5.1 ABB Ability™ Marine Advisory System - OCTOPUS

The common nominator for the OCTOPUS Advisory System modules is the significance of full scale and real time measurements.

ABB has developed algorithms using multidimensional non-linear regressions model methods to measure and interpret the vessel operations. The algorithms provide much more accurate results than for example Computational Fluid Dynamics (CFD) calculations or towing tank tests. Most of the OCTOPUS modules require a three month learning period after installation to fill in the statistical database. Using this data the solution is then commissioned and the user interface providing the decision support is turned on.

The statistical model of the vessel provides very accurate results and moreover, perfect analysis tools for operations. The back bone of the energy modules is the Propulsion Energy Breakdown which can separate the required propulsion power from the environmental and operational aspects. This enables Dynamic Trim advice for optimizing vessel’s attitude on any environmental conditions as well as analysis and reporting on Hull Fouling.

OPERATIONS MONITORING MODULES

ABB MRV Software

The European Union (EU) has introduced a Monitoring, Reporting and Verification (MRV) regulation of carbon dioxide, which will further cut back emissions coming from maritime transport. MRV will require large ships (over 5 000 gross tons) irrespective of where the ship or the company is registered calling at European ports from 1 January 2018 to monitor their carbon dioxide emissions and other relevant information.

The ABB MRV software has been certified by Verifavia as a tool to monitor all parameters required to comply with within the EU’s Monitoring Reporting and Verification (MRV) regulation requirements, which come into effect from August 2017. OCTOPUS is considered to be in compliance with the requirements of the Regulation (EU) N° 2015/757, the associated Delegated and Implementing Acts and the ISO IEC 25051 standard on software engineering. Affected ship owners have until August 2017 to present an accredited method of reporting the information.

ABB’s unburdens ship-owners and – operators in this process by offering a user- friendly and fully compliant monitoring tool. So the advantage is two-fold. On one hand this takes away any efforts the ship-owner and – operator in the process of coming up with an accredited method of reporting. On the other hand ABB delivers a plug-and-play MRV set-up that isready to for ship-owners to comply with the EU’s emission regulations in the coming years.

The ABB MRV set-up offers a standardized software solution based on ABB’s industry proven decision support software solution for sea-going vessels. The system that collects and visualizes data from onboard sensors on a ships fuel consumption, the bunkering procedure and carbon dioxide emissions on a per-voyage basis. Further-
more data such as the total amount or weight of the carried cargo, total transport work, aggregated CO₂ emissions, expected distance at sea and start & stop of the voyage can be entered into the system. All this information is then further processed within the cloud to create an annual emission report as required by the MRV regulation.

**Hull monitoring ISO 19030**

OCTOPUS can collect and store data and calculate relevant KPIs to allow measurement of changes in hull and propeller performance as described in ISO19030.

It requires among others the following information: power, torque and rpm in the shaft, weather information, SOG, SOW, draft, water depth and rudder angle.

**Basic performance monitoring**

With daily fuel costs taking in a huge portion of the daily operational costs of a vessel, and new SEEMP (Ship Energy Efficient Management Plan) regulations within the shipping industry, having an insight in fuel consumption KPI’s (Key Performance Indicators) becomes increasingly important for shipping companies. The SEEMP guideline, which is set-up by the IMO in 2009 and became mandatory in 2013, seeks to improve a ship’s energy efficiency through four steps: planning, implementation, monitoring and self-evaluation & improvement. ABB has developed an effective integral approach to tackle these four steps of the SEEMP, making the implementation of the SEEMP very cost effective and simple to execute.

The Basic performance monitoring set-up consists of easy to install mixed sensors and a software solution that is capable of measuring and displaying important vessel fuel consumption KPI’s and making this data available as well on the vessel as to the onshore operations department.

By using ABB’s Coriolis Master high performance fuel flow measuring instruments and Torductor system (for torque measurement), important fuel consumption and performance KPI’s can be shown onboard the vessel on the onboard fuel advisory monitor.

**Basic Motion Monitoring**

The basic Motion monitoring module consists of the needed software including 1 motion sensor. For example for container vessels, Basic Motion Monitoring is an affordable solution for measuring Roll and Pitch of the vessel. Onboard records real-time data from one motion sensor, typically (but not necessarily) placed in or near the center of gravity of the vessel. Onboard records Motion, Velocity, and Acceleration in the 6 degrees of freedom: Roll, Pitch, Yaw, X (Surge), Y (Sway), Z (Heave), a total of 18 signals. The long-term mean values of Roll Motion and Pitch Motion are used to determine the List and Trim of the vessel.
**SFOC Monitor**

The SFOC Monitoring module gives dynamic view to the performance of diesel generators. The performance is evaluated by calculating how much fuel the engine uses to produce certain amount of energy in g/kWh (SFOC). The performance is visualized with three SFOC curves.

Grey is the static factory baseline reported by engine manufacturer. White curve displays the baseline calculated for example after engine maintenance. Orange curve displays current state of the diesel generator. It is automatically updated based on measured values. Reduced performance of the diesel generator can be noticed as lower engine performance index. It is also visible as growing difference between current and baseline curves. The current, orange curve moves slowly upwards as the engine consumes more fuel per produced energy due to reduced performance i.e. dirty filters.

**Power Plant optimization**

The Power Plant Optimizer is a tool for minimizing the fuel consumption of a vessel. The system advices the user on how to operate the power plant in the optimal way in order to save fuel. The system monitors the status and load of each engine. In addition to displaying the required power demand, the Power Plant Optimizer provides the user instructions on when to start and stop engines and how to balance the load in the most efficient way. During the optimization, the system also takes into account the external conditions (such as weather) and vessel auxiliary loads (such as reefer containers or HVAC). If fuel flow measurements, weather data and vessel speed measurements are available, those readings can also be used to calibrate the system.

**Energy Flow**

For visualizing vessel energy consumption. Visualizes energy flow all the way from fuel into various consumers, showing how much energy is wasted due to steam dump and other losses.
5. DETAILED SOLUTION DESCRIPTIONS

**Dynamic Trim & Propulsion Analysis**

OCTOPUS’s dynamic trim optimization is a good example of the adaptive and self-learning algorithm ABB has developed. This solution advises the operating crew on the vessel’s optimum trim in all operating conditions (including variations in conditions such as speed, draft, water depth, wind and waves). Depending on the vessel type and operational profile, the savings potential can be up to 5% of propulsion energy costs. The user interface follows the latest design guidelines in user experience and works intuitively without any user input or configuration. Trim is an important part of voyage optimization and it is recommended to be used in combination with speed / RPM optimization.

The ABB propulsion power analysis tool allows to understand where shaft power is used to and to breakdown power losses (fouling, trim, squat, wind, rudder).

**Response forecasting and basic motion monitoring**

OCTOPUS combines wave measurements, weather forecasts, and navigation datalike speed, course, RPM and the voyage plan, with ship characteristics, loading conditions, and motion sensor measurements. This facilitates continuous monitoring as well as simulation and forecasting of the ship responses and performance. Warnings can be instigated for possible hazards and their consequences. As a result, the system makes the main tasks of the officer on watch easier, by giving support for safe and economic navigation, damage avoidance and route planning.

**Benefits:**

- Integral solution for safe and economic navigation
- Advice on safe speed and heading in heavy weather
- Warning against parametric roll, bow-and stern-slamming, green water, high lashing loads, propeller racing and more
- Reduced operational costs
- Increased passenger comfort and prevention of motion sickness
- Increased comfort level of the cargo-owner

Included in this module is a motion sensor to measure the roll and pitch of the vessel.
DP Operation Optimizer and Forecast
For vessels equipped with a Dynamic Positioning system, ABB’s DP Forecast software includes a prediction if the vessel is capable to maintain her DP position during an operation. This leads to maximized workability, less fuel consumption and more productive hours during operations where the DP system is used. The DP software calculates an onboard forecast of the mean and slowly varying forces acting on the vessel due to currents, wind and waves.

Benefits:
• A clear and complete indication of the operational windows for weather-sensitive operations at sea
• Reduced fuel consumption because of efficient usage of DP thrusters
• Better and efficient preparation and execution of projects
• Less damages and stress to the vessel
• Optimal use of man and machine in a safe environment, leading to significant cost reductions.

Performance monitoring
Measuring the energy consumption of different equipment is the basis for improved energy efficiency. OCTOPUS calculates energy efficiencies and provides easy to use visual tools for monitoring of the ship’s overall performance and following the target values. The system helps to reduce the ship’s energy consumption by comparing the actual consumption against the targets and identifying the areas where improvement is required in real time.

The measured energy consumption data is stored in a database. The recorded data is presented to the users via the user interface in the form of history, reports and process-specific displays. The system comprises of a server, the needed client computers and connections to external systems for the needed data.
Users are typically ship personnel who can affect the energy consumption of production onboard. In practice, this means deck and engine office.

Crane tip monitoring
The OCTOPUS-Onboard crane tip monitoring function provides real-time monitoring, display and storage of crane-tip motions, velocities and accelerations in OCTOPUS-Onboard software. When OCTOPUS is interfaced with the crane to receive parameters like the slewing angle and boom angle, the time-varying (x,y,z)-coordinates of the hang-off point can automatically be calculated within OCTOPUS. This way, the crane tip can be specified as a dynamic Virtual Motion Reference Point, for which OCTOPUS can monitor the motions/velocities/accelerations in 6DOF.
Advanced Motion Monitoring
The Advanced Motion Monitoring provides virtual measurement of motions, velocities and accelerations in any thinkable location on the vessel, such as CoG of the cargo or a high point in a crane boom tip. By the installation of three MMS acceleration meters. The user can monitor any location by simply adding a virtual location in the system, the MMS-3 system calculates with high accuracy the motion and acceleration at the given virtual location. With this setup all critical parts of the vessel and cargo can be monitored with redundancy and without the need of a physical sensor installed on difficult locations.

The system includes full alarm management for real-time and statistical values. The system ensures reliable monitoring with a minimum of setup cost for each project / cargo. For this reason the system is the primary choice for shipping companies involved in project transportation.

Bunker Transfer Monitoring
Bunker fuel is a significant cost for vessel operations. Today saving fuel is an important target and forces the requirement to exactly measure the amount bunkered. Mass flowmeter technology allows monitoring the correct amount, eliminating errors caused by, for example, water and air content in the bunker fuel (Cappuccino effect).

The difference between the value of the bunker bill and the real consumption of fuel could be optimized. The proven ABB CoriolisMaster mass flow sensor technology in combination with other ABB sensors and ABB control and flow computer technology fulfill the application of fuel transfer measurement during bunkering process on board.
Clean Hull module

The Cleanhull algorithm estimates the hull condition of a ship and provides decision data with an aim to saving fuel versus hull fouling condition. It estimates the effect hull fouling has on the drag as the ship moves through water (called the fouling estimate). Hull Condition is a relational index and each vessel has its own scale. Value 1 is set as the starting value. Therefore, absolute Hull Condition index values between vessels are not directly comparable. Hull fouling is assumed to cause a multiplicative error to the drag component in the OCTOPUS Propulsion Analysis.

Speed Advice

Using the in-service determined speed curves and dynamic characteristics of the vessel in combination with weather forecasts and in-depth knowledge about ship motions in waves, an accurate advice can be given on the RPM, which results in a just-in-time arrival with minimum costs of fuel. The advice is based on the vessel monitored data and can be started after approximate 3 months of monitoring with OCTOPUS-Onboard.
Most of the OCTOPUS modules require a three month learning period after installation to fill in the statistical database. Using this data the solution is then commissioned and the user interface providing the decision support is turned on.

**Comfort optimizer**

OCTOPUS provides virtual measurement of motions, velocities and accelerations in any thinkable location on the vessel, such as the restaurant, bridge/wheelhouse, cabins, shopping area, pool area and theatres. The system is included with a full alarm management for real-time and statistical values. The OCTOPUS software can also interface to other motion sensors; this way the same benefits can be obtained using existing motion sensors.

This solution gives a clear advice for safe operation in difficult weather conditions. The weather forecast(s) and measurements are transferred in an actual response forecast.

OCTOPUS-Onboard automatically imports the needed information, calculates the hydrodynamic properties and displays the expected responses. This way during transfer, too heavy motions and accelerations of the any area can be avoided. Different displays for heading control and optimization, and visualization and planning of operational windows are available.

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*Basic view onboard*