Offshore service vessel for the Barents Sea

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Interest in oil and gas exploration in the Barents Sea region has increased significantly in the course of the past few years. MARINTEK recently completed a study of a vessel for all-year intervention operations on subsea oil and gas installations in the North-eastern part of the Barents Sea. An initial review of normal and abnormal intervention tasks was carried out with the aid of experts from the offshore industry. A business case was prepared and a vessel designed to meet open water and ice conditions for a specific field east of Svalbard.

For the business case it was decided to compare operability of an offshore vessel working at different locations on the Norwegian Continental Shelf; the Norwegian Sea (Haltenbanken), Southern Barents Sea (Goliat) and North-eastern Barents Sea (Olga Basin). Hammerfest was chosen as shore base for the vessel. Figure 1 illustrates the operational area of the vessel. Only the North-eastern Barents Sea location lies in seasonally ice-covered waters. The primary focus of the project was development of a vessel that could perform intervention operations on a year-round basis in the Olga Basin.

The basic vessel design was made by STX OSV for optimum sea-keeping and dynamic positioning (DP) performance in open waters. Initial resistance, propulsion and sea-keeping tests were carried out in MARINTEK’s Towing Tank. The initial design had large headboxes at the stern in order to allow twin azipod thrusters to be mounted. For some tests, tufts were added at the stern to visualize flow patterns. In parallel, computational fluid dynamics studies (CFD) studies were performed in order to determine the influence of stern and headbox design modifications on the total calm-water resistance of the vessel (Figure 2). The results were combined with input on special design considerations for ice-going vessels with
the objective of modifying the initial model to reduce resistance and improve its ice-going characteristics. The modified model was then subjected to a series of tests to investigate resistance, sea-keeping and station-keeping in open waters using both the Towing Tank and the Ocean Basin. Modifying the headbox design significantly improved resistance (by approximately 15% at the design speed of 15 knots). Compared to an existing offshore vessel design without any ice-performance characteristics incorporated in the design, the increase in power requirements is only 7% at design speed. When we take into account the fact that the efficiency of an icebreaking propeller is usually significantly lower than that of a conventional propeller, this suggests that the final design is good.

The final sea-keeping (Figure 3) and station-keeping tests were run in MARINTEK’s Ocean Basin: Sea-keeping tests are performed to establish response amplitude operators (RAOs) for different vessel speeds and headings. Station-keeping tests are used to establish operational limits for a range of sea conditions and for tuning dynamic positioning (DP) controllers for open-water operation during installation and Inspection, Maintenance and Repair (IMR) tasks.

A series of model tests in ice were performed in the Aker Arctic ice tank in May 2011. The model was equipped with Azipod units and MARINTEK stock propellers. The test series comprised three days of free-running performance tests, one day of manœuvring tests and three days of DP tests. Level-ice tests were performed at three different power levels and tests in ice floes at two power levels. Three ice thicknesses were used in these tests: 0.5, 0.8, and 1.2 m. Since the vessel has been designed as a double-acting vessel, the tests were run both going ahead and stern-first.

Most tests were performed at a defined ice trim, with the vessel trimmed significantly by the bow. Some tests were run in level-trim condition, with the vessel at normal operating draft. On the basis of the test results it has been suggested that the vessel should operate bow-first (with a specific trim by the bow) when transiting in thin, level first-year ice (ice thickness less than 0.5 m). In thicker ice and in regions with ice ridges the vessel will operate stern-first.

The broken ice after the level ice and ice floe tests was used to build ridges with heights ranging between 4 and 8 m.
Energy management in practice

In collaboration with Norwegian ship managers Grieg Shipping, Wilh. Wilhelmsen, Klaveness Ship Management, BW Gas and Solvang, system suppliers Kongsberg Maritime and MARORKA, and the Norwegian University of Science and Technology (NTNU), MARINTEK is continuing its research into ways of improving practices in vessel energy management via joint efforts in the EMIP II project.

The project aims to systematically improve data quality by using state-of-the-art sensors and analyses the performance of case vessels that have implemented efficiency measures, both technical and operational, aimed at reducing their energy consumption. The energy profiles of a number of ships have been mapped in the EMIP I project, and energy profiles will also be mapped, together with information from other tests as improvement measures are implemented. High-quality tests and credible measurement methods from full-scale trials and tests are needed in order to enable reliable judgments of the impact of measures to be made. More systematic documentation for selection of the most useful measures is still required, and MARINTEK has suggested the operational and technical measures that ought to be evaluated and possibly implemented.

Highly integrated plans have been developed by the shipping companies for holistic and systematic testing and mapping of the impact of measures under a wide range of operational conditions, thus improving our understanding of the combined efficacy of the measures and the case-specific improvements obtained.

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vessel was accelerated to a constant initial speed before it hit the ridge. When it stopped it was reversed away from the ridge and new charges were made until it had penetrated the ridge. These tests were conducted running both bow- and stern-first.

Turning tests started a little off the centre-line of the test basin. The Azipod units were turned to the target angles and the vessel was free to turn. Horizontal positions were measured in addition to linear and angular speed.

Finally, DP capability in ice was tested; four different entrance angles of the ice were studied (0-5-10-20°). Tests were carried out under two different ice floe conditions, representing 70% and 90% ice concentration. Peak ice loads measured on the vessel were compared with the maximum thrust that could be delivered by the vessel’s thruster units. Based on the analysis using thrust allocation we noted that the ship was able to maintain position in 0.5 m- and 0.8 m-thick floe ice. The effect of floe size was not examined in this study; previous knowledge suggests that reducing floe size will also require smaller forces. Further tests are needed for a closer study of the influence of variations in managed ice characteristics.

Figure 3. Sea-keeping tests in MARINTEK’s Ocean Basin.

Figure 4. Graphic model showing the vessel working in the marginal ice zone. (Illustration: STX DSV)
Started by InterManager in collaboration with the Research Council of Norway, MARINTEK and Wilhelmsen ASA, the Shipping KPI Project has developed standard tools for measuring the performance of both companies and vessels. Now established as the independent, not-for-profit KPI Association Ltd, the project works with a wide range of industry stakeholders and aims to develop an industry-wide standard for vessel performance measurement.

Performance data from 1158 vessels (as of mid-June 2012) are now being input into the Shipping KPI database – enabling the system to produce informative and meaningful performance measurements for the industry as a whole. The data input by each company is completely confidential and cannot be accessed by any other user of the service. However, the combined data enable the KPI Project to calculate industry averages that enable individual companies to benchmark the performance of their vessels.

Now that theShipping KPI standard is up and running it is time to go beyond the standard itself. The next stage involves optimising the implementation process and the actual reporting as well as reaping the benefits it offers.

Managing Operational Performance in Ship management

The MOPS project was launched to create a basis for competitive advantage for ship managers and ship owning companies via the application of a performance-management methodology including benchmarking, with the aim of continuously improving environmental performance, safety standards and operational efficiency.

The project utilises the established set of Shipping KPIs as a basis for the development of an organisational performance management model used for in-house processes, while also covering external constraints as defined by contracts, regulations and the expectations of the general public.

The project addresses challenges associated with implementing performance management and gaining value from performance measurements through the MOPS Performance Management Model.

Challenge 1: Getting up and running with reporting Shipping KPIs

The initial implementation of the Shipping KPI reporting regime can be rather cumbersome and is dependent on the existing maturity of the company related to performance management. There are three main blocks to cover:

1. Making sure that the measurement (PI Values) definitions are understood and complied with
2. Retrieving these measurements from within the organization
3. Reporting the measurements to the InterManager KPI Environment (IMKE).

In MOPS, a standardized step-by-step procedure is developed and validated by the project partners in order to streamline the implementation process. The procedure covers both organisational and technical issues, which most organizations will face during this initial phase. The procedure helps ship managers to raise their levels of efficiency and maturity as regards reporting on the Shipping KPI Standard. The overall mantra is that the less time and resources are spent on reporting measurements, the more time and resources will be available to reap the benefits of the Shipping KPI Standard.

Managing Operational Performance in Ship management

Figure 1. Efficiency and maturity related to reporting Shipping KPIs.
Challenge 2: Reaping the benefits

The project considers two main questions:
1. How to develop and sustain a performance management model for internal improvement?
2. Can we identify and scrutinise the potential for improved agent-principal relationships through performance measurement and communication.

For internal improvement several theories, tools and methods will be scrutinised, validated by the project participants and tuned to ship management. The main idea is to support ship managers in answering questions such as
- ‘Where am I underperforming?’,
- ‘Why am I underperforming?’ and
- ‘How do I improve?’.

Mapping KPIs to critical business processes and added value services as well as the use of benchmarking are concepts (among others) that will be explored by MOPS. Identification of sub optimisation is a key issue with regard to KPIs acting as incentives for behaviour, a concept that could lead to overall underperformance.

Performance-based contracting is a key concept to be explored by MOPS. An initial study performed by MARINTEK in the EU FLAGSHIP project (http://flagship.be/) demonstrated the Shipping KPIs’ usability as an addendum to the SHIPMAN contract which is currently the de facto standard contract between ship managers and ship owners. By selecting KPIs to represent the ship owner’s areas of interest (as regards technical management of the vessel) and defining target values as operational targets for the ship manager, a bonus/penalty regime was created and validated through the use of real-life data from the original Shipping KPI database. The MOPS project will build on this study, in addition to exploring other potential ways of using KPIs in ship managers’ external interactions.

MOPS Participants

The main pillar of the project is the Bergen shipping cluster, with Odfjell Management AS as the project owner. Most participants are integrated shipping companies, which provide the project with access to both ship managers and ship owners and, just as important, the possibility of analysing the relationship between the two. Another prospective pillar is in Singapore, where the National University of Singapore is interested in being the research partner. The Singapore cluster is also highly likely to include ship managers, who were part of the original Shipping KPI project. These companies, with their existing hands-on experience with the Shipping KPI Standard, will provide an important addition to the Bergen cluster.

The Norwegian cluster

Bergen Tankers AS
Grieg Shipping Group AS
Kristian Gerhard Jebsen Skipsrederi AS
Odfjell Management AS
Rederiet Stenersen AS
Westfal-Larsen Management AS
Wilson Ship Management AS

Associated partner: Deloitte AS
R&D partner: MARINTEK
Sea freight is the most economical and efficient means of transporting large amounts of goods and merchandise over long distances, and most transported cargo is carried by sea freight. The shipping industry is thus a major contributor to air emissions locally and globally.

Emissions from ships include sulphur, nitrogen and carbon oxides and particulate matter, resulting in acid rain, global greenhouse gas effects, human respiratory problems, etc. Therefore it is necessary to reduce atmospheric pollution and harmful emissions from ships.

In order to comply with the International Maritime Organisation’s (IMO’s) MARPOL rules and regulations on sulphur emissions, shipowners and operators will be obliged to use fuel with a sulphur content as low as 0.1% when their vessels enter Emission Controlled Areas (ECAs), after January 1st 2015.

From January 1st 2020, the global cap on the sulphur content of marine fuels is likely to be 0.50%. In order to be compliant, most shipowners and operators will have only two choices for their existing fleet: either to purchase more expensive distillate fuels or invest in Exhaust Gas Cleaning Systems (EGCS), i.e. scrubbers that reduce sulphur emissions to an equivalent level. If scrubbers are used, vessel performance will have to be verified in order to ensure that total sulphur emissions are within the specified limits.

Wärtsilä Moss has entered into an agreement with Wilh. Wilhelmsen ASA to install the world’s largest multi-stream scrubber on one of the latter’s RoRo vessels. The system will reduce emissions of sulphur and particulate matter from the exhaust gases of the vessel’s main and auxiliary engines. The installation of the scrubber will prepare the vessel for the upcoming sulphur emission regulations.

MARINTEK will perform verification measurements of sulphur and particulate matter emissions. Exhaust gases will be measured both upstream and downstream of the scrubber in order to evaluate the efficiency of the scrubbing system. These tests will be carried out on fuels with different sulphur content for the most relevant engine loads and operational modes of the vessel.

Energy consumption will also be measured with and without operating the scrubber, in order to evaluate the cost efficiency of the scrubber compared to using distillate fuels. Preliminary tests will be performed in the engine laboratory prior to the full-scale testing programme on the scrubber pilot installation on board the vessel.
Since 2007 MARINTEK has run several projects investigating the status of communication at sea in the Arctic. From interviews, theoretical analyses and practical field tests we have learned that the current communication infrastructure is inadequate for the operational requirements of expected future maritime activities in the Arctic.

We are also concerned that insufficient communication infrastructure will have a negative impact on safety, which the Norwegian authorities insist should be at least as good as in the Norwegian Sea, where the oil and gas companies have been operating for many years. Focus is sharpening on the safety and efficiency of maritime operations, and support systems based on digital communication are being developed and brought into use. However, such systems depend on communication systems that have adequate capacity and reliability, which is not available in large parts of the Arctic.

What then is really the problem with communication in the Arctic? Have people not been communicating at sea in the Arctic since Marconi invented radio at the end of the 19th century, and the SOLAS convention in the beginning of the 20th century required vessels sailing in international waters to carry radios for emergency calls? This article highlights some of the most important issues that can provide some answers to these questions.

Terrestrial radio systems

VHF is still largely used for communication at sea, but only over short distances (line of sight) and normally only for voice communication. HF and MF are also used for emergency situations and for distribution of navigational and metocean data in NAVAREA 19 (Arctic) which is a Norwegian responsibility. However, as vessels are being equipped with more and more advanced IT and decision-support systems, the MF and HF systems will be unable to offer enough digital capacity. Digital VHF, mobile phone systems and other types of wireless technology offer enough digital capacity for many maritime applications, but only to ships within sight of shore base stations and are therefore not generally available at sea in the Arctic. AIS could also be used for low data-rate communication, but there are very few base stations, and the satellite-based AIS system is designed for data reception only.

Satellite systems

The most widely used maritime communications systems are based on geostationary (GEO) satellites that orbit the earth above the equatorial line, such as Inmarsat and VSAT systems. The problem with GEO satellites is illustrated in Figure 1: They have little or no coverage at all in the Arctic, and their low angles of elevation makes them more vulnerable to external influences.

The theoretical limit of coverage for GEO systems is 81.3° north, but instability and signal dropouts can occur at

Figure 1. Satellite systems in low earth orbit (LEO), high elliptic orbit (HEO) and geostationary orbit (GEO). The lower illustration shows GEO system coverage and low elevation angle. (Illustration: Knut Gangåsæter)
What is the problem with ... cont. from page 7

latitudes as low as 70° north under certain conditions. Many factors influence the quality of service offered by GEO systems, and they have different effects depending on the system design. The most common factors are summarised as follows:

- Attenuation and depolarisation of signals due to atmospheric dispersion, such as is caused by rain and snow. The most severe effects are found at high frequencies, such as the Ku- and Ka-bands. The longer the path of transmission through the atmosphere, the more the signal is attenuated. This length increases significantly at high latitudes.
- Signal scintillation and attenuation due to temporal and spatial variations in the ionosphere, mostly affecting lower-frequency bands such as L-band.
- Reflection of signals from the sea and coastal topography can disturb signals.
- Atmospheric sea spray and snow result in icing on antennae, which attenuates satellite signals.
- Heavy vessel movements can lead to antennas losing track of signals, or even tracking the wrong satellites.
- Latencies and delays in information transmission can occur, due to lack of earth stations, gateways and modulation techniques.

The only satellite system that currently provides full coverage in the Arctic is Iridium, which offers digital capacity via Iridium OpenPort services. However, problems with Iridium have been reported by maritime operators in Arctic areas. The system occasionally shuts down and it can take several minutes to reconnect.

The majority of the challenges outlined above are qualitatively reasonably well known and experienced, but a better understanding of the limitations of the individual systems and their effects on performance and quality of service at different times of day, under different weather conditions and in the course of the year would be highly useful. This is the main topic of the Norwegian MARENOR project, which aims to develop quantitative models that can better predict the total quality of service of communication systems, and enable maritime operators to adjust operational constraints accordingly (e.g. by backup communication channels and/or operational modifications).

The short answer to the question in the heading of this article is therefore: "Current maritime digital communication systems were not designed to cover the Arctic, and maritime operators lack sufficient knowledge and information about the real quality of service they can expect when they are operating in the far north".

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