Discover how intelligent data can help you implement and reap the rewards of smarter, streamlined operations.

Multiple pressures on the global marine industry mean that ship owners and contractors can no longer afford to ignore the performance of their fleet.

A ship’s energy consumption depends on a number of different parameters. To improve the consumption you need to measure these elements, transform collected data into actionable information and understand the impact of any action on the complete economic model.

To do this, and to make the most of the cost and efficiency savings that Fleet and Vessel Performance Management undeniably offers, you need a partner who understands all of the complexities and challenges. A partner like BMT SMART.
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We are proud to present the fourth edition of our informative, free-to-access publication series – Fathom FOCUS.

The commercial pressure to evaluate and act upon ship performance hardly needs underlining. The shipping industry business landscape has fluctuated immensely over the past decade at the hands of the global economy, regulatory pressures and heightening bunker fuel costs. This means that managing ship performance and streamlining operations is more important than ever.

What Information Can you Expect

This Fathom FOCUS publication gives you an overview of some of the key aspects of Ship Performance Management. It explains what Ship Performance Management is and outlines the drivers and challenges to managing ship performance.

This publication also provides an overview of the different functions frequently incorporated into Ship Performance Management systems and how much fuel can be saved by each individual function. Given the wide variety of measuring instruments and software applications available for Ship Performance Management available on the market, the FOCUS also includes a few sample manufacturer profiles that present key facts and figures around the technologies and software on offer.

However, there is more to Ship Performance Management than what is held within this free-to-access publication! For example, how do you choose the right fuel flow meter, what types of torque meters exist and how do you get from installing measuring instruments to a full-fledged Ship Performance Management system? These are just a few of the questions we cover within the all-inclusive book ‘Ship Performance Management: The Guide’. In addition, the Guide features over 60 products that are available right now for Ship Performance Management, including fuel flow meters, torque meters and comprehensive software systems.

While the FOCUS will provide you with key information with regards to the main aspects of Ship Performance Management, the Guide is for those wanting to delve deeper into the issue and explore the full range of possibilities that managing your ship’s performance can offer.

You can purchase Ship Performance Management: The Guide via www.fathomshipping.com

We hope that you find this publication useful and an interesting read!
SHIP PERFORMANCE: AN OVERVIEW

WHAT DRIVES SHIP PERFORMANCE MANAGEMENT?

THE FUEL SAVING IMPERATIVE

REGULATION

TRANSPARENCY

WHAT IS SHIP PERFORMANCE MANAGEMENT?
WHAT DRIVES SHIP PERFORMANCE MANAGEMENT?

The commercial pressure to evaluate and act upon ship performance management (SPM) hardly needs underlining. The shipping industry business landscape has fluctuated immensely over the past decade at the hands of the global economy, regulatory pressures and heightening bunker fuel costs. The drive for SPM and the streamlining of operations is stronger than ever.

THE FUEL-SAVING IMPERATIVE

Over the last decade, sharp increases in bunker fuel prices coupled with low freight rates and continued charter scrutiny have certainly catalysed the shipping community to monitor their operating expenditure and act on monitoring and reducing their fuel bills.

You only have to look at the array of fuel price figures over the last few years to see the increasing pressures that ship owners/operators are facing. During 2012, fuel prices peaked and the Rotterdam 380 centistoke averaged US$639.6/tonne compared to an average of US$234/tonne back in 2005. At the time of writing (April 2014) the Rotterdam 380 centistoke was sitting at values above US$570/tonne.

These figures illustrate that the days of US$100/tonne bunker fuel will not be returning anytime soon.

Therefore, it is not surprising that the industry is constantly evolving from previous practices conducted under a state of fuel gluttony to becoming an industry that is trying to monitor and reduce every drop of fuel consumed.

REGULATION

The commercial driver for greater fuel efficiency runs parallel with the influx of stringent regulations concerning the environmental impact of the global shipping industry.

In July 2011, the International Maritime Organization (IMO) passed a package of regulations that enforce greater actions around ship efficiency and the reduction of greenhouse gas (GHG) emissions from ships.

The Energy Efficiency Design Index (EEDI) is a design-based index that quantifies the amount of carbon dioxide (CO₂) that a ship emits as a function of a ship’s transport work performed. This equates to grams of CO₂ per tonne nautical mile. The index currently applies to newbuild ships only.

Many of the ships sailing today were in fact designed and built when bunker fuel prices were closer to US$100/tonne, or even less.
The Ship Energy Efficiency Management Plan (SEEMP) is an operational measure that applies to all ships. The aim of the SEEMP is to establish a mechanism to improve the energy efficiency of a ship in a cost-effective manner. The SEEMP also provides an approach for shipping companies to manage ship and fleet efficiency performance over time through a four stage approach: planning, implementation, monitoring and self-evaluation and improvement.

Both of these regulatory instruments came into force in January 2013.

However, many agree that EEDI and SEEMP alone are not sufficient to curb the growth of GHG emissions from the industry. Therefore, further policy tools are in development. These regulations, if passed, would act as a driver for the increased monitoring and evaluation of ship efficiency, fuel use and emissions.

At the time of writing, the European Commission had proposed regulation on monitoring, reporting and verification (MRV) of CO₂ emissions beginning 1 January 2018. If approved, ship owners/operators will have to monitor and report the verified amount of CO₂ emitted by ships above 5,000 gross tonnage on voyages to, from and between EU ports.

France has already moved ahead in this field, in 2013 they introduced a CO₂ reporting regulation for ships departing from or travelling to a location in France.

Whilst such policies described above have the ultimate aim of reducing the environmental impact of shipping, the necessity to collect data from shipping operations will undoubtedly feature more frequently across regulation, and not solely environment-centric regulation.

The shipping industry is not immune to the growing societal demand to account for the ‘impact’ of business and trade on society and the environment. As the environmental consciousness of end customers increases, the importance of improving the transparency of operations and supply chains is something that the shipping industry is not immune to.

The drive for transparency around the environmental impact of freight movement and logistics across the shipping industry is increasing and demands for improvements are thus pushed onto suppliers and transport providers. Cargo owners, charter companies, banks, investors and insurance companies are increasingly demanding evidence of environmental and operational efficiency commitments when making contract decisions with operators. Additionally, a number of benchmarks and incentive schemes have been developed to rate the environmental performance, and/or efficiency of ships, in order to placate the demands of stakeholders.

These benchmarks and incentive schemes demand that ship owners/operators provide varying levels of information around their effluents, emissions and ship efficiency. In return, the more efficient, less polluting ships receive benefits and incentives.
WHAT IS SHIP PERFORMANCE MANAGEMENT?

Many ship owners/operators have long had processes in place to measure and manage fuel consumption. Tank measurements and noon reporting have been, and still remain, common practice.

However, in order to assess ship performance and act on fuel use and efficiency, many other parameters besides fuel consumption must be monitored. This is the case because the fuel consumption of a ship is dependent on several factors including:

- External factors (e.g. weather and sea conditions).
- The technical efficiency of a ship.
- The state of maintenance of a ship (e.g. hull resistance due to algae fouling).
- The way the ship is operated (e.g. load and trim conditions).

Therefore, in order to act on SPM, the ship owner/operator must be able to accurately ascertain the ship’s fuel consumption and in addition to this, how each part of machinery, each piece of equipment and all parts of the ship affect the ship’s performance and correspondingly its fuel consumption.

Over the past decade, a variety of software products, packages and services have been developed and launched within the maritime market that can monitor, collect, analyse and optimise every aspect of a ship’s operation. Within this FOCUS we describe such systems and packages as ‘Ship Performance Management Systems.’

The utilisation of SPM systems can help ship owners/operators understand where each drop of ship fuel is consumed and whether it is used efficiently and optimally. Many of the systems and technologies can even be set up to transmit the collected data directly ashore via satellite communications, thus placing the ship manager in the driving seat of a ship from the comfort of shore-side offices.

In combination with increasingly accurate measuring instruments, SPM systems offer a step change in accuracy and flexibility compared to the older practices of tank measurement and noon reports.
BMT SMART

We are part of BMT Group, the leading international design, maritime engineering, science and risk management consultancy with a reputation for engineering excellence. We’re driven by a belief that things can always be better, safer, faster and more efficient.

BMT has over 20 years’ expertise and experience in the specialist area of fleet and vessel performance management (FVPM). In fact, it was BMT that pioneered the intelligence behind successful voyage optimisation systems currently on the market.

Intelligent Solutions

We’re always on hand to help you work with, interpret and analyse the smart data that our advanced FVPM system collects - in the best way for you. We can help you access the information in a number of ways, both on-board and on-shore, and create views based on your requirements - by vessel or fleet; for charterers, owners or manufacturers. We’ll enable you to understand how the information that’s at your fingertips can help you optimise your operations, anytime, anywhere.

Our system automatically collects the vessel data and uniquely combines this with independently sourced and validated Metocean data. This allows you to consider weather and sea parameters independently. Once each of these elements is monitored, you need to transform this data into actionable information - and understand the impact of any action on the complete economic model.
**Optimisation Solutions**

When it comes to optimising vessel performance, things are not always clear-cut; each action has a knock-on effect on other aspects of your operations. If you slow down to increase fuel efficiency, will you still avoid late arrival penalties? How can you tell if maintenance carried out on the engine has positively affected performance?

These are all types of decision crews make on a day-to-day basis. Our optimisation suite of solutions helps you make the best decisions for your business. Our comprehensive data optimisation solutions use a highly visual system of traffic light and dial displays to provide you with a consolidated view of your vessel.

Feedback on daily/hourly actions or adjustments and short-term trending information is at your fingertips. This will give you all the insight you need to make independent, informed decisions; the tools to implement sensible, aligned actions to achieve efficiencies - and the knowledge to understand the impact of those decisions.

**Management and Analysis Solutions**

You’ll have all the help you need in managing and analysing your fleet or vessel performance over any period of time, and retain complete control over your operations throughout. The ability to process historical vessel and Metocean data, complete with in-depth analysis, helps you report on previous performance, identify key trends and create data forecasts so you can plan ahead.

Whether you’re looking for daily or weekly insights into what’s happening on-board and why it’s happening, you can set different profiles to define user access to your choice of modules. We can help you to better understand the impact of various changes on overall vessel performance and any potential efficiency gains that could still be made.

**Consultancy and Benchmarking**

At BMT our specialist teams are able to advise and help all stakeholders who are keen to find ways to improve vessel performance, as well as provide validated results to those requiring independent verification of vessel or equipment performance.

Whether working with you on benefit analysis, vessel design or human factors, for example, our 1,400 consultants and marine surveyors aim to help you manage your assets in the most cost effective, safe, reliable and environmentally responsible way.
Ongoing Excellence

We’ve combined our technical excellence and innate understanding of what it takes to achieve optimal vessel performance to launch our own innovative FVPM system - a package of optimisation, management, analysis and consultancy solutions that provides all the insight and support that ship owners and charterers need.

As your partner, BMT SMART can help you to identify the optimal balance of all the factors affecting each voyage and the overall performance of the vessels you’re responsible for.

Choose to work with BMT SMART and you can reap the rewards of innovation that continually sets the standards for others to follow. The strength of our solutions and capabilities is second to none.

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- With our support you can save where it makes sense.

KRAL is a leader in the field of pump and flow measurement technology and with its high-quality products and services a reliable partner to the global players.
FUNCTIONS OF SHIP PERFORMANCE MANAGEMENT SYSTEMS

TRIM OPTIMISATION

SPEED AND THROTTLE OPTIMISATION

WEATHER ROUTING AND ROUTE OPTIMISATION

CONDITION-BASED MAINTENANCE (CBM) - HULL AND PROPELLER

ENGINE PERFORMANCE MONITORING AND CBM

EFFICIENCY OF MACHINERY

EFFICIENCY OF HOTEL FUNCTIONS

FLEET MANAGEMENT
Over the past decade, an increasingly wide and sophisticated array of tools have become available to the maritime market for optimising the operational performance of ships. These ship performance management (SPM) systems differ widely in terms of their complexity and the functions that they cover.

In this chapter, we describe the range of functions and discuss what fuel savings they can offer.

The definition of fuel savings achieved through the application of technical and operational interventions is a contentious issue. This stems from the fact that they are often presented as generalised numbers rather than presented for specific ship types. However, it is the ship specifics such as froude number, hull form, machinery and propulsion type that are key parameters in determining the true magnitude of the fuel saving. Contention also stems from an absence of independent, high quality empirically validated information in the public domain.

In order to alleviate some of the contention, we present fuel saving figures for the principal functions of SPM systems drawn from three different sources.

The first listed are taken from IMarEST (2011), these figures may give an indication of the potential saving for an individual operator who is either implementing a measure for the first time or radically upgrading an existing measure.

The second listed are from OCIMF (2011), which report numbers for the overall savings potential for the tanker fleet, assessed as additional to typical current practice.

The third listed are taken from ABS (2013), which is an advisory on ship energy efficiency measures. This is intended to give an indication of the range that may be achieved either because of the specifics of a given ship type or because of variation of opinion on the realistic saving potential.

Note: No percentage figure is given for fleet management, as this is a widely-varying category that may contain a number of the other individual elements. The savings resulting from the different functions are not necessarily additive, and they always depend heavily on the efficiency of the ship’s baseline operation.
Sailing a ship at its optimum trim for current speed, loading and sea state reduces its hydrodynamic resistance to the minimum possible, reducing propulsion energy requirements and hence fuel consumption.

Defined simply, optimum trim is the trim angle at a given condition (displacement or speed) where the required propulsion power is lower than for any other trim angle at that condition.

This method was previously considered to be less important or too expensive and therefore has only recently been gaining speed, offering substantial savings. It is with these savings that hull forms are being studied in order to provide bow and stern modifications to achieve the least resistance. It is important to ensure that the water level at the bow and stern are as close to the designed level as possible. If these water levels are even slightly different, water resistance can increase dramatically and hence fuel consumption rises.

Trim not only relies on hull form but also on cargo distribution, ballast and consumables which can all affect how the ship sails. It is therefore important to collate as much information to allow the best combination of draft and trim in relation to cargo, with the addition or reduction of ballast depending on the amount and location of said cargo.

Loading computers and pre-sailing trim calculations have been available for many years that allow operators to adjust ballast in port. The latest equipment, however, takes this concept a step further and monitors actual trim during the voyage, comparing this to the calculated optimum under present conditions and advising the bridge whether small adjustments of ballast or consumables could be beneficial.

This real-time trim advice is known as ‘dynamic trim optimisation’ and can offer measurements of actual performance (speed, power and fuel consumption) compared to corresponding draft and trim while in motion. The data produced can be used to generate optimum trim tables.

In-service measurements can also benefit these tables though it must be noted that this approach can be difficult to implement with sufficient accuracy to be useful, especially with difficulties isolating the effects of trim and draft on fuel consumption from the other myriad of factors that add to resistance.
IMarEST: 19 - 36% (for 10 - 20% speed reduction)
OCIMF: 13% (for 5% speed reduction); 1% for even engine load
ABS: 20% (for 10% speed reduction)

The practice of ‘slow steaming’ reduces propulsion power requirements significantly. It is understood that if you double the speed of a ship, the increased power requirements is increased by a factor of at least 8. Conversely, if you reduce the speed to 90% of the design speed, then the ship would only require 75% of the power. Thus reducing ship speed by 10% can achieve savings of around 20% in fuel.

It must be noted that even though slowing down can save fuel consumption, it may also come at a cost when the volume of cargo being transported with the same time frame is unchanged. To combat this factor it may require more ships to sail ensuring that the same volume of freight is delivered on time. In addition, running an engine below its design point can reduce its specific fuel oil consumption (SFOC, the fuel consumed to achieve a given power output) and running the ship below its design speed can reduce its hydrodynamic efficiency.

The optimum ship speed for any voyage will therefore be a function of several factors, including the charter rate, scheduled arrival time (and any flexibility in allowable arrival time), engine rating and condition, ship design speed, current fuel price and potentially the need to avoid adverse weather conditions. SPM systems can be used to help untangle these many interacting factors and therefore enable the operator to get a more sophisticated understanding of the particular ship’s speed/fuel characteristics in different conditions.

Some systems use the charter rate, fuel price and fuel consumption data to calculate the overall net costs of time at sea at different speeds, as a voyage-planning tool for shore-based fleet managers. Others interact more closely with engine monitoring modules to offer real-time advice to the bridge on optimal throttle settings. A few interact with weather monitoring systems to ensure speed decisions take account of the likely weather the ship will encounter.
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Find out how we help them save fuel, get 100% visibility into their consumption, and reduce CO₂ emissions.

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WEATHER ROUTING AND 
ROUTE OPTIMISATION

IMarEST: 0.1 - 4%
OCIMF: 0.1% (weather routing); 0.5% (minimising rudder adjustments)
ABS: Savings vary depending on climate and voyage length (can be significant in severe weather or where just in time arrival is possible)

Weather routing involves the practice of selecting the optimum course from start to finish, providing the safest passage and on-time arrival whilst taking into account wave, wind and current conditions that will be experienced on the voyage.

In the past decade, routing systems have evolved from finding the fastest and safest route to instead finding the safest and most fuel efficient route.

Systems that support such functions plot optimal routes using information on predicted weather, and sometimes known currents; some also take into account non-weather factors such as fuel price, speed, charter arrangements or time spent in Emission Control Areas (ECAs). Systems also differ in terms of how much logistical support they offer on a fleet-wide basis: some are able to advise managers on optimum deployment of a portfolio of ships, given the range of specific missions to be performed and the prevailing commercial situation.

Weather routing software can be easily installed within the back of bridge systems. If the ship has Internet access, regular updates can be relayed to the captain on the sea state and any weather conditions that the ship will experience. This makes it possible for routes to be planned according to the company requirements, to ensure a safe voyage and adjust sailing times for ships to arrive on time.

The routing service is only as good as the weather forecasting ability and meteorological expertise of the service provider. However, with the increasing advancements in data collection and analysis that providers offer, models and forecasts are becoming more sophisticated and accurate.
IMarEST: up to 10%  
OCIMF: 2%  
ABS: for hull cleaning, savings vary depending on the degree of fouling: cleaning a heavy macro fouling can result in up to 30% fuel savings. Propeller polishing can lead to reduction up to 6%.

Hull fouling – the accretion of marine organisms on the hull surface – increases the roughness of the hull and thereby its resistance through the water. Hull cleaning or re-coating can be carried out at fixed intervals, but these may not be the optimum intervals given the speed at which hull fouling is occurring on a particular ship which will vary with the type of coating applied, the areas of operation and the time spent anchored or in port.

In addition to hull fouling, propeller service degradation will also reduce propulsive efficiency. Propellers suffer from physical surface roughness created by corrosion, cavitation, erosion and impingement attack. Failure to properly maintain propellers in the form of overspray from hull coatings, excessive and aggressive grinding/polishing and nicked edges can also reduce the efficiency of propellers. Even though a fouled propeller has a less negative impact on the ship’s efficiency than a fouled hull, it can still increase fuel consumption by about 6 - 8%.

SPM systems that offer CBM for hull and propeller monitoring track engine power and changes in fuel consumption to identify degrading surface conditions. In order to understand the impact of hull and propeller surface conditions on fuel consumption, it is necessary to isolate the effects on fuel consumption of the parameters being studied. This is primarily done by collecting records of fuel consumption in controlled or repeatable conditions. The data is then either normalised to remove effects of draft, trim, wind and waves, or compared with similar conditions in earlier tests.

This information is then presented in raw form, or used in calculations against drydock and out-of-service costs to advise on the optimum maintenance schedule. The roughness through fouling with losses in propulsive efficiency can be correlated, thereby drawing up schedules for cleaning and polishing for their economic benefits.
There are numerous engine parameters that can be measured and analysed by SPM systems, including temperature, pressure and running speeds of various components and lubrication system rates.

Systems that assess the criticality and probability of failure for the various engine parameters have been available for many years. These systems carry out this function with a view to ensuring safety and avoiding unscheduled downtime by detecting early warning signs.

In general, any problems related to the engine will reduce the efficiency of the engine, and there is thus considerable overlap between safety/maintenance systems and modern tools that are designed specifically to optimise the engine performance by small adjustments to settings of fuel rack, injection rate etc.

All machinery onboard ships consume energy and thus can be tuned to perform at their optimum efficiency. Dated systems, for example, can be upgraded or replaced to reduce the power consumption.

Some SPM systems monitor the efficiency of auxiliary engines and boilers, others monitor pumps and other machinery. Some of these systems provide optimisation advice on the aforementioned machines.
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Electrical power onboard ships is becoming ever more important and there are several means by which to assure its continuous availability. A few SPM systems are able to monitor the energy consumption of hotel functions such as lighting, communications, climate control, refrigeration, water desalination and treatment and entertainment. Where these work in conjunction with machinery monitoring, they are able to ensure optimal matching of power generated to required load and ensure availability of consistent electricity as well as avoid blackouts.

SPM systems commonly allow data to be relayed to shore-side managers for analysis. Where they are installed on multiple ships, further functionality is often available, for instance the ability to compare performance between ships within a fleet (a useful tool for assessing the effectiveness of hardware upgrades or operational procedures being trialled) or to improve the efficiency of the fleet as a whole.

The increased connectivity between ship and shore has now allowed shore-side managers to view their fleet in real-time giving them the ability to monitor all aspects of their operation.

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- Monitoring fuel consumption
- Shaft power

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Your challenge:
- Engine efficiency
- Checking hull resistance status
- Monitoring fuel consumption
- Shaft power

How?
By precise and reliable Shaft power and fuel consumption monitoring

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Be sensible • Save money • Monitor your efficiency:
VAF Instruments provides accurate torque and fuel measuring systems
UTILISING FLOW DATA FOR SHIP PERFORMANCE IMPROVEMENT

What you need to know about flow measurement to master the daily hunt for needless fuel consumers.

Thomas Flauger, KRAL AG, Lustenau, Austria

The ongoing economic crisis is one of the most difficult the maritime industry has experienced in decades. Due to low charter rates, profit margins are thin and high bunker prices put shipping companies under additional pressure. The gap between charter rates and bunker prices is constantly widening, as illustrated in Fig. 1. Since the 2008 financial crisis, bunker prices have almost reached the high pre-crisis level, whereas charter rates have plummeted.

Because bunkers have a high impact on the ship operating costs, ship owners are now implementing projects with a strong focus on fuel efficiency.

Precise measurement technology is the basis for cost optimisation

Shipping companies are investing in ship performance monitoring (SPM) systems, for example from M.A.C. System Solutions, Egestorf / Germany.

M.A.C. uses the precise fuel consumption values from KRAL Volumeter. KRAL Volumeters are high precision flow meters manufactured by KRAL AG, Lustenau / Austria.

The implementation of fuel-efficient measures such as SPM follows a simple logic: despite the crisis, shipping and charter companies must work profitably. Charterers opt for ships with low fuel consumption rates which means that shipping companies which do not offer fuel-efficient vessels will not be successful.
As part of a charter party, the shipping company must guarantee daily fuel consumption rates in metric tons per day. Ship yards and equipment suppliers, e.g. the supplier of the main engine, must warrant concrete values regarding fuel- and lube oil consumption. These promises must be kept, otherwise the calculated figures will not be achieved in real sea operation. The shipping company verifies the assurances during the sea trial, whereas the charterer checks the charter-party during the daily ship operation.

The most important question of the charterer is about the daily fuel consumption at a given speed. The M.A.C. SPM shows the charter party, noon report and the measured values on clearly arranged displays.

**Ship performance monitoring needs precise measurement values**

Almost all measures to optimise ship performance are examined by measuring fuel consumption. Essentially, ship performance is based on a complex fuel consumption measurement system. KRAL Volumeters measure all relevant liquids: HFO, MDO and lube oil of the main and auxiliary engines and of boilers. Engines and boilers are supplied by ring lines. If each individual consumer is to be measured, single flow meters must be installed in the supply and return lines. The difference between supply and return is the consumption. Fig. 2 illustrates a differential measurement.

![Differential measurement in the fuel or boiler ring line.](image)

A differential measurement requires the flow meters to be installed very close to the engine which is shown in Fig. 3.

![Installation directly at the ME. Only screw-spindle flow meters can stand engine vibrations and fuel pulsations without damaging the measurement values.](image)
If the engine load is reduced, e.g. for slow steaming or when approaching the port, pressure pulses to the fuel will increase. Fig. 4 shows the reason for pulsating fuel flow: the lower the fuel consumption, the more fuel will be sheared-off by the injection pumps and the higher the amount of fuel delivered back to the fuel pipe with high injection pressure. These high pressure fuel waves cause brief reverse flow. If a flow meter cannot measure in both flow directions and if no electronic device will detect and measure reverse flow, the measurement will be wrong.

![Fig. 4: Injection pumps cause high pressure backflow during the shear-off at the end of fuel delivery.](image)

Fig. 5 illustrates M.A.C. measurement results taken with a flow meter which cannot measure in both directions.

![Fig. 5: Useless measurement results around 18:00h at 28.6.13 (not a KRAL flow meter). Source: M.A.C. System Solutions](image)

The oscillating measurement (yellow) is wrong compared to the reported values (blue). The unsuitable flow meter misinterprets the back and forth fuel flow caused by injection pump pulses as high flow rate.

Fig. 6 shows a similar situation. The used flow meters are KRAL Volumeter.

![Fig. 6: Correct measurement values at reduced load with KRAL Volumeter. Source: M.A.C. System Solutions](image)

The engine load reduces from 02:00h at 28.06.13. The reported values (blue) show that the KRAL measurements (yellow) are very accurate.
### PROVIDERS OF MEASURING INSTRUMENTS

#### FUEL FLOW METERS
- Aquametro
- Bopp & Rheuter Messtechnik
- Emerson
- Endress+Hauser
- FloScan Instrument Company
- Katronic Technologies
- KRAL AG
- Krohne Skarpenord
- Macnaught
- Total Control Systems
- VAF

#### TORQUE METERS
- Aquametro
- Bopp & Rheuter Messtechnik
- Datum Electronics
- Hoppe Marine
- Hottinger Baldwin Messtechnik (HBM)
- Kongsberg Maritime
- Kyma
- Lemag Lehmann & Michels
- SeaTechnik
- Shoyo Engineering
- TecnoVeritas
- VAF

### PROVIDERS OF SHIP PERFORMANCE MANAGEMENT SYSTEMS

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<td>ABS Nautical Systems</td>
<td>Lemag Lehmann &amp; Michels</td>
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<td>Propulsion Dynamics</td>
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<td>Kongsberg Maritime</td>
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<td>Weather Routing Inc</td>
</tr>
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Manufacturer Profiles Provided in Full Version of the Guide
PROVIDERS OF MEASURING INSTRUMENTS

FUEL FLOW METERS
EMERSON
KRAL AG
VAF

TORQUE METERS
LEMAX LEHMANN & MICHELS GMBH
TECNOVERITAS
VAF
Micro Motion F-Series Coriolis meters offer highly accurate mass flow, volume flow, and density measurement. They maintain their flat spec accuracy of 0.1% at a turndown of 15:1. For instance, a F100 sensor with a maximum flow rate of 1,200 lbs/min can take accurate measurements at flow rates of 80 lbs/min. Even at flow rates of 30 lbs/min the F100 measures within ±0.26%.

Micro Motion F-Series Coriolis meters have a compact design that fits into tight spaces. F-Series meters come with a smooth exterior finish that can easily be kept clean, and all F-Series meters can be installed to be self-draining.

<table>
<thead>
<tr>
<th>Type</th>
<th>Coriolis mass flow meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>± 0.1% of actual reading</td>
</tr>
<tr>
<td>For Supply and return flow meter systems:</td>
<td>± 1.0% of flow rate</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 0.05% of flow rate</td>
</tr>
<tr>
<td>Flow rates</td>
<td>Up to 272,000 l/h</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>-100°C to +204°C</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>1450 psi (100 bar)</td>
</tr>
</tbody>
</table>

**Components:** The consumption measurement requires 2 F-series sensors and special software that calculates the differential flow across the supply and return meters.

**Cost:** The price of the system is heavily dependent upon customer requirements. For ships with multiple engines and generators that want the visibility of each engine this requires as many as 12 flow meters. For customers with one main engine, fewer sensors are needed which reduces the cost of the sensors as well as the installation.

**Installation:** Micro Motion Coriolis meters can be installed while the ship is underway. Emerson recommends working with their installation partner SeaTec who supplies the ship with a rider team that can make the modifications while the ship is underway.

**Maintenance requirements:** The F-series sensor has no moving internal parts resulting in no wear and tear, no maintenance and an expectation that meter calibration will not drift over time. In order to support integration with the ship’s automation systems, Emerson has marine service engineers in all of the major ports to help with any electronics issues.

**Calibration requirements:** The F-series has the option of using Smart Meter Verification (SMV) to verify the health of the meter. As the mechanical stiffness of Micro Motion Coriolis flow tubes are directly related to its flow calibration factor, SMV is able to identify changes, damage or degradation in the measurement performance of the meter. This helps reduce the cost of unnecessary calibrations of meters that are still in good health.

**Additional equipment requirements:** None.

**System integration:** Emerson works with several integrators to provide energy efficiency systems, however does not provide these systems themselves.

**Number of systems installed:** So far, Emerson has installed fuel consumption systems on more than 160 ships.
The KRAL Volumeter is a very compact positive-displacement meter. The measurement chamber consists of the casing and two screw spindles. The spindles continually divide the liquid in a precision made closed measuring-chamber. The precise measured value is calculated from the known measuring-chamber volume and the spindle rotation speed.

The KRAL Volumeter measures irrespective of the viscosity of the fuel and is therefore suitable for Heavy Fuel Oil (HFO), Marine Diesel Oil (MDO) and the continuous mixing stages.

<table>
<thead>
<tr>
<th>Type</th>
<th>Positive displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>±0.1% of actual reading, 0.8% in differential system</td>
</tr>
<tr>
<td>Repeatability</td>
<td>&lt;± 0.01%</td>
</tr>
<tr>
<td>Flow rates</td>
<td>0.1-7,500l/min</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>Max. 250°C</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>Max. 690 bar</td>
</tr>
<tr>
<td>Components:</td>
<td>Screws, casing, ball bearings, sealings &amp; gaskets, sensors and electronic.</td>
</tr>
</tbody>
</table>

**Cost:** Between €2,500 - €25,000.

**Installation:** Fuel consumption measurement of diesel engines in differential measurement arrangement. Can be installed in either drydock condition or while being in port. Ship’s crew is suitable to handle the system themselves.

**Maintenance requirements:** Change of ball bearings.

**Calibration requirements:** Calibration depends on the liquid and service.

**Additional equipment requirements:** None.

**System integration:** The KRAL Volumeter can be used together with different display units provided by KRAL.

The KRAL BEM 500 electronics unit displays current and total flow rate as well as consumption. Two Volumeters can be connected to this device. With its optional sensors, the BEM 500 registers fuel backflows and temperature differences in the supply and return flow.

The highly precise consumption values from the BEM 500 can be transferred to any other system suitable to process analog outputs or bus connection. Together with the onboard GPS data be displayed as fuel consumption per nautical mile.

**Number of systems installed:** >500 onboard ships.
VAF Instruments’ positive displacement flow meters that operate on the sliding vane principle. The meter consists of a specially shaped housing in which a rotor can rotate freely.

VAF Instruments’ flow meters are accurate and reliable and their accuracy and repeatability are not affected by pressure, viscosity or temperature of the fuel. They are approved by 14 independent classification societies, which is more than any other flow meter can boast on. Specific models are suitable for operating pressures up to 160 bar and a standard choice of high quality materials cover almost every service condition.

Apart from the positive displacement flow meters VAF Instruments also supplies a range of other types of flow meters such as turbine-, magnetic inductive-, mass- and ultrasound flow meters.

<table>
<thead>
<tr>
<th>Type</th>
<th>Positive displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>±0.1%</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.05%</td>
</tr>
<tr>
<td>Flow rates</td>
<td>1 l/h up to 960m3/h</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>-20°C to +180°C</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>Up to 160 bar</td>
</tr>
</tbody>
</table>

**Installation:** Flow meters are connected to the fuel pipes through flanges (intrusive). Flow meters can be installed by shipyard or ship’s crew when the ship is afloat.

**Maintenance requirements:** For flow meters that are running continuously, VAF recommends to inspect bearings every year.

**Calibration requirements:** None.

**Additional equipment requirements:** None.

**System integration:** VAF liquid flow meters can be extended by the T-Sense torque measuring system and speedlog/GPS input. It can be integrated into the PEM2 or PEM3 Propulsion Efficiency Monitor. PEM2 displays shaft power, torque and speed, whereas PEM3 displays all fuel consumption data, engine load diagram, power data, etc.

**Number of systems installed:** Approx. 75,000 units.
LEMAG Shaftpower is a permanently installed torque measuring device that calculates the actual power output of the ship’s propulsion engine. The measured data is displayed on the self-explanatory touch-screen panel in “real-time” and the comparison of the actual data with the preset “propeller curve” provides the operator with a tool to help avoid overloading the engine.

LEMAG Shaftpower operates absolutely contact-free and without the use of strain gauges. The shaft twist is measured between two points approximately 500mm apart on the shaft, using two highly accurate linear precision position encoders. The measured data is digitalised on the rotating shaft and then transferred contact-free to the evaluating processor unit for further analysis.

<table>
<thead>
<tr>
<th>Type</th>
<th>Contact-free proximity sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>Sensor accuracy ±0.25%</td>
</tr>
<tr>
<td>Repeatability</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Speed range</td>
<td>≤200RPM</td>
</tr>
<tr>
<td>Shaft diameter</td>
<td>320mm, smaller on request</td>
</tr>
</tbody>
</table>

Cost: < €13,000

Installation: Because the LEMAG Shaftpower does not use strain gauges and operates contact-free, a quick and easy installation and a long lifetime without any attendance of a service engineer is possible.

Maintenance requirements: LEMAG Shaftpower does not have any serviceable parts and is thus maintenance-free.

Calibration requirements: The zero calibration can easily be done by the crew whenever the engine is stopped.

System integration: LEMAG Shaftpower can be can extended to measure specific fuel oil consumption (SFOC) and can be integrated with third party systems such as the LEMAG SEEAmag system, a fully automatic performance monitoring system.

Number of systems installed: Approximately 1,000.
Optipower is a fixed system developed to monitor propulsion plant performance easily and accurately, including:

- Shaft Power (kW or hp).
- Shaft Torque (kNm).
- Shaft Speed (RPM).
- Shaft Thrust (kN).
- Torsional Vibration on Spectra (Frequency Analysis).

<table>
<thead>
<tr>
<th>Type</th>
<th>Strain gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>0.5% of full scale</td>
</tr>
<tr>
<td>Speed range</td>
<td>0 - 1,800RPM</td>
</tr>
<tr>
<td>Shaft diameter</td>
<td>Up to 1.2m</td>
</tr>
</tbody>
</table>

**Components:** Fixed Collar (induction coil) and a rotating collar

**Cost:** The costs depend on the shaft diameter, but do not exceed €15,000.

**Installation:** The installation of Optipower only consists of tightening screws and takes about 6 hours. This, however, does not include the laying of cables.

**Maintenance requirements:** None.

**Calibration requirements:** None.

**Additional equipment requirements:** None.

**System integration:** Optipower can be connected to standard interfaces and the ship’s communication system (NMEA 0183). It can also feed information into TecnoVeritas’ Voyage Energy & Emissions Optimiser (VEEO).

**Number of systems installed:** So far, 30 Optipower torque meters have been installed onboard ships.
The T-Sense measuring system can be mounted on propeller or drive shafts. When a shaft is subject to torque this will result in a small strain at the shaft surface. A LED and an extremely accurate optical cell can detect these small movements of the surface. The measured values are transferred continuously from the rotating shaft to the stator part through a 2.4GHz wireless data connection.

The stator part consists of a bracket, a power transmission coil, a data signal receiver and a control box equipped with digital and analogue output connections. These outputs can be linked directly to the ship’s data network, monitoring or control system.

<table>
<thead>
<tr>
<th>Type</th>
<th>Optical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of accuracy</td>
<td>&lt;0.25% of full scale</td>
</tr>
<tr>
<td>Repeatability</td>
<td>&lt;0.05% of full scale</td>
</tr>
<tr>
<td>Speed range</td>
<td>0 - 1,100RPM, depending on shaft diameter</td>
</tr>
<tr>
<td>Shaft diameter</td>
<td>100 - 1,000mm</td>
</tr>
</tbody>
</table>

**Components:** The standard T-Sense torque measuring system is delivered with a control box for easy connection to the ships data network, monitoring or control system. A PEM2 touch screen display or PEM3 Propulsion Efficiency Monitor can be supplied as a monitoring device.

**Cost:** Budget price for a torque measuring system, including flow meters and PEM3 monitoring system for a 50,000DWT Handymax bulker amounts to €20,000.

**Installation:** The T-Sense can be mounted around the shaft by the ship’s crew or shipyard without engineering or commissioning assistance.

**Maintenance requirements:** T-Sense torque measuring systems are maintenance-free as a result of contact-free power and signal transmission. They are designed to work continuously.

**Calibration requirements:** No recalibration is needed, because signals are stable during its lifetime.

**Additional equipment requirements:** None.

**System integration:** The T-Sense torque measuring system can be extended by VAF fuel flow meters and speedlog/GPS input. It can be integrated into the PEM2 or PEM3 Propulsion Efficiency Monitor. PEM2 displays shaft power, torque and speed, whereas PEM3 displays all fuel consumption data, engine load diagram, power data, etc. If VAF’s TT-Sense Thrust & Torque sensor is installed, thrust and the thrust power quotient can be calculated as well.

**Number of systems installed:** 450 units.
PROVIDERS OF SHIP PERFORMANCE MANAGEMENT SYSTEMS

BMT
CLASSNK AND NAPA
ENIRAM
MARORKA
SKYSAILS
TECNOVERITAS
BMT SMARTSERVICES helps owners and operators make informed decisions regarding ship operation and maintenance. The services offered are founded on a unique system that integrates comprehensive ship recorded data with fully validated meteorological and oceanographic data.

The system consists of an onboard and an onshore tool: SMARTVESSEL and SMARTACCESS. SMARTVESSEL is a data gathering and recording tool that automatically collects data from onboard sensors. Once collected and processed the data can be displayed on screen in numerical or graphical format. KPIs are used as an onboard, real-time tool for the crew and provide a simple representation of the current ship operation. This allows the crew to quickly identify any degradation and take corrective action. At period intervals, data is transferred from ship-to-shore where it is co-located with the corresponding environmental data available and stored in BMT databases which can be accessed by clients anywhere over the Internet. The display and analysis of the data is conducted using the SMARTACCESS application. Through this secured web portal, users can compare the performance of sister ships, evaluate the effectiveness of maintenance events, compare the efficiency with which crews operate, or simply monitor and trend specific values over time.

Unique Selling Point
BMT SMARTSERVICES makes measured data readily available both on the ship and from BMT’s shore-based data servers. Crews receive real-time feedback on the effects of their decisions onboard and any authorised stakeholders can access the data via the Internet. Web-based analysis tools allow users to understand both short- and long-term ship performance. SMARTACCESS also offers a Voyage and Charter Party reporting tool, giving a clear detailed summary of performance and compliance over a voyage.

Costs
BMT SMART offers a range of pricing options depending on the system configuration and the length of licence. BMT SMARTSERVICES is a modular system with the price also depending on the number of modules desired.

Typically the costs break into a capital expenditure for system installation and an operational expenditure for annual licence, support and servicing agreements.

Installation Considerations
SMARTVESSEL collects data from various sources (e.g. shaft torque and fuel flow meters, GPS, speed log, anemometer, ECDIS and echo sounder). The system identifies existing onboard sensors and selects suitable data sources. Prior to installing the system, a survey is conducted to ascertain what metering is already installed and how this can be interfaced to in the most reliable way. If additional metering is required, this is identified and BMT SMART can advise in the procurement process. For each project a bespoke scope of work is created and approved by all stakeholders. It outlines any hardware provision and preparatory works to be completed.

The installation itself typically takes 2-3 man days onboard and includes system configuration and verification. It can be completed at any time (drydock, in service, alongside etc.). BMT SMART trains the crew on how to use the system.

Technical Maturity
BMT SMARTSERVICES has been taken up by a wide range of clients from various sectors, including tankers, bulk carriers, LNG and cruise ships.
ClassNK-NAPA GREEN provide a comprehensive solution for greater eco-efficiency and business insight for ship owners, operators and charterers, generating up to 30% savings in operating costs by optimising factors such as speed, voyage execution and advanced hull coatings.

The solution consists of the following modules:
Real-time monitoring for combined and customisable display data from ship systems.
Voyage reporting for operational reporting to ashore.
Ship server providing a centralised server for data automation and synchronisation.
Office platform providing business intelligence portal for fleet monitoring.
Analytics services including normalised speed power curve, effect of full fouling and hull performance index, ships operating profile, hull performance and power usage decomposition.
Voyage optimisation through speed profile, engine configuration and route recommendation.
Trim optimisation system.

With the additional optional modules of:
Electronic logbook for collecting, recording and replicating data to shore.
Speedpilot with automatic and accurate speed profile execution.
Loading Computer with safe and optimal stowage, cargo and ballast planning.

Unique Selling Point
ClassNK-NAPA GREEN uses an accurate dynamic performance model that tunes the ship performance model on a continuous basis - taking into account factors such as wave and wind resistance, propeller efficiency and effect of different drafts – to give up to 99.6% accuracy in voyage optimisation, trim optimisation and performance reporting. Payback on the investment can be realised within months. ClassNK and NAPA aim to provide a best in class approach to reducing fuel spend and greenhouse gas emissions whilst also providing compliance with SEEMP legislation.

Costs
ClassNK-NAPA GREEN is purchased on an annual fee plan only. The software can be purchased with initial cost upfront and annual fee, or the initial fee can be divided and paid over a three to four year period.

Installation Considerations
Actual implementation of ClassNK-NAPA GREEN is dependent on the features required, but takes an average of two to four months involving integration of the system with other onboard equipment and software. The process focuses on developing ship hull model, interfaces and controls with the onboard automation and bridge systems as well as the installation of sensors such as torque meters on the shaft and fuel flow meters.

The installation itself typically takes 2-3 man days onboard and includes system configuration and verification. It can be completed at any time (drydock, in service, alongside etc.). BMT SMART trains the crew on how to use the system.

Technical Maturity
The first commercial installation of ClassNK-NAPA GREEN was aboard a Taiwan-based Wan Hai Lines’ containership. In March 2014 Finnish ship operator Bore announced that it had unlocked fuel savings of between 4-6% across a fleet of three Ro-Ro ships: the 2,863-lane metre (lm) Bore Sea, 2,863lm Bore Song and 1,606lm Seagard. Furthermore, additional savings of 10% have been identified by the software and can be achieved through installation of a shaft generator frequency converter that enables the ship engine to operate at variable rather than constant.
Dynamic Trimming Assistant (DTA): Eniram’s original offering is an advanced trim optimisation system that continuously monitors the actual hull attitude, meaning that it can always recommend the optimum trim once real-time factors such as sea state or acceleration have been taken into account. The optimum for the specific ship is based on measurements done on the ship performing in real-life conditions, increasing the accuracy. The company states that the system is unique in the depth and complexity of the dynamic attitude advice it offers – one result being that crew are more likely to trust its recommendations, implement them, and realise available savings. The system uses both real-time and historic MetOcean data to improve performance. The company claims that the DTA can save 3% fuel savings on propulsion.

Fleet Performance Manager (FPM): a software solution that allows onshore fleet managers to compare efficiency data on a historical series of voyages including analysing MetOcean data, which can be complemented by varying levels of consultancy support from Eniram. Customers can benefit in several ways from the copious data that the company collects: route performance comparisons can support logistical planning; data analysis allows for hull condition monitoring and hence maintenance planning. The data will also help with SEEMP reporting. The company’s dataset has even allowed it to determine which hull coatings perform best in which sea area, facilitating improved decision making on which routes to send a particular ship. The company claims the system can produce fuel savings of 2%, and 10% together with onboard optimisation.

Optimum Speed Assistant (OSA): collects and measures real-time operational and environmental data to generate continuous analysis of a ship’s optimum speed in prevailing ocean conditions, delivered to the crew in clear graphical format. It can also function to give an indication of the engine condition for maintenance purposes. The OSA makes use of both real-time and historic MetOcean data to improve performance. The company claims the OSA system can provide 3% fuel savings.

Engine Load Assistant (ELA): assists the crew in using the ship’s engines for optimum efficiency. The system balances the required load for multiple engines which can enable 1% fuel savings. Combined data from onboard fuel flow meter, engine load and ship speed ensures that no more fuel than required is burnt to sustain the desired speed and service power requirements in prevailing conditions.
Vessel Performance Manager (VPM): supports the onboard crew analyse and track the total energy efficiency of the ship and offers actionable guidance to optimise the overall performance of the ship. The VPM uses a combination of real-time and historic MetOcean data to improve performance. The data collected by the system can be used for SEEMP reporting and the company claims by the system can provide fuel savings of up to 5% of service power. The VPM is currently being deployed on the first 10 ships, so no long-term savings cases are available.

Unique Selling Point
Eniram collects, measures and analyses real-time ship-specific data, taking account of the prevailing sea state, to understand how ships consume energy and how performance impacts their fuel consumption.

Costs
The Eniram platform and its installation cost between €30,000 to €60,000. The price for each module ranges from €30,000 to €70,000. Financing options are available for all modules.

Installation Considerations
All Eniram modules require the installation of the Eniram Vessel Platform (EVP), onboard solutions also require a minimum of an Eniram Attitude Sensor and an Eniram Display. The installation process starts with a “site inspection”, where all the ship systems are investigated and proper installation plans are created. While the technical commissioning takes a couple of days, the installation time frame depends on the ship type and itinerary. For a passenger ship, it may only take a couple of weeks, but on large tankers it may take months due to operational limitations.

Technical Maturity
The number of installations is different for each module. So far, DTA has been installed on 210 ships, FPM on 170 ships, OSA on 90 ships and ELA on 70 ships. The VPM is currently being deployed on the first 10 ships.

To date, Eniram has seen the most uptake from cruise ships, containerships and LNG/tankers.

WWW.ENIRAM.FI

THIS COMPREHENSIVE GUIDE EXAMINES THE FULL RANGE OF OPTIONS FOR SHIP PERFORMANCE MONITORING, FROM CHOOSING THE RIGHT MONITORING SYSTEMS AND MEASURING INSTRUMENTS TO HOW DATA CAN BE APPLIED AND ADVISORY AIDS THAT ARE AVAILABLE.

MEASURE, ENHANCE, PERFORM

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Marorka energy management products aim to save resources by utilising information technology. Reliable onboard data collection, decision support for the crew, reporting to the officers and ship-to-shore data communication are key features of Marorka’s products. Marorka Onboard is located onboard the ships and offers energy system monitoring, electronic measurement logging, simulation-based decision support and extensive energy analysis.

Key applications that are part of Marorka Onboard include:

- **Propulsion Optimisation** – supports the ship’s officers in reducing the shaft power required to move the ship through the water and in maximising the utilisation of fuel in the propulsion plant.
- **Voyage Optimisation** – identifies speed profiles that result in minimised voyage costs for given routes, making voyage planning simpler and more economical. The simulations are based on weather and sea state forecasts.
- **Machinery Optimisation** – identifies ways to improve the operation of all onboard machinery systems.
- **Fuel Management** – tracks and reports fuel consumption broken down by fuel type, consumer and ship operational state. Also tracks fuel quality and remaining onboard status.
- **Report Management** – provides tools for automatic reporting based on collected data.
- **Data Management** – completes recording and structuring of collected data, performs quality control of logged data and includes analysis tools for graphically trending and comparing real-time operational values over a period of time.

Marorka Online is a web-based fleet management application that gathers performance data, allowing the fleet manager to track and compare energy performance and the condition of the fleet. It also guides users through the creation of the required SEEMP.

**Unique Selling Point**
Marorka’s integrated solutions offer transparency of fuel saving procedures, ensure compliance with relevant regulations and enable integration with other fleet management tools.

**Costs**
Marorka offers scalable solutions where costs are dependent on selected server size and modules. Financing and rental options are available upon request.

**Installation Considerations**
Marorka solutions are integrated solutions consisting of hardware and software components. Specially trained engineers will oversee the installation of each Marorka solution.

The system can be fitted in the shipyard at build time or installed onboard ships that are already in service. Service engineers will check the suitability of onboard equipment such as sensors (fuel flow, shaft power, etc.) and check the availability of signals from onboard equipment. They will also oversee start up and final configuration of the system to make it ready for operation. The ship’s crew will receive basic training in the day-to-day operation of the Marorka solution.

**Technical Maturity**
Marorka has a reference list of more than 300 ship installations. Marorka solutions have been installed on many types of ships, particularly containerships, tankers and bulk carriers.
The SkySails Performance Manager collects real-time data about shipboard operations and ambient conditions using dedicated sensors for fuel consumption, ship motions and wind. It is, however, possible to add as many sensors to the system as the customer wants - e.g. torque meter -, making data collection even more sophisticated. The data collected is analysed and turned into easy-to-read and concise information tailored to the customer’s needs. The data can be accessed by onshore staff via a web platform. The ship’s fuel consumption, resistance curve and optimal speeds - the most economical, most profitable and estimated time of arrival – as well as a trim optimisation tool are displayed in real-time on the bridge. The captain and other relevant staff can thus immediately see the effect of their decisions, and if necessary, correct suboptimal operations straight away.

Furthermore, the SkySails Performance Manager generates automatic reports, including voyage reports, class-accepted documentation and environmental reports. For example, it displays the EEOI and other emission values which can then be used as a basis for SEEMP. According to SkySails, automated reporting with pre-completed forms can save 80-90% of the time needed for preparing reports, thus freeing up time for crew and onshore staff for optimisation tasks.

Unique Selling Point
By providing relevant and reliable real-time information, the SkySails Performance Manager offers simple, yet complete decision support enabling the crew onboard and staff onshore to optimise the fleet’s operational efficiency. The system is customisable and extendible and can be complemented by SkySails’ analysis and consultancy services.

Fuel Savings
The SkySails Performance Manager generates fuel savings by providing information about suboptimal operations. The amount of fuel savings, however, depends on how extensively the system is used. So far, customers have seen fuel savings in the range of 3-10%.

Costs
The costs for the SkySails Performance Manager depend on customer requirements. Different financing options are available.

Installation Considerations
The Performance Manager comprises dedicated sensors for fuel consumption, ship motions and wind. It is capable of collecting data from more than 250 additional sources.

The prerequisite is adequate Internet connectivity. The satellite communication system needs to be able to transfer large attachments of up to 40kb.

The installation of the Performance Manager takes about two days and can be done during general cargo operations. During that time, the crew can also be trained on the use of the system.

Technical Maturity
So far, more than 100 Performance Managers have been ordered from SkySails and mostly been installed on tankers, bulkers, multi-purpose vessels and containerships.
The Voyage Energy & Emissions Optimiser (VEEO) is a monitoring and data logging system that logs bunker consumption, shaft and electric power generated as well as the ship’s position via GPS. Based on this data, the system calculates the EEOI of the ship, as well as other parameters such as hull resistance and the efficiency of the generators and boilers.

VEEO covers all the ship energy systems, identifies their performance, flags deviations and highlights opportunities for saving energy. It provides real-time feedback allowing the crew to take corrective action if necessary.

A shore version - VEEO-SHORE - allows the ship owner to track the ship’s performance over time. VEEO-SHORE is a live web-based ship monitoring solution that offers data filtering, efficiency management reporting, ship performance comparison and benchmarking (over time and compared to other ships), and predictions of Specific Fuel Oil Consumption (SFOC) and speed loss.

**Unique Selling Point**
VEEO uses a holistic approach to ship energy systems. The system is fully certified by major classifications societies, and has won the first prize of the Seatrade Awards 2012 in the category ‘Clean Shipping’.

**Fuel Savings**
According to TecnoVeritas, using VEEO can result in fuel savings of up to 15% depending on the type of ship and operational profile.

**Costs**
VEEO costs between €24,000-€130,000. Alternatively, the system can be rented and periodic ship performance monitoring reports be requested.

**Installation Considerations**
Prior to installing VEEO, TecnoVeritas inspects the ship to understand what equipment and instrumentation is already onboard and what still needs to be installed. The equipment typically needed are mass flow meters, temperature transducers, pressure transducers, torque meters, current transformers, exhaust gas probes, oxygen probe, a NMEA hub, a cabinet with touch screen display in the engine room and one computer in the bridge. During the initial inspection, the distances between the transducers and switch boards are checked as well as the locations of the hardware.

Once the cables have been laid, the installation and commissioning of the system takes about three days.

**Technical Maturity**
The first version of VEEO was first installed 1998 onboard a 60,000DWT product tanker.

VEEO has seen the biggest uptake with containerships, tankers, bulk carriers and naval ships.
New for 2014
The CTech database has been refreshed, updated and expanded.

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