Project Report

LAURIN
MARITIME

Group:
Maria Arnholm
Laura Cierpinski
Jamil Jasim
Swantje Krupp

Maritime Energy Management
Chalmers University of Technology

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List of abbreviations

ECR	Engine Control Room
EnMS	Energy Management System
EnPI	Energy Performance Indicator
KPI	Key Performance Indicators
GPS	Global Positioning System
KPI	Key Performance Indicator
ME	Main Engine
PROP	Propulsion Performance
RPM	Revolutions Per Minute
SFOC	Specific Fuel Oil Consumption
Kn	Knot
NM	Nautical Mile

1. Introduction

This chapter provides a brief introductory overview about the project's background, objectives, methods and limitation.

1.1. Background

Energy efficiency has become and will remain the key differentiator in shipping for the future. This is mainly due to high bunker costs, low global transport demand and the steadily increasing environmental requirements from legislation. Thus, in order to stay competitive, shipping companies are required to work much harder on the energy efficiency of their vessels (Germanischer Lloyd, 2013).

The Swedish tanker company Laurin Maritime has recognized this industry requirement and is working constantly on further improving the energy efficiency of their fleet. Part of this continuous improvement initiatives are the installation of energy efficiency systems by Marorka on large parts of their fleet.

1.2. Objectives

An additional propulsion optimization module has been implemented on Laurin Maritime's three C-type tankers. So far the company has not registered any significant benefits resulting from this installation. Thus, this paper aims on evaluating its overall performance on these three ships and the benefits in energy management, which this additional Marorka module provides to the company. Based on the evaluation results recommendations for further improvement are provided.

1.3. Methods

The information provided in this paper is mainly based on a number of interviews that have been conducted with both the shoreside management as well as the responsible chief engineers of Laurin Maritime. In addition the system manufacturer Marorka has been interviewed online as well. Also a literature review has been carried out for collecting further information.

1.4. Limitations

Due to the short time period available for carrying out this project, this paper will only focus on the experiences of the company Laurin Maritime with the propulsion module of Marorka. A small benchmark with other similar systems is also not provided in this study but is recommended to be investigated in a further study. Also, the system is reviewed only from a management perspective. Technical aspects of the system are excluded from the analysis and the improvement recommendations.

2. Energy Efficiency Management at Laurin Maritime

This chapter provides an overview of energy efficiency management in shipping in general and the specific efforts undertaken at Laurin Maritime.

2.1. Definition of Energy Efficiency Management in Shipping

Energy efficiency is defined as using less energy to produce the same amount of useful output (Jafarzadeh & Utne, 2014). When applying this definition to shipping in a simplified way, it relates to consuming less fuel oil for achieving the same amount of ship propulsion by minimizing the energy losses during processing, as shown in figure one below.

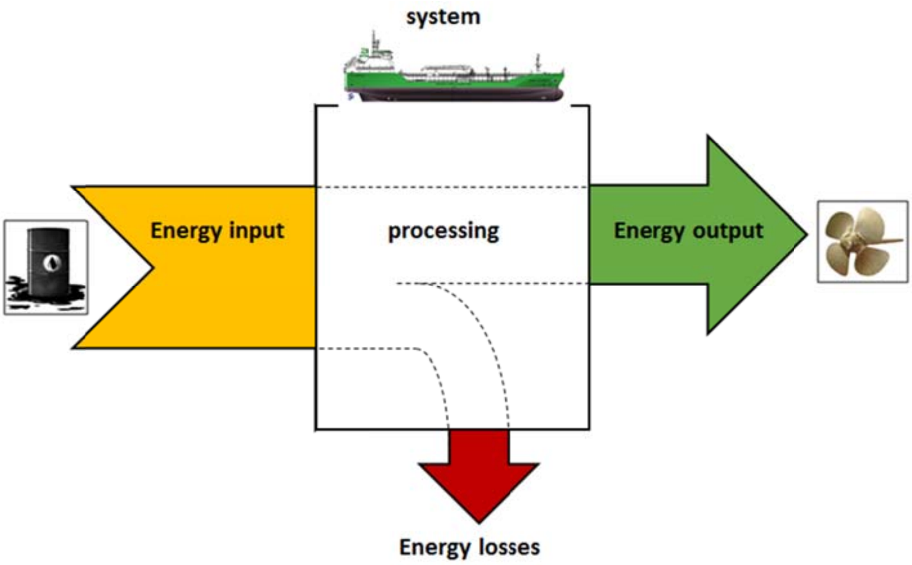

Figure 1: Energy efficiency in shipping (own illustration).

Even though shipping is considered to be the most energy-efficient transport mode, the overall emissions from shipping are constantly rising and presenting a global environmental problem. Thus, international and regional regulation regarding environmental pollution from shipping, especially from air emissions, is increasing (Ma, 2010). At the same time revenues in shipping are low due to a lack of transport demand for shipping and bunker costs remain on a high level. The combination of those factors lead to shipping companies being forced to work much harder on the energy efficiency of their vessels in order to comply with regulation but also to stay competitive in the market. Thus, energy efficiency has become and will remain the key differentiator for shipping companies in the future (Germanischer Lloyd, 2013).

2.2. The importance of Energy Management at Laurin Maritime

Laurin Maritime is a Swedish family owned shipping company that is operating a modern fleet of eleven 46,000 dwt chemical tankers all over the world (Laurin Maritime, 2014a). Laurin Maritime follows a proactive approach to energy efficiency management on its vessels and has started a so called “Energy Conservation Program” already in 2008 (Laurin Maritime, 2014b). Although not officially certified, the company is also working according to the requirements set out in the

ISO 50001 standard dealing with Energy Management Systems (EnMs) (Laurin Maritime, 2014c).

The main reasons for these efforts are primary of monetary nature: Since more than 50% of a ship's operating costs are nowadays related to fuel costs, Laurin believes that investing in increasing energy efficiency is essential in achieving fundamental cost savings (Brandholm, 2013). In addition, there is more and more interest from the company's customers to use environmentally friendly vessels for their transport. According to estimations of Laurin Maritime, 20-25% of their business is based on their good overall environmental performance (Brandholm & Karlsson, 2014).

The energy efficiency efforts are achieved by different constructional and operational measures on almost all ships within the fleet. All ships in Laurin's fleet have been delivered between 2002 and 2012 and are thus very young (Laurin Maritime, 2014a). In the ship design the company has emphasized an energy efficient way of construction by using measures like e.g. lightweight material or waste heat recovery systems (Brandholm & Karlsson, 2014). In order to also increase operational energy efficiency the company has implemented further procedures with a focus on reducing energy consumption and air emissions, such as speed reductions, weather routing optimization and regular hull cleaning (Laurin Maritime, 2014b). In addition, the company has invested in an energy management system from Marorka, which provides additional overview of the ship's energy efficiency performance in real time.

As a result of above mentioned efforts all vessels of Laurin Maritime are constructed and operated in a higher-than-average way, which is represented by their high B+ rating by RightShip on shippingefficiency.org.

3. About the installed Marorka systems

As mentioned above, part of Laurin Maritime's energy efficiency efforts is the installation of energy efficiency systems by Marorka on parts of their fleet. This chapter is supposed to provide an overview about this system and especially the additional propulsion module, which is the central part of further analysis in this paper.

3.1. The Marorka Maren system

Marorka is an Icelandic company which provides different energy management solutions for the shipping industry in order to enable operators to reduce their fuel consumption and consequent air emissions (Marorka, 2014a).

The general system architecture of the Marorka Maren operating platform is demonstrated in figure two below and consists of both software and hardware. Like other competing systems on the market, the Marorka Maren platform is connected to the ship's network and collects a variety of input data via a number of sensors and data files distributed all over the ship. Such input data is generated from e.g. the propeller, the camshaft, the engine, trim, boilers but also from GPS and the navigation systems. This data is collected and processed at the onboard Marorka operating server. After that the data is lead to the two Maren interface user screens, one at the bridge and another one in the engine room. On those interface user screens the generated data is displayed on several screens which provide an overview about the real time energy efficiency state of the vessel. In addition to the current situation it also provides access to historical data as well as reporting and analysis tools (Marorka, 2009).

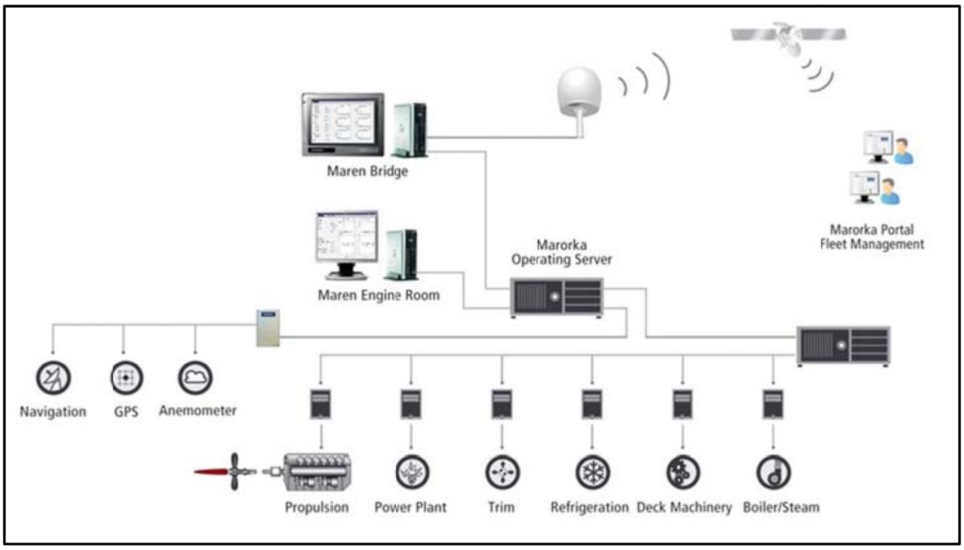

Figure 2: Marorka System Architecture (Marorka, 2009).

Via internet or satellite connections the generated data can also be transmitted to the Marorka Portal which is an onshore reporting and monitoring system for individual vessels or comparisons within a fleet that can be accessed through a web browser (Marorka, 2009).

The standard Marorka Maren operating platform can be complemented by a number of further modules, which provide additional and more detailed energy efficiency information on a specific area of interest. When being installed on the ship, additional screens with further information are

made available on the Maren interface user screens both at the bridge and in the engine room (Marorka, 2009).
Independent of the installed Marorka system scope, the system only provides transparency but does not generate benefits from itself. For this a management system has to be established and implemented, that uses the generated data for continuous improvements (Stefánsson, 2014).

3.2. The additional propulsion module

The Marorka propulsion module is one of the available additional modules in the Marorka system that has been installed on the three C-type tankers of Laurin Maritime for a test run.
The propulsion module is mainly intended to support the ship's engineers in finding the most energy efficient shaft power to move the ship through the water by providing advisory support about RPM, pitch and thermal efficiency (Marorka, 2013).

3.2.1. Technical description

The main reasons for poor propulsion energy efficiency are adverse weather, an unstable autopilot and rudder in non-zero position, poor efficiency of main engine in terms of g/kWh, increased hull fouling, increased propeller slip or non-optimal RPM and pitch combination (Marorka, 2012). Thus, five additional pages in the onboard system provide information about the propulsion plant and propulsion efficiency in order to increase awareness for most of those aspects. The specific layout of those pages is demonstrated in Annex I, providing screenshots of the Marorka propulsion module. In general each page is devoted to one significant propulsion aspect, and a number of related measures are shown in order to help locating the potential source of a deviation (Atlason, 2014).

The first page, "Propulsion Overview", is the central chart in the propulsion module and presents a summary of the propulsion plant and propulsion performance. Data provided here are trend charts for the ship's speed (kn), propeller slip (%), shaft power (kW), shaft torque (kNm) as well as propulsion performance in kg fuel per nautical mile. This is complemented by an energy summary, which gives an overview about the total amounts and shares of energy supplied to different consumers. In addition other key measurements such as shaft power (kW), shaft torque (kNm), shaft rpm, main engine load (%), main engine fuel consumption (kg/h) and GPS and log speed (kn) are displayed (Marorka, 2012).
The second page, "Main Engine", displays information related to the main engine's energy efficiency in terms of specific fuel oil consumption (SFOC) in g/kwh. Two large graphs show the current specific fuel oil consumption vs. engine load and the current engine load vs. engine RPM. Both charts are supposed to indicate a potential engine overload. The measurements are shown on a curve in comparison with a reference curve generated from the ship's engine manual. As long as the measurements are displayed below the reference curve the engine is working as it should (Atlason, 2014). Smaller charts provide information about the main factors for engine efficiency, such as engine load (%), fuel consumption (kg/h), fuel inlet temperature (°C) and fuel inlet pressure (kg/cm2). Other key engine metrics such as fuel input energy (kW), engine RPM, fuel consumption (kg/h and MT/day), fuel density (kg/m3) as well as fuel inlet temperature (°C) are displayed (Marorka, 2012).
The third page, "ME Air and Exhaust", supports the engineer with key energy efficiency information about the main engine's emitted exhaust gasses. As for the main engine page, this

page is mainly supposed to indicate potential engine overloads (Atlason, 2014). Four small graphs display engine load (%) and engine rpm, scavenging air temperature (°C) and exhaust gas temperature after the turbocharger (°C). A larger graph in the center displays the main engine load vs. the engine rpm. In the lower section the exhaust gas temperature (°C) in each cylinder as well as the average exhaust gas temperature (Marorka, 2012).

The fourth page, “Main Engine Boiler”, provides information about the auxiliary steam boiler operation. A central chart provides a chart showing the fuel oil consumption (kg/h) vs. inlet pressure (kg/cm2). Again, the reference curve is provided by theoretical information from the boiler manual and significant deviations of the actual measurements from this curve indicate a problem (Atlason, 2014). Two smaller charts display trends for boiler efficiency (%) and steam production (kg/h). In addition key metrics for the boiler, such as exhaust gas temperature (°C), boiler drum pressure (kg/cm2) and boiler drum level (m), as well as metrics which are signaling boiler inefficiency, such as boiler fuel consumption (kg/h), boiler fuel inlet pressure (kg/cm2), boiler fuel inlet temperature (°C), boiler drum pressure (kg/cm2) and turbine RPM, are provided (Marorka, 2012).

The last page, “Propeller”, is aiming on identifying propeller slip, which defines the difference between the theoretical forward speed and the actual forward speed. The propeller slip is always defined as a percentage, where 0% means that the propeller is working in best possible way (Atlason, 2014). Different graphs illustrate trends of propeller slip (%), shaft rpm and both GPS and log speed. In addition measurements of the propeller and shaft such as shaft power (kW), shaft rpm and torque (kNm) are shown (Marorka, 2012).

3.2.2. Benefits from the propulsion module

According to the system supplier Marorka the most important aspect of the propulsion module is the provision of an overview of the ship’s propulsion measures to the crew onboard. This transparency of the ship’s propulsion performance is considered to assist mainly the technical crew onboard in improving the overall performance or in the detection of defects. Nevertheless, also the navigational crew onboard is considered to achieve benefits from taking the propulsion performance into account in navigational and administrative tasks (Stefánsson, 2014).

There are several areas in which the propulsion module contributes to improve energy efficiency onboard. As described in chapter 3.2.1 above, detailed values for parameters of the main engine, exhaust gases, propeller efficiency and the boiler are displayed in order to assist the crew on what parameters that can be improved in order to reach higher energy efficiency. The collected data will provide recommendations for improving the different propulsion parameters which are included in the system. These recommendations are then shown as a message on the Marorka user interface screens both on bridge and in the engine room. There is also an advisory support function that will provide immediate recommendations to the current mode of operation and suggest changes for achieving optimal propulsion performance (Atlason, 2014).

4. Experiences with the propulsion module of Marorka

This chapter will provide an overview about the different experiences that the involved parties at Laurin Maritime gained from implementing and working with the propulsion module.

4.1. Laurin Maritime's shoreside management

The shoreside Management of Laurin Maritime is using the Marorka Online Portal, in order to get access to the collected data from the Marorka systems. However, the additional data which is provided by the module is not used or displayed in Marorka Online. The collected data is just available if being exported into a Microsoft Excel document, which is not very practicable (Brandholm & Karlsson, 2014). Nevertheless, the collected raw data from the excel files is generally used for further calculations and analysis. Laurin has defined specific Key Performance Indicators (KPIs) for the Energy Management onboard, so called "Energy Performance Indicators" (EnPIs). These specific operational parameters are measured against baselines values, which have been established in cooperation with SSPA and from sea trial values. (Brandholm, 2014). The EnPIs only generally cover the general energy efficiency management onboard the vessels; specifically for the propulsion module, no further KPIs or targets have been established.

This is, because as mentioned in chapter two, Laurin Maritime is working with shipboard management teams, that are granted extensive autonomy in decision making and operations compared to other crews, which are managed more closely from shore. Thus, Laurin Maritime considers the shoreside management only as a supporting function that is available to the shipboard management teams but not as a party, that is actively involved in day-to-day decision making. Part of this philosophy is that the engineers on the ship should take decisions on how to work with the propulsion module by themselves. The only instructions that the shipboard management teams receive from shore, are instructions regarding the intended eco speed level, on which the ships are supposed to be run. How this eco speed level is achieved, has to be decided by the ship's crew. The provision of the additional module was only intended to provide increased transparency about the propulsion plant to the crews (Brandholm, 2014).

In order to encourage employees to work actively with energy efficiency management, Laurin Maritime does provide an annual monetary incentive for employees who come up with suggestions for improving environmental and energy efficiency performance (Brandholm, 2014).

Also the remote connections, which provide the shoreside management with a real time view of the user interface screens on the ships, is generally not used for shoreside management. This connection is regarded as an additional feature that can be considered for support reasons to the ships in case of incidents only (Brandholm, 2014).

4.2. Laurin Maritime's chief engineers onboard

During interviews with two chief engineers of Laurin Maritime's C-type ships their overall experiences and their opinion on the Marorka system was discussed.

When discussing how the system was working the general impression was that it functions quite well (Johnsson & Johnsson, 2014). There have been a few times when the software freezes and a restart has to be performed. At the beginning there were some input values on fuel

consumption that were incorrect which ended up with the wrong end data. This was corrected after the vessel noticed something was not right with the figures.
In some aspects, the system was considered to be a helpful tool in the long run and for raising the interest for how to work actively with energy efficiency questions. Those aspects included mainly the real time data, which the engineers receive. Also, prior to the system the fuel consumption had to be calculated manually and was done only once a day. With the installation data is collected automatically on a regular basis.

4.3. Summarizing the overall experiences

The overall impression from Laurin Maritime's experiences with the propulsion module is, that it is a useful tool in providing additional transparency over the ship's propulsion plant,

The module is supporting the engineers onboard with additional transparency and support, that takes over some of the calculations that had to be executed manually before, but it does generally not provide any new knowledge to the engineers.

5. Analysis

As shown in chapter 4.3 Laurin Maritime is now in the first stage of gaining additional benefits from the installed propulsion module.

According to the interviews the technical operation of the propulsion module works fine, with some exceptions when the system has to be restarted after a crash. The system itself is user-friendly, since it is easy and intuitive to use. As Marorka communicates to its customers, this system is a foundation for building a knowledge base. *"With accurate information, maintained by the systems, Key Performance Indicators (KPIs) can be established and the ship's energy system can be simulated and optimized for the best results"* (Marorka, 2009). Competitors like ABB and Eniram are stating the same approach to use the system by using KPIs (ABB, 2014 & Eniram, 2014). Furthermore, it is necessary to motivate the users with recognition and rewards to gain maximum benefit. A common value must be created for the engineers, managers and everyone else who interacting with the system (Marorka, 2009).

As mentioned earlier Laurin Maritime works in accordance with the ISO 50001 standard (Laurin Maritime, 2014c). In Laurin Maritime the above mentioned KPI's exists in the company Energy Management System as EnPI's (Energy Performance Indicators) and can now be easily gathered and evaluated by the crew onboard. Several energy efficiency systems have been implemented on onboard the vessels as well as onshore. Therefore the analysis will only focus on the propulsion module of Marorka and no other process in the energy management system will be analyzed.

The company has already identified the main significant energy use: the fuel consumption. One of the EnPIs of Laurin Maritime is the PROP (propulsion performance) which states the fuel consumption per nautical mile. One of the opportunities of improvements to reduce the fuel consumption is the propulsion performance. The ISO 50001 standard requires continuous improvement according to the Plan-Do-Check-Act structure (EnergyGov, 2014), which is illustrated in figure three below. Since Laurin Maritime already has an energy management system in place, the first step of identifying opportunities for improvements is already identified by focusing on the fuel consumption and the propulsion system.

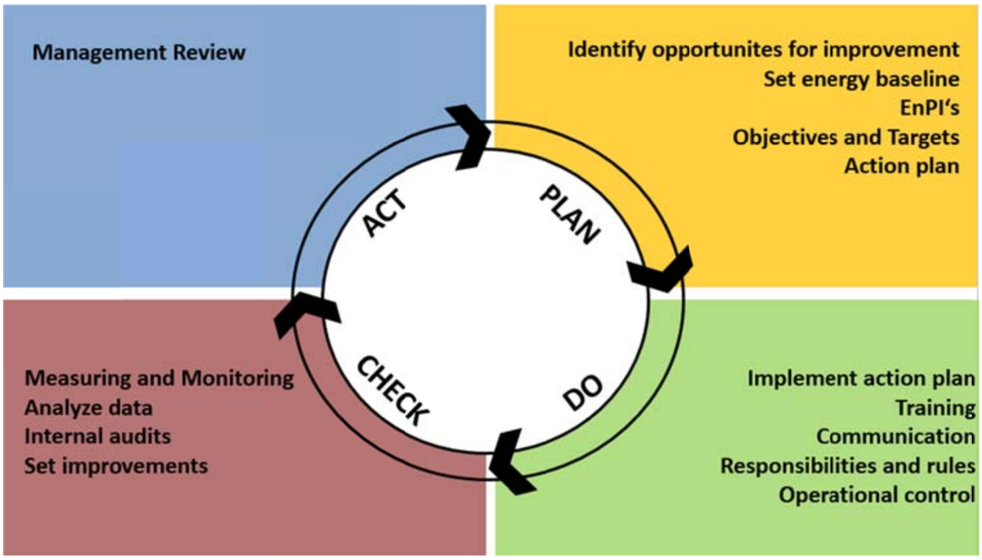

Figure 3: Plan-Do-Check-Act framework related to the propulsion module (own illustration).

According to Eccleston (2012) in the planning phase a baseline should be defined to quantify the current energy consumption and the associated costs. In a continuous improvement process this baseline is the output of the previous period. Laurin Maritime set baselines for each vessel in the company. Furthermore EnPIs should be defined to provide more detailed measures than a baseline and defines the efficiency of a unit. EnPIs enables measurement of the energy performance in detail to be able to identify improvements within the system (Eccleston et al, 2012). With the already implemented EnMS the company is keeping track of the records and improvements, and the propulsion EnPIs are are already included and can now easier be documented and analysed.

6. Recommendations

This chapter will provide recommendations based on the identified gaps, in order to improve the effective use of the propulsion module.

Laurin Maritime has invested in the propulsion module in order to further increase the ship's efficiency and reduce fuel costs.

It is recommended that once the module is fully implemented onboard additional EnPI's should be created. LM will have their annual Energy Management Review (in accordance with the ISO 50001 standards) during the spring 2015 where additional EnPI's may be suggested to be created and were gaps in the expectation of the module will be discussed and remedies decided upon.

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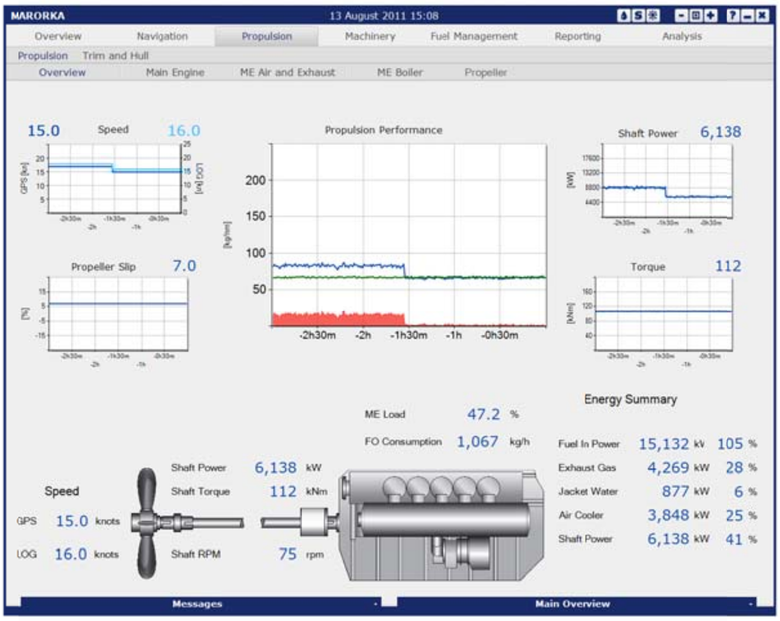
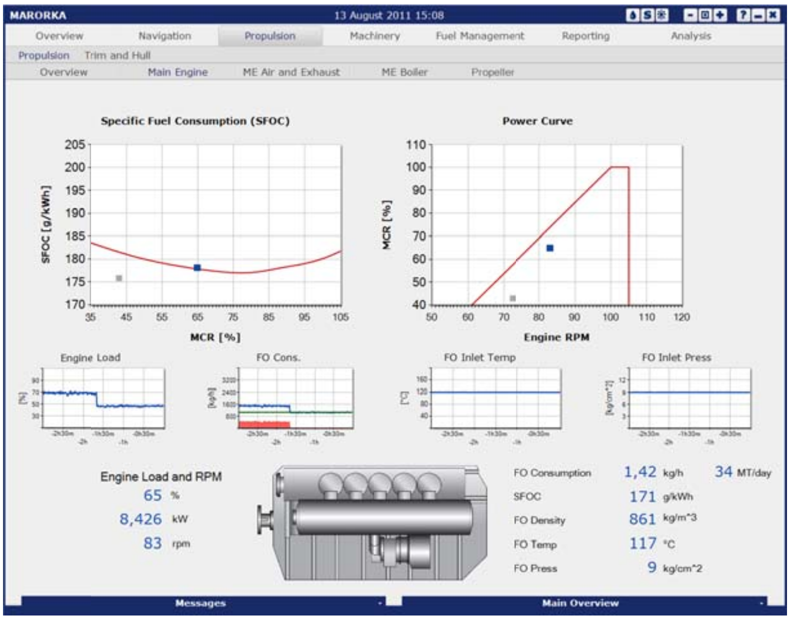
Annex I

Screenshots of the Marorka Onboard Propulsion Module (Marorka, 2012)

Page 1: Propulsion Overview

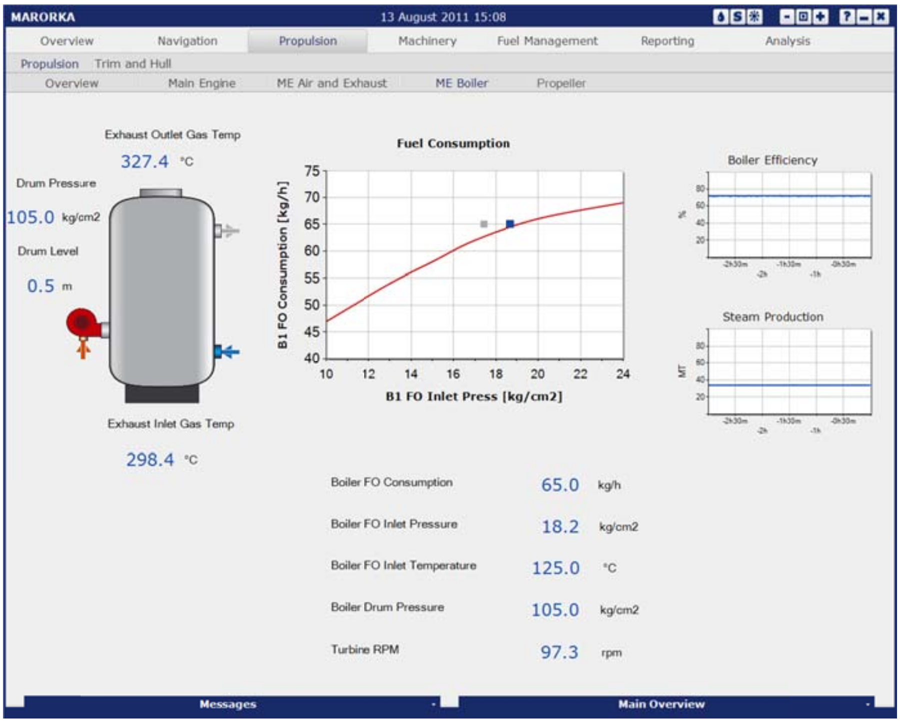


Page 2: Main Engine



Page 3: ME Air and Exhaust

Page 4: ME Boiler



Page 5: Propeller