Studies on Oil and Ice*

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Abstract

Shipping in the Arctic and the Baltic in ice covered waters has been going on for over 100 years. During the last 30-35 years, oil exploration has entered these icy regions and brought the threat of oil spills on a larger scale. When the first oil exploration started in icy areas the knowledge of what the behavior and effect of oil would be was limited. However, at the end of the 1970's emphasis on this was put at the Wärtsilä Arctic Design and Marketing (WADAM) together with Wärtsilä Ice Model Basin (WIMB), both predecessors of today's Aker Arctic Technology. At first the studies included the basic understanding of the processes when oil gets mixed with ice, followed by initial model testing to confirm some of the parametrical influences. Later a full-scale test was done in the Helsinki Harbor Basin to get confirmation on practice. In the late 1980's and early 1990's the involvement in the studies done in the conjunction of the Antonio Gramsky catastrophe - one of the biggest oil spill incidents in the Baltic - gave quite a good confirmation on the earlier observations. These earlier studies, together with present knowledge and possibilities to integrate oil recovery systems onboard vessels, have generated completely new types of icebreaking vessels like the Oblique and Trimaran icebreakers. This article discusses the early development, together with testing the possibility of oil collection from ice, and shows the new possibilities in ship design relevant to oil recovery.

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Studies on oil and ice

October 2013

Göran Wilkman, Esa Ritari, Arto Uuskallio

Contents

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AKER ARCTIC TECHNOLOGY INC

Hi-tech
for
ICY and COLD MARINE
environment

Aker Arctic Technology Inc

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- First icebreaker, IB VOIMA 1954
- First model basin WIMB 1969
- Second model basin WARC/MARC 1983
- New testing facility AARC 2006

- 60 years of icebreaker design and construction
- 495 model test series
- 97 ships tested on 142 voyages
- 62 ice condition reconnaissance surveys

- 500 person - years of experience

Oil companies - Engineering companies
Shipping companies - Authorities

60 years of icebreaking experience, technological background

Idea for ice model tests raised by Exxon along the T/T "Manhattan" experimental voyages to North Slope

TESTING - BUILDING

1954 Icebreaker "Voima" delivered

1969 Project "Manhattan", Wärtsilä Icebreaking Model Basin (WIMB) established

1982 Wärtsilä Arctic Research Center (WARC)

1989 Masa-Yards Arctic Research Center (MARC)

1991 Kvaerner Masa-Yards Arctic Technology Center (MARC)

2005 Aker Arctic AARC

Wärtsilä Shipbuilding

Valmet Shipbuilding

Rauma-Repola Shipbuilding

Holming Shipbuilding

Wärtsilä Marine

Masa-Yards Kvaerner Masa-Yards

Finnyards Aker Finnyards

Aker Finnyards Aker Yards

stx Europe

Activities / services

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Field research
- Ice conditions/properties
- Route selection
- Design basis development

Concept development
- Feasibility studies
- Performance predictions
- Transit simulations
- Ship concepts

Testing in model and full scale
- Ships
- Structures
- Offloading operations
- Rescue and evacuation

Ship designs
- Basic design
- Tender packages
- Aker ARC standard designs

Other
- License agreements
- Project executions
- Operation training

Aker Arctic DAS™

History

of oil in ice testing

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The year-round traffic in Finland had started already in the early 1970ies

Finnish export is dependable of sea transport

In the early 1980ies it was seen that the traffic is to increase more in icy waters

Oil exploration activities in the icy seas was taking off (i.e. Sakhalin)

Oil spill was seen as a threat

Oil accidents like Antonio Gramsci in 1979 in Baltic had already taken place

It was decided to start research in the subject, which consisted of:

desk studies - laboratory tests and - full-scale tests.

The work was done together with Government authorities and in co-operation with Soviet Union

Testing

of oil in ice

Two examples:

1. Model test

2. Full scale test

Basic knowledge

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- Oil may be spilled directly on ice
- Oil may penetrate through the porous ice from underneath or through leads in ice on top of the slush in the leads
- Together with waves and wind the edges of the ice floes will be contaminated by oil and the wind may transport oil particles to a larger area
- In an open lead the water under ice may start freezing and the oil will be capsulated in the ice
- Through the movement of ice floes, oil may get also on top of the ice floe. Ice floes hitting against each other may start to pump oil on top of the ice.
- When there is snow on top of ice (almost always), oil may form together with snow viscous slush, which may stop the oil from moving around.

Basic knowledge

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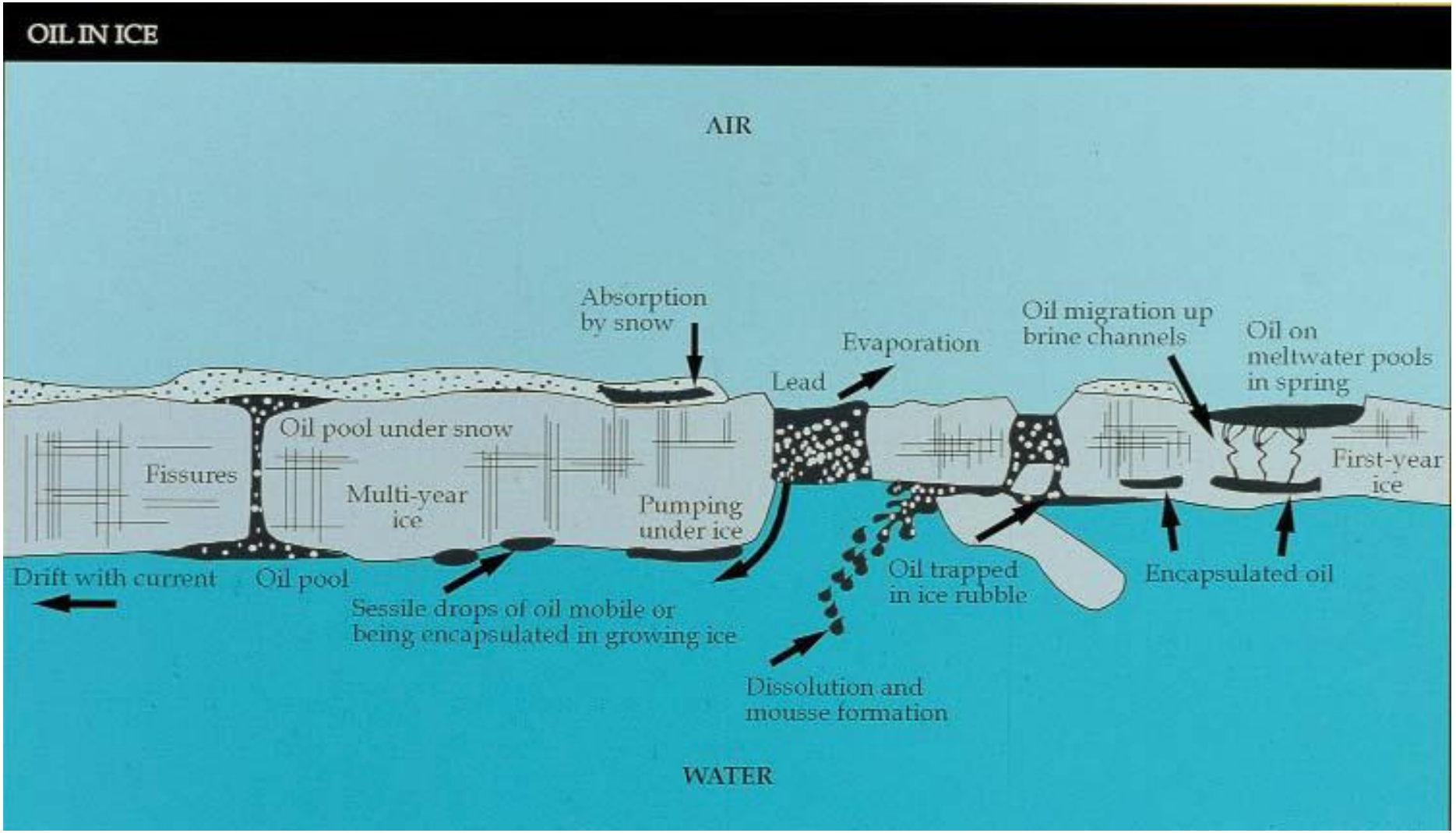

(Allen/Spilltec)

Model tests, 1983

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The tests were done in a separate plastic glass basin, which was located inside the WARC basin. The objectives of the tests were to:

- Study the behavior of oil and ice in open water and in different ice conditions
- Spreading of oil in 0°C water, thickness of the formed film and how the presence of ice will affect
- Amount of oil to be engaged and absorbed in ice and how oil is driven and moving under ice
- Study different methods to separate oil from ice
- The test conditions were: open water, broken ice field, channel and level ice, and oil is poured either on top or underneath.

Model tests, 1983

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Conclusions on model tests

•The engagement of fresh oil with ice is minimal

•Oil content in ice increases with the aging of oil

•After a few days it is difficult to separate oil from ice (freezing climate)

•Oil attaches easier to the bottom than top of ice (ice bottom is porous)

•Most of the oil stays separate from ice in an ice channel, the ice pieces limit the spreading of oil. However, ship traffic may help the spreading of oil under surrounding ice.

Recommendations in 1983

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To start the oil collection procedures as soon as possible after the accident

The contaminated area is to be closed from ship traffic

Oil could be collected by separating it from the ice blocks when being still in the water

Ice blocks can be washed after the liquid oil has been separated

A ship hull could be used to separate oil from ice as the tested boxes worked rather well and they could be built to be part of the vessel

In case the oil is no longer in running mode, it could be collected together with ice with using excavators

It seems to be quite impossible to collect all the oil spilled

Full-scale tests, 1985

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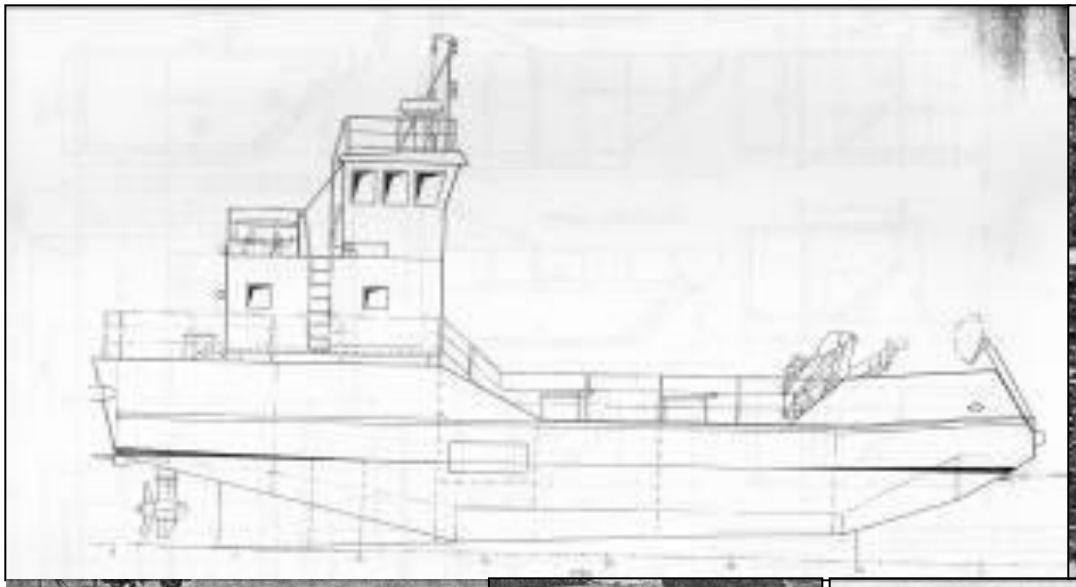

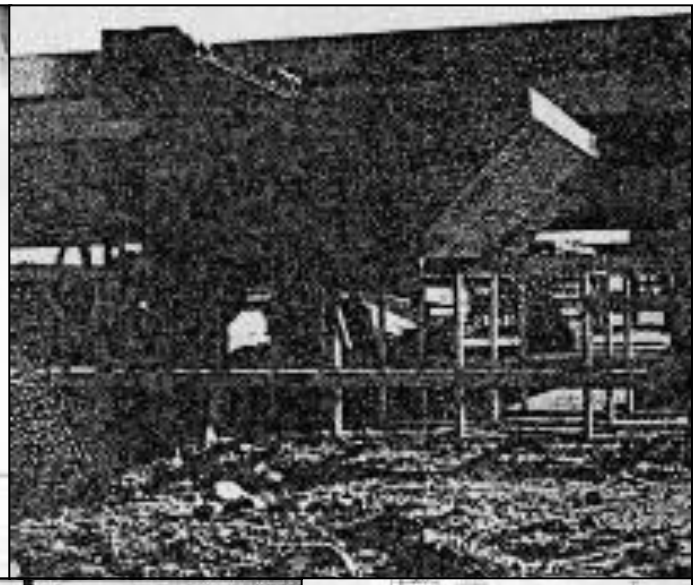

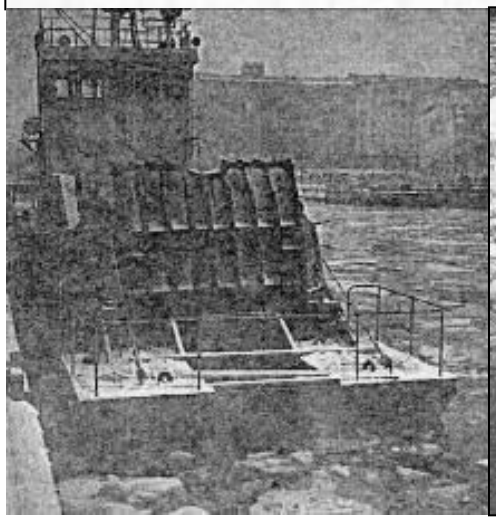

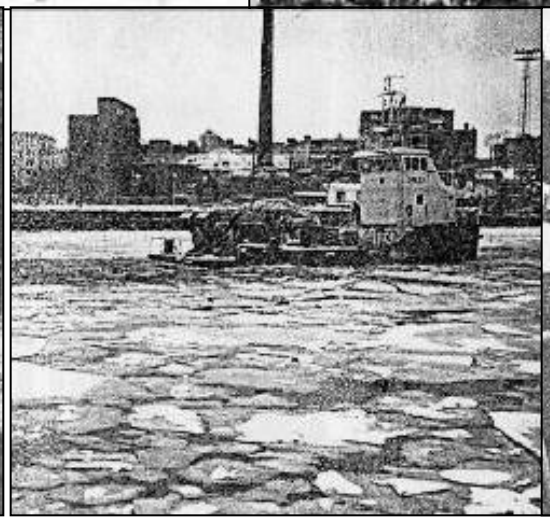

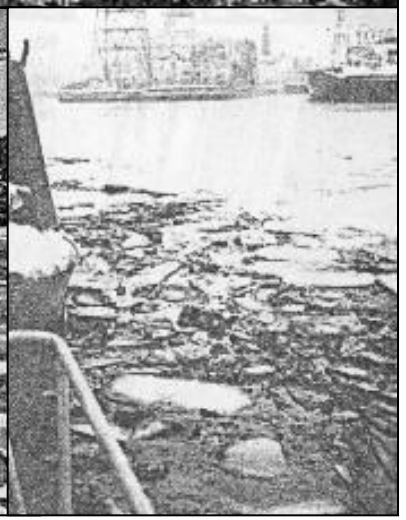

Full-scale tests, 1985

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- Based on the previous studies the idea of performing a full-scale verification of how such a devise could work came through in winter 1985
- A box with holes and a landing craft front was built and attached to the bow of one of the buoy tender vessels MS Oili
- The tests were done in one of the Helsinki harbor basins at Wärtsilä Helsinki Shipyard
- The amount of oil to be spilled among broken ice was 180 liters. The landing craft box had the following dimensions: length = 5.32m, width 3.00 m and height 2.00 m

Full-scale tests 1985

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Conclusions from full-scale tests:

1. The amount of oil poured was too small
2. Amount of collected oil was only 5.5%
3. Oil was attached to snow and ice slush very quickly
4. The test area could not be restricted
5. The landing craft bow was too steep, 45°
6. Ice blocks got stuck to the bow at small speeds
7. At higher speeds the oil had not enough time to get separated from ice

Equipment

Developed for oil in ice

Mechanical methods used in the Baltic Sea

- Brush technology
- Ice bow
- Brush bucket
- Vibrating grid
- Using of air or propeller flow to steer oil under ice
- Using of ice barriers and ice dwells
- Vacuum pumps
- Skimmers operating in ice

LOIS – Oil Ice Separator

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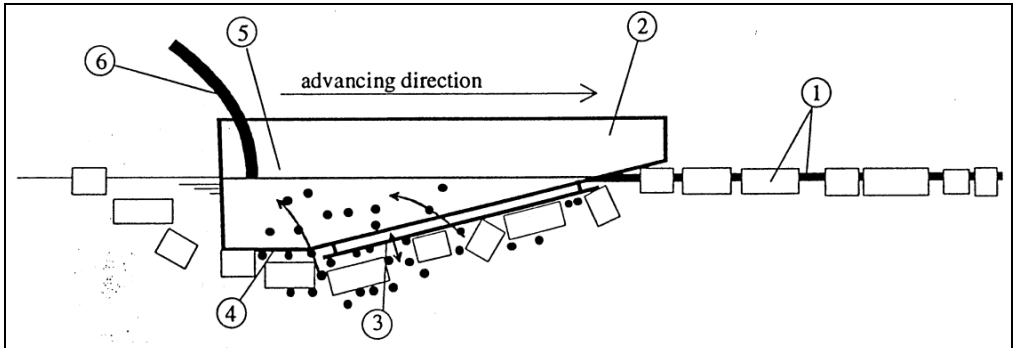

1: oil between ice blocks
2: recovery unit
3: vibrating perforated plate or grid to make the ice blocks vibrate and rotate
4: perforated outer shell of the recovery unit
5: space inside the recovery unit where the oil enriches on the water surface
6: skimming the oil off the water surface inside the recovery unit

Use of vibrations to separate oil from ice

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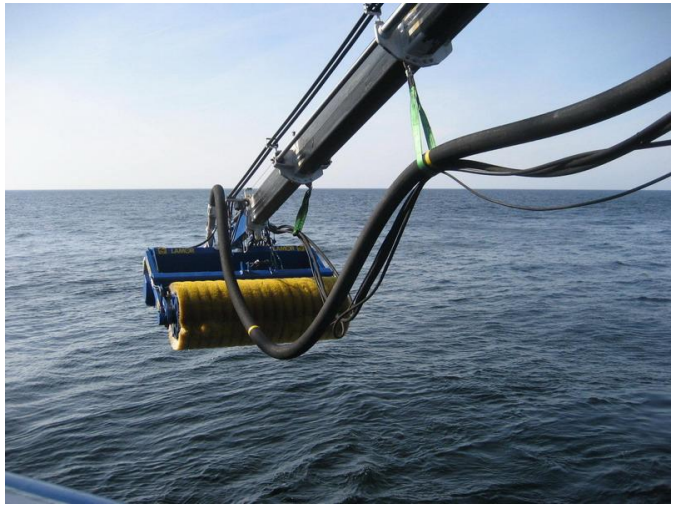
Winterization



The Ice Technology Partner

The Finnish Environment Institute has developed a new brush system which today is believed to have the best capability for Arctic oil spill response. First installation is in the newly built *LOUHI*

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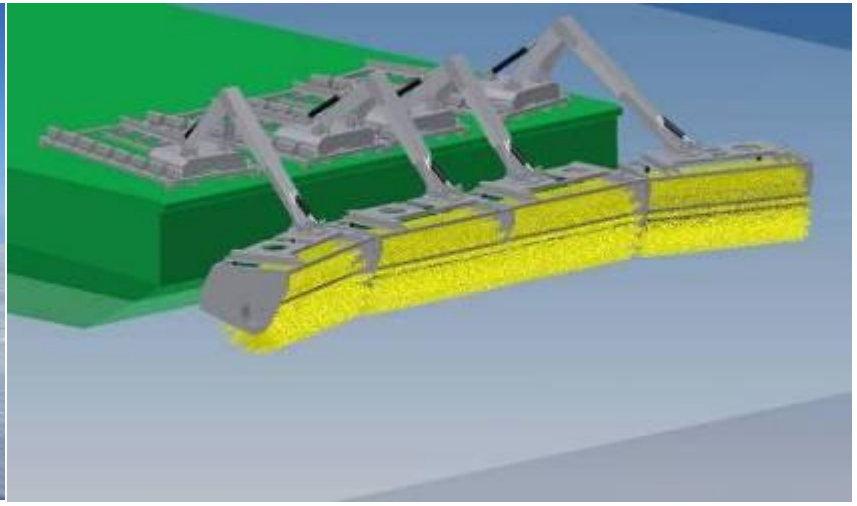

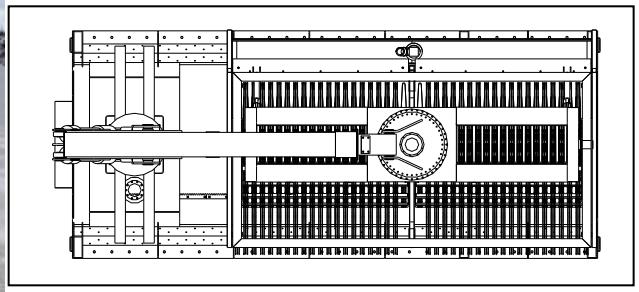

The SYKE oil combat module: Can be built in 6 m brush width, securing a 24 m wide sweeping area

Brushwheel units on LOUHI

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The Ice Technology Partner

(Syke)

Future

Finnish Coast Quard Patrol Vessel

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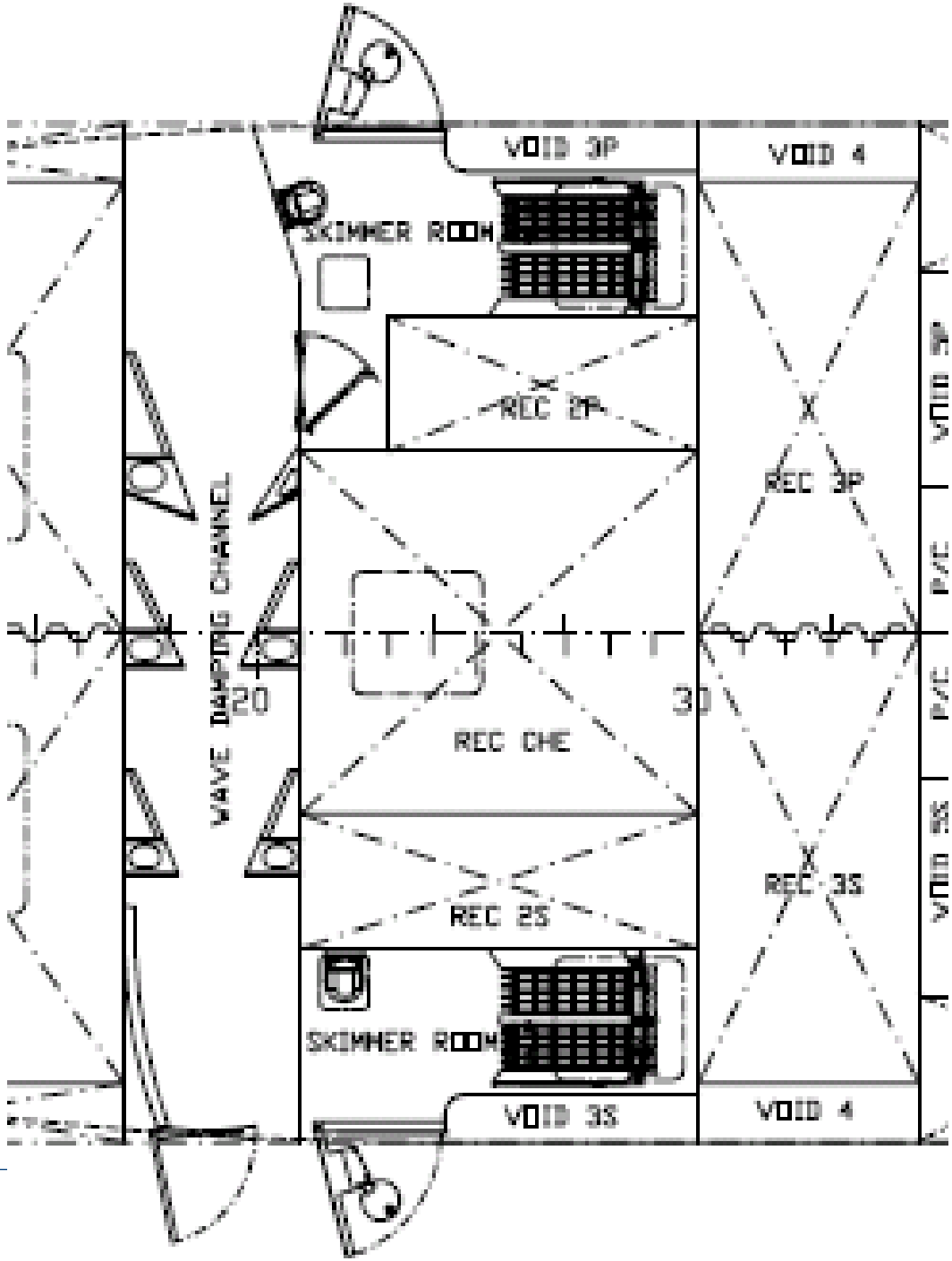
- The Offshore patrol vessel, TURVA, is expected to be delivered in 2014 for Finnish Border Guard.
- Storage capacities of 1000 m^3 oil and 200 m^3 chemicals.
- The vessel can operate in 0.8 m thick level ice conditions.

TURVA will be equipped with:
Built-in recovery units
Brushwheel units 3 pcs.

Turva built-in OSR

- 2 Built-in skimmer units
- 200m^3 chemical tank
- 1000m^3 oil tanks
- Wave damping channel with retractable boom



Oblique Icebreaker

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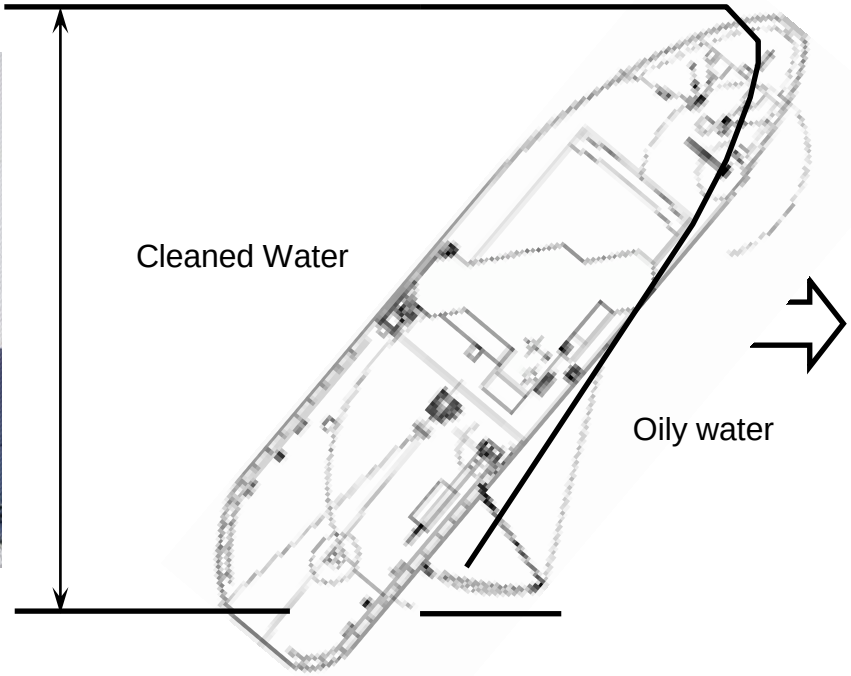

- First vessel of this type is under construction with delivery early 2014
- Oil response equipment both for open water recovery and for recovery in ice conditions
- Operation area will be Gulf of Finland area

Conclusions

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- Oil recovery equipment in ice has been developed in Finland since early 80’s. Different equipment has been studied in both in laboratory and in full-scale tests in order to gain performance data of different methods and equipment. Tests have been carried to understand the oil-in-ice behavior.
- Experience has shown that different marine environment conditions require tailored approach to oil recovery especially in icy waters. There are a number of solutions used but the oil recovery efficiency is still quite varying.
- Purpose build vessels dedicated to oil recovery missions and vessels equipped with equipment suitable for different conditions.

Trimaran Icebreaker - concept

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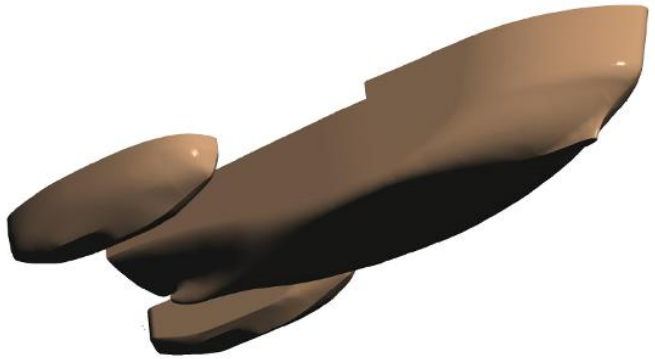
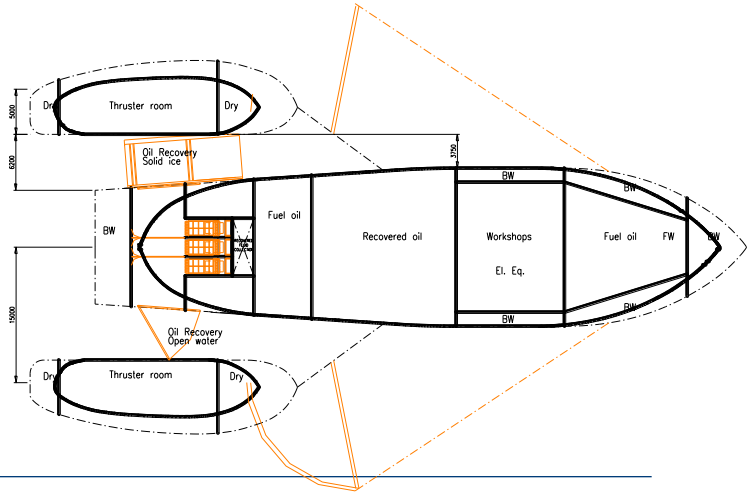
Development and testing ongoing since 2007





Creativity is our business

Towards new challenges

Thank You!