Safe and green ship operation in ice-covered waters

The consequences of global warming may reduce the need for icebreaking assistance in certain shipping areas, but will also open up for increased sea traffic and offshore activities in pristine Arctic areas. This situation provides opportunities to reduce the carbon footprint from maritime transport through reduced fuel consumption in sea areas such as the Gulf of Bothnia and the Gulf of Finland, and also through favourable conditions for transoceanic short cuts in the Northern Sea Route (NSR). But it also entails considerable environmental and safety risks that must be carefully assessed and controlled. SSPA is currently engaged in a number of client assignments and inter-disciplinary research projects related to oil-spill risk assessment and safe traffic management in ice-covered waters.

Ship grounding and collision events may potentially cause spills of crude or bunker oil, and it is of the utmost importance that proactive prevention and response organisations are established in parallel with the development of Arctic offshore and shipping activities. SSPA has long experience of designing adequate contingency plans for offshore and ship operators, and is also regularly engaged by competent national authorities for advisory services regarding the development of spill-preparedness plans and state-of-the-art techniques for spill response and recovery at sea, as well as shoreline clean-up. These experiences have been combined with our competences in icebreaking ship design and winter navigation, and are further developed in our research activities, making SSPA a strong partner for consultancy assignments as well as training activities.

No operations without preceding spill-risk assessment and adequate preparedness

The most recent use of SSPA’s oil-in-ice expertise is as part of the EU Horizon 2020 project GRACE. In this project, SSPA provides expertise within spill recovery and beach clean-up techniques and has produced a dedicated oil-in-ice code to facilitate the choice of adequate response method. SSPA will also develop methodologies for oil-spill risk assessment as well as specifications on how to adapt existing icebreakers and supply vessels for Arctic spill response purposes. Logistics for supply of response resources as well as transport and disposal of recovered oily waste are of particular importance in remote Arctic areas far from land-based infrastructures and ports. Today’s increasing interest in cruising in Arctic areas also high-

Possibilities and challenges of ship operation in the Arctic and ice-covered waters

The 2016 minimum sea-ice coverage of the Arctic Ocean confirmed the recorded trend towards ice-free summer seasons in the NSR (Northern Sea Route) as well as in the Northwest Passage. Long-term measurements show that the Arctic ice thickness has reduced by around 40% in the last 35 years. Though ice conditions along the NSR are predicted to become increasingly attractive for shipping, there is still no upturn in recorded traffic statistics, although oil companies are showing renewed interest in Arctic offshore exploration for oil and gas. Such activities also involve a lot of sea transportation activities and, from a long-term perspective, shipping of crude and gas through sensitive Arctic sea areas.
lights the importance of enhanced resources for rescue operations and potential large-scale passenger evacuations.

Without safe measures to prevent and respond to oil spills in sensitive Arctic areas, the potential to be gained from new sea routes or permits for the exploration of natural resources will not be realised.

One important instrument for ensuring that ships operating in Arctic and ice-infested waters are safe and strong enough is provided by the new international Polar Code and by established regional ice class regulation.

**The Baltic Sea is our ice test basin – Full-scale field measurements of ice resistance**

The low salinity of the Baltic Sea makes the ice harder than normal first-year sea ice, and in the Gulf of Bothnia and the Gulf of Finland, ice conditions with pressure ridges and fairway channels with cumulated brash ice from repeated icebreaking make winter navigation challenging.

The Finnish Swedish Ice Class Rules (FSICR) have been drawn up and applied to ensure that only vessels with enough strength and power are operating in the area and assisted by available icebreaking services. Depending on actual ice conditions, different ice class restrictions are in place for different areas and ports. For the highest ice class, IA Super, a vessel should be capable of traversing a broken brash ice thickness of one metre plus a consolidated ice layer of 0.1 metres at five knots.

In addition to hull shape and sufficient displacement, one cornerstone in the performance of ice-strengthened vessels is the installed main engine power output. In the FSICR, the
SSPA has long and wide-ranging experience and great technical competence in Arctic shipping and spill prevention.

The required minimum engine power is calculated using a formula including an ice-resistance figure that can be derived using two optional methods: using either a theoretical calculation method or model tests. The two options sometimes result in different power requirements, and there is a concern that the model test option tends to underestimate the power requirements. Full-scale verification is needed to investigate this issue.

In the “ChanIceRes2” project, SSPA therefore equipped one vessel regularly operating in the Baltic Sea ice with on-board measurement equipment for recording speed, output power, etc. The data is transferred, together with AIS (Automatic Identification System) information, to SSPA where it is combined with actual ice observations and measurements on site. The results indicate that the model test may underestimate the power requirements, but due to extraordinarily mild ice conditions during the two last winter seasons, more field measurement data in tougher ice conditions, and preferably also from other vessels, is needed for conclusive verification of results.

**How to balance engine-power requirements for EEDI compliance and ice-class denotation**

Another area where conflicts may occur between potential fuel-saving measures and safe ice navigation of ships has been identified: the introduction of the EEDI (Energy Efficiency Design Index) and the design requirements implicated by the FSICR.

In a recently initiated study called “ICEEDI”, SSPA uses experience gained from the Baltic Sea to analyse conflicts between ice-going capability and EEDI compliance for FSIC-classed vessels.

Potential adjustments to the proposed correction factors for EEDI calculations for ice-classed vessels are estimated and analysed in order to ensure safe and consistent ice-manoeuvring capability for EEDI compliance of ice-going vessels. Existing technical and potential innovative measures to bridge diverging minimum FSIC power requirements and more stringent EEDI requirements will be systematically analysed and compared. Ship-design aspects influencing the energy-efficiency of FSIC-classed ships will be reviewed from a cost-benefit perspective. The use of low-carbon fuels and in particular the use of bio-fuels will also be analysed in terms of regulative EEDI compliance and flag-state approval.

**Next generation of Swedish icebreakers**

SSPA is currently supporting the Swedish Maritime Administration (SMA) with technical
expertise in the design and procurement process of new icebreakers. The plan is to replace existing Swedish icebreakers, which are about 40 years old, with the next generation within a period of ten to fifteen years.

SSPA’s tasks cover a wide range of design and planning aspects, and one important environmental issue is of course the fuel. Engines allowing fossil free operation will be considered and various options for local production of renewable fuels will be assessed by SSPA from technical, economic, and environmental point of view.

Major forestry industries are located around the Gulf of Bothnia, and black liquor from wood pulp plants, for example, could be used to produce methanol. Other potential fuel options to be addressed include HVO (hydrotreated vegetable oil), FAME (fatty acid methyl ester) and LNG (liquefied natural gas). Typical operational cycles of icebreaker engines with repeated ramming of ice ridges etc. also make battery hybrid solutions particularly interesting and may offer attractive combos with dual-fuel-electric propulsion systems.

SSPA has long and wide-ranging experience and great technical competence in Arctic shipping and spill prevention, facilitating your efforts to ensure efficient and environmentally sustainable maritime transport solutions in a future environment with new ice conditions, sea routes and regulations.

GRACE (Integrated oil spill response actions and environmental effects) is coordinated by the Finnish Environmental Institute (SYKE). The 3.5-year project will involve 13 research institutes and companies in total, from nine different countries.

Ship traffic requires regular icebreaking to keep the brash ice channels navigable.

**Nelly Forsman**
Project Manager.
Nelly has an M.Sc. in Sustainable Energy Systems, majoring in Mechanical Engineering. She graduated from Chalmers University of Technology in 2012. Since joining SSPA in 2014, Nelly has mainly worked on studies of LNG as a marine fuel, LNG bunkering, AIS analysis and maritime risk analysis. Nelly is also currently involved in research projects on winter navigation and ice related projects. Prior to joining SSPA, Nelly also gained experience of numerous different permit processes.

Contact information
E-mail: nelly.forsman@sspa.se

**Björn Forsman**
Project Manager.
M.Sc. Mech. Eng. Björn joined SSPA in 1980 and has been active in areas related to the marine environment, oil spill prevention and clean-up as well as the reduction of ship emissions and alternative fuels. Currently, maritime safety and risk analysis are the main fields of expertise in his projects and in the research projects that he is engaged in. He has also been the programme manager for a number of advanced international training programmes.

Contact information
E-mail: bjorn.forsman@sspa.se

**Anders Broberg**
Senior Consultant.
M.Sc. Naval Architecture, graduated from Chalmers University of Technology in 1981. Anders has spent most of his professional life working with tankers, both as Class surveyor and as owner’s representative. He has, spent many years in Asian shipyards supervising the construction of tankers, some of them ice-classed.

Anders joined SSPA in June 2016 and works with the Swedish Maritime Administration in their project in developing and building next generation icebreakers for the Baltic.

Contact information
E-mail: anders.broberg@sspa.se