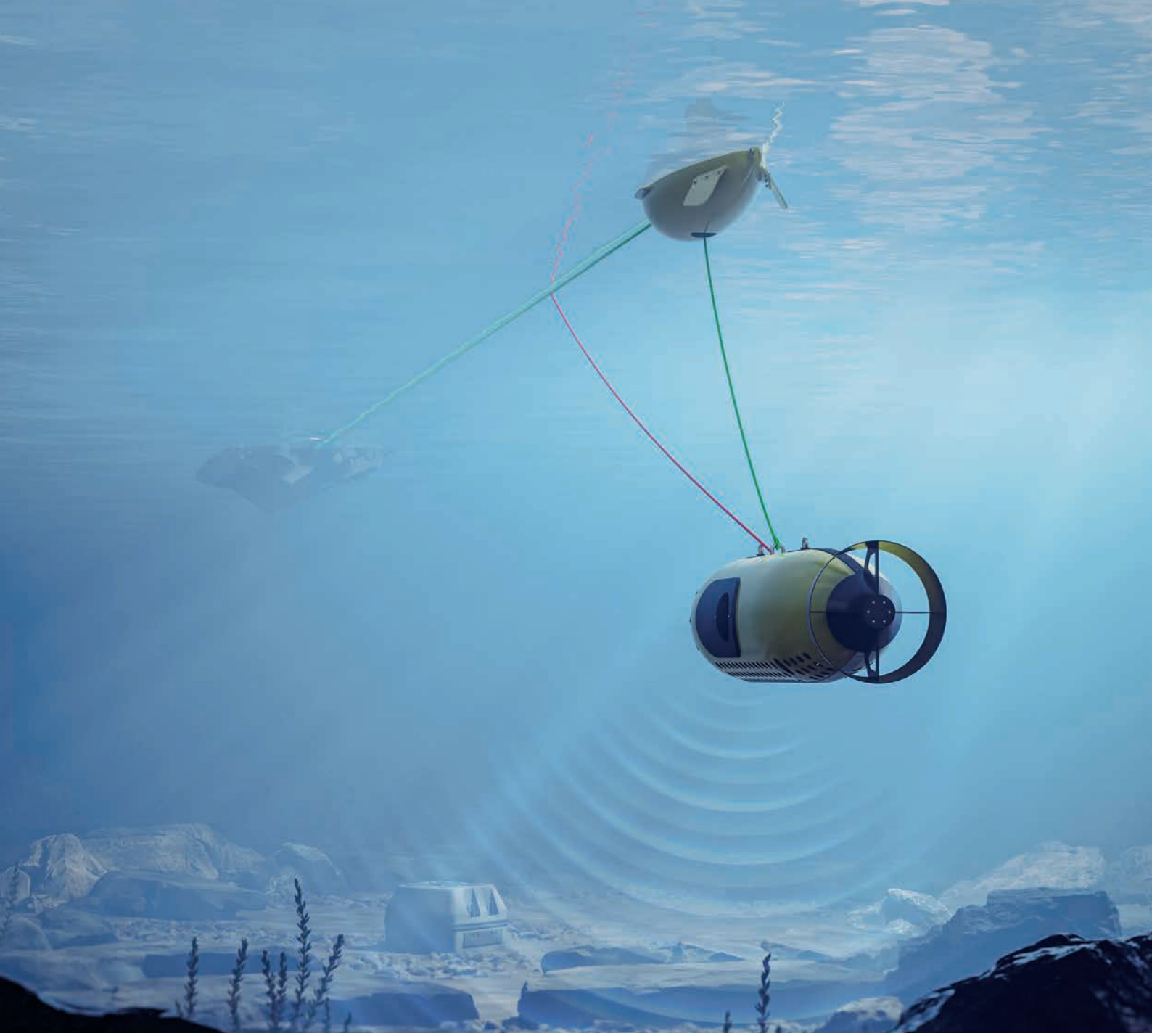

From Extreme Conditions:

FINNISH TECHNOLOGIES IN THE BALTIC SEA

FINNISH DEFENCE AND AEROSPACE INDUSTRIES **PIA**

ABSTRACT

The Baltic Sea presents a uniquely challenging operational environment for naval defence due to its shallow waters, complex archipelagos, and harsh climatic conditions. These geographic and environmental factors, combined with the increasing strategic importance of the region, demand specialized technologies and innovative solutions to ensure maritime security, protect critical infrastructure, and maintain uninterrupted sea lines of communication.

This document outlines the key challenges posed by the Baltic Sea and highlights the advanced solutions developed by the Finnish defence industry to address them. **If it performs in Finland's challenging conditions, it will perform anywhere.**

The narrative focuses on three critical areas: securing sea lines of communication, naval mine warfare, and mission enablers.

Securing sea lines of communication requires comprehensive surveillance and anti-submarine warfare capabilities to monitor both surface and subsurface threats in the region's congested and shallow waters. Naval mine warfare leverages the region's natural geographical features, making it an effective method for area denial and protecting vital assets, with advanced Finnish mine technology playing a central role. Mission enablers, such as ice-capable vessels, resilient ship technologies, and advanced damage control systems, ensure that naval operations can continue in the region's demanding conditions.

Through these technological innovations and strategic solutions, the Finnish defence industry is contributing to enhanced naval defence capabilities in the Baltic Sea, ensuring the security and stability of this critical maritime region.

Cover photo: Patria SONAC ACS, the acoustic minesweeping system. The most advanced acoustic sweep on markets, capable to simulate sounds of any ship or submarine.

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INTRODUCTION

The Changing Security Environment and Rising Tension in The Baltic Sea

Image: Finnish Defence Forces

The security environment in the Baltic Sea region has changed dramatically in the past years, due to new and emerging threats and the role of Russia. Accession of Finland and Sweden as members of the alliance has increased the strategic importance of the region for both NATO and Russia. This has created new challenges and opportunities in the region.

One of the main drivers of the change in the security environment is Russia's behavior, which has been perceived as increasingly assertive and aggressive by its neighbors and the international community. Russia's annexation of Crimea in 2014, its attack in Ukraine and its cyber and hybrid activities have raised concerns about its intentions and capabilities. Russia has also modernized and expanded its military forces, especially its naval and air assets, and conducted frequent and large-scale exercises in the Baltic Sea region. These actions have posed threats to the sovereignty and territorial integrity of the Baltic Sea states in the region.

In response to Russia's behavior, NATO has enhanced its deterrence and defence posture in the region, by deploying multinational battlegroups in the Baltic states, increasing its air policing and maritime presence, and conducting regular exercises and training. In 2023 Finland and Sweden decided to join NATO as full members, marking a historic shift in their security policy and regional alignment.

Enlargement of NATO, including the accession of Finland and Sweden as members, has altered the Baltic Sea region's security-political balance. This has strengthened NATO's position in the region and simultaneously limited Russia's strategic maneuverability. Russia's countermeasures, such as military exercises and strengthening of military infrastructure in the Kaliningrad region, as well as actions and threats in the Gulf of Finland, have heightened tensions.

The evolving security environment presents both opportunities and challenges for the defence and security industry. The large-scale Russian attack on Ukraine in February 2022 led European decision-makers to reassess their defence and security strategies. As a result, nearly all European countries are increasing their defence budgets, and every NATO member is striving to meet the 2% of GDP defence spending target. Finland alone plans to spend 6.3 billion euros by the end of 2025 which is 2.3% of GDP. This renewed focus on defence spending signals years of heightened European preparedness and growing demand, regardless of the outcome of the war in Ukraine.

Finland is known for high technology and extreme resilience. Our harsh Nordic and Arctic nature have pushed us to learn and innovate efficiently. Thorough preparation for the future is the backbone of our culture. This applies particularly to our thinking about operating in a maritime environment of Baltic Sea. Finland is considered, in terms of logistics, an island. Over 90 % of Finland's goods flow through maritime routes, underscoring the critical importance freedom of navigation and secured sea lines of communication.

1. Naval Defence in Uniquely Challenging Operating Environment

The Baltic Sea, with its shallow waters, dense archipelagos, and harsh Nordic climate, presents a uniquely challenging operational environment for naval defence. These geographical and environmental factors make traditional maritime operations difficult, requiring specialized approaches and advanced technological solutions to ensure effective protection of maritime infrastructure and uninterrupted operations.

Finnish defence industry companies have met these challenges head-on, applying their expertise and innovative capacities. By heavily investing in cutting-edge technologies and comprehensive strategies, they have devised strong solutions to improve situational awareness, counter underwater threats, and secure vital maritime infrastructure.

Three critical areas of naval defence technology have emerged as essential to maintaining security and operational capability in the Baltic Sea: securing sea lines of communication, naval mine warfare, and mission enablers.

Firstly, securing sea lines of communication (SLOCs) is vital, as the Baltic Sea serves as a key trade route and a conduit for critical undersea infrastructure such as telecommunications cables and energy pipelines. Ensuring the safety and functionality of these lines demands cutting-edge surveillance and anti-submarine warfare systems designed specifically for the region's shallow and congested waters.

Secondly, the unique geographical features of the Baltic Sea – such as its narrow straits, shallow seabed, brackish and typically muddy water and extensive archipelagos – create both challenges and opportunities for naval mine warfare. These natural barriers make the region especially conducive to the strategic deployment of sea mines, allowing for effective area denial and protection of key assets. Finnish expertise in influence mine technology and mine countermeasures is particularly well-suited to exploit the region's geography, enabling both offensive and defensive mine warfare capabilities.

Finally, mission enablers such as ice-capable vessels, resilient ship technologies, and effective damage control systems ensure that naval operations can continue despite the demanding conditions of the Baltic Sea. These technologies provide the necessary support to maintain operational readiness and safeguard critical infrastructure under even the most challenging circumstances.

The following chapters will explore these three key areas of technology, showcasing how innovative solutions are shaping naval defence capabilities in this complex maritime environment.

"The unique geographical features of the Baltic Sea – such as its narrow straits, shallow seabed, brackish and typically muddy water and extensive archipelagos – create both challenges and opportunities for naval mine warfare."

2. Securing Sea Lines of Communication

Surveillance and Gaining Dominance in Underwater Domain

According to the European Union Maritime Security Strategy (EUMSS), 77% of the EU's foreign trade and 35% of goods moved internally travel by sea, being also the sea hosting a critical part of the EU infrastructure of its digital economy, with hundreds of submarine cables used to transfer data (more than 95% of data is sent by cables), as well as EU's critical pipelines and strategic minerals.

In order to secure the sea lines of communications and the seabed infrastructure, one must have the ability to form situational awareness, to command-and-control operations, use force if necessary, and ensure the availability of the necessary support measures for operations. Sea sines of communication must be understood broadly, including undersea telecommunications and energy connections.

Finnish defence industry companies have invested in these issues. For example, situational awareness, anti-submarine warfare (ASW) capabilities, and mine countermeasure (MCM) capabilities are required to gain and remain control in the maritime domain and to secure sea lines of communication, including seabed infrastructure.

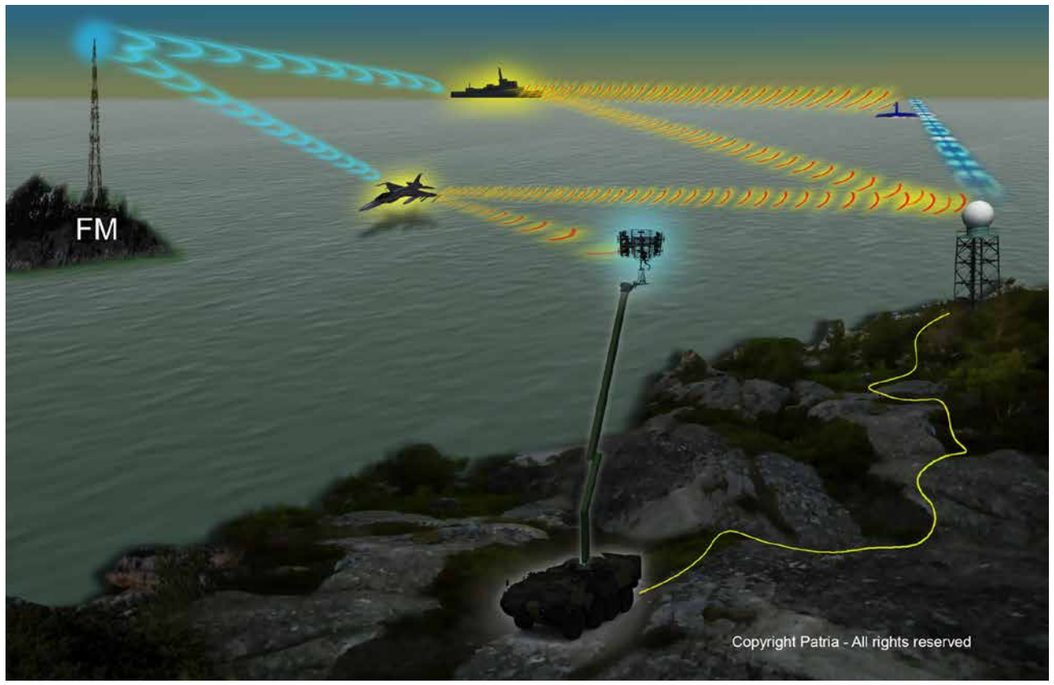
To be able to monitor the entire maritime domain, one must be able to monitor above and below the surface. Finnish companies offer solutions for situational awareness in the modern electromagnetic battlefield. They have surveillance system offering superior situational awareness - even in the form of passive radar.

Some Finnish companies have been working on the underwater surveillance for a very long time, and they are providing surveillance fields that are designed based on maximizing the probability of detection based on both environment and the threat analysis in the area of interest. The performance is optimized for operations in challenging environments of confined and shallow waters, approaches, and archipelago areas.

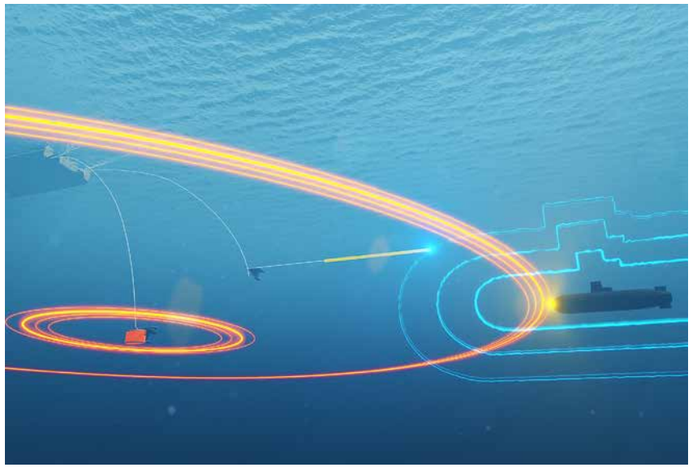
For underwater dominance, it is also important to be able to measure signature of underwater and surface vessels in very high detail.

For action to be taken against potential hostile submarines, ASW capability is required. Finnish companies specialize in enabling ASW operations in the demanding conditions of the Baltic Sea, but the capabilities created can naturally be used outside the Baltic Sea region as well.

It is clear that the underwater monitoring and target detection capabilities of the future must be mobile and networked, both among themselves and with the situational awareness and management systems in place. The entity could consist of, for example, sensors for unmanned and manned vessels, the capabilities of a fixed and mobile underwater surveillance system, and their communication under water and on the surface, utilizing already existing upgraded systems and the technological know-how gained in the home country by, among other things, participating in national and international research activities.



Patria MUSCL. A passive radar system for surveillance, early warning, and critical infrastructure protection by detecting, locating and tracking silently full range of aerial and surface threats in the modern battlefield.



Patria SONAC DTS. A Dual towed sonar system for Anti-Submarine operations. Sonac DTS is a combination of Variable Depth Sonar and Towed Array Sonar. It has traditional active and passive sonar modes, as well as modern Bi-static operation mode.

Patria is an international provider of defence, security and aviation life cycle support services, technology solutions and pilot training. Patria provides its aerospace and military customers with equipment availability, continuous performance development as well as selected intelligence, surveillance and management system products and services.

Patria's mission is to give its customers confidence in all conditions, and the vision is to be the #1 partner for critical operations on land, sea and air.

Patria has several locations including Finland, Sweden, Norway, Belgium, the Netherlands, Estonia, Latvia and Spain. Patria employs over 3,000 professionals.

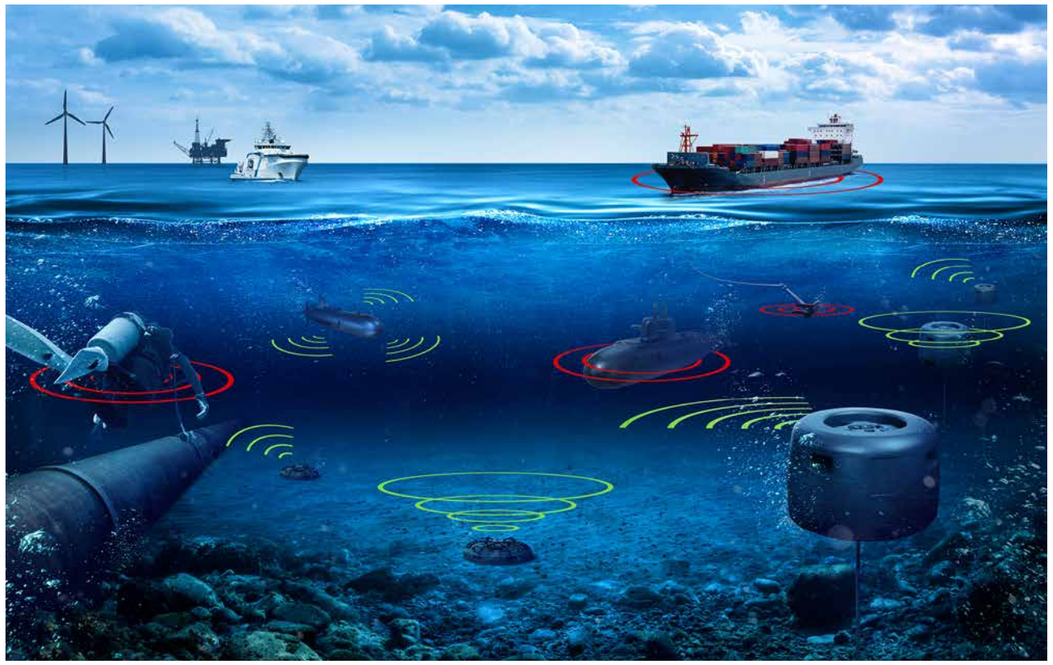
Patria is owned by the State of Finland (50.1%) and Norwegian Kongsberg Defence & Aerospace AS (49.9%). Patria owns 50% of Nammo, and together these three companies form a leading Nordic defence partnership.

Patria

A Multi-Domain Distributed Sensor Network of Layered Protection for Critical Undersea Infrastructure

The world has become increasingly dependent on undersea energy pipelines and data cables as well as offshore energy facilities and electricity cables. The existence and development of emerging and disruptive technologies open new opportunities to conduct monitoring and protection of critical undersea infrastructure through the cutting-edge technology used in modern influence sea mines and planning and deployment systems.

By integrating advanced seabed warfare capabilities with emerging disruptive technologies, traditional mine warfare is evolving into broader seabed operations, focused on protecting critical undersea infrastructure from hybrid threats. Capable sensors, autonomous warning systems and suitable effectors constitute a capability for surveillance and especially protection of port facilities and structures, communication and data



The disruptive technology used in modern smart sea mines can also be dual-used to monitor, surveil, and protect critical undersea infrastructure.

cables, energy pipelines, cables, power plants, oil rigs and other underwater structure.

Growing concerns about the vulnerability of seabed infrastructure needs solutions not only to monitor but also to protect these critical connections from malicious seabed activities. Technologies used in uncrewed vehicles may be the first line of protection, but sophisticated technology used in smart sea mines can be a cost-effective deterrence and a force multiplier role to interrupt and repel hostile actions.

As sea mines have traditionally been seen as a malign weapon, it might sound unorthodox to use smart influence sea mine technology to monitor and protect critical infrastructure on the seabed. It may not be possible to protect thousands of miles of cables and pipelines. However, awareness that these "safe guardian watch keepers" are deployed in vulnerable areas of the network creates uncertainty for adversaries. Using mines in traditional manner to deny access to larger areas remains still as a possibility if a conflict escalates.

Threats to undersea infrastructure can be countered by a disruptive technology used in modern influence mines. A new generation of smart mines and autonomous planning and execution systems offers new ways to deploy mines or digital autonomous technology used in them in this sophisticated anti-access and area denial concept. Acquiring stock of precise and scalable Smart Mines and/or their Integrated Multi-domain Sensor Systems, together with a modern Planning and Execution System, could be a relatively quick and inexpensive way to increase deterrence by deploying a distributed and layered network to protect critical undersea infrastructure.

Situational Awareness in Maritime Domain

Timely response and decision-making in one of the world's busiest maritime areas require the most comprehensive situational awareness possible. To achieve this, reliable and decentralized solutions are needed, with data transmission capability, usability, and cybersecurity meeting the highest standards. The strategic nodes of the Baltic Sea and numerous diverse connections, including underwater ones, emphasize the importance of securing telecommunications in preparedness. Environmental cyber situational awareness is essential for identifying and countering cyberattacks. Ensuring the identity of devices and individuals, as well as the integrity of applications, builds trust in system security.

In particular, the extensive archipelago of the Finnish area, with its high elevations and large marine depths, offers numerous opportunities for unmanned operations, including surveillance and rescue operations. In military applications, innovative and entirely new unmanned defence technology solutions are needed to support combat. Autonomous underwater systems and swarming technologies, still largely in the research stage, will further enhance opportunities for use in the air, water, and underwater environments.

Advanced CBRN Monitoring for Maritime Security
Despite of international work to prohibit use of chemical weapons by OPCW, it has been witnessed in Ukrainian war, that the threat is still real. On the other hand, attacks against civilian and military vessels have been performed recently with less developed equipment by governmental and non-governmental operators. This ongoing technological development enables even less skilled operators to attack maritime targets.

Finnish expertise provides naval environments with advanced situational awareness of potential CBRN hazards. By providing early warning and comprehensive CBRN monitoring, this expertise ensures that ship crews can operate effectively even after contamination. It helps minimize consequences by supporting informed decision-making and enabling timely protective measures. Real-time hazard information is crucial not only for immediate response but also for higher command levels and other authorities to grasp the broader situation.

Dedicated CBRN monitoring system has been designed specifically for maritime environment to give accurate and prompt situational awareness during crises. This system operates 24/7, ensuring that situational awareness is maintained not only during emergencies but also throughout routine operations, thereby enhancing overall maritime safety and response capabilities.

The CBRN surveillance capability must cover the entire ship, both exterior and interior.

ChemProX-DS detects both chemical warfare agents and a large number of toxic industrial gases.

RanidX is Bertin Environics' new radiation detector designed for mobile and stationary platforms.

ENVI BioScout is a continuously operating bioaerosol detector with a 3-in-1 capability, which warns the ship's crew of the potential biological threat.

© Bertin Environics

"Dedicated CBRN monitoring system has been designed specifically for maritime environment to give accurate and prompt situational awareness during crises."

Bertin Environics has been developing, manufacturing, and delivering CBRN detectors and systems since 1987, with the first Naval CBRN system deliveries in 1994. We are the only supplier capable of providing full CBRN detection capability with in-house COTS detectors. Our CBRN systems are suitable for both military and civil security needs, widely used by navies, coast guards, rescue teams, and firefighting organizations. Over 140 vessels in 26 countries are equipped with Bertin Environics' CBRN systems. We are a trusted turn-key system supplier for Navies, Coast Guards, and Rescue and Fire Fighting organizations.

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3. Naval Mine warfare

Baltic Sea Mines

Introduction
At the end of the Cold War, many countries quickly abandoned their naval mine-laying capabilities and stockpiles, deeming them unnecessary in the reduced threat environment. However, smart influence sea mines remain one of the most cost-effective deterrence in the naval domain.

Mines have historically been used to deny enemy forces access to vital sea areas and protect coastal infrastructure during crises. Although often seen as unsophisticated and restricted by legal and ethical considerations, modern smart mines are vastly different from their predecessors. Advances in intelligent target detection, planning systems, AI, and autonomy have transformed naval mine warfare also into a multi-domain, layered defence system for protecting critical undersea infrastructure.

Mine warfare
A completely new type of domestic influence Sea Mine was produced in the Sea Mine 2000 project replacing the mine inventory acquired from the Soviet Union in the 1980s. Several research and technology studies, such as acoustic signal processing and positioning, ignition chain, stealthy mine shell material and design, and insensitive explosives charge were carried out during the project.

One of the most important requirements was the development of an insensitive explosive, as well as low-energy electronics. The mechanism of an intelligent Target Detection System was based on technologies for magnetic, acoustic and pressure influence. A significant customer requirement was that the end user can configure mine algorithms and operational parameters. The new Sea Mine reached its operational capability at the beginning of the 21st century being the first fully digital and software-based domestic influence Sea Mine.

The design of the modern next generation Target Detection System began during the first decade of the 21st century. The requirements stipulated that the same type of System must be able to be used in several types of smart influence Sea Mines, and it must be freely programmable including signal processing, algorithm development and functional logics by the end users. Signal processing and evaluation algorithms were not freely programmable in the previous generations of influence Sea Mines.

From legacy to present day

1850s: Large-scale mine warfare in Crimean War. Russia prevented landing operations to Finnish Gulf.

1917: Finnish independence is the starting point for technical research, testing and training of Finnish mine laying capability.

1941: Finns used German magnetic influence sea mines and prevented Soviet landing to the Finnish coast.

1960s: The development work of magnetic acoustic influence seamine begins.

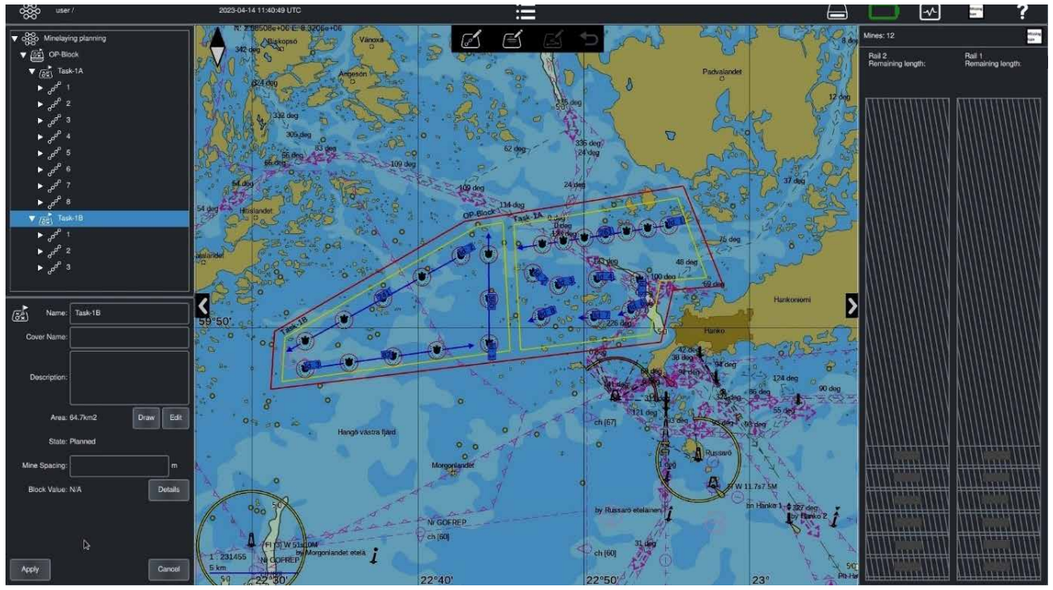
1990s: Finnish magnetic-acoustic mine added into Finnish Navy inventory after decades of R&D.

2010s: Fully digital and software-based domestic influence Sea Mine.

2020s: New Generation of Smart Sea Mine with technology extension for protectiong Critical Underse Infrastrucuture.

The Finnish minelayer Ruotsinsalmi lays naval mines in the Gulf of Finland during the Second World War.

Currently, modern Influence Sea Mines are equipped with state-of-the-art target detection, safety and arming systems, and utilize insensitive explosive solutions. Demanding explosive safety tests in accordance with international explosive safety regulations are integral part of the sea mine development. Disruptive technologies used in a modern influence Sea Mines enable to detect,



ATLAS ELEKTRONIK Minelaying Planning and Execution System user interface.

identify and select targets autonomously, based on e.g. pressure, acoustic, magnetic, seismic and light, as well as underwater electric potential and distance. These above-mentioned sensor technologies have been used in current influence Sea Mine projects. This existing and disruptive technology can be scaled from the "traditional" influence Sea Mine capability i.e. Anti-Submarine and Anti-Surface to Seabed Warfare, including surveillance and protection of critical undersea infrastructures.

The Finnish industry and Defence Forces have all necessary means including infrastructure, assets, personnel and knowhow to research, design, manufacture, plan, operate and maintain the comprehensive Mine Warfare capability. This capability enables also sharing of information and e.g. standardized Tactics, Technics, Procedures (TTP) and experiences among users within the Alliance. Several different ecosystems do not provide this possibility for the user countries.

Planning of Naval Mine Warfare Operations

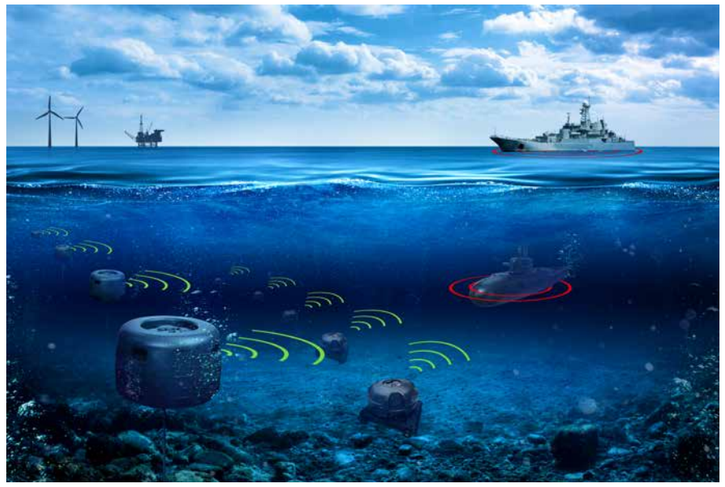
The naval minelaying operations need to be thoroughly planned based on operational requirements and especially by means of purpose or objective, efficiency, and precise positions of the mines and minefields. To utilize the capabilities of naval mines to full potential, a robust, efficient, and reliable planning and execution system is essential.

A modern Minelaying Planning and Execution System is a modular, intelligent solution that optimizes minefields and guides operators in the loading and deployment of mines. This system can function independently or integrate with a vessel's navigation, combat management, and platform management systems. It plays a crucial role in mine warfare situational awareness and supports seabed warfare operations at all levels within the command structure.

The system provides operational commanders with a powerful tool to plan mine warfare operations according to specific operational needs, including the entire logistics chain from storage to seabed deployment. When integrated with C4I networks, it enhances both surface and subsurface situational awareness.

Advancements in Operational Planning and Execution systems, along with Modern Influence Sea Mine technologies, drive the incremental development of mine warfare technologies and systems. Emerging and disruptive technologies will further enhance operational mine warfare systems through artificial intelligence in planning, autonomy in execution, and next-generation communication networks.

The integration of modular autonomous platforms, uncrewed containers, and deployment equipment, along with new energy and propulsion solutions, forms the foundation for next-generation seabed warfare operations conducted either from the surface or covertly underwater. These combined technologies will increase deterrence and accelerate decision-making, execution cycles, and provide greater operational flexibility including e.g. covert seabed operations.



FORCIT DEFENCE: Naval sea mines remain one of the most cost-effective deterrence in the naval domain

ATLAS ELEKTRONIK FINLAND
A company of the ATLAS ELEKTRONIK Group

FORCIT DEFENCE

Mine Countermeasures

Like many underwater warfare tactics, mine warfare was quickly forgotten in the aftermath of the Cold War. Lulled into a false sense of security, Western navies focused on removing old mines and shifted their focus on other missions. And, like many underwater warfare tactics, mine warfare is making a strong comeback in naval strategy books, at industry level and in Research & Development (R&D) departments.

Perhaps more worrying still than the resurgence of this type of weapons – Russia is rumored to have approximately 500,000 naval mines or more, China upwards of 80,000 – is the technology that is being leveraged to turn them into smart systems. Today, industry leaders in the mine warfare domain are leveraging complex algorithms that can simultaneously process magnetic, acoustic, seismic and pressure signatures to identify their targets and trigger the explosion.

As such, in shallow water areas where the seabed can be rocky and where water conditions can adversely affect visibility smart mines are particularly disruptive. Pre-programmed to target certain types of military or commercial vessels, they can render entire port areas inhospitable or whole sea lanes of communication (SLOC) inoperable.

Finland has always placed a high priority on mine warfare, as the Finnish waters, or the Baltic Sea waters, are shallow and the archipelago create natural narrows in many locations. In littoral warfare operations, you must be able to detect the opponent's mined areas, locate them and to get around them or clear them.

Freedom of maneuver is very important in littorals. Depending on the geography, operating areas may be defenceless to mining. Considering littoral lower projection, naval mine countermeasures might be necessary. The naval forces, or mariners, or coastal troops need to have safe transit, and operate in an area that ensures the flexibility to project power when and where the commander desires.

Keeping the littoral waters free from hostile mines is not a nice-to-have capability but is very important for naval forces to be able to keep fighting and from the point of view of freedom of merchant shipping. Mine countermeasure capabilities are required to gain and remain control, especially in the littorals. And Finnish companies know how to build such capabilities.

Minesweeping, as opposed to mine hunting, is the important viable option against influence mines silently waiting in shallow waters. And minesweeping with advanced acoustic capabilities is critical for tackling the continuous development and spread of smart mines. For example, that is why Finnish company built on decades of experience in developing both smart mines and acoustic minesweeping systems to offer its customers secure sea lines of communication .

Patria

4. Mission Enablers

Global Leader in Arctic Shipbuilding

During parts of the year when Finland is surrounded by ice, the critical role of icebreakers becomes evident, ensuring that ports remain accessible and fully functional. Over 50% of worlds icebreaking capacity has been manufactured in Helsinki. Helsinki Shipyard provides our allies a unique opportunity for to strengthen their naval capabilities in civilian and grey ship production through Finnish know-how and edge in designing and building world-class ships quickly, efficiently and cost effectively.

Icebreakers are key enablers for military mobility at Northern Baltic Sea and strategic assets for securing the sealines, communications and energy infrastructure in the High North. Finland is one of the very few NATO countries with ice-capable naval surface combatants and with the knowhow for designing and building of such ships.

Finland's expertise in clean energy solutions is playing a key role in developing a greener and more sustainable ocean-going fleet. The country's strong maritime knowledge and manufacturing capabilities offer significant opportunities for creating eco-friendly ships and advancing sustainable technologies in Arctic shipbuilding. These efforts are contributing to the development of a global center of excellence for green shipbuilding, positioning Finland as a leader in the transition to environmentally sustainable maritime operations.

Helsinki Shipyard and Davie Shipbuilding
Founded in 1865, The Helsinki Shipyard and the cluster of cooperating companies have a strong know-how in shipbuilding for Arctic conditions. Helsinki Shipyard and Davie Shipbuilding have combined 360 (2025) years of experience in arctic shipbuilding.

Through the acquisition of the shipyard by Davie Shipbuilding, the historic transaction combines the skills, experience, and capabilities of two leaders in Arctic shipbuilding and other high-value products. This will create opportunities for employees, encourage collaboration, faciliate the transfer of know-how, provide access to resources, and stimulate export potential.

HELSINKI SHIPYARD

The Polaris, the most advanced icebreaker in the Finnish fleet, was delivered by the Helsinki Shipyard in 2016.

Vessel Technologies in Icy and Demanding Conditions

Icebreaker fleet needs to operate efficiently in icy conditions, maintaining uninterrupted maritime operations and supply chains throughout the year, regardless of the harsh weather.

Finnish expertise in designing advanced ice-going and icebreaking vessels addresses the growing demand for efficient and sustainable solutions in challenging maritime environments. Central items to these innovations are ship design, ice model testing and feedback from actual constructed vessels. Utilizing sophisticated testing facilities in Finland, they simulate various ice conditions found in the Baltic Sea, including level ice, brash ice channels, and ridges. This model testing is vital for developing ships that can navigate these waters safely and efficiently.

The practical application of ice model testing has been a cornerstone in realizing ambitious projects that once seemed beyond reach. Through comprehensive model testing, different concepts including icebreakers and LNG carriers have been brought to fulfilment, demonstrating the tangible benefits of this approach. Currently, a significant focus of these tests is on optimizing the hull designs of ice-going vessels to reduce ice resistance, thereby lowering emissions and fuel consumption.

Finnish expertise in icebreaking and ship design plays a crucial role in developing new technologies and services, including the design and delivery of ice propellers and shaft lines. The Squadron 2020 project marked a significant milestone. Finnish experts initially focused on hull development, considering the need for high open-water speed and low noise levels, while ensuring excellent performance in ice. As the project progressed, attention shifted to ice strengthening and propulsion system development, which has been vital in meeting the operational performance requirements of the Finnish Navy's new multi-role corvettes.

The demanding conditions of the Baltic Sea require a propeller system that can withstand high ice loads while maintaining a low acoustic signature. Achieving this combination has involved extensive design and testing efforts. This research work culminated in the contract to deliver the CP propellers and shaft lines for the four vessels. An essential part of this development is matching the propeller with the hull to achieve high open water speed, ice-going capability, and low underwater noise levels. The delivery of the propellers and shaft lines for the first vessel of the Pohjanmaa-class corvettes is scheduled in 2024.

Aker Arctic specializes in the design of ice-strengthened vessels and offers testing services and consulting for operations in ice conditions. We also provide ice-strengthened propellers and shaft lines, as well as ice load measurement systems (ILMS) for ship hulls.

The demanding conditions of the Baltic Sea require a propeller system that can withstand high ice loads while maintaining a low acoustic signature. Achieving this combination has involved extensive design and testing efforts. An essential part of this development is matching the propeller with the hull to achieve high open water speed, ice-going capability, and low underwater noise levels.

Aker Arctic

Aker Arctic's third generation ice laboratory.

Maintaining Mission Capability with Robust Ship Stability Technology

In challenging environments like the Baltic Sea, managing ship stability is essential for the safety and performance of naval vessels. Effective stability management, intact and in the face of damage, ensures that ships can handle various operational conditions, minimize the risk of capsizing, and maintain their mission capability, even under extreme conditions.

Evolution of Ship Stability Technology

The science of ship stability has evolved significantly over the centuries. From basic principles of buoyancy to the introduction of metacentric height in the 18th century, each advancement has improved ship design. The 20th century brought a revolution with computer-aided design (CAD), enabling precise stability calculations. Today, Finnish maritime industry is at the forefront, offering simulation technologies that provide real-time stability monitoring and adjustment capabilities, ensuring modern ships are equipped to handle the demands of their missions.

Finland: A Leader in Ship Stability Technology

The Baltic Sea, with its shallow waters, narrow passages, and winter ice coverage, presents some of the most challenging maritime conditions in the world. Ships navigating these waters require advanced stability management systems, especially ice-class vessels that must be equipped with reinforced hulls and sophisticated stability features. Continuous real-time monitoring systems are critical to maintaining stability amid sudden environmental changes. Finland, known for its strong maritime heritage, plays a pivotal role in advancing these technologies, setting global standards for ship stability.

The Importance of Stability in Modern Naval Operations

Recent geopolitical tensions in Europe, particularly in the Baltic and Black Sea regions, have underscored the need for enhanced ship stability and survivability. As nations modernize their fleets, there is an increasing emphasis on improving stability systems to withstand threats such as missile strikes and underwater mine explosions. These developments highlight the critical importance of robust stability systems in ensuring mission continuity and the overall safety of naval operations.

This narrative of Finnish expertise demonstrates how the country's advancements in ship stability technology are vital not just for regional safety, but for the broader global maritime industry as well.

NAPA: Your Partner for Advanced Technological Solutions for Modern Naval Challenges

For over 30 years, NAPA has led global ship safety and stability technology advancement, offering software that integrates seamlessly with ship systems. Naval architects worldwide rely on NAPA's ship design solutions to build various naval ships, creating accurate 3D models for safe operations.

On the operational side, NAPA has deep roots in the commercial maritime industry, but we also tailor solutions to meet defence needs. NAPA Stability manages intact and damage stability with real-time situational awareness, while the NAPA Emergency Computer assesses operational capabilities based on flooding and heeling analysis and shows how real-time countermeasure impacts the situation.

We constantly seek deeper cooperation with EU and NATO defence forces to further our solutions that ensure naval fleets are prepared to meet modern challenges with confidence.

NAPA is a global leader, providing proven solutions for ship stability and damage control.

Effective Damage Control

Ship survivability and effective Damage Control (DC) requires the correct use of equipment and techniques to prevent or minimize the damage effects caused by harsh environmental effects, battle, fire, collision, explosion, and so forth. DC also includes active and passive measures used to reduce these effects including weapons of mass destruction (CBRN) mitigation. Maintaining the vessel's operational availability and survivability in various damage cases is extremely important. Optimizing the manning including damage control functions is today's trend, so e.g. automatic fixed fire suppression systems are commonly used on Naval vessels of different types and sizes. Finland's advanced expertise in these technologies ensures their naval systems are among the most resilient and effective in the world.

High-Pressure Water Mist (HPWM) systems have increasingly been chosen as the primary first-response fire protection solution due to their immediate activation and ability to address various types of fires onboard without requiring separate systems for specific areas like engine rooms, galleys, or crew quarters. Additionally, HPWM systems avoid the risks associated with harmful additives, ensuring the safety of personnel and critical equipment. This approach saves space, reduces weight, and optimizes lifecycle costs while minimizing training requirements.

For small navies, such as Finland's, where ships are multipurpose and fleet numbers are limited, immediate and effective firefighting is crucial. In this context, modular systems that can respond to fires instantly upon detection are indispensable. Finland's expertise in maritime innovation has led to advanced Integrated Platform Management Systems (IPMS) and state-of-the-art modular high-pressure water mist systems that operate in harmony. These systems are utilized not only in Finland but also globally across multiple vessel types, reflecting Finnish excellence in both design and operational functionality.

The survivability of a ship depends on the level of preparedness of its personnel and the condition of the equipment, and shipboard systems. The amount of training in the use of extinguishing systems is key to efficient performance. With a high-pressure water mist system, people can be trained in realistic conditions and in the right way, because clean water does not cause dangerous situations and the system's recharging is simple and inexpensive at sea during exercises and deployments.

Marioff HI-FOG® high-pressure water mist technology is the result of extensive research and development, as well as thousands of full-scale fire tests.

Marioff is the leading developer and innovator of High-Pressure Water Mist Fire Protection Technology with unrivalled experience supplying system solutions worldwide under the brand HI-FOG®. HI-FOG safely controls and suppresses fire by discharging fine water mist at high velocity, using significantly less water than conventional water spray or sprinkler systems. Our system provides fire protection for a wide range of naval vessels, buildings, and facilities, including patrol ships, submarines, hangars, command centers, and other specialized applications on land and at sea.

MARIOFF

HI-FOG® water mist fire protection

Resilient Infrastructure

Finland's robust preparedness and defence contingency plans contribute significantly to building resilient infrastructure. Given Finland's strategic location, ensuring the security of maritime traffic is crucial. The country's diverse and challenging maritime conditions, coupled with Arctic weather, demand specialized solutions. Finland has developed systems that address these challenges, with applications extending to both civilian and defence sectors.

Finnish experts have collaborated with authorities to develop a solution to enhance national preparedness for disturbances and emergencies. This has resulted in a versatile floating pontoon system designed to replace static harbor infrastructure with agile, deployable alternatives. While intended for civilian use under normal conditions, the system can be rapidly adapted for emergency situations.

In these scenarios, the pontoon system can be used to build various structures such as floating harbors, bridges, temporary and relocatable ports, RoRo ramps, and helicopter landing platforms. Its modular design enables quick and efficient construction without requiring extensive calculations for each deployment.

The system's modular and patented design allows for cost-effective, customizable, and relocatable solutions that enable rapid response and increased resilience for various needs and situations.

NorD:

- Concrete pontoon: 10 m x 5 m x 2 m
- Load capacity: 45 tons
- Pontoon weight: 50 tons
- Transportable by road or water
- Easily connectable to each other
- Unsinkable. Withstands weapon effects well
- Service life: 50+ years

NORD PRO A-LAITURIT

Above: Dual use ferry port. Main purpose ferry port, secondary purpose road bridge.

On the right: Helicopter landing platform, transferrable.

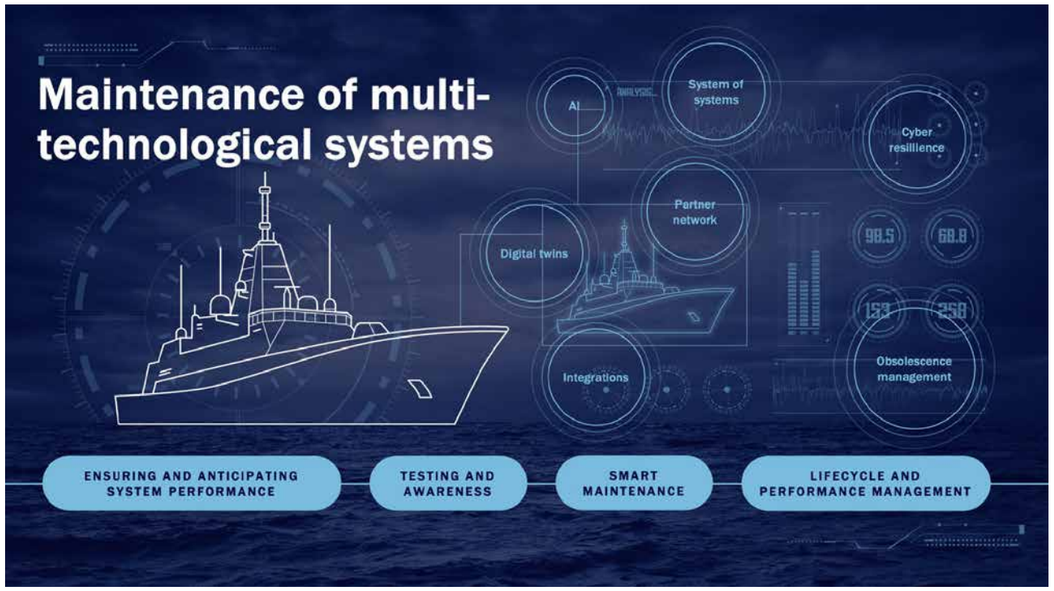
Military Security of Supply

Finland, renowned for its robust security of supply, has taken comprehensive measures to ensure the continuity of critical societal functions even in exceptional circumstances. The primary objective of supply security is to guarantee that society, the private sector, and citizens can operate safely despite potential crises and disruptions. These arrangements also prepare for military emergencies.

Finnish expertise in lifecycle management, logistics, and maintenance services is vital for ensuring the security of supply. Strategic partners of the Finnish Defence Forces are essential in supporting and sustaining the operational capabilities of the defence forces.

In addition to maintenance of ships' hulls and their systems, strategic partners' services include maintenance of naval navigation systems, sensors, communications systems, combat management systems, weapon systems and others. Software testing and cyber support is also available. Comprehensive network of dockyards ensures that Finnish maritime industry can provide full and timely service for different hull related work including maintenance, mid-life extension projects, fittings and emergency dockings.

Millog maintains both large and small vessels.



In addition to the maintenance of ship's hulls, Millog offers comprehensive maintenance for all of ship's systems.

Millog

- 30 locations throughout Finland
- Mobile service teams sent to locations defined by the customer anywhere in the Baltic Sea area
- Host nation support services and NSPA / NCIA arrengements
- ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, AQAP-2110 (Edition D V1), EN 1901-1 and FIN, FIMAA, EMAR145.0020.
- All our personnel and facilities are security cleared including NATO security clearances when necessary.

Millog

FINNISH DEFENCE AND
AEROSPACE INDUSTRIES **PIA**

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