will be important for Canada to embrace emerging technologies to deliver a competitive advantage.

# Addressing environmental challenges

**The implementation of cutting-edge technologies into defense organizations is not straightforward. There are several industry-specific challenges that must be addressed before success is assured. Some of the challenges that industry is currently working to overcome include:**

## Processing at the edge

Whether in headquarters (HQ) or an edge environment, personnel need rapid access to information and sensors, as well as the ability to apply AI to assist with rapid decision making. Further, they need to be able to do this without a permanent connection to centralized computing. Modern, secure hyperscale cloud architectures give you the best of both worlds, with high performance computing for the analysis and development of deployable technologies, complemented by deployable secure computing processes. This requires technology and infrastructure that can operate disconnectedly, for both extended periods and sometimes indefinitely, and the ability to conduct safe, secure syncing when (and if) connectivity becomes available.

## Data classification and cybersecurity

Typically, the types of data processed across these use cases are at the higher end of security classification. These require very specific technical protection to avoid loss or leak of information. In addition, like any technology that relies on data and communication systems, cybersecurity threats are a major concern in sub-surface warfare. There is an ever-present threat that malicious actors could compromise the security and integrity of the data. Legacy solutions - including maintaining data in on-premises infrastructure- do not necessarily provide the level of protection

required. Rather, recent advances in cyber threat intelligence and end-point protection can help withstand a high percentage of destructive cyberattacks. From these lessons, we are now increasingly using AI, new analytics tools, broader data sets, and a growing staff of experts to track and forecast this cyber threat. Using a collaborative approach to cyber defense, using hyperscale capabilities together with contemporary technology adoption, will certainly be required.

## Data quality

The quality of the data collected by sensors on submarines can be affected by a variety of factors, such as weather conditions, ocean topography, and interference from other sources. Inaccurate or incomplete data can produce misleading results when using AI for analysis. This is especially relevant for operations in the marginal ice zone and under-ice, where classifying and identifying vessels transiting these areas can be impacted by the ambient noise coverage from the ever-shifting ice cap.  Some of these challenges can be overcome by both refined analyses using AI, and fusing acoustic data with other sources, such as weather, sea state, temperature, salinity, and depth of sensor etc. Doing so provides an opportunity for much greater understanding of the operating environment.

## Responsible AI considerations

Spurred by advances in the use of generative AI, much has been written recently about the  ethical considerations of the increased application of AI across industries.  Moreover, the use of AI in military operations raises particular  ethical concerns. At the forefront of any AI development, the need to ensure that the use of AI is consistent with ethical principles and international norms is paramount.

Furthermore, while AI is a powerful capability, it also has limitations. For example, AI algorithms may be susceptible to bias or may not be optimal in use with certain types of data or situations. Therefore, careful consideration must be given to the limitations of AI when designing systems for military operations.

For that reason, public and private sector organizations alike are adopting responsible AI practices to support the development of safe, secure, and reliable AI systems, such as Microsoft's AI Principles and Responsible AI Standard. Standards like generating impact assessments for AI systems, data governance, and creating mechanisms for human oversight of a system. Application and continuous improvement of responsible AI practices throughout the AI development process and beyond will help build the trust, transparency, and accountability necessary to apply AI to a variety of scenarios.

# Expanding the AI horizon

As highlighted, the application of AI to the analysis of the electromagnetic spectrum has the potential to provide an exemplary use case in sub-surface operations. However, there are many other applications of AI that can be applied to the domain.

## Fusion of data sources

Building on the use of acoustic data to detect and track vessels, contemporary technology provides an opportunity to fuse other large data sets, such as radar, passive radar, and computer vision, to compile a more detailed operating picture. This enables the combined use of sensors from sea, land, air, and space, with, for example, acoustic data being combined with satellite imagery, autonomous underwater vehicles (UAV) feeds, and fixed or mobile radar analysis. Furthermore, as understanding of operating patterns and tactics grow, AI has the power to use complex algorithms to run impactful simulations that predict sub-surface activity. This could include enemy vessels' routes and likely responses to detection etc., providing guidance on prioritizing areas for sensor deployment.

Microsoft partnered with the Royal Navy for an innovative challenge to showcase how edge cloud technology could be used to integrate different technologies into a Command Mission System (CMS) to enhance warfighting capabilities. This exercise demonstrated how sensors, software and cloud technology can enhance missions, ranging from military operations to humanitarian assistance.

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## Microsoft's Point of View on AI

Microsoft believes that AI represents the most consequential technology advance of our lifetime. We see AI as a powerful tool for advancing critical thinking and stimulating creative expression.

At Microsoft, we are committed to AI that is driven by ethical principles that put people first and are developed responsibly and in ways that warrant trust.

We are focused on three key goals for AI development:

- First, we must ensure that AI is built and used responsibly and ethically.
- Second, we must ensure that AI advances international competitiveness and national security.
- Third, we must ensure that AI serves society broadly, not narrowly.

AI provides a powerful capability that can contribute to national security in a meaningful and positive way. We at Microsoft continue to hold ourselves to the highest ethical standards and commit to responsible AI research, development, and innovation for the safe and ethical use of these technologies.

## Autonomous vehicles

Autonomous underwater vehicles (AUVs) and unmanned underwater vehicles (UUVs) are increasingly used in sub-surface operations. These vehicles are already performing tasks autonomously, such as searching for enemy submarines or conducting mine clearance operations. AI is becoming increasingly more sophisticated in the training and control of these vehicles and has the potential to automate the implementation of maritime rules of the road.

The design of AUVs enables them to travel horizontally and vertically; they are also fitted with sophisticated sensors to collect data continuously, such as currents, temperature, salinity, and dissolved chemicals.  AUVs are more cost-effective and less time-consuming to use than traditional monitoring equipment attached to ships. Combined with edge compute capabilities which place powerful processing at the source of collection, the potential to extract insights directly from the AUV and disseminate to the point of need (either via satellite, direct to surface vessel or remote collection node) is now a reality. Another dimension of this capability is the ability to swarm. We are seeing advancements in AI-enabled swarming technology, particularly in the UAV sphere. Expansion of maritime swarming capabilities is an obvious next step as AUV use grows.  AI is a fundamental enabler to coordinate the movements and actions of these vehicles, enabling them to operate in a coordinated and efficient manner.

## Decision making support to command

The application of AI can also be exploited in simpler cases to remove some of the manual calculations that are still commonplace in submarine operations. For example, when determining a safe course to return to periscope depth, or periscope range finding. These actions currently rely on mental calculations in many situations. The fusion of data from varied sources, and the application of simple algorithms, could reduce the cognitive load on a busy Officer of the Watch (OOW) and provide additional context to reinforce human judgment.

Similarly, applying AI in decision support can mitigate information overload in command situations, and Command (or Battle) Management Systems are already becoming increasingly sophisticated. The ability to conduct substantial data analysis - from a myriad of sensor feeds, all happening in the background, bringing operators' attention to anomalies or critical situations - can help focus the commander's view and accelerate decision to action. This type of application should certainly be considered in future surface combatants.

## Communications

Although military communications are increasingly multichannel – from satellite imagery to video, text, and photographs – speech communication remains key. This is readily apparent in surface to surface, surface to shore, and surface to air, which is essential for collaboration across maritime operations. A survey of Finnish Defense pilots found that problems in radio communication occurred, on average, during 14% of flight time due to a variety of reasons, including: overlapping speech, missing acknowledgements, and high background noise.[2]

Artificial intelligence is already being considered for automatic transcription and analysis of combat net radio by several allied forces. These capabilities bring clarity to what can be a chaotic operational environment by equipping personnel with reports and searchable transcripts. This not only improves situational awareness, but also frees up personnel for more rewarding, human-centric work by automating transcription. Importantly, the output can also be used to create intelligent digital foundations to support AI-enabled decision making.

## Predictive analytics

Warships and submarines are collectively the most complex, critical, and expensive warfighting assets within many defense force inventories, making sustainment a critical function of the naval service.

In the commercial industry, particularly in the aviation sector, there's been tremendous growth in the use of predictive analytics to improve efficiency and increase asset availability; and accordingly, for military use cases, an uplift in military readiness. AI can analyze historical data and predict future outcomes across the surface and sub-surface fleets. Maritime assets operating in these harsh environments are complex systems of machines that require regular maintenance to function properly. By analyzing sensor data from ship and submarine mechanical and electrical systems, AI-enabled tools could help predict when components are likely to fail. This would enable proactive maintenance that could prevent costly downtime away from the mission, or even dangerous malfunctions at deep ocean depths. This has become common in the safety-critical aviation industry, and great strides have also been taken to significantly improve the availability of United States Air Force aircraft. The confluence of engineering data with other operational data, such as speed, sea state, meteorology, etc., further refines the specificity of maintenance per mission and can help build a sophisticated picture that fuels the integrated logistics needs over an asset's capability lifecycle.

Furthermore, we do not have to rely solely on contemporary systems. AI can assist in digitizing records from legacy or manual systems to build the historical picture. There's also the ability to modernize ageing systems that may not already be fitted with sensors to incorporate IoT technology. This enables the implementation of a digital twin to further enhance analysis and forecasting through simulation.

## Advanced weather and oceanography modelling

Sensor performance, warfighting tactics and safety have always been impacted by weather and oceanography. The combination of AI and high-performance computing (HPC) offers a practical way to improve both the accuracy and speed of weather and oceanography analysis. It introduces the vast compute capacity needed to rapidly aggregate and interpret multiple meteorological data sets, enabling navy teams to detect, understand, and predict weather and oceanographic patterns and behavior.

A recent example is the creation of an advanced weather modelling and simulation tool called COAMPS-TC (Coupled Ocean/Atmosphere Mesoscale Prediction System for Tropical Cyclones). Developed in partnership with the US Navy, COAMPS-TC predicts tropical cyclones off the Gulf Coast in the United State of America by aggregating global meteorological data from multiple sources in the cloud to power rapid weather modelling on-demand. This enables naval teams to quickly build and disseminate weather and ocean proof-of-concept models to the fleet.

## Cybersecurity

When commenting on the future Canadian Surface Combatant, the Canadian Global Affairs Institute stated that:

"The CSC will be a much more digital platform than any warship Canada has previously operated. Its sensors will collect orders of magnitude more data and do significantly more analysis of those data on the actual ship than its predecessors. Whether those data come from the ship's combat systems, machinery health-monitoring systems, aircraft, supply system or sailors, the data and the networks that support them need sophisticated protection from cyber-threats."[3]

AI is already being exploited to detect and respond to cyber threats, helping to protect critical systems and data. Its use in continuous monitoring, the identifying of potential vulnerabilities, and recommending mitigation is becoming a staple of military cyber defense. Simulations are also being used in cyber ranges, which can be built around a single vessel or more broadly, to play out red versus blue attacks and counter-defense actions.

## Training and Simulation

The advent of mixed reality capabilities in allied Navies have, and continue to, provide remote support and improved maintenance and repairs aboard active naval vessels. AI capabilities are also being used to develop sophisticated modelling and simulation environments. The confluence of these types of technologies holds the promise of unlocking training pipelines, placing trainees in cost-effective, safe, and realistic environments to master their drills and gain a thorough understanding of a vessel's systems prior to embarking onboard.

The development of the Integrated Visual Augmentation System (IVAS) in the US military also provides soldiers with enhanced situational awareness in the field. There is the potential to take this concept into the maritime domain, integrating low-light sensors and data feeds into breathing apparatus face masks. For example, this could not only assist firefighting and rescue in a smoke-filled compartment, but also potentially, carry out complex engineering or maintenance tasks in those sorts of environments.

# Conclusion: Unlocking effective digital transformation

With technology playing an ever-increasing role in modern conflict, effective digital transformation must be a key priority for defense decision-makers.

Success in the modern battlespace hinges on information dominance – secure connectivity and joint interoperability from headquarters to the tactical edge, along with the ability to turn data into insights so forces can make informed decisions at the time of need.

Microsoft helps defense and intelligence organizations achieve their mission of promoting national, regional, and global security and stability through technology solutions. The Microsoft for Defense and Intelligence team can support military and government achieve this by:

- prioritizing a trusted and secure digital backbone,
- optimizing decision advantage using AI and contemporary technologies,
- enhancing interoperability with partners, allies, and agencies,
- and maintaining effective collaboration with the DIB through a modern capability lifecycle.

To find out more about our work across the globe with defense and intelligence organizations contact our authors or your Microsoft account representative.

**Empowering militaries. Improving operations. Protecting national security**

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With nearly 40 years' experience in the Royal Navy and Royal Australian Navy, Lloyd Hewitt served as a logistics officer on submarines, surface ships and land operations. Lloyd sub-specialized in IS development, working on a series of technology transformations, culminating in the Defense ERP program. He brings military expertise and passion for technology to the Microsoft Defense & Intelligence team, to help enact positive change in defense.

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## References

[1] Australian Government Defense, Joint media statement: Australia to pursue nuclear-powered submarines through new trilateral enhanced security partnership, September 16, 2021.
[2] Lahtinen, Taija M M et al. "Radio speech communication problems reported in a survey of military pilotsv." Aviation, space, and environmental medicine vol. 81,12 (2010): 1123-7. doi:10.3357/asem.2468.2010
[3] Canadian Global Affairs Institute, The Canadian Surface Combatant: Capability and Context, February 2021.