# Arctic Passion News

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# Announcements



Rob Hindley has joined Aker Arctic as team leader, for machinery and structures. Previously Rob was a global principal specialist in arctic technology at represented the

Lloyd's Register and represented the International Association of Classification Societies (IACS) at the IMO during the development of the Polar Code. Rob has worked in Canada, the UK, the Middle East, and in South Korea in roles involving ship surveying, classification rule development and technical consultancy. He holds a master's degree in naval architecture from Newcastle University.



Olli Kokko has joined Aker Arctic as development engineer in the electronics & IT team. Olli graduated in 2017 with a master's degree in

mechanical engineering and mechatronics from the Aalto University School of Engineering. In his master's thesis he studied autonomous navigation in model scale.

# Dear Reader,

Activity in the global shipping and shipbuilding market continues to be at a low ebb, as it also is in offshore activity related to the oil and gas industry. However, some new and remarkable things are happening with ships intended for use in icy conditions. The announcement in December by French cruise operator PONANT that they are planning to build an icebreaking cruise vessel introduced a completely new vessel type to the world. At the same time, we revealed that we had been working in close technical co-operation for nearly two years. Together with the client, our naval architects and engineers developed this unique vessel design. For us, of course, developing icebreakers capable of reaching the North Pole is nothing new. But the combination of an extremely heavy icebreaker and a cruise vessel is a new one.

The technical details are explained in this magazine, but the most important thing to note is the introduction of a completely new type of ship and operation in the high arctic combined with the icebreaking technology. At the same time, this vessel raises interesting questions about the "exploration cruise" market, how popular it will be among clients and tourists, and how boldly others will react with their own plans. A number of vessels currently under construction with lower ice classes are being marketed as polar cruise vessels, and this will bring significantly more capacity into this segment of the cruise market.

While you are reading this magazine, LNG shipments are going at full pace from the Sabetta terminal. The operation to bring these first-ever Arctic LNG carriers on line has been a success. Not many major LNG production projects have started on time and able to deliver their planned capacity of LNG to the market. So far, over a million tonnes of LNG has been loaded from Sabetta on the first four arctic LNG carriers. This also demonstrates their capability to break through the ice and bring results for Yamal LNG. Hopefully, this success will encourage the industry to make new investments, and then the passionate icebreaking engineers will once again have challenges to solve.

We can expect new types of activities in polar shipping, the cruise industry and LNG deliveries, and there will also be more ships in these challenging operations. The Polar Code has been introduced in order to improve safety in shipping, but another important action regarding safety issues is co-operation between national coast guard organisations. Together, they are looking for best practices and studying the best ways to improve preparedness in response to potential risks in arctic marine operations.

I hope you enjoy the articles, and that you are looking forward with great interest to the next projects and developments.

Reko-Antti Suojanen

Managing Director



# Meet Petri Tolonen



Petri joined Aker Arctic as the new director of sales and marketing last year. He has a strong background in the Finnish pulp and paper industry, where he worked for more than twenty years of his career. About seven years ago, he transferred to the marine business and was vice president of sales and marketing and later president and CEO of Steerprop Ltd. Before Petri joined Aker Arctic he was the director of the Thruster & PCS product line at Wärtsilä Marine Solutions. Petri says he is very pleased with his new work and colleagues. "The atmosphere at Aker Arctic with all our specialists is very innovative, open and respectful. We trust and appreciate each other."

Petri's home is in Turku, about 170 km from the Vuosaari office. "I jump on the train early every Monday morning and stay in a flat close to work during the week," Petri says. "I often spend the weekends in my cottage in the Turku archipelago with my wife. Our two children are finalizing their studies, so they don't come home very often."

Petri enjoys all kinds of outdoor activities and is an eager golfer when he has the time.



# The world's first luxury icebreaking cruise vessel

Over the past two years Aker Arctic has designed the first Polar Class (PC) 2 icebreaking cruise ship in close cooperation with Stirling Design International and the luxury expedition cruise company PONANT. The construction of the vessel will begin later this year at the Norwegian shipyard VARD, which has previously built icebreaking vessels based on Aker Arctic

designs The PONANT Icebreaker intends to take passengers to previously never explored polar destinations, such as the true geographic North Pole, the Weddell Sea, the Ross Sea and Peter I Island. This will be possible due to her PC 2 ice class and her excellent ice breaking capabilities. "There are not many icebreakers in the world which can manage the same," says Maximilian Vocke who is chief designer and the project manager, from Aker Arctic.

Before starting to design the vessel, Aker Arctic gathered and analysed ice data over a period of ten years to establish how harsh and demanding the circumstances for the cruise ship would be. "The cruises will go to the Arctic region in the summer, when the ice is least thick and at its softest, and to Antarctica when the southern hemisphere has its summer. Nevertheless, these are not easy regions for any vessel," Vocke adds.

#### **Unique vessel**

The hull is a modern PC 2 icebreaking hull design, which combines smooth icebreaking ahead in up to 2.5 m thick multi-year ice, and astern in severe ice conditions using a double acting ship principle (Aker Arctic DAS<sup>™</sup>) and a twin azimuthing propulsor arrangement. The vessel's performance is comparable to existing polar icebreakers but with lower ice resistance ensuring better fuel economy. This concept is the first commercial application of its kind for both efficient icebreaking and open water operation in high arctic conditions.

The recently introduced Polar Code has many requirements regarding passenger and environmental safety, and this vessel fulfils them all and more. "Other expedition cruise vessels for polar cruises currently under construction are PC 6 or 7 ice class," Vocke says. "PC 2 is a completely different story and opens a lot of new possibilities for an expedition vessel."

One of the rule requirements for passenger vessels is that a vessel must be able to return safely on its own even when damaged. For the defined operational areas of the *PONANT Icebreaker* this was discussed at an early stage of the concept development with both the selected classification society and the Flag Administration. A vessel must also carry equipment for five days of evacuation off the vessel, i.e. tents, warm clothes and food.

Passenger safety has been one of the crucial points in the design of this vessel. "The choice of a high ice class, taking all the requirements of the Polar Code into account, the 'safe return to port'-concept and winterization aspects, i.e. how all the machines and equipment can function in a cold climate, are all



important with passenger safety in mind," Vocke emphasizes.

#### Hybrid fuel options

PONANT is particularly committed to preserving the environment and protecting the poles. For this reason, highly advanced choices have been made. This will be the first hybrid cruise ship powered by liquefied natural gas (LNG) and electric batteries in addition to oil fuel. The advantage of LNG is that the emissions are considerably lower than for oil fuel. LNG-fuel produces no sulphur oxide (SO,) and very low nitrogen oxide (NO<sub>x</sub>) and carbon dioxide (CO<sub>2</sub>) emissions. The cruise ship complies with future IMO (International Maritime Organisation) and ECA (Emission Control Areas) regulations and fulfils the so called "Clean Ship" requirements with advanced wastewater treatment, energy optimisation, a heat recovery system and zero emissions in its electric hybrid mode.

During the concept development phase Aker Arctic was responsible for everything from the main deck downwards, as well as the machinery and design of the steel hull. Stirling Design International was responsible for the upper decks and interior design, while PONANT provided the guidelines for the development and ensured that the overall concept met their company's requirements. The steel hull will be constructed at VARD in Romania and then towed to Norway for finalizing work, interiors and finishing.

"VARD will perform the basic design and we will take care of ice related aspects, such as the hull form, steel classification drawings, model tests and propulsion design," Vocke adds.



Aker Arctic analysed ice data for a period of ten years before beginning to design the vessel to ensure that she would have the required features to manage the harsh conditions in the polar regions.



The vessel will bring passengers to previously unreachable areas.



PONANT already has several expedition cruise vessels, but none of them can break ice as this vessel can. "A cruise vessel like this one has never been built before," says Vocke.

This is a completely new, innovative vessel concept and therefore, after detailed calculations and careful evaluations, Aker Arctic decided to revise the initial design slightly so that the vessel can function efficiently in all the demanding areas it will sail in.

"It is a new step in the cruise industry," Vocke emphasises. "Technically the hull is optimised for both icebreaking and open water. All the machinery and equipment chosen is highly advanced and environmentally friendly. At the same time the vessel will be thoroughly luxurious." The PONANT icebreaker is a new step in the cruise industry.

"In addition to the exciting areas the passengers will be visiting, they will have the chance to experience icebreaking. It will be a unique experience not many have had before."

Vocke also wants to thank all the partners in this project. "The cooperation between all the partners has been extremely positive. We have all had the same interest in advancing this unique project and to make it come true."

# **Technical details**

Length	150 m
Beam	28 m
Draught	10 m
Power plant	Dual-fuel engines and electric batteries
Propulsion	2 x 17 MW ABB Azipod
Ice class	Polar Class 2
Classification society Flag	Bureau Veritas France
Staterooms	135
Passengers	270
Crew members	187
Passenger facilities	Two panoramic restaurants
	Grill restaurant
	Spa & Wellness
	salon
Zodiac boats	16
Helicopters	/



Passengers will have the chance to experience exciting areas. Photograph N. Dubreuil.

# Expert in adventure expeditions

**Director of Expeditions Nicolas** Dubreuil, at PONANT, has been guiding trips to the polar regions for 27 years. He has a proven track record in organising skiing, kayaking, and diving trips, as well Nicolas Dubreuil personally visits all the as all kinds of sportive adventure expeditions. Now he is busy planning the itineraries for the new icebreaking cruise vessel.



remote places he intends to include when he is creating an itinerary for expedition cruises.

Photographs N. Dubreuil.



# Building a story

Dubreuil personally does the scouting when he is creating an itinerary in order to locate interesting things, such as wildlife, geology, people and settlements.

"It is like creating a movie, I need to find exciting moments and build a story for our passengers. To experience ice for real is fantastic, but there is so much more you can see and do during a two or three-week cruise," Dubreuil adds.

"The new icebreaker will give us completely new possibilities. It is like a brand-new space ship. We can actually bring people to places I have had to ski for one month to see in the past. The passengers can disembark in locations where fewer people have been than have walked on the moon."

Apart from the extraordinary experience, the new vessel is dedicated to educating passengers about the polar regions, the eco-systems that exists there and sustainability. The last pristine places on earth are extremely vulnerable and must be treated carefully to preserve them. "As an example, we will not break ice to reach all the areas we intend to visit because both settlements and animals need uninterrupted ice cover, but instead we will use other means of transport to reach the most remote places. In Greenland the local residents will meet us with dog-sledges and in Antarctica we will be able to use our two helicopters, snowmobiles, skis or Zodiac boats to disembark and watch emperor penguins, for example, as we don't want to disturb them," Dubreuil says.

The first cruise is intended to depart around mid-2021 and will follow the east coast of Greenland. There will be plenty of activities and Dubreuil is working with the local settlements in the planning. "Just imagine the scene, the brand-new luxury cruise vessel arriving through the coastal ice to the fast ice where a group of residents with dog-sledges come to meet our passengers. It will be a once in a lifetime experience."



In 2001, Nicolas Dubreuil had a terrible accident in North Greenland when he was leading a ski expedition. He fell through the ice and in freezing temperatures nearly lost his fingers. "Luckily, with my body being used to the cold, I managed to preserve them in the end," Dubreuil says.

"A wise person once said: 'You have two lives and the second only starts when the first one ends'.'

At the time Dubreuil was a teacher of computer science at university. "For me, the accident was a wake-up call and changed everything. I wanted to dedicate my life to expeditions and adventures, so I quit my teaching job and bought a house in the most remote settlement in Greenland."

He continued as a guide and started to work with PONANT as an expedition leader.

"This taught me how useful a cruise ship is as a tool to bring people to remote areas, people who would otherwise not have a chance of experiencing them, for instance my parents."

"I also learnt that PONANT is a very special company. At PONANT we care about the passengers, the environment and how we do things. And we are prepared to go to wild places."

Today Dubreuil is the director of all the expedition cruises. His job is not only to plan routes and destinations, but also to recruit and train naturalists who are on board the ship to teach passengers about the polar areas.

"We take this matter very seriously and plan in detail how to minimize the impact on the environment. We also offer space for scientists on board so that they can have the opportunity to perform experiments, measure the ice and find out how to preserve the polar regions," he says.

# New Chinese polar research vessel under construction

Aker Arctic completed the basic design of a highly advanced icebreaking research vessel for the Polar Research Institute of China in the autumn 2017. The steel fabrication for the hull is now ongoing at Jiangnan Shipyard in Shanghai and the PC 3 ice class vessel is planned for delivery in 2019.

The icebreaking research vessel ordered by the Polar Research Institute of China will be used for research and logistics tasks for the polar oceans, mainly in Antarctica, where China has four permanent research stations. It will be possible to transport cargo and scientists independently to and from the polar regions, as well as perform advanced scientific research on-board the ship. which is equipped with all the main scientific equipment needed. All the technical solutions chosen for both the vessel itself, and for research purposes. represent the most modern available on the market.

## Design process

In 2012 Aker Arctic was selected for the conceptual and basic design of a new Chinese polar research vessel. "After the concept design we carried out a substantial number of model tests both in open water and in ice to verify the performance of the vessel," says Kari Laukia, head of ship design at Aker Arctic. "Then followed a three-year period of feasibility studies together with the ship owner to ensure that the vessel was designed to meet its mission goals and the solutions chosen were adequate and the best available."

The basic design was completed in 2017 and the classification societies, China Classification Society and Lloyd's Register of Shipping, have both verified the design. Construction is now well underway with the steel hull being welded at Jiangnan Shipyard in Shanghai, China. "Although Aker Arctic has successfully finalised the basic design, we are also supporting the owner in areas which are typically important for an icebreaker's operation and reliability by participating in tests such as inclining tests, open water





sea trials and other checks before ship delivery," Laukia says.

The vessel, named *Xue Long 2*, will be launched in 2018. According to the plans, it will be ready and delivered in summer 2019. Full-scale tests are planned to take place the following winter.

#### Advanced solutions

"While planning the vessel, the aim was to create a hull with good icebreaking performance and open water characteristics because the vessel will be travelling for long distances in open water on its way to Antarctica." Laukia explains. The PC 3 ice class vessel will be able to break ice which is 1.5 metres thick with snow cover of 20 cm. This can be performed bow first, which is the primary operation mode. In its astern mode the ship can move in difficult ice conditions effectively, but the ship is not designed to move astern continuously. A considerable amount of CFD (Computational Fluid Dynamics) calculations together with model testing were also made to take

hydrodynamics into account. The ship's icebreaking performance was verified by conducting numerous ice model tests.

The vessel will be fitted with dieselelectric machinery and two azimuthing propulsors. For manoeuvring and maintaining position, two bow tunnel thrusters will be provided. The power generation station consists of four main diesel generator sets. The propulsion power is 2 x 7.5 MW and in the aft ship two skegs will protect the propulsion from multi-year ice floes. The vessel can maintain an economic transit speed of 12 knots in open water using one engine and 15 knots with two engines, and in difficult ice conditions all four engines can be used.

A DP-2 dynamic positioning system was chosen to assure both redundancy in general sea conditions and good performance in bad Southern Ocean sea conditions.

March 2018





Winch room arrangement





Moon pool arrangement

Double classification ensures that the vessel complies with the rules from both China Classification Society and Lloyd's Register of Shipping.

"A special feature for the ship is the use of an LNG driven generating set, which ensures clean air operation when needed. This posed some challenges in taking the impact of hazardous areas into consideration in the design," Laukia says.

"Another demanding design challenge was to combine the Polar Code requirements for ice damage and special purpose ship damage stability requirements."

## Scientific equipment

The main task of the vessel is to carry out research operations in the polar regions. It is therefore fitted with highly advanced scientific equipment and instruments for marine geological and geophysical research, as well as marine biological and ecological research in addition to climate change monitoring and marine and seismic surveys. Laboratory space is abundant and there are several scientific winches.

"It is an extremely advanced research ship in addition to having icebreaking capabilities," emphasises Laukia.

When operating in icy conditions, researchers can make use of a moon pool to extend their research work. A special feature of the ship is a box keel below the ship. The location of the box keel was designed with the aim of achieving a minimal disturbance of the water flow while performing scientific tasks and for the minimum degree of ice contact during ice operation. This has required a significant amount of calculations, simulations and model testing.

Additionally, there are large cargo spaces in the bow, spacious cargo fuel tanks and a cargo crane for efficient cargo handling. A helicopter landing pad and a hangar accommodating two helicopters are located on deck 7.

The design has taken efficient internal logistics into account on board the vessel to ensure that all logistic operations are carried out easily and effectively.

Underwater noise, as well as inboard noise prevention have been significant design drivers. This has resulted in a double resilient mounting for the main engines and raising the diesel generator



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Length	122.5 m	
Beam	22.3 m	
Draught	7.85 m	

sets one deck higher than usual, for instance. Special noise insulation arrangements, as well as extensive vibration analyses were carried out in order to achieve low vibration and noise levels.

#### Expert in research icebreakers

"It has been an interesting long-term project to design and develop this advanced polar icebreaking research vessel with our Chinese customer," Laukia says. "We have both learnt a lot from each other. In this process we have learnt about research in polar waters and our customer has discovered how to utilise advanced ice technology in fulfilling the demands of a research vessel for polar regions."

China currently has one research icebreaker, *Xue Long*.

Power plant Propulsion Personnel 2 x Wärtsilä 16V32, 2 x Wärtsilä 12V32 Two azimuthing propulsors (2 x 7.5 MW) 90

"Once this new advanced polar research vessel is delivered in 2019, China will be in an excellent position to service the stations in Antarctica as well as perform scientific research," Laukia adds.

In addition to the new, icebreaking research vessel, Aker Arctic has had an extensive role in designing the Canadian Coast Guard polar icebreaker CCGS John G. Diefenbaker, which also will have research missions once it is constructed. The company also worked on the basic design of a French polar logistics vessel L'Astrolabe which was delivered last year. In the winter of 2015, Aker Arctic further performed full-scale trials of the American research vessel Sikuliag in the Bering Sea while conducting ice operational training of the officers. Aker Arctic was part of the design group for the vessel long before it was built.

"We took part in the design team supporting Glosten Design with ice issues and confirmed the ice performance with model tests before the *Sikuliaq* was built," says Aker Arctic CEO Reko-Antti Suojanen.

For the United States Coast Guard medium icebreaker USCGC *Healy*, delivered in 1999, Aker Arctic experts provided extensive conceptual development and design support, including hull form development and propulsion line engineering.

"Through our extensive experience we have gained essential competencies which can benefit new polar research vessel projects," Laukia emphasizes.

# Arctic LNG shipments commence

December 8th, 2017 was an important date for the longterm development of liquefied natural gas (LNG) shipments from the Arctic to the market. The LNG plant on the Yamal Peninsula above the Arctic Circle was officially inaugurated and the start of LNG cargo loading was celebrated.

Russia's President Vladimir Putin and other prominent guests watched as the first cargo lot from the Yamal LNG plant was loaded onto the icebreaking LNG carrier *Christophe de Margerie*, owned by the Russian shipping company Sovcomflot, one of the world's leaders specialising in the transportation of crude oil, petroleum products, and liquefied gas.

## Challenging area

The joint venture between Russian natural gas producer Novatek (50.1%), France's Total (20%), China's CNPC (20%) and the Silk Road Fund (9.9%) is expected to cost US\$ 27 Billion. Novatek started the building project in 2012. When completed, the project will comprise three production units with a total annual capacity of 16.5 million tons of LNG and up to 1.2 million tons of gas condensate from the resources of the South Tambey Field. Products will be shipped to Europe and Asia. The first LNG train, with an initial capacity of 5.5 million tons a year, is now operational and the other two will be ready in 2018 and 2019 respectively.

Durce: www.kremlin.ru

Russia's President Vladimir Putin and other prominent guests watched as the first cargo lot from the Yamal LNG plant was loaded on the icebreaking LNG carrier Christophe de Margerie.



The destinations of the first LNG shipments have been traced. The white lines are routes by Arctic LNGCs, the yellow ones show transshipments. So far all cargoes have been sold on the spot market.

Apart from the LNG plant, the project includes Sabetta port with two berths for large tankers and other port facilities for various supplies and a supporting fleet. Worth mentioning are the vast dredging jobs done for the port and the deep navigable fairways in Ob Bay which is very shallow by nature. The new international Sabetta airport serves the community and a 282 MW power plant is expected to become operational in 2018. The primary export markets for LNG will be both the East and the West. To China and other Asian markets LNG will be shipped via the Northern Sea Route during the summer season. Yamal LNG aims to tap into northwest Siberia's enormous natural gas reserves, accounting for 84% of Russia's total natural gas, and, once fully operational will double Russia's share in the growing global LNG market. Five completed arctic LNG tankers Christophe de Margerie, Sovcomflot Boris Vilkitsky, Dynagas Fedor Litke, Dynagas Eduard Toll, Teekay Vladimir Rusanov, MOL

While the Yamal peninsula has huge hydrocarbon reserves, it is an isolated region north of the Arctic Circle, about 2,500 kilometres from Moscow and is covered by ice for most of the year, with temperatures dipping as low as minus 50 degrees Celsius.

#### Successful long-term development

Aker Arctic's CEO Reko-Antti Suojanen also braved the polar night and freezing cold to be present for the historical occasion.

"It is a great pleasure to see our longterm development with Yamal LNG come true," he says.

From 2010 onwards, Aker Arctic has supported the development of the project by designing the Arctic LNG carriers, port fleet and related shipping infrastructure for transporting natural gas from Sabetta.

"Finnish engineers have been involved in developing transportation solutions for LNG since the 1970s," Suojanen adds. "After our invention of the double acting ship principle and the growing interest in LNG transport from the Arctic, the development of an Arctic LNG tanker began in 2004." (Read about the development of Arctic LNG carriers in the September 2017 issue of Arctic Passion News.)



#### Fifteen independent tankers

The LNG tanker Christophe de Margerie is the first in a series of 15 icebreaking LNG carriers ordered for the Yamal LNG project to transport LNG in the challenging ice conditions of the Kara Sea and Gulf of Ob. The vessels will open a new class of YamalMax ships. The 300-metre-long lead ship has a capacity of 172,600 m<sup>3</sup>, and is managed by a crew of 29. Furthermore, the vessel is capable of sailing independently through ice of up to 2.1 metres thick. Possessing the Arc7 ice class, the highest amongst existing merchant vessels, Christophe de Margerie can sail westward unassisted from Yamal yearround and eastward to the Asia Pacific destinations along the Northern Sea Route for six months during the summer season (from July to December). Previously, the summer navigation window in the eastern region of the Northern Sea Route was limited to only 4 months with icebreaker support.

In August 2017, *Christophe de Margerie* demonstrated her capability when she shipped a load of LNG without icebreaker assistance along the Northern Sea Route (NSR) from Melkøya, in Arctic Norway, to South Korea. The transit shipment along the most demanding NSR part was made in a

Novatek Arctic LNG 2 project status

Novatek has announced plans to further expand its LNG production on the Gydan peninsula. Located on the other side of Ob Bay from their recently operational Yamal project LNG facility at Sabetta, the Gydan peninsula has substantial natural gas reserves to provide for another, larger LNG project. The initial plans are to build gravity-based production facilities for a total of 18 million cubic metres of LNG production.

Three companies have partnered up with Novatek for this project, Linde (Germany), Technip (France) and NipiGas (Russia). Construction is planned to start 2019 with the first production train ready by around 2023. It is notable for the project that the costs are expected to be significantly lower, i.e. about one third of the costs for Yamal LNG. This can be achieved by using local resources to a larger extent than for the Yamal LNG project, reducing transportation and ground preparation costs.

Novatek has signed an agreement with Linde for the license concerning the natural gas liquefaction technology for the Arctic LNG 2 project. Capitalizing on the competencies gained from the Yamal The LNG tanker Christophe de Margerie is the first in a series of 15 icebreaking LNG carriers ordered for the Yamal LNG project to transport LNG in the challenging ice conditions of the Kara Sea and the Gulf of Ob.

days, whereas the whole loaded voyage took less than 18 days.

Since the first loading of LNG from Sabetta in December, there have been hectic activities in the new Arctic port. The first four completed tankers, *Christophe de Margerie, Boris Vilkitsky, Fedor Litke and Eduard Toll* have all visited the Sabetta port frequently to load LNG cargoes. The fifth ship is in the process of final commissioning in Russian waters.

At the inauguration ceremony, Chairman & CEO Leonid Mikhelson of Novatek said that the Yamal LNG plant would start regular deliveries under major long-term contracts in April 2018. According to him, 96% of the LNG produced at the plant has been contracted. Before April and later in the year, spot deliveries to different locations will continue. The destinations of the first LNG shipments have been traced. See details on page 10.

The port of Sabetta is working well and the tankers are loading and discharging their cargoes according to plan. Construction work on the site is continuing to complete the second and third train on schedule while the remaining ten tankers are at various building stages at the Daewoo Shipbuilding & Marine Engineering (DSME) shipyard in South Korea.

LNG-project, the partners have chosen new techniques for the project. The production facility will be gravity based, with the plant sitting on a trio of platforms, which will be held in place on the seabed.

"Three aspects of the new project are important: the location of the facility, thus creating an LNG hub with a common port and cargo fleet; the building and testing of the gravity based structures and the topsides at the Kola yards in Murmansk; and the targeted destination of the trans-shipment port in Kamchatka, closer to major end users," says Roumen Tzvetanov, head of business development for oil and gas at Aker Arctic.

# Self-propelled detachable icebreaking bow for Lake Saimaa



The Finnish Transport Agency has together with ILS Oy developed a new and innovative self-propelled detachable icebreaking bow to improve and ensure icebreaking capacity in freshwater Lake Saimaa and the Saimaa Canal. This bow will be pushed by the tugboat *Calypso*, which usually assists vessels in sea-ports in Southern Finland.

The innovative detachable icebreaking bow will be fitted on the tugboat Calypso.

Lake Saimaa is the biggest lake in Finland and the fourth largest freshwater lake in Europe. The Saimaa Canal, which opened in 1856, is a transportation canal that connects Lake Saimaa to the Gulf of Finland near Vyborg in Russia. The canal has been of great importance for industry in Eastern Finland, and is still today the most economical route for timber and other export goods.

During the winter the lake and canal freeze, therefore icebreakers are necessary to keep the waterways open and extend the season in support of the export industry. Products for domestic use can be transported by road or by rail, but it is more beneficial and ecological to transport export cargo along waterways.

## Fitted on existing tug

In order to improve and secure icebreaking capacity in Lake Saimaa and the Saimaa Canal, the Finnish Transport Agency and Finnish company ILS Oy have under the WINMOS II project together developed an innovative selfpropelled detachable icebreaking bow. Based on a procured ten years contract,



The new detachable ice bow will be 25.3 metres long and have a beam of 12.6 metres. A special feature is that the bow will have its own propulsion system, which will improve its efficiency and manoeuvrability.

the bow will be pushed by the tugboat *Calypso*, which is owned and operated by Finnish shipowner Alfons Håkans Ltd. Calypso usually assists vessels in seaports in Southern Finland and is suitable for winter use with Finnish-Swedish ice class 1A.

Previous winters, the icebreaking vessel Protector with a non-motorized loose bow and a few other tugs have kept water ways in the lake and the canal open, but these vessels are getting old and inadequate and capacity needs to be renewed. Before *Protector*, icebreaker *Arppe* performed the main task, but was later sold to become an icebreaker on the Caspian Sea.

Acquiring a completely new icebreaker is a huge investment. Traffic on the lake and the canal are still limited and seasonal, so currently it does not make sense to buy a new icebreaker.

The Finnish Transport Agency is responsible for winter navigation in Finland and is trying this innovative option as part of the EU-funded WINMOS II-project: "Winter Navigation Motorways of the Sea II". The WINMOS II is a continuation to the WINMOS Iproject, in which Aker Arctic also participated. The aim of the WINMOS IIproject is to improve winter navigation for the future by developing existing vessels and finding new options. The Finnish Transport Agency acts as a coordinator in the project.

#### Own propulsion system

The new detachable icebreaking bow will be 25.3 metres long and have a beam of 12.6 metres. One special feature is that the bow will have its own propulsion system, which will improve its efficiency and manoeuvrability. Two shaft-lines will be installed on both sides of the bow, each having 600 kW power.

The tugboat *Calypso* when outfitted with the new icebreaking bow will break a wider channel than before, which will enhance the transportation of cargo along the Saimaa waterway.

While ILS has developed the icebreaking bow, Aker Arctic has performed the model tests for the design.

Turku Repair Yard in Naantali has been selected to construct the bow and additionally make alterations to *Calypso* in order to connect two units seamlessly. The bow is to be delivered to the owners by the end of 2018. Full- scale ice trials are planned for next winter. The aim of all involved participants is to gather as much information and experience as possible to establish whether this removable ice-bow concept will be possible to enlarge and use on other, bigger vessels and in other sea areas. In some areas it could be very useful to have this kind of multipurpose vessel, which could break ice in winter and perform other duties in summer.

#### New propellers for winter

An additional feature will be to equip *Calypso* with new propellers for the icebreaking season. The existing nozzles are susceptible to clogging during icebreaking operations, but this is avoided with the new nozzle-free propellers. For summer, the original propellers will be re-installed. This is something quite new, as the vessel has to be dry-docked in order to change the propellers.



During winter the lake and canal freeze and an icebreaker is necessary to keep the waterways open and extend the season in support of the export industry.



The Finnish Transport Agency is investigating the possibility to enlarge the locks on Saimaa Canal, as this would allow larger vessels on the canal. Larger locks would also benefit existing vessel sizes during winter faring.

# Model testing of autonomous ships

Remotely controlled and autonomous ships represent a fundamental change in shipping over the next decades and are driving the digital transformation in the sector. Aker Arctic is currently developing the in-house testing facility to enable tests with autonomous vessels.

Multiple instruments are used in support of operating and manoeuvring modern ships and all current vessels have a captain and crew who are responsible for handling the ship and ensuring that nothing goes wrong. However, during the past few years, the idea of developing vessels which can work autonomously has evolved and it is believed that these will become reality over the next decades. The development is expected to start with small vessels with a reduced crew and will eventually evolve into large unmanned ocean-going ships. There are nevertheless many opinions on how the development will take place and how quickly autonomous ships will become reality.

# Model testing benefits the development

When developing technologies and automated control systems for autonomous vessels, it is useful to test these first in model tanks. Aker Arctic's ice laboratory provides an attractive tool for testing and developing automated controls because many different conditions, even freezing and misty weather, can be simulated. It is a much more economical way than to first building a real size vessel and then testing it under full-scale conditions.

In order to carry out autonomous ship model testing, some major improvements to equipment and procedures have been made. The testing facility is currently being equipped with a wireless system allowing complete free manoeuvrability of the models when testing autonomous vessels.

# "New propulsion units and propulsion control units have also been developed,"

says project engineer Jukka-Pekka Sallinen, who is heading the development team at Aker Arctic.



New propulsion units for model testing have been developed.



"We will initiate tests with the new propulsion unit system, which allows specific control of the vessel motion. Once the tests prove successful we will continue to test our in-house path finding algorithm and route execution tests," says Sallinen.

#### What is DIVEC?

Aker Arctic's newly developed software DIVEC is a simple, powerful and almost zeroconfiguration networking architecture, originally designed for the ice load monitoring system to transmit messages between different systems. It proved to be so useful, that it has also been applied in the ice simulator and the autonomous model testing system. The software architecture allows reliable communication between different software components. Expanding the network is easy due to the automatic node discovery, and its centralized configuration management enables the development of plug-and-play devices.

With the DIVEC framework Aker Arctic can provide modern solutions for transferring data between various sensor interfaces, data acquisition systems and visual user interfaces.

# Co-operation with SSPA and Aalto University

One of the challenges in developing autonomous vessels is that maritime laws do not recognize vessels with a reduced crew, or no crew at all. "The technology is evolving, but there are no regulations or technical standards for autonomous vessels yet," Sallinen says. Aker Arctic, SSPA and Aalto University have therefore decided to start a co-operation project with the aim to standardize the procedures for autonomous ship model testing. The purpose is to create an interface that allows testing the same systems and algorithms in all test facilities.



A wireless system allows complete free manoeuvrability of the models.



Aker Arctic's ice laboratory provides an attractive tool for testing and developing automated controls because many different conditions, even freezing and misty weather, can be simulated.

# Meet Olli Kokko







Olli Kokko joined Aker Arctic in fall 2017 after graduating from Aalto University. In his master's thesis, he developed a reactive navigation system for model testing, and has since been tasked with various software and technical development projects for the Electrical and IT team. DIVEC networking architecture and its various components are a major part of his development efforts.

In his spare time, Olli enjoys climbing, jogging and tinkering with electronics and machines.

# Our man in Moscow

Alexander Nemchinov has served as a link between the Russian and Finnish marine industries since the 1970s. He has been part of many important icebreaking projects, such as the SA-15 series Arctic cargo ships, the building of nuclear-powered icebreakers *Taymyr* and *Vaygach* as well as the introduction of double acting ship principle with the Arc7 ice class Arctic container vessel *Norilskiy Nickel*. This year, he is turning 70 and is slowly easing up on his professional activities.

Alexander Nemchinov was born in Moscow and lived with his family directly opposite the Moscow North River port. From early spring until late autumn the shipping life flowed before his eyes. As a teenager he began to spend his free time on ships and from the age of 16 started to work during his holidays as a sailor. In 1966, Nemchinov entered the ship mechanics department at the Higher Marine Engineering College in Odessa. While studying, he practiced onboard various ships, among them the Arctic steam tug in the Tiksi port on the Northern Sea Route.

#### Arctic experience

Nemchinov started his career as an engineer on board the arctic fleet of the Murmansk Shipping Company, sailing along the Northern Sea Route and abroad. He later joined the Ministry of Merchant Marine in Moscow, where his role was mostly with the icebreaking fleet as he had gathered hands-on experience in his previous job.

"When the *Taymyr* project was initiated in the late 1970s, I was an employee at the customer's shipbuilding office. I was about 30 years old, had some basic knowledge in nuclear technology and ambitions to join the project," Nemchinov says.

"So I became involved in a rather complicated development project in close cooperation with Wärtsilä and USSR industry until the shipbuilding contract in 1984. I then took part in the construction process at Helsinki Shipyard as the customer's representative."

"Rosatomflot, the operator of *Taymyr* and *Vaygach*, is very happy with the icebreakers as they have run without a hitch through their long operational history," Nemchinov adds.

In the early 1990s, Mikko Niini invited Nemchinov to join a Kvaerner Masa-Yards representative office in Moscow and when Aker Arctic Technology was founded in 2005, it was natural to proceed as their representative as well, reporting to Niini, who was in charge of that office.

# Revolutionary double acting ship concept

Another significant project, Norilsk Nickel's Arctic container vessels project, was initiated in the early 2000s. This opened a new era in the Arctic with the introduction of the double acting ship principle on Arc7 ice class vessels.

"The challenges were that the customer wanted the vessel to be delivered at their berth in Murmansk after full-scale tests. At that time, it was unheard of to attempt operations on the Northern Sea Route without icebreaking support. However, today the *Norilskiy Nickel*-class vessels are one of the best references for Aker Arctic Technology and most Northern Sea Route vessels follow the double acting ship principle."

Some other memories from his early career involve being an apprentice for the Arctic Shipping Company based in Tiksi, running supply operations along Northern Sea Route.

"They still had 800 horsepower coal-fired Turku-built tug boats. I served for a few months as a stoker, which was a really tough job and a unique experience. It was a breakpoint in my life career, and I truly understood that what doesn't kill us makes us stronger."

Another special memory were the sea trials of the icebreaker *Kapitan Nikolaev* in 1990. The ship had undergone a conversion outfitted with a new conical bow susceptible to slamming in open water.

"After some confusion with the crew, who were unfamiliar with the converted ship, the MARC (Masa-Yards Arctic Research Centre) team managed to prove the vessel's performance."

Nemchinov recently celebrated his 70th birthday but is not yet certain on what he wants to do when he retires. He is fond of many things ranging from classical music to outdoor activities and marine adventures.

"Maybe I'll sail on a tall ship as a deck hand," he says.



Alexander Nemchinov loves boat life.



Nuclear-powered icebreakers Taymyr and Vaygach, built in the 1980s, are still running and have done so without a hitch through their long operational history.



Norilsk Nickel's Arctic container vessels opened a new era in the Arctic with the introduction of the double acting ship (Aker Arctic  $DAS^{TM}$ ) principle on Arc7 ice class vessels.



Nineteen SA-15-class multipurpose Arctic cargo ships were built for the Soviet Union in the 1980s by Wärtsilä in Turku and Valmet in Helsinki.

# Safe winter traffic on the Baltic Sea

The European Union's northernmost waters are covered by sea ice every winter, affecting smooth maritime transport in the region. During normal and cold winters a high number of vessels are frequently delayed due to ice conditions. The Winter Navigation Motorways of the Sea II (WINMOS II) project aims to ensure safe and reliable winter traffic in a cost-efficient way by further developing the winter navigation system and ensuring sufficient icebreaking capacity.

WINMOS II is a continuation of the previous WINMOS (I) project. The main objectives of WINMOS II are to further develop and enhance the maritime winter navigation system and its safety and to safeguard the required icebreaking resources by developing new options as well as by upgrading the old capacity to meet modern day environmental standards.

#### Ice extent varies

The debate on global warming is continuously ongoing and some people think that there will be no ice in the Baltic Sea in the future. It is therefore important to underline the fact that sea ice is expected to occur during the foreseeable future and will not disappear for many generations. Long periods with mild winters have happened before, e.g. between 1930 and 1940. merchant vessels to pass through without icebreaker assistance, hence making icebreaking a necessity in the region even during mild winters. Ice coverage in the Baltic Sea varies between winters. During severe winters, even the Danish straights freeze over. navigation system must continuously be developed and meet the requirements of trading countries. More efficient, economical and environmentally friendly transportation is needed due to increasing traffic volumes, increased demands for sustainable development and more demanding environmental laws. This equally applies during the winter, and it is further important to remember that education and training is required to work and operate in cold icy conditions.

#### Implementation

The implementation period of the project is from 11 February 2016 till 31 October 2019. The budget of the whole project is



Different ice extents between mild, average and severe winters.



#### Ice extent 1900-2015

It is impossible to forecast the extent of ice coverage for the next coming years and therefore there must always be preparedness for severe winters. It is also very important to bear in mind that winters with lesser ice coverage are not easy from a merchant vessel's perspective. During these winters the winds are typically stronger, causing heavy ridging, and pressurised and drifting ice-fields in the fairway entrances. Most often these are either impossible or at least not safe for

**Costs of icebreaking services** The annual cost of icebreaking services depends on how severe the winter is, but during an average winter the cost of icebreaking in the Baltic Sea for Sweden, Finland and Estonia is about 86M€. The cost of the whole winter navigation is much greater. The operational season for icebreakers is usually between December and May but in a severe winter it can start as early as October.

Modern logistic standards require predictability in the transport system the whole year round, which is why the winter 18.97 million euro and the amount of granted CEF funding is 6.64 million euro.

#### Nine focus areas 1. Implementation and further development of IBNext

The objective of this activity is to further modernise and deploy the IBNext platform. The existing 20-year-old icebreaking network, IBNet is a system where satellite images, AIS-targets, port list, ships register, weather forecast, information on other icebreakers' intentions etc. are integrated in one system aboard the icebreakers and ashore in control centres.

#### 2. Study on battery hybrid for safer and more environmentally friendly operation

The objective is to investigate the needs and potential savings for the large *Atle/Urho*-class icebreakers, which have a diesel-electric propulsion system. The outcome of this study can be used for a number of applications in the maritime field when additional power is required for a short time.

# 3. Further development of the common rail system

The objective for this activity is to complete the installation of the common

# 4. Life extension of Finnish icebreakers

The aim of this activity is to execute a life extension and upgrading programme for two Finnish icebreakers, the 1954-built *Voima* and the 1976-built *Sisu*.

#### 5. Pilot study on removable icebreaking bow

The objective of this activity is to pilot the transformation of ice strengthened vessels and larger tugboats into icebreakers during wintertime by installing a removable icebreaking bow equipped with engines and propellers. With reduced investment costs, this concept would provide more flexibility for the use of the fleet and will be of great assistance in terms of extra resources during extremely hard winters when more icebreaking services are needed.

# News in brief

The aim of this development activity is to develop a programme and tools for training icebreaker officers. In the previous WINMOS (I) project, a training programme for ship officers was developed. The focus of the project was mainly on merchant vessels and the required skills of the ship officers navigating in ice covered waters. The training of icebreaker officers also needs further development.

# 7. Study on life extension works for Estonian icebreakers

The objective of this activity is to prepare a detailed study of the current technical situation of Estonian ships. A detailed technical study will be focused on the icebreaker *Tarmo* and the multipurpose vessel *EVA-316*.

# 8. Study on the adequacy of icebreaking capacity in the Baltic Sea for severe winters

Statistically, severe winters occur once or twice in a decade. The last winter classified as a severe winter was in 2010-2011 with a maximum ice extent of 309,000 km<sup>2</sup>. Since then the winters have been classified as normal or mild. The simulation model for winter navigation traffic from the WINMOS (I) project will now be utilized in the analysis and will be further developed and a scenario for very severe winters will be studied.

Based on these findings, a contingency plan will be drawn up to ensure icebreaker capacity and other operational means to safeguard maritime transport in the whole Baltic Sea during a very severe winter when most of the Baltic Sea freezes.

# 9. Project management and dissemination

This activity covers the technical and financial coordination of the action by the project coordinator – the Finnish Transport Agency, with the support of the activity leaders.

http://www.winmos.eu/about/



# Novy Port icebreakers close to delivery

The two icebreakers designed to support loading operations at the Arctic Gates oil loading terminal off Novy Port are currently in the final stages of construction at Vyborg Shipyard. The first vessel, *Alexandr Sannikov*, will be delivered to Gazprom Neft this spring and the second icebreaker, *Andrey Vilkitsky*, will follow later this year. The oblique icebreaker *Baltika*  is currently performing ice management and standby duties at the offshore oil terminal, while waiting for the two more powerful vessels based on the Aker ARC 130 A design to start service in the Gulf of Ob next winter. Full-scale ice trials will be performed after delivery of the vessels.

# Port icebreaker for Sabetta to be launched

The port icebreaker for Sabetta LNG-terminal, *Ob*, will soon be launched at Vyborg Shipyard. The Icebreaker7 ice class vessel is expected to be ready for delivery before the end of this year. Based on the Aker ARC 124 concept and basic design by Aker Arctic, *Ob* will become part of Atomflot's Portoflot project, tasked with keeping the harbour in Sabetta open and assisting LNG-tankers in berthing and loading at the terminal. Additionally, three tugboats have been delivered for the harbour: two Arc4 ice class tugs and one Arc6 icebreaking tug.



# L'Astrolabe on her first missions

The French polar logistics vessel *L'Astrolabe* has her first summer in the southern hemisphere behind her. She has successfully undertaken several supply trips from Hobart in Tasmania to the French research station, Dumont D'Urville, in Antarctica. Now she is returning to Reunion Island for patrolling duties in the Indian Ocean during the winter months.

Stanislas Devorsine who is the vessel's acting ice pilot for the first voyages to the Antarctic, has tweeted (@StanDevorsine) regularly about their first summer season. The vessel has encountered rough seas, tough ice conditions, freezing temperatures and snowstorms, but also blue skies and beautiful scenery. He has praised the vessel's manoeuvrability in both open water and coastal ice.

At the start of the season, *L'Astrolabe* parked at the edge of the fast ice, about 50 kilometres north of Dumont D'Urville, and supplies were transported to the station by a convoy of snow vehicles and the helicopter that the vessel carries on-board.

The helicopter was also used to survey the route and to find an optimal path through the ice pack. By the end of the season, *L'Astrolabe* had managed to reach all the way to Dumont D'Urville through the ice.

The CEO of Chantiers Piriou (the shipyard responsible for the construction of *L'Astrolabe*) Pascal Piriou was onboard the polar logistics vessel during its last voyage for this austral summer in the beginning of February 2018. Mr Piriou had the chance to experience operations hands on and to gather valuable feedback on the vessel for both the shipyard and designers.

L'Astrolabe parked close to Dumont D'Urville. Photograph: S. Devorsine

"More detailed information about the successful operation during the first voyages to Antarctica will be available at the Arctic Passion Seminar in March 2018," says project manager Anders Mård.

In addition to the basic design and testing of the vessel, Aker Arctic provided technical support to Chantiers Piriou throughout the construction period. Specialists visited the shipyard at regular intervals to ensure that technical aspects for the ice-going ship were taken into account. The vessel was finished on time within a tight two-year schedule.

L'Astrolabe was delivered in September 2017 to her owners and operators TAAFthe French Southern and Antarctic Lands, IPEV - the French Polar Institute and the French Navy.

# USCGC Polar Star reaches McMurdo station

The Seattle-based, US Coast Guard cutter *Polar Star* forced its way through the Antarctic ice in January as part of its annual mission and cleared a path through frozen waters for supply ships headed to Antarctica's logistics hub, the McMurdo Station.

The summertime supply deliveries allow the station to stay operational yearround. The McMurdo station is home to the largest laboratory in Antarctica, the Albert P. Crary Science and Engineering Center. McMurdo also serves as a staging area for teams headed to the Earth's geographic south pole, were the Amundsen-Scott Pole Station is located, and other deep-field research camps.

USCGC *Polar Star*, commissioned in 1977, is the US Coast Guard's only functioning heavy polar icebreaker. However, according to Coast Guard Commandant, Admiral Paul Zukunft, it is living on borrowed time. Her sister ship, USCGC *Polar Sea*, is currently being used for spare parts. (news.usni.org.)

Acquisition programme underway The acquisition programme launched in 2016 to replace USCGC *Polar Star* with a new, modern, heavy polar icebreaker is well underway with industry studies being finalized and proposals for construction being prepared. The decision on where to construct the first vessel is expected in 2019, with delivery in 2023.



In a recent seminar, Admiral Zukunft explained that the need for heavy icebreakers is growing, as other nations including Russia and China, routinely stake claims in the polar regions. The plan, as of now, is to build a total of six icebreaking vessels: three heavy and three medium icebreakers. However, budget constraints may alter this plan.

# Improving Arctic shipping safety

A consortium of 13 research organisations and industrial partners from six countries has launched a joint development project, SEDNA, to address improved safety and efficiency in arctic shipping operations. Funded by the EU's Horizon 2020 programme, the three-year project sets out to develop a novel risk-based approach to arctic navigation, ship design and maritime operations. Aker Arctic is one of the partners in the project.

SEDNA focuses on: modern bridge systems with state of the art tools, improvement in voyage planning incorporating data transfer and big data utilisation, research into anti-icing

# Learning about technology

At the end of November, all of Aker Arctic's staff gathered for a Technology Day. The purpose was to learn about the different technologies we work with every day.

Managing Director Reko-Antti Suojanen opened the day and told us about the company strategy. He spoke about what are we supposed to do, why are we doing it and where we are heading. We then worked in groups preparing how to present to each other the different technologies we work with, listened to various presentations as well as prepared targets and actions for the coming years.

# Christmas party celebration

After the serious part of the day, we all boarded a private boat for transfer to Suomenlinna fortress for a casual Christmas dinner. Suomenlinna is a bastion fortress built on a group of solutions, safety assessment of low flash point fuels, as well as risk-based methodologies in the design and operation of ice-going vessels.

"This international development project provides a good platform to further improve areas in safety and efficiency of the designs for the arctic shipping and navigation," states Mr Reko-Antti Suojanen, Managing Director of Aker Arctic Technology Inc.

Further information about the SEDNA project can be found at https://sedna-project.eu/

# Development of icebreaker training

Aker Arctic, jointly with Aboa Mare, Finnpilot, Alfons Håkans, Simulco and Image Soft, has continued to develop the Aker Arctic ice simulator.

"We have added a component which can be used to train a crew in how to perform icebreaker assistance," says Jukka Salminen, Aker Arctic. "Assisting another vessel in ice is a challenging task and to be able to practice it before actually doing it for real, is a fantastic opportunity."

User feedback is now being gathered and training can begin in the autumn.



islands close to the Finnish capital Helsinki. It was built during the Swedish era of our country's history as a maritime fortress and was a base for the archipelago fleet. A special feature is that in the course of history, Suomenlinna has served in the defence of three realms: Sweden, Russia and Finland. In 1991, the Suomenlinna fortress was added to the UNESCO World Heritage List as a unique monument of military architecture. It continues to be a living, tended and inhabited district of the city of Helsinki, and can only be reached by boat. Christmas party at Suomenlinna fortress outside Helsinki.

The evening culminated with a quiz presented by Aker Arctic's famous master of ceremonies Anders Mård. The quiz was titled: Who wants to be an Arctic Naval Architect in 2017?

Aker Arctic expert teams competed to answer correctly some extremely challenging questions regarding topics such as the Canadian icebreaker *Canmar Kigoriak*, the Caspian Sea Monster, and Göran "Gösse" Wilkman.

# Meet us here!

We will participate in the following events:

Arctic Meteorology summit, Levi, Finland 20 - 21 March 2018

Current policy and Operational Issues in Arctic Shipping Safety and Environment Protection, Brussels, Belgium 20 March 2018

Russian Shipbuilding Conference, St. Petersburg, Russia 5 - 6 April 2018

**Neftegaz,** Moscow, Russia 16 - 19 April 2018 Arctic Shipping Forum, Helsinki, Finland 17 - 20 April 2018

Navigate, Turku, Finland 16 - 17 May 2018

International Economic Forum, St. Petersburg, Russia 24 - 26. May 2018

Yamal Oil and Gas, Salekhard, Russia 7 - 8 June 2018

**ISOPE**, Sapporo, Japan 10 - 15 June 2018

International Marine Design Conference, Espoo, Finland 11 - 14 June 2018 ICCE International Conference on Coastal Engineering, Baltimore, USA 30 July - 3 August 2018

**SMM**, Hamburg, Germany 4 - 7 September 2018

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