FINNISH SOLUTIONS FOR THE FOR THE ENTIRE ICE BREAKING

AN AMERICAN-FINNISH PARTNERSHIP

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FINNISH SOLUTIONS FOR THE ENTIRE ICEBREAKING VALUE CHAIN

FINLAND IS A GLOBAL LEADER IN ICEBREAKER DESIGN, POLAR SHIPBUILDING, ICE TECHNOLOGY AND FLEET OPERATION Finnish companies have designed about 80 percent of the world's icebreakers, and about 60 percent of them have been built by Finnish shipyards. We have a creative and agile polar maritime network that is known for delivering on schedule and on budget. We are also known for delivering sustainable, innovative and effective solutions for demanding tasks in Arctic conditions.

Finland is the only nation in the world that offers iceproven products and services with a solid, cost-effective value chain. This value chain covers R&D, education, ship design, engineering, building, operation, program management and life cycle support services. Globally recognized Finnish companies and shipyards offer icebreaking solutions for the U.S polar icebreaker program that can be considered as a complete package or configured as individual options to suit specific needs.

The key players in the innovation platform for Finland's shipbuilding and marine industry are companies, research organizations, internationally recognized universities, the Finnish Funding Agency for Innovation and the Finnish Meteorological Institute.

Partnering with Finland means that the U.S. icebreaker renewal program will benefit from the latest research and technological advances. It will also ensure that production and technology risks are managed effectively and that the highest quality standards are met. The Finnish polar maritime network also offers many flexible options for designing, building, operating and maintaining icebreakers.



ICEBREAKING SOLUTIONS DELIVERED ON TIME AND ON BUDGET

FINNISH COMPANIES COMBINE THE LATEST TECHNOLOGY WITH A LONGSTANDING TRADITION IN THE POLAR MARITIME BUSINESS. THIS GUARANTEES NOT ONLY WORLD-CLASS ICEBREAKING SOLUTIONS, BUT ALSO SIGNIFICANT TIME SAVINGS.

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THE FOLLOWING EXAMPLES UNDERLINE HOW WE HAVE MASTERED EFFICIENCY



Finland sets the benchmark for effective, environmentally friendly and safe icebreaking. Our companies and technologies play a crucial role in setting international polar maritime rules, regulations and standards.

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Finnish companies have perfected their project execution models. For example, the multipurpose icebreaker Botnica was delivered and ready for service just 13 months after the shipbuilding contract was signed. Moreover, we can conduct full-scale ice trials in Nordic waters, so there is no need to travel around the globe for sea ice. These unique benefits save time, without compromising quality.

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The Finnish polar maritime network and supply chain has consistently led to the creation and implementation of new icebreaking technologies. Our innovations in propulsion, electric power systems and winterization, as well as double acting technology, help maintain cost-effective marine operations around the globe by improving vessel performance, energy efficiency and safety.

THE POLAR MARITIME **NETWORK IN FINLAND**



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Finland is known for designing vessels that meet performance requirements while still being economical to build, maintain and operate in both open water and ice-covered seas. Finland has the capacity to develop, build, deliver and commission several icebreaking ships every year. The latest Finnish icebreaker, Polaris, delivered in 2016, is the most recent example of our cost-efficient advanced technology.

Finnish icebreaker innovations are used worldwide. The world's first environmentally friendly LNG-powered icebreaker was built in Finland. Additionally, the oblique icebreaker (which maximizes icebreaking efficiency and operational capability), the azimuth propulsion system Azipod[®], the air bubbling system and the multipurpose icebreaker concept are also Finnish innovations.

FINLAND IS A PIONEER IN INTELLIGENT SHIPS AND DIGITAL SOLUTIONS

FOR EXAMPLE, OUR TECHNOLOGIES ARE USED FOR:

- · optimizing ice-management and operations
- autonomous operation
- fleet and asset management
- integration of scientific functionalities and operational capabilities
- remote diagnostic and predictive maintenance

FINLAND IS A FORERUNNER IN INTERNATIONAL COLLABORATION

Finland is a forerunner in bilateral partnerships as well as public-private arrangements for icebreaking services. It can procure icebreaking services from both public and private partners and currently has three icebreaking treaties with neighboring countries.

In Finland, icebreaking services are financed through a market-driven system based on fairway dues. During the Arctic summer when the fleet is not required in the Baltic Sea, Finnish icebreakers are available for charter missions in polar areas.

An icebreaker charter is a cost-effective way to experience the latest technologies and operating procedures, conduct technology benchmarking and train future crews before making final decisions on the future operational requirements of the U.S. icebreaker renewal program.

A HISTORY OF COOPERATION

Previous United States Coast Guard icebreaker projects have benefitted from American-Finnish cooperation. For example, Finnish companies provided extensive conceptual development and design support, including hull form development and propulsion line engineering, for the medium icebreaker USCGC Healy. Finnish companies also developed the vessel concept for the Great Lakes icebreaker USCGC Mackinaw, which was based on the double acting ship principle and the podded propulsion system. In both projects, Finnish companies were also responsible for model testing.

Finnish multi-purpose icebreakers have operated in U.S. Arctic waters and transited through both the Northwest Passage and the Northern Sea Route.

PARTNERSHIPS INCREASE ICEBREAKING OPTIONS

Like the U.S., Finland is also renewing its fleet of icebreakers. The timing of the two countries' renewal programs offers a unique window of opportunity to share icebreaker assets, opening affordable options to strengthen U.S. icebreaking capacity and the cost-efficient deployment of new icebreakers.

In the following pages, leading Finnish companies and Aalto University describe their solutions, and share some thoughts on the U.S. icebreaker renewal program.



RESEARCH



Cutting edge research, testing knowledge and facilities.



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Aalto University's research group on Arctic and Marine Technology is studying the behavior of ships and structures both in open water and in areas covered by sea ice. The work is linked with the design and operations of passenger vessels, icebreaking ships and Arctic marine structures. It focuses on ice loads on ships and structures, ship performance, ship safety and ice mechanics. Furthermore, the research on open water ships includes work on advanced structures, hydrodynamics as well as risk and safety.

Currently, the group consists of eight professors, including two Finland Distinguished Professors (FiDiPro), lecturers, post-docs, and doctoral students. The group has an excellent national and international support network, including CEARCTIC, a Joint Research Center of Excellence for Arctic Shipping and Operations funded by Lloyd's Register Foundation in London and led by Aalto, and SAMCoT, a Center for Research-based Innovation on Sustainable Arctic Marine and Coastal Technology led by NTNU in Norway and funded by the Norwegian Research Council and international industry. Members of the research group have organized several international scientific conferences at Aalto and are active on the editorial boards of international scientific journals.

AALTO ICE TANK IS THE LARGEST TESTING FACILITY IN THE WORLD

Aalto Ice Tank is a 40m × 40m × 2.8m basin equipped to produce sea ice at model scale. Typical tests include ship resistance in different ice conditions and ice failure against marine structures. The facility is open to visitors through the Hydralab+ network funded by the EU, or through other arrangements.



DESIGN

Aker Arctic

The world's leading designer of icebreaking vessels

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Established in 2005 as a spin-off of Aker Yards (the former Wärtsilä Helsinki Shipyard), **Aker Arctic** has the accumulated icebreaker design and construction knowledge that the shipyard and its design department have accumulated since the 1950s. Aker Arctic's past references, both as the shipyard's Arctic technology research unit and as an independent engineering company, include more than half of the icebreakers built worldwide. Today the company is involved in most of the high ice class projects that are on order or under development around the world.

ICEBREAKER INNOVATIONS

Aker Arctic prides itself on being a forerunner in icebreaking technology and can claim a number of "firsts" in the world of icebreakers. In the 1950s, the company established a new standard for Baltic escort icebreakers with two bow propellers and developed the first large diesel-electric polar icebreakers. The construction of one successful icebreaker class after another for both domestic and foreign customers led to the perfection of the various design features and systems that are typical of ice going vessels today, such as the AC/AC diesel-electric propulsion system. By the late 1980s, Aker Arctic was responsible for constructing the only nuclear-powered icebreakers built outside the Soviet Union and Russia. More recently, Aker Arctic developed several state-of-the-art icebreakers for their clients, including the concept for the world's first LNG powered icebreaker for the Finnish government.

During its history, Aker Arctic has contributed to the development of the podded propulsion known today as ABB's trademark, Azipod^{®.} This has enabled the development of Double Acting Ship (DAS[™]) concept. As a result of its work, Aker Arctic has also found new ways of operating ships in heavy ice conditions. For example, Aker Arctic also invented the sideways-going oblique icebreaker to take full advantage of the azimuth propulsion units. Recently, the company demonstrated the unique capabilities of the first such vessel in extensive full scale trials in the Arctic. Aker Arctic's latest vessel concepts such as the new Finnish icebreaker have been widely regarded as the world's most advanced icebreakers and in full-scale ice trials, Aker Arctic's icebreaking innovations continue to outperform other designs.

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MORE THAN A DESIGN OFFICE

One key to Aker Arctic's success has been its in-house ice model testing laboratory and the close relationship between model testing and design. The company has carried out over 500 ice model test series since the first model basin was opened in 1969, and today operates its third generation testing facility in Helsinki, Finland. Aker Arctic also has one of the world's largest reference databases of full scale ice trials. This guarantees that its icebreaking performance predictions are accurate and help to achieve maximum icebreaking capability with the least possible propulsion power. The goal is to design vessels that not only meet performance requirements, but are also cost-effective to build, maintain and operate in both open water and ice-covered seas

BUSINESS FINLAND

COOPERATION WITH THE U.S. COAST GUARD

Aker Arctic and its predecessors have also been involved in Coast Guard icebreaker projects, providing extensive conceptual development and design support, which included hull form development and propulsion line engineering for the medium icebreaker USCGC Healy. Aker Arctic also developed the vessel concept for the Great Lakes icebreaker USCGC Mackinaw in cooperation with the USCG. The concept was based on the Double Acting Ship (DASTM) principle and podded propulsion system. In both projects, the company was also responsible for model testing. Aker Arctic has also done concept design in co-operation with VARD Marine (Canada) for the Canadian Coast Guard (CCGS) Polar Icebreaker John G. Diefenbaker. It will be the most powerful diesel-electric icebreaker in the world with advanced hull form and a hybrid azimuth/ shaftline propulsion system.







RAUMA MARINE

A specialist in ice-going vessels

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Rauma Marine Constructions Ltd. (RMC) was founded in 2014, and this new beginning marks the culmination of centuries of shipbuilding experience at the Rauma shipyard. The shipyard in Rauma, under various owners, has built up a vast knowledge of naval architecture and technological innovation.

The Rauma shipyard has extensive experience building, upgrading and overhauling specialized vessels, including all Finnish multi-purpose icebreakers, large border guard patrol vessels, and all Finnish Navy surface combatants built since 1986.

RMC'S PRODUCT PORTFOLIO INCLUDES

COAST GUARD VESSELS	CAR & PASSENGER FERRIES	
ICEBREAKERS	NAVAL VESSELS	

RESEARCH VESSELS

PROPOSAL FOR PARTNERING WITH A U.S. SHIPYARD

RMC and its network partners for engineering, model testing, construction and performance verification are ready to establish in-depth cooperation with a U.S. shipyard. This partnership would include the design, construction and maintenance part of the value chain. Both pre- and post-delivery activities, as well as operations-related assistance can also be given to the U.S. polar icebreaker program. The objective is to decrease costs and optimize the delivery schedule while managing production and risks.

PARTNERSHIP EXECUTION MODEL

RMC's proposal for work-sharing in a joint American-Finnish polar icebreaker program is to complete a first-in-series functional vessel at a shipyard in Finland. The construction would be implemented in two main phases. Phase one would take place in Finland where the engineering, steel section manufacturing, hull assembly and outfitting would be performed. The ship would be completed, assembled, outfitted and commissioned to the level agreed. Then, testing and trials would be performed to verify performance, especially icebreaking capability. In addition to shipbuilding, RMC is willing to include training and education as part of the production phase. U.S. participation in project execution would create benchmarking opportunities and best practices for the program.



After the first phase is completed, the ship would be ready to sail to the U.S. partner shipyard for government furnished equipment, sensitive equipment installation, and final outfitting and commissioning. This proposal acknowledges 14 U.S. Code § 665 restrictions on the construction of vessels in foreign shipyards.

BENEFITS OF COOPERATION

American-Finnish partnership enables close cooperation between shipyards. The main objective is to work together to enhance icebreaker building capability in the U.S. by utilizing high-level research and development programs in connection with the world's best experts in Arctic shipbuilding. This partnership would encourage dialogue between operators, designers and builders that leads to increased safety, functionality and performance. The exchange of ideas would come through personnel exchange, training, education and the development of best practices. Last but not least, this partnership would ensure efficient execution of the building schedule while still providing the partnering U.S. shipyard with the major part of the construction. For example, the main equipment and components, ABS Class involvement, GFE and sensitive equipment installation and commissioning.

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REFERENCES: SHIPS CONSTRUCTED IN RAUMA AND THE STATUS OF RMC'S FOCUS PROJECTS

A wide range of ships are built at Rauma: car & passenger ferries, research vessels, icebreakers and naval surface combatants. The Rauma Shipyard has built the Finnish multipurpose icebreakers Fennica (1993) and Nordica (1994), all Finnish Navy surface combatants since 1991, multipurpose icebreaker Botnica (1998), the ice-going Polar Research and Supply Vessel S. A. Agulhas II for South Africa (2012), and the Finnish Border Guard Patrol vessel Turva (2014).

Our future focus is on the renewal of Finland's entire icebreaker fleet, which the Finnish government expects to be completed by 2029. We're also focusing on the Finnish Navy's ice-going Squadron 2020 corvettes, for which RMC and the Finnish Defense Forces have signed a Design Contract in 2017. Polar Research and Supply Vessels for harsh conditions is the key focus segment where RMC's knowledge and experience adds value.



OPERATE



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Arctia Ltd. deploys one of the strongest icebreaker fleets in the world. This specialized shipping company currently has eight icebreakers in its fleet, including two PC3 multipurpose icebreakers and one PC4 icebreaker classified in accordance with the IMO Polar Code requirements. The company has extensive international experience in providing icebreaking and ice management services, as well as specialized multi-purpose vessel services in all polar and sub-polar areas.

Arctia has operational experience in the Northern Sea Route and the Northwest Passage, as well as offshore operations in Alaska, Greenland and elsewhere in the Arctic. Arctia's customer base includes international energy companies, research institutions and other organizations active in polar areas. The company's offshore services include, but are not restricted to, fairway icebreaking, ice management, pipe and cable laying, towing, service work for production platforms, and the installation and maintenance of underwater structures.

Arctia's current fleet includes three conventional icebreakers: Voima (commissioned in 1954, major refits 1979 and 2016), Urho (1975) and Sisu (1976). It also includes the converted polar icebreaker Otso (1986), the oil recovery icebreaker Kontio (1987), the multipurpose icebreakers Fennica (1993) and Nordica (1994), and the world's first LNG-powered icebreaker Polaris (2016). From 2010 to 2016, IB Kontio was in a continuous state of readiness for oil spill response operations in the northern Baltic Sea as mandated by the EMSA (European Maritime Safety Agency).

Arctia has more than 150 crewmembers IMO-trained for oil spill preparedness and response operations. The company works in close cooperation with national and regional rescue authorities. Arctia also develops oil recovery from ice with Lamor in the IMOR (Ice Management in Oil Recovery) programme.

In September 2016, the icebreaker Polaris joined Arctia's fleet. IB Polaris is unique in many ways. It is the first icebreaker in the world capable of running on both liquefied natural gas (LNG) and ultra-low-sulphur diesel. Its total output of about 22 MW also makes it Finland's most powerful icebreaker and it is the most environmentally friendly diesel-electric icebreaker in the world. The vessel is equipped with three Azipod® propulsion units which rotate 360 degrees to enable excellent maneuvering qualities. The icebreaking capacity of IB Polaris is 1.2 meters at a speed of 6 knots. The Finnish company Lamor Corporation Ab delivered the built-in oil recovery system, which enables Polaris to collect 1015 square meters of oil at a rate of 200 m³/h in harsh weather and ice conditions.

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BUSINESS FINLAND



Sharing icebreaker assets with the U.S. would maximize operational use time and bring affordable strategic icebreaking options to both Finland and the U.S.

Finland is a forerunner in international collaboration as well as public-private arrangements for icebreaking services. Arctia's icebreakers are available for international charter missions in polar areas. Arctia's multipurpose icebreakers Nordica and Fennica, as well as IB Otso which has been recently converted to handle open-water conditions better, have been used for various maritime services in the Arctic.

American industry has raised concerns about the commercial effects of the so-called icebreaker gap. Even if there are a small number of capable icebreakers in the water before the first new heavy polar icebreaker is ready, the U.S. still faces a capacity gap with potentially severe effects on socially and commercially important operations in the U.S. Arctic. Sufficient icebreaking capacity is also needed to conduct and support scientific research in the Arctic and Antarctic.

To avoid this capacity gap, an interim bilateral solution with Finland is in the interest of the U.S. The Finnish state-owned shipowner and icebreaker operator Arctia Ltd. has icebreakers available and is prepared to support the U.S. in all of its icebreaking and ice management needs. Finnish companies are also ready to discuss several flexible strategic cooperation models that would benefit U.S. shipbuilding, ship model testing and engineering with regard to icebreaking technology and operational models.

There are currently three Finnish icebreakers that are the best on the global market today to meet the key performance parameters set by the USCG: the multipurpose icebreaker MSV Nordica, her sister vessel the MSV Fennica, and the converted polar icebreaker Otso, all polar classified according to the recent new requirements by the IMO Polar Code. These Finnish icebreakers have a long and proven history working in the U.S. and Canadian Arctic. The MSV Nordica currently holds the record for both the earliest and latest season transit across the Northwest Passage.



POLARIS, THE WORLD'S FIRST LNG-POWERED ICEBREAKER EQUIPMENT & SYSTEM SUPPLIERS / DIGITAL SERVICE PROVIDERS

ABB

nestix»

Ø WÄRTSILÄ

TRAFOTEK









PEMB WELDING AUTOMATION



navidium 🌐

Danfoss

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conditions.

ENVIRONMENTAL SOLUTIONS

Lamor Corporation, headquartered in Finland with

solutions for a wide range of scenarios and climate

The company has an extensive portfolio of Arctic oil

recovery applications, including high-capacity vessel-

mounted and inbuilt skimmers, pumps, heavy duty oil

Lamor Corporation has supplied the oil recovery systems

for some of the most innovative icebreakers in the world.

booms and dedicated ice-class oil recovery vessels.

For example, Polaris, the world's first LNG-powered icebreaker, and the unique, oblique icebreaker Baltica.

strategically located offices, hubs and partners worldwide,

is a global leader in oil spill response and environmental



The built-in oil recovery system (LORS) represents the latest technology in winterization features and has a recovery rate of 200 m³ of oil per hour even in harsh weather and ice conditions. The system is equipped with Lamor cargo pumps, which are world renowned for handling very viscous products.

Lamor has successfully participated in many oil spill drills, exercises and equipment tests. For example, the BSEE Ice Month Testing at Ohmsett and the Advanced Oil Spill Response in Ice Course at CRREL conducted by Alaska Clean Seas in 2013.

Client references for arctic equipment deliveries for icebreakers and ice-class vessels from the past four years include: Arctia, Gasprom Neft Shelf, GosMorSpasluzhba, Karmorneftegaz, Norwegian Coast Guard, Shell Alaska, Sovkomflot and Swedish Coast Guard.





ABB is a pioneering global technology leader in the marine industry for electrical power and propulsion systems for ships. Building on a 125-year history of innovation, ABB is helping to create the future of industrial digitalization and is at the forefront of the energy revolution.

ABB us uniquely positioned to manufacture total electric power and propulsion solutions for icebreaking vessels. The company's main products are produced in-house, enabling them to control and secure complete deliveries and to simplify lifetime maintenance and service. By using ABB throughout the vessel, the right specifications, configurations and dimensions are implemented to achieve optimal system interaction and functionality.

PROVEN ABB TECHNOLOGY IN USE TODAY INCLUDES

PODDED PROPULSION – Azipod® propulsion systems deliver up to 20 percent better fuel economy, superior maneuverability, greater flexibility of design, and lower maintenance in a smaller footprint compared to conventional driveshaft propulsion systems. ABB's Azipod® is the leading propulsion system for icebreaking vessels and has proven its unique reliability and icebreaking capability in a wide range of ship types. Azipod® has changed the traditional perception of icebreakers, and is a perfect match for the new generation of commercial vessels which can operate independently in ice without the assistance of icebreakers.

AKER ARCTIC'S DOUBLE ACTING SHIP (DAS)™ with

podded Azipod[®] propulsion provides better capability than legacy designs while requiring less equipment, allowing for smaller, lighter ships which cost less to construct. Furthermore, hulls optimized for both open water (bow-first) and ice breaking (bow-first or astern) offer better performance in both environments with lower power requirements (up to 50 percent less) compared to conventional designs, providing fuel savings and lower long term operational costs.

BUSINESS FINLAND



ONBOARD POWER SYSTEMS – Power distribution systems designed to operate at variable frequency allow diesel generators to run at optimal levels (i.e. fewer units running at peak performance), improving fuel efficiency and reducing emissions.

ADVANCED OPERATIONS AND MAINTENANCE – Remote (onshore) monitoring and condition-based maintenance reduces O&M costs and increases uptime. ABB is a total system integrator and their portfolio of services covers the entire vessel life cycle. For example: project management and engineering, site support, commissioning, installation supervision, warranty and after-sales support. ABB has strong Service presence and ever growing organization in the USA, which works in close cooperation with the business unit in Finland.



NESTIX OY was founded in 1982 and has been a subsidiary of Hexagon Intergraph AB since June 2016. The company develops Shop Floor Management Solutions for the shipbuilding Industry and for pipe steel fabrication. They follow the philosophies of lean manufacturing, digital shipbuilding and industry 4.0 strategies for intelligent fabrication and smart production.

NESTIX has almost 500 customers in 40 countries and more than 8000 professionals use their solutions on a daily basis. Its customer base includes major shipyards, offshore yards, pipe fabricators, steel service centers, mechanical engineering companies and steel construction companies. The fabrication processes supported by NESTIX have been utilized in many of the biggest cruise ships in the world and in a number of extremely complex naval vessels.

NESTIX provides engineering & design data agnostic import capabilities as well as integration with standard schedule and ERP systems. By taking material availability, project schedules, resources and a direct connection to the machines into account, a productive and efficient shop floor schedule and a detailed fabrication plan leads to Business Intelligence Reporting that's based on real-time information.

NESTIX PROVIDES

- Intelligent integration with engineering & design solutions that can lead to a significant reduction in time spent on work preparation
- Consistent and automatic management of change
- Smart backwards and forwards scheduling functionality resulting in an optimized Shop Floor
- A production schedule with individual work center instructions, thereby shortening throughput times and improving resource utilization
- Improved material management through powerful nesting and remnant management
- Real-time interactions with resources, machines and work centers (through different technologies, such as PC monitors, QR or bar codes, RFID and other) and therefore up-to-date Business Intelligence information, such as Availability To Produce (materials) as well as Capacity To Produce (resources)
- Full traceability of materials, logistics and production

BUSINESS FINLAND

NESTIX HAS ALMOST 500 CUSTOMERS IN 40 COUNTRIES AND MORE THAN 8000 PROFESSIONALS USE THEIR SOLUTIONS ON A DAILY BASIS

Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy industries. By emphasizing sustainable innovation and total efficiency and data analytics, Wärtsilä maximizes the environmental and economic performance of its customers' vessels and power plants. It has over 200 locations in more than 80 countries around the world. With the knowledge gained from operating in harsh Finnish conditions and over 50 years of experience in delivering products and solutions for advanced icebreakers and vessels with high ice-class specifications, Wärtsilä offers efficient and reliable propulsion machinery that can handle even the most demanding arctic temperatures with extremely low air suction.

WÄRTSILÄ MARINE SOLUTIONS

Wärtsilä Marine Solutions enhances the business of its marine and oil & gas industry customers by focusing on their need to provide innovative products and integrated solutions that are safe, efficient, flexible, environmentally sustainable and economically sound. With its smart technologies and high level of connectivity and digitalization, Wärtsilä is leading the marine industry's transformation towards a smart marine ecosystem. The goal is to create a new era of shipping in which operational efficiency, safety, and environmental sustainability are optimized to create greater customer value. 34

WÄRTSILÄ IS A GLOBAL LEADER IN ADVANCED TECHNOLOGIES AND COMPLETE LIFECYCLE SOLUTIONS FOR THE MARINE AND ENERGY INDUSTRIES

WÄRTSILÄ DEFENSE OVERVIEW

Wärtsilä Defense Inc. (WDI) is a U.S. subsidiary of Wärtsilä. WDI is headquartered in Chesapeake, VA, and has an excellent reputation with the U.S. government. It serves the surface and submarine fleets of the U.S. Navy, Coast Guard, Military Sealift Command and Army with ice-class solutions and a broad range of products and services including, waterjets, thrusters, fixed pitch propellers, shaft lines, propulsion controls, bearings, seals, and propeller repairs. WDI has a long and distinguished history of providing integrated systems and service solutions to the marine market. The company has established strong customer trust by ensuring the availability and cost-efficient operation of the equipment it supplies. WDI has one of the leading propeller repair facilities in the world, operated with over 350 combined years of propeller repair experience. WDI is present in Chesapeake, Virginia; Poulsbo, Washington; and San Diego, California.

WDI has a long history of experience in providing seal removal and installation services for the U.S. Navy. It supplies mechanical and lip seals to almost every surface ship in the U.S. Navy, MSC and Coast Guard with exclusive supply to the entire submarine fleet.

WDI works with the U.S. government under a Special Security Agreement performing ITAR compliant work and has extensive experience as a government contractor.

It is certified to ISO 9001:2008, ISO 14001:2004 and to OHSAS 18001:2007 and has ABS, Lloyds Register and NAVSEA weld qualifications. Wärtsilä/WDI also supports and is the Original Equipment Manufacturer (OEM) of water jets, supporting three major U.S. Navy shipbuilding programs: The Littoral Combat Ship (LCS) (USS Independence variant, built by Austal USA); Expeditionary Fast Transport (EPF), formerly Joint High-Speed Vessel (JHSV); and the Improved Navy Lighterage System (INLS)

By utilizing an OEM, the U.S. Navy benefits from having their entire power system fully serviced by a single global supplier. WDI's proven project management and quality control structure provides the best solution for the Navy's needs. It also provides service and support throughout each vessel's lifecycle, from installation and commissioning all the way to in-service performance optimization, including upgrades and conversions, environmental solutions, technical information and online support.

WÄRTSILÄ AND THE POLAR ICEBREAKING PROGRAM

The USCG currently has two working polar icebreakers (Polar Star and Healy) and the design experience with these types of ships is outdated. There is a need to acquire new polar icebreakers and to construct these ships in the USA while utilizing technology and equipment from other countries. The potential clients for design services and technology transfer will be the General Dynamics NASSCO shipyard, Huntington Ingalls Industries, Fincantieri teamed with the Philly shipyard, VT Halter, or Bollinger teamed with Tampa Ship.

WÄRTSILÄ'S SCOPE OF SUPPLY

Wärtsilä is currently assessing the U.S. Coast Guard's need in relation to the following marine solutions:

- Gensets
- Reduction Gear
- CPP and shafting
- Stainless Steel Propeller
- Seals and Bearings
- Emergency Diesel Generator
- Ships Service Diesel Generator

- Electrical & Automation Dynamic Positioning
- Multibeam Sonar System
- Underwater Telephone
- IBS
- Closed Caption TV
- Entertainment Systems
- Pumps and Valves

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harsh conditions.

TRAFOTEK

Trafotek has been providing the major shipyards of the

rigs rely on Trafotek for high-quality energy out at sea.

Currently, there are over 900 vessels sailing the world's

oceans with Trafotek transformers, and 37 of these ships

are built in the US. With 23 icebreakers on their reference

Trafotek transformers have a small footprint thanks to optimized core construction, intelligent structural solutions and efficient cooling. And to decrease the permanent load that a vessel has to carry, Trafotek has made minimizing transformer weight a priority.

list, they are an experienced supplier of power solutions for

world with transformer and electrical filter solutions since 1983. Luxury cruise liners, icebreakers and offshore

BUSINESS FINLAND

Company's transformers are designed and manufactured to withstand serious vibrations and shocks. The transformer housing is specifically designed for marine use and a wide range of transformer accessories can be selected to meet a customer's specific needs.

The power output of Trafotek dry-type transformers ranges from 1 kVA to 12.5 MVA, with a maximum voltage of 24 kV. Cooling can be air natural, air forced or water-based with a heat exchanger. Third party certification for marine and offshore applications such as ABS, LR, RINA, DNV-GL, BV and NK is available and transformers can be configured for electrical propulsion or distribution.





Marioff is a global leader in high pressure water mist fire protection technology. The company designs, develops, manufactures, installs and maintains HI-FOG® systems for ships at sea, commercial buildings and industrial applications. Marioff is a part of UTC Climate, Controls and Security, a unit of the United Technologies Corporation. Marioff's headquarters and factory are located in Finland.

With a long history in marine fire protection, the Marioff HI-FOG® systems are tested, proven and certified to comply with international and national maritime safety requirements and regulations including the USCG approvals. HI-FOG® has also passed the rigorous U.S. Navy fire tests aboard the ex-USS Shadwell. HI-FOG® effectively minimizes fire damage through fast activation and by using the least amount of water possible. It may also offer fire protection during vessel construction. Today, HI-FOG® systems protect machinery spaces, vehicle decks, accommodation, galleys and store areas onboard a large number of ships worldwide.

Marioff's client references include: over 100 naval vessels, including Mistral-class helicopter carriers (France), Hobart-class air warfare destroyers (Australia), Astute-class submarines (UK), Visby-class corvettes (Sweden), Katanpää-class mine countermeasure vessels (Finland) and BAM class patrol vessels (Spain), etc; over 200 supply vessels and work boats, including M/S Voima icebreaker, Edison Chouest Offshore ice class supply vessels (in cooperation with Fire Protection Systems USA Inc.) and USCG Bay-class icebreaking tug upgrades (in cooperation with Trident Maritime Systems Inc.); over 300 cruise ships, including Harmony of the Seas, Oasis of the Seas, Carnival Vista, Koningsdam, Norwegian Epic and MSC Preziosa; over 300 passenger car ferries, operators including Washington State Ferries and BC Ferries.





Starkice Oy designs and delivers turn-key solutions for shipping, harbors and offshore installations. Their main products and services are related to de-icing solutions and operational optimization for mission critical deck areas, rescue zones or other areas, such as observation decks, balconies and gangways.

In addition to their PolarPad pre-fabricated heating elements, they offer an Intelligent De-Icing System (IDS) that consists of one main unit, sensors, separate heating elements (PolarPad or cables), connection cables and auxiliary control cabinets. The system automatically senses ice on a surface and turns on de-icing elements. Additionally, separate de-icing areas can be established based on the level of importance (critical rescue area vs. comfort-related de-icing) or based on different climate conditions or location (starboard, portside, aft, fore etc.). IDS can be used as ice accumulation warning and sensoring system, if manual removal is preferred.

The main unit has a specially developed software program that is based on Starkice's extensive experience operating in arctic weather conditions. The main unit also has data logging and web-based access to system data. This feature is called Starkice Cloud and it can also be used for financial reporting and cost optimization of the fleet. It operates with GSM/satellite networks and data send/receive can be fully adjusted based on a customer's needs.



ICEYE

ICEYE provides commercial earth observation data and value-added services. Their data can be used to track changes around the world at any time. Specifically, they use Synthetic Aperture Radar (SAR) technology to provide earth observation imaging in all weather conditions. Their unique SAR microsatellite design allows them to operate a large constellation of satellites that enables unprecedented access to SAR data. They aim for an average 3-hour delay from order to acquisition. And with the high number of satellites in their constellation, ICEYE can provide large size imagery (50 x 100km) with a 3-meter resolution on short lead times. They provide frequent revisits, including rapid mosaicking of larger areas, and they also co-operate with other satellite operators and data providers to offer complementary data layers.

ICEYE VISION is a web-based user interface for real-time adaptive tasking. Rapid acquisitions can be directly tasked from a graphical user interface with everything from confirmation to delivery happening within the same system. ICEYE also provides API access for customers who require deeper integration with existing operational systems or software.

BUSINESS FINLAND

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Craftmer[®] Oy specializes in developing standardized and custom-made tools for shipbuilding. Their tools allow for easier positioning of large pieces in relation to each other during the installation of heavy steel structures at shipyards and other heavy workshops. Craftmer also offers consulting to shipyards during the hull assembly stage of production.

Craftmer's business dates back to the 1970s when they first produced the 'Jakki' with a pushing or pulling force of up to 12 tonnes. After extensive testing and optimization, the ease of use and materials/weight/capacity relationship of the Jakki has been refined and today more than 4,000 Jakkis have been produced. All Craftmer products are designed and manufactured in their workshop in Finland.

New products are developed in close co-operation with their customers and they aim to solve problems for specific working conditions or applications. Most Craftmer® products help apply the right amount of force for shifting heavy components in the assembly of ship or large steel structures. For example: frames, bulkheads and hull sections. Craftmer products are also used for the alignment of stiffener ends and plate edges during the welding process. They have a simple design and low-weight construction that helps eliminate unnecessary welding, cutting and grinding of temporary lugs.

CRAFTMER TOOLS ARE USED BY OVER 50 SHIPYARDS WORLDWIDE











Pema WELDING AUTOMATION

Founded in 1970, **Pemamek Ltd.** is a global welding and production automation provider. The company designs, develops and manufactures intelligent production solutions for the shipbuilding and maritime industry. Pemamek exports over 90% of its annual production and has delivered over 15,000 automated welding solutions to customers in 50 different countries.

Pemamek is a solid, privately-held limited company that today employs 200 people at its headquarters in Finland. It also has a strong global presence, with PEMA Sales offices in the USA, Brazil, Russia and Poland, and a broad partner network across every continent on the globe. All of the company's manufacturing operations – from design to assembly and testing – are carried out in Pemamek's modern and technically advanced factory in Finland.

PEMA welding and production automation solutions for shipbuilding are recognized worldwide, with a client portfolio that includes some of the world's foremost shipbuilding corporations, including Fincantieri, Vard, Navantia, STX France, Ingalls Shipbuilding, Philly Shipyard, Irving Shipbuilding and Meyer Turku.

PEMA SHIPBUILDING

- 25 years of experience delivering shipbuilding solutions
- Broad offering ranging from single station to entire steel production facility
- Expertise in welding processes, material handling and control systems
- Smart production digitally and technologically advanced shipbuilding solutions
- One-stop-shop



Steerprop

Established in 2000 by a group of azimuth propulsion professionals with decades of experience, **Steerprop Ltd.** produces high-quality azimuth propulsors with outstanding lifetime economy for demanding applications and operating conditions.

Steerprop Azimuth Propulsors combine proven technologies with a robust design and innovative solutions to provide superior reliability and efficiency. The number of moving parts in the propulsors is minimized to further enhance their reliability and service life. Steerprop's experienced personnel work in close cooperation with a worldwide network of dedicated partners to provide clients with flexible service. Steerprop Ltd. is certified according to ISO 9001, ISO 14001 and OHSAS 18001 -standards.

ICE-BREAKING ENDURANCE

Azimuth propulsors are the tool of choice for ice management operations. The ability to control vectored thrust (i.e. slipstream) over a full 360 degrees allows the ship to not only open and widen channels, but also to blow ice ridges and free Arctic offshore installations from ice pressure. Focusing the slipstream with a nozzle further enhances the ice management abilities of the azimuth propulsor. Ice milling is also an option with a ship equipped with azimuth propulsors.

One example Steerprop's constant commitment to R&D is the development of the contra-rotating propulsor (CRP) which combines the excellent hydrodynamic features of the Steerprop CRP ECO propulsor with an electric Permanent Magnet (PM) motor to create one efficient, extremely compact propulsive unit.

Steerprop has delivered or been contracted to deliver over 760 azimuth propulsors globally, including the world's most powerful and highest ice-class mechanical azimuth propulsors. Steerprop's references also include 8 icebreakers and 85 ice classed units, among which is the world's first oblique icebreaking oil recovery vessel Baltika. This innovative vessel, based on the oblique Aker ARC 100 design by Aker Arctic, is the first vessel in the world capable of opening a wide channel in ice by operating sideways in oblique icebreaking mode.





Navidium Plc is a Maritime CleanTech company with a wide range of innovative IoT products. The company's strategy is to provide innovative solutions that increase its customers' revenue without sacrificing sustainable values. Navidium's solutions are designed to ensure more effective use of routing, reduce overall operational costs, reduce emission levels, increase the visibility of operations, and enable compliance with regulations.

The MareCast® offers real-time forecasting of weather, sea and ice conditions. The current situation and forecasts as well as observations and warnings can all be seen in one view. Marecast is designed as a standalone solution on the vessel and works reliably even in sea areas where the network connection is poor.

The IceTrails[®] service is specially designed to support navigation in ice-covered water areas. It shows in real time the best route options through the ice, providing exact ETA and icebreaker information for shipping companies and operators. The service utilizes satellite assets to present accurate information on ice conditions globally. This is the first time in the history of the industry that this information is available in a simple and accurate way for more informed decision-making.

Navidium's FuelCast[®] tool is a comprehensive, real-time data support system for sea route management that analyses fuel consumption and reduces costs, delivering optimal route efficiency and route planning. By observing, for example, how speed and acceleration affect fuel consumption, and analysing patterns, averages, variances, and anomalies, FuelCast[®] helps Navidium's customers to guide their operators and to make informed adjustments for improving their business.

Based on real-time data, Navidium's solutions offer safe IoT support that enables vessels to be en route and sites to stay operational, no matter what conditions they face.

Navidium works together with leading shipping companies, cruise lines, shipyards, ports, and oil companies globally. We also cooperate with several Research Institutes, like ESA (European Space Agency), VTT (Technical Research Center of Finland), FMI (Finnish Meteorological Institute), AARI (Arctic & Anarctic Research Institute Russia) and top universities in Scandinavia. 52

NAVIDIUM'S INNOVATIVE IOT SOLUTIONS DELIVER OPTIMAL ROUTE EFFICIENCY AND RELIABLE REAL-TIME FORECASTING FOR WEATHER, SEA AND ICE CONDITIONS.

Danfoss

With a global presence and more than 40 years of experience, **Danfoss Drives** offers a comprehensive portfolio of high-quality, application-optimized VLT[®] and VACON[®] drives that meet the demanding needs of the marine and offshore industry. Danfoss Drives' low and medium voltage products are designed and manufactured to maximize process performance, save energy and minimize emissions.

When optimizing performance and efficiency, it is never enough to consider individual components in isolation. Danfoss Drives provides expert collaboration for every corner of a ship, from power conversion to propulsion, ventilation and cooling systems, and from the cargo deck to the accommodation quarters – always considering the big picture before offering concrete advice on the specific drive system to optimize performance.

By installing the correct, reliable Danfoss drives from the keel to the topside, it is possible to boost vessel performance, extend lifetime and suppress harmonics in heavy-duty industrial applications. Danfoss Drives' numerous case studies across a wide range of vessels demonstrate how its highly efficient products can, for example, lower operating costs, reduce fuel consumption, improve air quality, reduce noise, and boost maneuverability. Danfoss AC drives are certified by the world's leading classification authorities.

SHARING	INVENTING	ENGINEERING
Support for you to invent vesselwide drive or grid systems	Modules, components and functionalities to suit any application on board	Total of nine marine certifications
Dimensioning and selection tools	Liquid-cooled or back- channel air-cooled drives	Drive modules up to 5.3 MW
Professional advice in locations around the globe	Customer-specific fit using the best software development methods	Long lifetime, robust performance and highly efficient equipment
Experience and information about existing installations	Constantly developing new technology capability in vessel construction	IP55 and IP66 drives suitable for engine rooms, designed for ambient temperatures from -25 to 55 °C
Digital EPLAN documentation to reduce your design cost	n	PLC function blocks for easy PLC integration



POLARIS: THE FIRST LNG-POWERED ICEBREAKER IN THE WORLD

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FF 51

dome

inland

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Commissioned in September 2016, the icebreaker Polaris is the latest addition to the Finnish fleet. Polaris is the first icebreaker in the world to feature environmentally friendly dual-fuel engines capable of using both low-sulfur marine diesel oil (LSMDO) and liquefied natural gas (LNG). Like other Finnish multifunctional icebreakers, Polaris is also capable of oil recovery and rescue operations. Finland will renew its whole fleet of eight icebreakers by 2030.

BENEFITS OF AN AMERICAN-FINNISH PARTNERSHIP



BUSINESS FINLAND

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Finnish companies and academia provide world-leading expertise and the latest technologies

Finnish solutions maximize efficiency, operational capabilities and sustainability

New icebreakers can be built in Finland efficiently and cost-effectively

Partnerships between Finnish and American shipyards strengthen U.S. capability to build icebreakers Partnerships, chartering or joint ventures offer affordable ways to boost U.S. icebreaking capacity

Finland is a forerunner in bilateral partnerships for icebreaking services

As one the most stable and secure countries in the world, Finland is a trusted partner both in business and world affairs

CONTACT INFORMATION

ULLA LAINIO

Arctic Maritime & Offshore from Finland Program Director Business Finland Itsenäisyydenaukio 2 FI-20800 Turku, Finland ulla.lainio@businessfinland.fi Tel. +358 40 3433 357

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Porkkalankatu 1 | FI-00180 Helsinki, Finland | Tel. 0294 6951