U.S. Department of Transportation
Maritime Administration

Memorandum

Date: April 22, 2003

Subject: Trip Report to Northern Europe for National Science Foundation project

From: Richard P. Voelker
Chief, Advanced Technology
Office of Shipbuilding and Marine Technology

To: Joseph A. Byrne
Director
Office of Shipbuilding and Marine Technology

During March 12-27, I traveled with representatives of the National Science Foundation (Alexander Sutherland), Raytheon Polar Services Corporation (Paul Olsgaard) and Science and Technology Corporation (James St. John and Aleksandr Iyerusalimskiy) to Finland, Sweden and Germany. The purpose of the trip was to gain insight into the design and operation of their national icebreakers, many of which incorporate innovative concepts.

Visits were made to the Finnish Maritime Administration (Markku Mylly) and their icebreaker BOTNICA, the Swedish Maritime Administration (Anders Backman) and their icebreaker ODEN, and the German Alfred Wegener Institute for Polar and Marine Research (Eberhard Fahrbach). Information was also obtained on the new Swedish icebreaker class VIKING and the German polar research vessel POLARSTERN.

Attachment A provides some of the notes from our visit while Attachment B contains a discussion on some elements of the technical specification for the new generation research/icebreaker vessel. The trip was very valuable and provided a great start to the feasibility-level design study that MARAD has been contracted to perform for the NSF.

A presentation describing this trip and some interim results from the feasibility-level design study will be made in mid-May to interested MAR-760 members.

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Attachment A – Notes from the visit

Briefing by Paavo Lohi - Aker Finnyards, builder of BOTNICA

The bow skeg or bilge keels do not affect the flow of ice around the hull. A 6.5 x 6.5-meter moon pool is mostly used for ROV's, but they used a small rig last year in open water. A portable large rig was built and never used and is stored at the charter's site in Norway

The moon pool has a submergible door. It is left off in open water and the trunk of the moon pool has holes to dampen the waves inside. The door rests on the bottom in shallow water. The ship moves over and a diver attaches a cable from the crane to lift it up in place. The water is pumped out with portable pumps and then turnbuckles are placed around the perimeter to secure it for the icebreaking season.

Discussions with Markku Mylly (Director, Traffic Department, Finnish Maritime Administration) and visit to BOTNICA

General – All Finnish Maritime Administration shipping operations will be under his management in 2004. While the nine vessels (icebreakers and special offshore vessels) are government owned, they will be operated independently from the government. He also has a fleet of buoy tenders that come under his supervision and control. All of these vessels will employ about 500 people. The icebreakers, which are seasonal, must now find work in the summer and so the FMA will be selling their services on the open market. Currently, port fees and taxpayers pay the cost of icebreakers equally. He said that if they have had excess capacity in the icebreaker fleet, they could be used in Antarctica. The summer day rates were unknown at this time and were being developed.

Their next vessel will be an icebreaker with a summer oil spill recovery capability (dual purpose).

FMA does an annual report of operations and it can be ordered.

Hull form – BOTNICA performance in open water is very poor. This applies not only for the bow, but for the stern as well. Major problem is slamming and vibration in head seas.

Propulsion System – Azipods cost about $2-3 million more than traditional line shafting with propeller for the BOTNICA, March 1997 dollars. The system was ordered at the time of vessel contract and there was no advance procurement. BOTNICA was delivered 16 months after contract award. Currently the Azipods leak oil and this should be fixed with time. It was suggested that oil in the bearings should be biodegradable oil. The Chief Engineer who also served on NORDICA and FENNICA said that their azimuthal propulsion system (Aquamaster) did not leak oil. He felt that the Azipods were simpler, required less space and less maintenance but had a higher initial cost. He also felt that both systems worked equally well in ice, although BOTNICA has a much less icebreaking capability than the other vessels. BOTNICA has 120 MT of bollard pull as opposed to FENNICA/NORDICA that have 220 MT. Bow thrusters aren't used in ice. They only use the pods. To reverse they normally turn the pods outboard. Nozzles on FENNICA/NORDICA clog in thick brash ice. You can tell because you feel the drop in rpm. No blocking of the nozzle is experienced. The have accumulated 20,400 hr on pods. Both upper and lower seals leak. Use Mobil Oil 629. Seals only leak icebreaking – okay in summertime. ABB has a new shaft seal design. They are getting refit soon. They expect they will not have a problem with the new design. Azipod is simpler and requires less space than Aquamaster. 3300 v motors for pods, 10 cables into motors. They have had no damage to pods or props. Propeller rotation is inboard when the vessel moves ahead.

Podded propulsors worked generally very well. The Chief Engineer reports that maintenance of Azipods are slightly better (less labor) than the Aquamasters on FENNICA and NORDICA. However, both AZIPOD units aboard BOTNICA have had some lubrication oil leaks inside the pod. One unit has mild external leak of lubrication oil through the shaft seal. Lubrication oil is Mobil 629. The ABB 5-year warranty is still open and believe problems will get fixed. ABB is working on the new generation of Azipod without leakage. ABB technical information is very poor, as no drawings have been provided of the unit. High-speed CAT diesels are "nightmare"(124 cylinders). Cooling system is circulating through the tank. It is possible to run the engines for up to 30 min in the dry dock. Vibration is a big problem. It is better during the summer offshore operations because the draft is 8.4 m in oppose the 7.5 during the Baltic icebreaking season. Propellers are very good. They are light and strong. Made of the experimental new steel manufactured by the 'LOCO", Finland.

Propulsion machinery – The propulsion plant consists of 12 Caterpillar diesel generators vice 6 Wastrel diesel engines because the initial acquisition cost was less with the Caterpillars. The Chief Engineer would have preferred few diesel engines to lessen the maintenance requirements. With the CATS he has 144 cylinders and they require maintenance every 2000 hours of operation, but he believes the CATS are more fuel-efficient than the Wartsila engines. A life cycle cost analysis was not done as part of the engine selection process. There was also insufficient space in the machinery room for engine maintenance. He believes that the vessel is under powered and feels the power level of the FENNICA is better. With the small engines, there are many maintenance points. She requires 144 hr of maintenance every 2000 hr of operation. CAT's are fuel-efficient 12-15 cu m/hr during DP on BOTNICA; 18 to 20 cu m/hr on NORDICA/FENNICA. Not enough space for maintenance of engines on BOTNICA. The Chief engineer wants more power and space.

We commented about vibration. He said it was because the ship is light. He said the problem is greatly reduced when the vessel is ballasted down. She operates icebreaking at 7.6-7.7 m draft but if she can ballast to 8 m, it helps a lot.

The sea chest is designed for ice. Ship can run using a spare ballast tank if necessary.

Engineering control – There is no engineering control room. Rather, in the Chief Engineers day room, one corner of the space as the propulsion machinery control panels (ABB & SIMRAD). All instructions and labels are in English. He has a staff of five (Chief Engineer, 1st Engineer, Motorman, Electrical Engineer, Repairman and Electronics Technician). There are two people doing maintenance all the time and no one stands watch per se. They work 6-hours on and 6-hours off. They have UPS for computers, hotel services and operating stations. UPS systems need to be replaced often. All ship service is on UPS. Paul said the NBP has replaced their UPS system as well after many problems.

<u>Hull structure</u> - Shell plating thickness in the bow area of the ice belt is gradually reduced from 40 mm down to 20 mm. For both plating and framing D 36 steel is used. Typical scantling for the main frame in the bow is shown in the figure below. The stainless steel ice belt used for low friction purposes is in the bow area from the stem through the aft edge of the reamers. It is 2 m high. No hull damage reported yet.

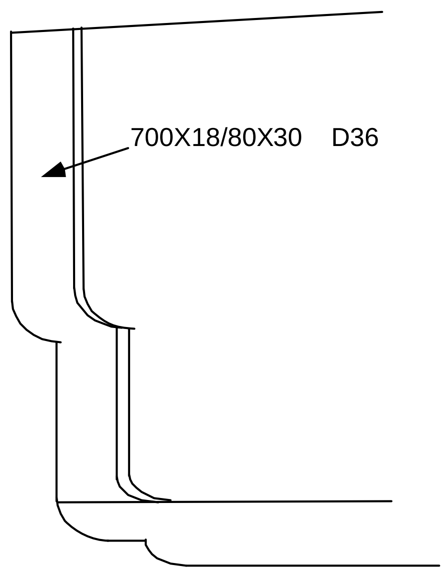


Figure 1. MSV BOTNICA main frame

<u>Maneuverability in ice</u> - The ship is very maneuverable and works great astern. FENNICA class is very similar but a little better, perhaps because of the greater power. Bow thrusters are very bad in ice. They shouldn't be used and they are not used in ice. In open water (North Sea) the ship is superior.

Bridge information for open water:

Tactical turning circle diameter:	*81 m*
Crash stop reversing props	*268 m*
Crash stop reversing pods	*250 m*

AZIPODS 360 degree turning speed: 4 drives – 30 sec; 2 drives – 60 sec.

Stationkeeping – BOTNICA satisfies DNV rules for maintaining station in required sea state (unknown what the limiting environmental conditions are) to satisfy stationary vessel and roll limitation during drilling with a 99.99 percent assurance. The vessel has a Simrad control system for station keeping.

Low friction hull coating – only Finnish icebreakers use a stainless steel ice belt (two meter wide) at the waterline and Interta below. The reason for this is the icebreakers operate in waters that have sand and other sediment in the ice and this would wear away the Inerta coating at the waterline. An impressed current system is used to prevent corrosion of the hull.

Roll stabilization – prefer Intering System and it was specified in the vessel specification.

Double hull – the vessel has a double hull on the side of the vessel such that it can absorb a 1.5 meter penetration with affecting the interior. Some machinery space sumps (of very limited size) are adjacent to the skin of the vessel. This appears to be consistent with the IMO Arctic Guidelines. Basically, the comment is made that operationally, it is a double hull vessel, but operationally, limited oil is next to the skin of the vessel.

Moon pool – The moon pool bottom cover built as a pontoon and can be installed only in the relatively shallow regions where the divers can operate. The sketch of the moon pool installation is shown in figure below. The ship designer characterized this solution as a cheap and primitive one.

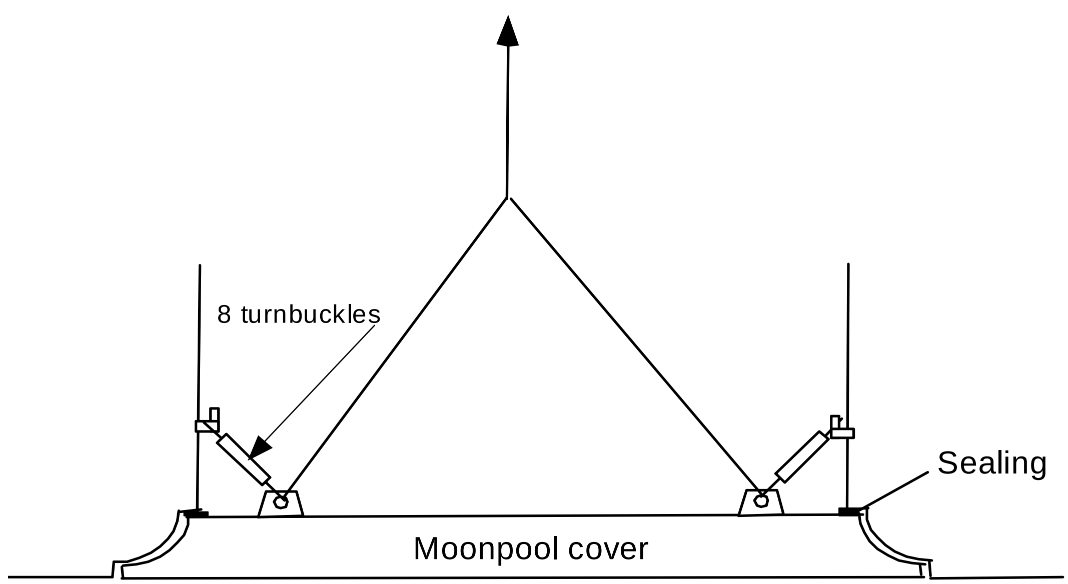


Figure 3. MV BOTNICA moon pool bottom cover

Elevators – All Finnish icebreakers have elevators.

Navigation Bridge – The crew regards the bridge as the best known to date. The "oblique bridge" that used on FENNICA class ships is not as good as one on BOTNICA. The visibility is excellent from the Starboard conning station (approximately 310-320 degrees). The blind spot ahead is small (see the sketch below).

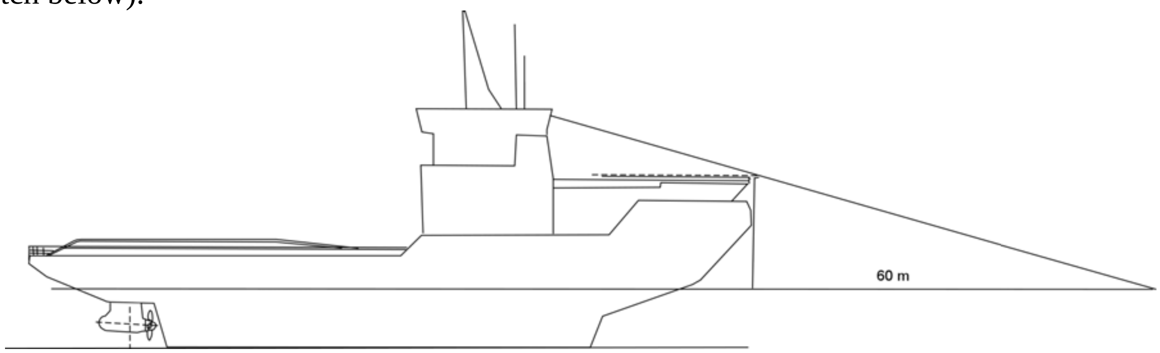


Figure 2. Blind spot

Bridge controls – There are dual controls, port and starboard with the starboard being the primary control station. It is important that sufficient heat be provided at the corner control stations as they are surrounded by glass and below freezing temperatures can drop the temperature in this area. No windows on the bridge open. It was felt that the icebreaker KONTIO was the preferred bridge arrangement, from their perspective. Should the bridge extend out beyond the maximum beam of the vessel to improve visibility?

Seakeeping – The flat shape of the BOTNICA bow causes the vessel to slam in open water and has adversely affected computers and other electronic equipment on the vessel. NORDICA has a better bow form with less slamming. The stern form of the BOTNICA also results in much slapping of the waves against the hull. It was reported that the slamming at the bow was so great that it caused a pump to self-start.

Manning – Winter operations are based on a crew of 19 and summer operations have a crew of 23 as they need extra staff in the galley as the number of non-crew members can increase to over 40.

Wiring - Cable trays and outlets surface mounted.

Mud room - This space has a door to the interior and outside deck.

Ceiling height – The BOTNICA has a 9-ft high clear ceiling height and this was found attractive; the NBP has 8-ft.

Meeting with Captain (He was the former Captain of NORDICA)
Dislikes
Bridge on FENNICA
Bow shape on BOTNICA in open water. Spoon bow slams. NORDICA is better.

BOTNICA slams astern as well. 25 kt of wind from the stern is too much.
BOTNICA has only 23 in the crew, only 2 AB's so no ability to paint.

Likes

FENNICA/NORDICA have better steering.
FENNICA/NORDICA have low maintenance compared to BOTNICA.
FENNICA/NORDICA are quieter and have better icebreaking capability.

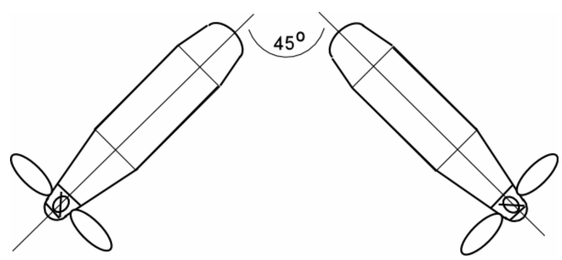
Moon pool - hard to core during shallow water drilling. Mostly used for ROV's.

During the stay onboard MV BOTNICA in the South of Bothnia Gulf the ice conditions were mild. The short test (demonstration) was performed on March 15 at 2:10 PM local time near the port of Pori.

The ice conditions were as follows.

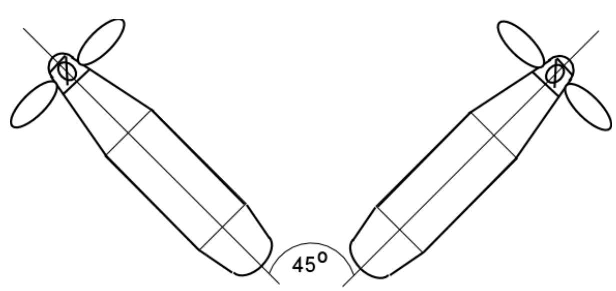
Ice concentration	9-10 tenth
Ice floe size	pancake-cake ice
Rafting	up to 40%
Ice thickness	30-50 cm

The vessel performed two runs with Azipods turned 45 degree in order to increase the channel width. The first run was performed in the pulling mode of the propellers (see the figure below)



Azipod position during the test #1

After the first run propulsors were turned around and test was repeated (see the figure below).

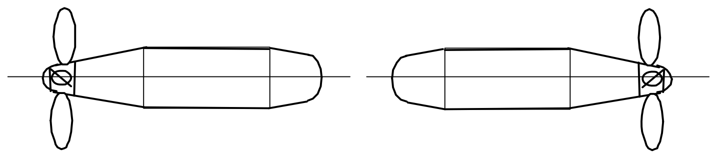


Azipod position during the test #2

In both cases the power was 2X4.5 MW (90% MCR) at 180 RPM. The average speed was approximately the same in both cases 2.4 kts. The channel width was increased insignificantly according to the visual estimate.

The U-turn maneuver was performed to the port side in the conditions above. The vessel was able to turn in 42 sec. The second U-turn took 35 seconds. The Azipod angles in both cases were $30^0/40^0$

Crash stop was conducted by turning the Azipods 90 degrees as shown in the figure below.



Azipod position during the crash stop

Two straight steady runs in the described above ice conditions resulted in the speed 6.5-7 kts ahead and 3.4 kts astern at 2X4.5 MW power and 185 RPM.

Reversing – During tests, it was demonstrated that with 4 drives on the Azipod, it took 30 seconds to rotate the pod 360 degrees. With 2 drives, it took twice as long. With 4 drives, it took about 16 seconds to 180-degree rotation. Broken ice in the channel when going astern is finely chewed up as viewed from the bridge looking forward.

Maneuvering – With the vessel traveling at 10 kts, the pods were turned 70 degrees and the vessel turned in its length in 42 seconds in ice.

Crash stop performance was posted on the bridge:
54 seconds and 250 meter reach from 15.9 kt, 13-degree change in direction.
Tactical diameter is 81 meters with an approach speed of 11.6 kt.
Reversing prop for a crash stop, 67 seconds and 258 meter reach from 14.3 kt, resulted in a 94 degree change in direction.

Visit to the Swedish Maritime Administration's icebreaker ODEN and discussions with Captain Anders Backman. The observations related to hull form and propulsion plant are described below and other notes were incorporated in Attachment B to this trip report.

Icebreaker ODEN study was focused mainly on two aspects: ice cleaning/ice removing hull form and one of the most powerful diesel-direct propulsion systems is being used for icebreakers to date. According to the icebreaker's long-time captain Anders Backman, ODEN's hull doesn't provide ice-free channel but makes it much cleaner than traditional hull shapes. STC observations during the 1990 and 1991 Arctic trips as well as ODEN escort operations in the Northern Gulf of Botnia during the March 2003 trip did not confirm that statement. Rather, the track behind the icebreaker looked pretty much the same for ice concentrations of 9/10 to 10/10 when breaking through the close pack. Escorted ships performance was not significantly better conditions behind ODEN. The close towing technique is used routinely in the escort operations when heavy ice is in the track.

An analysis of the ODEN hull lines shows that any significant ice removal from the channel is unlikely. An absolutely flat bow, within 60 plus percent of the maximum beam, directs every cusp of the broken ice under the hull. The centerline wedge was designed to break them in the middle and push aside under the unbroken ice edge. However, the wedge is shallow under the bottom and a lot of ice appears to get underneath the hull instead being pushed aside. A lot of ice emerges into the channel behind the reamers. The reamers are wide (the "beam at the midship/beam at reamers" ratio is 31/25). Since the ship aft of reamers is wall-sided the cusps go straight up along the ship's sides. The overall conclusion that can be drawn is the ODEN hull shape (or the similar to ODEN's) can not result in a clean channel. The ice conditions in the track don't enable the use a towing arrangements used for open water towing (seismic or others).

A rapid heeling system is used to assist turning and the turning reamers are effective only when heeled.
A water wash system can be used as a bow thruster and the bow waterwash system is effective in snow covered conditions.

The advantage of ODEN's hull form seems to be low resistance in level continuous ice. On the other hand, this shape has a number of disadvantages such as:

- High resistance astern in all types of ice conditions.
- Poor maneuverability in near limiting ice conditions because of poor backing. In the Baltic they don't use backing during the escort operations. The U-turn maneuver is used instead.
- High probability of pushing the ice floes ahead of the bow while working in cake ice and small floe close pack ice at low speed.
- Unacceptable bow form for a research vessel because of slamming and the resulting vibration in head seas.

There is no plan to use this hull form again on Swedish icebreakers.

ODEN propulsion system is the most cost effective and provides good performance both in the ice and open water. The controllable pitch propellers are good but some problems were experienced over the 14 years of service. It was felt that the manufacturer was the one to blame for the problems and for the new generation icebreaker (Viking class) the Swedish Maritime Administration switched from LIPS to KAMEWA. It was important to design a multi-program control system for the machinery-propeller system such that a lot of flexibility is provided in different ice conditions. ODEN operates on the conventional "combinator" or uses the constant RPM mode but supplemented with the range of RPM variations defined by the required torque. A torque meter is the critical part of the control system. Two rudders were designed to provide some protection for the nozzles while backing by turning rudders inboard at 45 degrees. It didn't work well and for the new generation icebreaker (Viking Class) this idea was abandoned. Nozzles provide very good thrust. Nozzle clogging problem is real but not considered as the critical one.

ODEN has a lot of extra power for Baltic operations and this creates a good margin of the performance, which is needed for the escort.

VIKING Class icebreakers cost $30 million each; a total of three vessels were built. Each has a bow water wash system that is kept in use all of the time when breaking ice. The VIKING Class is intended as a prototype for a new larger icebreaker in the future. The new vessel would be 1.5 times the size of the VIKING vessels and have 300 plus tons of bollard pull. The VIKING Class vessels have 14 MW power and they are classed as DNV IB 10, with a design level icebreaking capability of 1 meter. The VIKING Class has no reamers and has a bollard pull of 215 tons using a diesel-geared-controllable pitch propeller in a nozzle. VIKING Class has unmanned engine rooms, but two people do maintenance and repair 24 hours a day. On some trips they will have specialized engine personnel to do m&r. The VIKING Class has a Selective Catalytic Reducer system installed to reduce NOx and particulate matter emissions from the diesel engines.

Discussions at Alfred Wegener Institute for Polar and Marine Research

Dr. Hans Schenke – Swath Bathymetry

Originally, 1982, POLARSTERN had a Seabeam 16 beam system with a 42 degree sweep angle. There was a Kevlar window that failed every time in ice and the transducer array was inoperable many times.

In 1989, the Seabeam system was replaced with a Krupp-Atlas Hydrosweep system, now the company is Atlas System Technik. The problem with the original system was that when the ship went fast in ice, ice would rapidly move down from the bow and float up to impact the bottom near the array and damage the window. There was a lot of bottom damage as well over the middle 1/3 of the ship. The transmitters were installed in the keel (fore and aft) and the receivers installed in an athwartship position.

The bottom mapping discussion in AWI clearly indicated that both systems Seabeam (old system) and KRUPP (latest installation) were operational in open water and in ice because of using box keel. The main reason for this structural arrangement was the necessity to minimize the amount of air bubbles carried down under the system arrays. Some ice presence under the hull was qualified as a lesser problem than air. This technical solution was proven to be working.

AWI uses a box keel to house all of their transducers. The box keel is 1 meter deep and is located 25 meters aft of the forward perpendicular. It has been widened to 4 meters and 7 to 8 meters in length. Note that the original array was 40 meters from the bow and had a 2 meter width. The transducer is in front, length 3 meters, width of 0.3 meters. The receiving array is aft and 0.3 meter width. The Parasound sub-bottom profiler is 1meter square (same manufacturer. They have an extremely good MINS (military inertial navigation system) gyro stabilizing system to measure ship motion and get excellent results. They use an Anshultz inertial guidance system, military version, with excellent results. TSS used on HEALY not as well – worked when moving, but not at slow speed or stopped.

The high draft of POLARSTERN, 11.5 meters, helps bottom mapping. They can continuously map during icebreaking. Ramming mode icebreaking causes problems with lots of ice in the keel of the ridge. AWI recommends a box keel to avoid bubble sweepdown in front of the transducers. Even during icebreaking, the vessel at the bow gets air. AWI plans to convert the METEOR research vessel with a box keel (60cm) to get ride of bubble sweepdown. AWI recommends a 1-meter deep box keel on icebreakers. They cannot operate over 10-12 kts using survey system in open water and they operate at 5 kt average speed.

They believe that HEALY bottom mapping system is only for steady level ice operations. Believes that all bottom mapping systems are basically equivalent, but must have an ice strengthened transducer. The quality of the data from HEALY and POLARSTERN is comparable. HEALY however has orientation problems. It is recommended to get the smallest size arrays installed in the vessel. SIMRAD is now on the NBP. HEALY produces good results but has problems in alignment when moving.

Acoustic interference was noted from changing the pitch of the controllable pitch propellers in combinator mode and that the vessel is now using fixed pitch setting and variable speed to reduce cavitation. (10dB reduction in noise resulted). Pumps and reduction gears contribute to noise. Environment is 140 to 160 dB broadband.
They recommend deep draft vessels and like to survey at 10 to 12 knots in deep water. Also riding up on ice during ramming can damage the array.

Noise criteria for bottom mapping, for 5 to 130 kHz, should be no more than 120-130 dB.
Atlas Parasound is an excellent sub-bottom profiler, runs at 4, 12, and 20 kHz.

Find out where and what kind of positioning system is on the KILIMONA, Hawaiian Swath ship.

Their new vessel MERIAN will be ice strengthened and they looked at three competitors for the transducer. The new Seabeam system was recommended but never installed and the Hydrosweep could not meet the specifications. The vessel will have an ABB electric podded propulsion system. There is concern that it will generate an electromagetic field than can interfere with bottom mapping operations. SIMRAD says they can shield the multibeam. The new vessel is expected to cost $250 million and have greater than 30,000 shp or 50 MW total.

The Intering pumps (compressors) cause noise to be radiated in the ship and water column. The CP system on POLARSTERN was initially noisy during cavitation, but it is now quieter with a 10db reduction.

POLARSTERN has a 1m by 1m moon pool and the bottom ice cover has sustained ice damage.

Vessels need to be acoustically quiet, engine foundations; pumps and compressors are of concern. POLARSTERN is 140-160 dB and 120-130db is desired.

The Atlas sediment echo sounding system (Atlas) is best of all and on POLARSTERN.

Dr. Schenke thought an international conference by and for the science community to review operational results and equipment specifications with naval architects would be provide a great dialogue on what works and doesn’t.

POLARSTERN will continue to operate for another 15 years and has had a mid-life upgrade.

POLARSTERN is also a logistics supply vessel so this accounts for such a large ship and this sometimes interferes with science operations. Although the vessel can carry 70 scientists, they prefer a number like 50 to reduce problems aboard. Works better. There is competition with logistics so they are trying to find other ways to do logistics.

20,000 SHP is insufficient for the Arctic, but okay for the Weddell

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Dr. Wilfried Jokat, Geophysics and Glaciology

The power of POLARSTERN is insufficient to maintain speed in ice. In the high arctic, they must operate with other vessels. Recently with the HEALY made the track though the ice and POLARSTERN followed. In effect, Antarctic operations have single vessel missions whereas the Arctic is dual ship missions.

The comment was made that they like a 5-meter wide ice-free area to make things very safe for their towed equipment. The vessel must course and speed during the entire operation. It is best to keep the streamer at constant depth and location.

It was believed that all ships have the same broken ice pattern behind the vessel; there is no clear channel aft on any icebreaking ship.

He said there were 3 techniques for doing seismics in ice. He described 2; the one used by Art Grants at USGS and the European system, the one he uses. He later remarked that the three systems were Norwegian, German, and US. The USGS system uses a large clump weight hung off the stern (about 2 tons) and the streamer is deployed from that. The POLARSTERN has a stern ramp and the streamer runs down that and goes into the water before it goes beyond the transom. Note that they have a cover over the ramp when it is not in use. A large frame is suspended under the water aft of the transom from the A-frame. The seismic guns are mounted on the frame (he said they use 6) and the streamer runs over the top of the frame. The frame protects the streamer from floes coming up at the stern. Streamer depth is about 10 to 15 m with a 180 meter leader and 300 meter of active length. 32 channels of data (channels further away from the ship have less noise interference. Using the European style, they have never had ice damage and the speed limit is 8 kts because of the breaking strength of the wire rope.

Noise has not been a big problem on ships where he has experience: POLARSTERN and ODEN. They can deal with the noise.

8/10th ice coverage or greater makes it difficult to do geophysical studies. Limiting ice thickness at this concentration is 2 meter. Cannot operate in pressure. Pressure is very dangerous.

Visibility is also important.

They use 2000-psi compressors.

Geotechnical drilling
Dr. Michael Klages, Deep sea research
Prof. Dr. Jorn Theide, Paleontology (involved in the Ocean Drilling Program)

Stable landfast ice in the Antarctic may have MY ice and it may be difficult to penetrate.
Antarctic drilling will be difficult, as the soil will be hard to penetrate.
Coring is different from drilling and different technology is used.
They estimate it takes 24 hours to get a 100m core in 300m water depth.

Mentioned the safety aspects of drilling. Dynamic positioning requires redundancy

The plan to use the French Victor 6000 ROV (4 ton weight, 4 by 2 by 2 m) that is rated for 6000 meters, 32 ton winch, 8000 meter fiber optic cable, using Posidonia navigation system (plus minus 5 meter) and have the ROV operate for 3 days once lowered.

ROVs should have a manipulator arm and operators will make decisions based on video.

AUV is the Bluefin Robotics Corp, Odyssey III, 3.18 m to 5 m, 220 kg, 3000 meter depth, 160 km travel, and 5 meter length. Contact is James Bellingham at IMBARI.

They believe that each new research vessel with have an AUV/ROV capability.

Use an underwater docking system in a cage and recover the AUV vertically. Recharging of batteries should be done while the AUV is in the water. AUV will do long surveys at a 4 kt speed. It is used for mapping, krill-biomass, oceanography and sub-bottom profiling (under ice shelf).

No previous operations through moon pool so far.
3 days of operation and one day of maintenance is typical operating scenario.
They will need to operate through a moon pool in ice.
ROV's have more power, arms and video capability.

The EU (AWI is leading) has a feasibility design underway for drilling in pack ice in the Arctic. It would be dedicated to drilling and the name of the vessel is AUORA BOREALIS. It would have a portable drilling rig and two moon pools, one for drilling and the other for AUV/ROV. Size of the moon pools would be about 4m by 5m (other notes indicate 6 by 8 m and 4 by 5 m moon pools). HSVA is doing the design. The new vessel will do 3 months of drilling in the Arctic and then is available for other research.

Drilling operations take a lot of area on the ship and is not very compatible with a general purpose ship. Furthermore, drilling cannot be justified by itself; the ship must have other missions.
The vessel is designed for 400t/m^2, 36 mm plate, 16 m depth, and 6 m freeboard
Continuous presence in the Arctic – drill in 3500 m to 1000 m depth

Vessel will have 50 Mw power and will cost $250M.
Other characteristics include 23,000 ton displacement, 132 m LBP, 36 m beam. 8.5 m draft.
Seimens-Schottel azimuthal pods.

Pods – Electro magnetic field may affects geophysical measurements

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Operations and Logistics people in the afternoon,
Dr. Saad El Nagger, Physicist, Deputy Director Logistics – Head Technical Section
Eberhard Wagner, Reederei F. Laeisz (Bremerhaven) GMBH, Ship Operations and Engineering
Dr. Martin Boche, Former Captain of POLARSTERN and Logistics Director
Dr. Eberhard Fahrbach, Science Operations

One helicopter is good for 10 miles or less from the ship and anything greater should have two helicopters. With one helicopter they have two pilots and one mechanical technician. With two helicopters they have two pilots and two mechanical technicians. Their operations range from 20 to 200 flight hours on a mission.

POLARSTERN has a 1meter by 1 meter square moon pool. Ice damaged the moon pool cover and frame that had a hydraulic activated system. They did field load measurements and FE model to examine damage. Four years ago a new cover was installed and it functions as designed and can resist ice loads.

400 tons/sq. meter ice loads on the cover.

They use 4 hydraulic cylinders. The well is 16 meters deep, 6 meters is the water depth, 36mm thick plate.

Bottom mapping
Atlas Hydrosweep, no windows per se and sometimes it get damaged, very expensive to repair. Model tests show less ice than actually occurs under the vessel.

AWI and vessel operators have been examining bow shapes. Model tests deferred because of costs.

SIMRAD titanium windows, 120 system, one degree opening.

Kevlar windows used with ADCP works well on other systems and sensors and are now working with combinations.

Podded propulsion, it is unclear what effect it has on acoustics and the effect of electromagnetic radiation on other instruments. The shape of the hull aft must be designed for podded propulsion. AWI (Dr. Boche) is unclear if podded propulsion is the way to go, but two vessels are under design/construction with pods.

POLARSTERN has four main propulsion diesels with ship service electric take-off.
The engines are a 1965 design and they want new modern engines, as the current fuel consumption is high. New engines will also meet the latest environmental standards. POLARSTERN today is using water emulsion technology and produces 20% lower NOx than MARPOL Annex 6 requires.

They would also like to get rudders on the vessel instead of the one centerline rudder that currently exists.

Some people want the POLARSTERN to have more horsepower, say 30,000 however the hull is not designed for operations in this ice thickness or speed. The vessel's open water speed is 12 kts.

Currently, the vessel has 4 engines of 3.62 MW. The inboard engines can drive 2.16 MW generators through a PTO. Operating under IMO Rules for pollution (EP) and MARPOL Annex 6. Burns Marine Diesel Oil 1.5% Sulfur. KaMeWa propellers have given no problems. HDW shaft seals by Blohm and Voss – have had outside seal problems. 5 kt limit is imposed in certain ice conditions because of bottom damage. Fuel consumption is too high with the older engines and sometimes they can't use power because of endurance restrictions. Crow's nest required and used mostly used for science.

MISC.

NBP in January 2005 will conduct a SHALDRIL project with SEACORE in the Antarctic.

Anders Backman is spearheading an EU ARMADA summer 2004 Arctic drilling program.

Attachment B – Discussion of some elements for the PRV Technical Specifications

(Based on some of the findings and results from the March 2003 visit.)

ELEVATOR – A four person / one pallet sized elevator capable of one ton weight should be installed aboard the vessel for science use and should traverse from the science hold to the upper level of science accommodations.

BRIDGE CONTROL STATIONS – The port and starboard pilothouse control stations observed aboard BOTNICA and ODEN were deemed very desirable and precluded a control station amidships. The windows at the control stations should extend to within about one foot of the deck to give superior visibility forward and aft.

SCIENCE CABINS –A two-person desk was provided under the window. A tiled bathroom was good and the Euroshower was easy to maintain. Gravity drains in the shower are recommended with a soap dish and handhold in the shower.

STATEROOMS – A mock up of the cabin should be performed. The potential interference between the main cabin door and the head door should be closely examined in the design. BOTNICA has a limiter on the bathroom door so it can’t interfere with the cabin door. There should be a coat rack at the entrance that is of size to hold 8 coats with an overhead shelf. The upper bunk should be fold-a-way (as observed on ODEN, not BOTNICA) so there is more room when one person occupies the cabin. A split rail bunk is desired. A small shelf should be provided inside each bunk area on the bulkhead close to the pillow for placement of glasses, clock/watch and other small items. BOTNICA also had a ladder on the end of the bunks and a 4-draws under the lower bunk. Two large lockers were provided in each room for clothing and separate lockers were provided above for life jackets and survival suits. BOTNICA has a desk suitable for two persons along the outboard wall, under the window, with drawers in the middle of the desk. A series of electrical and electronic outlets at one end of the desk were provided including a telephone. There are big bookshelves on the wall near the desk and the shelves are sloped toward the wall to prevent books from falling out during ship motions. Windows/portholes are recessed from the inside bulkheads and a hard plastic material covers the window to eliminate condensation of moisture. In addition a window shade and curtain were provided. A closed circuit TV shall be provided in each room. Consideration should be given to a flat panel screen on a track on the bulkhead to allow for flexibility regarding location. A desk under the window was found attractive. A decision on the use of a rug vice vinyl flooring needs to be made. Each room should have a thermostat with electric room heating. Each bunk to have curtains around it. The bathroom should have no exposed pipes. Some people preferred the European style showerhead. A gravity shower drain should be installed in lieu of a vacuum drain. In each shower, a shelf should be provided sufficient to hold shampoo and soap and a handhold needs to installed in the shower.

STATEROOM DOOR – Each door should be capable of locking, US locksmith, and the door contain a kick-out pane. Plastic or magnetic keys that can be coded onboard are desired, similar to hotels, as keys are hard to replace. Once the door is open, it should be held in place against an inside wall with a magnetic, not mechanical, device.

PASSAGEWAY OUTSIDE EACH STATEROOM - There should be two business cardholders, one above the other to reflect the occupant of each bunk.

MESSDECK - Need portholes in messroom on new ship with tile floor. Non-fixed chairs are attached with bungy to table for easier clean up on vessels visited. Messroom had good clear space, overhead screen for movies and presentations, subdued lighting and low noise.

SCIENCE CONFERENCE ROOM – The arrangement aboard the NBP was considered good.

PILOT HOUSE WINDOWS – The arrangement of the windows including the shading, heating and defogging equipment aboard BOTNICA appeared very functional.

AZIMUTH PROPULSION – Consideration should be given to this type of propulsion as it provides many advantages for the mission station-keeping requirement. It eliminates the need for stern tunnel thrusters and rudders while providing excellent maneuverability.

NUMBER OF DIESEL ENGINES – Keep to six or less for both propulsion and ship service power. Open water speed should be made with either two or four engines on the line.

PROPULSION MACHINERY PRIME CONTRACTOR – There should be a single-source contractor selected by the shipyard for full and total responsibility of the propulsion system from prime mover, transmission system, propeller and control system. The shipyard selected to build the vessel may be of a medium to small size and probably will not have the in-house expertise to integrate all of the components and control system. A life cycle cost analysis should be performed in the selection of the propulsion plant. This includes the initial acquisition cost, fuel consumption, maintenance and repair of the diesel engines and other factors.

EVAPORATORS - Evaporators need to have the ability to make sufficient water during stationkeeping when waste heat from the diesels may be insuffient.

ROLL STABILIZATION SYSTEM – The icebreakers BOTNICA, ODEN, VIKING Class, and POLARSTERN all use the Intering system for open water roll control and operators felt it to be a superior system. It can also be used as a heeling system, but its effectiveness was less than a traditional heeling system. Intering system should be investigated further.

MUD ROOM – A mud room should be provided to support the change of clothes and related attire from geotechnical drilling operations and access should be provided from the geotechnical work area.

The space should be provided with a head and two doors to provide access to the dirty and clean parts of the vessel.

STAIRWELL – The width of the stairwell aboard the NBP, with emergency lighting, is recommended. The ships visited in March 2003 had narrow passages and were deemed of insufficient size for two people to walk conveniently side by side.

SMOKERS' ROOM – A lounge area with TV, shall have the proper level of exhaust ventilation (negative pressure) to assure smoke does not escape from the lounge. It shall be provided in the superstructure for smokers and shall be of about 10 ft by 12 ft size. There will no smoking in any other part of the vessel and that includes the bridge.

ALOFT OBSERVATION TOWER – An aloft observation tower shall be provided for the scientist in a manner similar to the NBP without any vessel controls but with monitors of vessel position, course, speed, weather and associated data. It shall have both white and red lighting, a GPS feed (RS 232 or similar), network connection, CCTV, heat, phone, navigation repeaters, and bench. Type of decking?

RECEPTION AREA - A reception area, suitable as an office for the Marine Science Project Coordinator or equivalent, shall be located on the 01 level and shall serve as initial contact point for new scientists and visitors coming aboard the vessel.

WINCH LAYOUT – The winch layout on the NBP was reported as very satisfactory.

OPEN DECK AFT – The starboard and aft open deck area on the NBP was reported as very satisfactory.

HULL STRUCTURAL VIBRATION ANALYSIS – Shall be performed, as part of the final design to assure there is no adverse vibration from slamming in open water and icebreaking.

HELICOPTERS – The number of helicopters to be accommodated aboard the vessel should be determined. One helicopter is sufficient if most operations will be performed with helicopter operations in visual range of the vessel. Otherwise onboard provisions should be made for two helicopters.

SEAKEEPING PERFORMANCE – The seakeeping performance of the NBP was reported as very satisfactory.

STATIONKEEPING PERFORMANCE – Yet to be determined.

LOW FRICTION HULL COATING – Inerta shall be applied to the hull as a low friction hull coating, similar to the NBP. The use of a stainless steel ice belt or water wash system or air bubbler system, as alternatives, is unwarranted.

VESSEL OPEN WATER TRANSIT SPEED – 12 knots. It shall be the basis for open water endurance calculations.

WIRING - Cable Trays and Outlets surface mounted. ???

HELICOPTER DECK and HANGAR - Deck and hanger for 2 Astar (Aerospeciale) helos (4 person)

DECK VANs - Need service boxes for deck vans located at each van location and near superstructure.