Ship Operating Safety and Efficiency Management Solutions

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Introduction

In recent projections for the shipping industry in 2020, Det Norske Veritas (DNV) describes e-Navigation technologies in its Technology Uptake report as "combining accurate position data, weather and surveillance data, onboard and remote sensor data, ship specific characteristics, and response models to prevent accidents and optimize secure, economic, and environmental performance (DNV, 2013)."

DNV envisions extending the Electronic Chart Display and Information System (ECDIS) beyond safe navigation toward a unified system that includes decision support for security and navigation risks (piracy), voyage planning and optimization, port logistics, and other operating safety, performance and efficiency management activities. Comprehensive and ongoing crew training will be a necessary component to ensure competence in using the new technology effectively.

This is a logical evolution for how ship owners and operators may address a staggering array of complex interdependent trends:

- Spiraling fuel prices
- Low charter rates
- Shipping overcapacity
- Tightening emission regulations
- New low-emission fuel types
- New IMO energy efficiency requirements
- New emission-reducing and higher energy efficiency technologies
- The commoditization of navigation data
- Increasing security risks
- Increased port congestion
- Increased coastal and port regulation complexity
- Increased documentation requirements
- Reduced crew sizes with limited training and experience
- Faster, cheaper computers

It is no longer sensible to limit individual functions to separate disconnected platforms, such as front-of-bridge/back-of-bridge, deck/engine room or shipboard/shoreside. Rather, managing all of these parameters should be accomplished with one interconnected system: a safety and efficiency management solution for ship operations. This does not necessarily imply that all functions are conducted from the navigation ECDIS, although when space is a constraint, this may indeed be the preferred method. Rather, all e-Navigation data concerning ship operating safety and efficiency should be managed in a unified database with a common, secure and robust communication network for exchanging data, similar to the "big data" concept favored in the IT world.
Jeppesen is in an excellent position to lead the industry by moving quickly toward this “total solution” approach, having already combined electronic ship navigation charts, voyage optimization, data acquisition and recording, and fleet management into one integrated ship safety and efficiency management system. This system results in better day-to-day decision-making, thereby driving more efficient operations at all levels. It establishes a tight and accurate information loop with minimal lag time that improves situational awareness for both the master on the ship and shore-based operations managers.
Navigation Safety: Electronic Charts

The core of every ship safety and efficiency management system is its electronic navigation chart data. New IMO regulations now require ECDIS on most commercial ships, a technology that has been shown to reduce grounding events by as much as 30 percent. Today, the ECDIS is typically reserved for safe navigation duties, but in the future, it is likely to be coupled to systems related to a broader scope of operating safety and efficiency management, such as route planning and optimization, piracy avoidance, performance monitoring, port and maintenance scheduling, and regulation compliance.

Jeppesen offers electronic chart data, which incorporates data issued by hydrographic offices (HO), thereby satisfying the requirements for Safety of Life at Sea (SOLAS) when used on an ECDIS. Jeppesen PRIMAR ECDIS Service supplements official ENCs with Jeppesen’s high-quality vector charts, thereby providing detailed global vector chart coverage even in areas where official HO data is unavailable.

Jeppesen PiracyUpdate service adds essential piracy data, including recent and historical attacks, to electronic charts. It is based on intelligence from multiple recognized sources, including the International Maritime Bureau’s Piracy Reporting Centre, the United Kingdom Maritime Trade Operations (UKMTO), the Maritime Security Centre – Horn of Africa, the United States Navy’s Office of Naval Intelligence, as well as information sourced from leading news media and a wide network of independent sources.

Jeppesen charts are supported on the majority of ECDIS systems, and are also integrated into Jeppesen’s other safety and efficiency management solutions, including Vessel Voyage and Optimization Solution (VVOS) and FleetManager (FM).

Advanced Ship Voyage Optimization: VVOS

According to the IMO, DNV and others, advanced route optimization can produce as much as 10 percent fuel savings over conventional weather routing methods. By avoiding bad weather and optimizing speed and heading to reduce excessive ship motions, it can also improve arrival time reliability and crew/passenger comfort, and reduce heavy weather damage and hull fatigue. Traditional weather routing is incapable of addressing increasingly complex fuel-saving strategies: slow steaming or drifting when time allows, virtual arrival to avoid port congestion, or managing fuel switching to accommodate Emission Control Areas (ECA). Weather routing typically sets a fixed power/RPM for the duration of the voyage, and simplistically guides the ship to go around bad weather.

Advanced voyage optimization, in comparison, uses ship motion response and performance modeling to simulate how a specific ship, under specific load conditions, will behave in forecasted weather and sea conditions. By adjusting speed and heading, the ship can be guided to slow down or speed up to avoid storms, and to change heading and/or speed to prevent excessive motions caused by waves and wind, including slamming, deck submergence or parametric roll. The master can take advantage of favorable currents, and avoid adverse ones. Furthermore, the master can intelligently conduct slow steaming, drifting and virtual
arrival maneuvers without risking excessive fuel consumption at the end of the voyage to make up for lost time.

The Jeppesen Vessel Voyage and Optimization Solution, or VVOS, has been used by the commercial shipping industry for over 15 years, both as a shipboard decision support aid and as a shoreside tool for Jeppesen’s route planners, who provide routing advice for commercial shipping clients. VVOS combines advanced routing algorithms, hydrodynamic and performance modeling, and high-resolution ocean forecasts to accurately optimize each route for a range of arrival times with minimum fuel consumption, while maintaining safe operating and user-specified limits. Such information “will facilitate synchronization and generate berthing schedules that maximize the terminals’ throughput at minimum transhipment cost, while minimizing vessels’ dwelling and fuel consumption (DNV 2013).”

Unlike traditional weather routing, VVOS incorporates a detailed model of each ship’s dynamic motion and performance characteristics. This virtual ship accurately simulates speed made good and seakeeping response under forecasted wave, wind and current conditions at a given engine power and propeller RPM. VVOS allows the user to exclude certain RPM ranges to minimize known engine and vibration issues, further enhancing operating safety and reducing equipment failures.

Integration of VVOS with Jeppesen’s cartography, including automated depth and obstruction checks, helps ensure a safe route. An ECDIS route import/export function supports a variety of file formats used by many popular brands, including Kongsberg, JRC, Furuno and Sperry Marine.

**VVOS Seakeep** is a unique utility within VVOS that predicts ship motions and seakeeping performance using ocean weather forecasts and accurate ship modeling. It provides the master with critical decision support information to minimize the risk of heavy weather damage and improve fuel efficiency. An intuitive polar diagram recommends speed and headings that reduce excessive ship motions, including parametric roll.

Jeppesen offers a shoreside **Vessel Routing Service**, provided by a team that consists exclusively of senior ship masters. This routing and optimization team uses the same VVOS tools that are available for shipboard use. They can also access ensemble weather forecasts to quantify the uncertainties in speed and motion predictions. As captains themselves, they speak the same language as the ship master, and have an intimate understanding of operating a large ship. Jeppesen captains work hand-in-hand with the ship masters to develop a mutually agreeable initial voyage plan, which is then updated daily based on the latest forecasts and voyage objectives. Ship masters who are using VVOS onboard can consult with Jeppesen’s routing team for second opinions or when they have questions about how to use the software. Over time, the Jeppesen routing team develops strong mutually trusting relationships with the ship masters. This service is available 24 hours a day, 365 days a year.
Data Acquisition and Recording: ShipReport and ShipLink

The data acquisition process is a key component of a safety and efficiency management system—one can only manage parameters that can be measured. Furthermore, to maximize efficiency, the turnaround time between data acquisition, analysis and responding with corrective action must be as short as possible. Ideally, adjustments to improve operating efficiency should be possible even within a single passage, rather than having to wait for weeks or months to complete the cycle.

By nature, data acquisition is a messy and difficult process. Data will frequently be noisy, corrupt, missing or just plain wrong. This is especially true of systems operating in the harsh environment of commercial ships. Any system that depends on data acquisition, whether automated or manual, must be able to recognize faulty data and then handle it gracefully.

Depending on data type, sampling and reporting rates range from once per second to several times per day, with the latter requiring onboard sensors and recording hardware. Finally, data acquisition and reporting should impact crew workload as little as possible, ideally being at least partially automated, with user-friendly interfaces, built-in validation and error detection. Duplicated reporting efforts can be minimized by making collected data available across multiple systems. For example, the same data collected by the ship’s voyage data recorder (VDR) should also serve the safety and efficiency management system.

Jeppesen’s safety and efficiency management systems are able to accommodate a wide range of data acquisition feeds. For example, the shoreside database can automatically ingest data received from Veson’s Veslink, Pole Star’s Purplefinder and Stena Line’s Stena Reporting. In addition, NEMA strings from sources such as AIS, Kongsberg Norcontrol, Sperry Marine VMS and Kyma can be imported. Jeppesen’s own ShipLink also enables automated bi-directional high resolution data feeds in a very compact, low cost, bit message format.

In a joint project with Boeing Defense Systems, Jeppesen developed ShipLink, a compact, self-contained device that monitors and reports relevant shipboard performance and environmental data in order to evaluate ship performance, efficiency and tactical readiness. ShipLink includes a calibrated weather station sensor that monitors time and date, GPS position, ship motions in pitch, roll, and yaw, wind speed and direction, temperature, humidity, pressure and several other parameters. Communicating this information shoreside in near real time in compact low-cost messages using the Iridium SATCOM system, ShipLink provides timely ocean-related situation awareness information to shoreside managers, and may be used to monitor actual ship position, speed and local environmental conditions for charter party validation.

ShipReport is Jeppesen’s user-friendly shipboard electronic logbook that makes reporting the latest ship operating details (departure, noon and arrival reports) easier and more consistent across the fleet. ShipReport facilitates reporting essential passage information, including position, speed, RPM, heading, draft and trim, and fuel consumption. The information is delivered in a uniform human-readable format.
Fleet Tracking and Monitoring: FleetManager

Once ashore, the reported ship data must be quickly categorized and recorded into a unified fleet-wide database, where it can be analyzed in order to generate intelligent decision-support information. Too much information can be as difficult to assess as too little information. Using metrics based on customer key performance indicators (KPI), the performance analysis tool must be able to find and identify trouble areas. While many companies already collect information perceived as necessary to monitor their KPIs, they often have difficulty in structuring the data in a way that allows more informed decision-making. Effectively presenting data, in a manner that facilitates interpretation and understanding, requires careful combinations of data charts, graphic representations and visual alerts; designing the user interface and reporting tools is as much an artistic challenge as a technological one.

Designed for shoreside managers, Jeppesen FleetManager integrates fleet-wide voyage reporting and analysis into a single display. The system provides operations managers with a user-friendly dashboard that allows them to easily determine which vessels in their fleet are having issues. The tool provides the ability to track vessel routes, ETA reliability, fuel analysis and weather forecasts, and includes robust analytics and extensive reporting capabilities.

Combined with an automated data acquisition feed, FleetManager enables shoreside managers to instantly detect underperforming ships, identify and evaluate the contributing factors, and act quickly to resolve the issues. FleetManager also may be used to identify trends, analyze and compare current performance within the fleet against historical baselines, and produce standard reports that may be used for purposes such as SEEMP and EEOI validation, and charter party arbitration and litigation.

Comprehensive Training

A key to long-term success using Jeppesen’s ship and fleet efficiency management tools is an ongoing training program. Typically, ship officers are rotated on and off the ship, sometimes for extended periods. New masters coming onboard may not be familiar with the software, and those returning after extended shore leave may find a refresher course helpful. For the customer’s convenience, Jeppesen offers several methods of delivering training. The most cost-effective is for Jeppesen instructors to train members of the customer’s training team, who then can provide periodic introductory training and refresher courses to end-users. This "train the trainer" exercise can take place at Jeppesen’s facility in Alameda, CA, USA, or at a site of the customer’s choosing.

Jeppesen maintains high quality installation manuals and user guides for all of its products in both printed and electronic formats. Jeppesen’s global technical support team is available 24/7 every day of the year. For vessel
routing advice and assistance, customers are encouraged to contact Jeppesen’s route advisory team, also available 24/7/365.

Jeppesen’s training documentation includes a detailed syllabus for each training level, comprehensive user guides and video tutorials. Jeppesen periodically offers workshops and seminars that can help users advance their skills and understanding, in order to ensure that the tools are used most effectively.

Where We Go From Here

DNV’s Technology Uptake for shipping in 2020 is a succinct and well-supported view of where maritime technology should be in the next decade. It is unlikely that energy prices will decline, although new, cleaner fuels such as LNG may become more readily available. Environmental concerns will also continue to drive new technology, such as exhaust gas scrubbers and ballast water treatment. Meanwhile, the easiest way to reduce both cost and emissions, not to mention maintaining the highest possible level of operating safety, is to focus on managing operating efficiency.

Operating safety and efficiency may be incrementally improved by implementing high-resolution fault-tolerant onboard data acquisition and recording, and real-time performance monitoring and analysis, thereby shortening the turnaround time between identifying performance issues and addressing them. Maximizing the automation of this process, combined with fleet-wide data sharing, reduces crew workload and their need for specialized skills.

Monitoring shipboard sensors provides more accurate and timely data for evaluating hull and propeller condition, engine state-of-tune and fuel quality. This allows condition-based maintenance scheduling, where cost of repair can be weighed against efficiency losses, and planned accordingly.

Acquiring shipboard sensor data enables continual improvement of the ship model for computer simulations and predicting motion response and performance. Automating this “smart learning” process eliminates the tedious and labor-intensive process of manually adjusting computer models to match observed ship behavior.

One area of efficiency management still presents significant technological difficulties—fleet deployment and logistics. This is the problem of optimizing ship assignments-to-passages and cargo-to-ship to maximize operating efficiency and profit. Several independent studies suggest that this type of transportation management has the greatest potential for efficiency gains, as much as 50 percent, compared with other technological and operational measures, which typically range from 1 to 10 percent (Alvik et al., 2009; IMO, 2009, Poulavassilis, 2010).

Toward this end, Jeppesen engineers, in concert with Boeing Research and Technology, are developing new advanced optimization processes that will be especially useful in both the aviation and maritime industries for fleet deployment management, routing vessel convoys, and other applications where multiple objectives must be satisfied.
Conclusion

In the Second IMO GHG Study 2009, researchers concluded that improvements in ship operating efficiency can lead to as much as a 50 percent reduction of carbon emissions, which is directly proportional to fuel consumption. Looking closer, they estimate that advanced voyage optimization alone can realize reductions up to 10 percent, and likewise for energy management, which includes avoiding unnecessary energy usage, optimizing engine and HVAC operation, using frequency converters for AC motor speed control, waste heat recovery and cold ironing (switching to shoreside power in port). Estimates of 3-5 percent savings are common for timely maintenance, and again for optimizing trim for a given draft and operating speed; another 3 percent may be gained using advanced hull coatings. As mentioned in the previous section, a potential improvement of up to 50 percent is available for successfully optimizing fleet deployment.

With bunker fuel hovering between $600 and $700 per metric ton, and low-sulfur and distillate fuels significantly higher, one can easily see that even small percentages quickly translate into substantial dollars. Coupled with the financial incentives, is the proportional decrease in harmful emissions, including CO2, SOX, NOX and particulate matter (PM or soot).

Considering that a container ship may consume over 1,000 tons of bunker fuel in a single crossing of the Pacific Ocean, a conservative 10 percent improvement in fuel efficiency results in more than $60,000 worth of savings for that one-way passage, and a reduction of more than 300 metric tons of GHG emissions. A typical container ship may make 15-20 such crossings a year, adding up to an annual savings of more than a million dollars.

Another way to look at potential return on investment (ROI) is to consider that in 2007, the world shipping fleet consumed some 300 million tons of fuel (and generated over 1 billion tons of CO2). In the absence of energy efficiency improvement policies, it is estimated that this may grow by a factor of two to three by 2050. A conservative 10 percent improvement over 2007 consumption levels would yield an annual financial saving of almost $20 billion, not to mention some 60 billion tons of CO2. For what it will be in 2020, you can do the math.

And once the measures to improve efficiency are implemented, the benefits are repeatable every year!

Shipping is used for 90 percent of international transport, and has also been shown to be one of the most energy-efficient means of transportation compared to other modes. Taking into consideration the anticipated growth of the shipping industry between then and 2020, it is obvious that developing new technologies that yield further improvements in energy efficiency will be well worth the investment.
References


