Improving ship safety and efficiency with proactive use of Voyage Data Recorders

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INTRODUCTION

The use of Shipborne Voyage Data Recorder (VDR) in the commercial maritime industry can raise both safety and operation efficiency levels. Although it is late coming compared with aviation industries, the International Maritime Organization (IMO) has recently passed the resolution A.861(20) Performance Standards for Shipborne Voyage Data Recorders. The International Electrotechnical Commission (IEC) is currently finalizing the technical specification of the VDR for type approval. Carriage requirements are now under discussion at IMO and will become a reality in the near future.

While mandatory carriage requirement is still years away, some progressive shipping companies have already started to install VDR as part of an advanced Integrated Bridge System (IBS). Actual field experience shows that cost-effective VDRs can be built and maintained to meet reasonable performance requirements with today's technology. Although the primary purpose of the VDR is for accident investigation after the fact, innovative uses of the VDR by the operators both in real-time and post voyage modes have demonstrated VDRs can improve safety as well as efficiency of operations. The concept is similar to the use of flight recorder to store engine data for maintenance in the aircraft industry. This paper describes several areas of proactive use of VDRs for central alarm management, performance efficiency monitoring, heavy weather damage avoidance and seamanship skill training.

SAFETY

The safe operation of commercial ships is most important to ship operators, regulators and the private sector. Just as in other industries, the prudent operator strives for a high degree of safety in its transportation operations. Operating safely and efficiently is a basic business requirement, which must be met just to stay in business. Today’s legal liabilities make it non-profitable to operate unsafely, and can soon put sub-standard operators out of business. The risk of fighting law suits and paying judgements and fine for loss of life, injuries, damage to property, and damage to the environment make it impractical and foolish to operate un-safely.

Tools that encourage and ensure that shipping operations are conducted safely must be a priority. The VDR and its potential for improving marine transportation safety are far reaching. The extensive recording of ship navigation equipment, propulsion system and bridge command as well as alarm status provides a comprehensive analysis database. The

data could be used to aid investigators in identifying causes of the accident. More important, it can also be used to study trends and precursor events, which lead to an incident, thereby assist in formulating proper procedures to avoid future similar scenarios. Incident data could be used as a training tool to make operators aware of potential hazards and assist in the avoidance of incidents. Data could also be used in the evaluation of certain critical equipment, to ensure proper maintenance and operation or to install added redundancy to further improve safety.

Furthermore, in the real-time mode and without affecting the recording function of the VDR, data can be made available for viewing by the operator to prevent accidents. The following are a few examples of the real-time use of VDR data:

Heavy Weather Damage Avoidance
Containers are lost and ships are damaged in severe sea states. Monitoring of vessel motion and hull stress can alert the operator when the safe operating threshold is about to be exceeded. The real-time display and analysis coupled with analytical prediction of motion and sea load with observed or forecast sea and swell condition can reduce the risk of heavy weather damage. Using these tools, the operator will be able to answer many "what if" questions on changing ship speed and heading to reduce motion and stress before it is carried out. The sensors will further confirm the operator's actions.

Central Alarm Management
With the proliferation of alarm signals on each piece of equipment and sensors on a modern ship, the sound and light signals quickly become confusing and unmanageable. The crew may take days to become familiar with the alarms and how to turn them off. Since the VDR is already monitoring all the major alarms, a Central Alarm Management System can automatically monitor, record and display ship's alarm at a central location so that the crew can easily identify the alarm and manage the condition in a timely manner. The entire system is designed to assist the mariner in overcoming the uncontrolled proliferation of alarms and warning sounds on modern ships by displaying the alarm status so that:

- Alarms are easily distinguishable
- Alerts or informs which important actions are to be taken
- Non-important action can be postponed or transferred
- Responsibilities, procedures, and routines are easily understood through the use of check lists and graphic display including video
- Records are kept for later investigation and training

Directional Stability
A large vessel with blunt hull form can sometimes exhibit directional instability in slow forward speeds. When ship's turning is not responding to the rudder action, it can lead to collision in congested waters and grounding in narrow waterways.

Real time display of turn rate, rudder angle and other factors influencing the ship's maneuver can alert the operator of potential dangers.

Incident Investigation

As in other transportation incident investigations, the marine incident requires accurate data records in order to gauge system and personnel performance as well as operating status prior to an incident. In maritime industry, most of these incidents are not fatal, the actions taken by the crew after the incident is also important. The VDR can record and save the data so that analysis can be made when the ship arrives next port. The determination of factors, which caused, or contributed, to an incident is most important in the prevention of similar future incidents.

Perhaps the most notable are maritime investigation involve passenger vessels and the loss of human life. It is critical to determine which regulations, equipment, and operational procedures require modification to prevent these incidents. Also incidents which damage the environment have a "high profile" with a lot of public demand to find ways to prevent future incidents. For the operator, all ship incidents are important if lessons can be learned to avert damage in a potentially dangerous situation. The second by second replay of important ship data recorded by the VDR could be a critical tool for the marine accident investigator in the determination of specific precursor events, sources causing incidents, and subsequent actions taken to avert the incident.

Bridge Team Training

Shipping companies spend a great deal of effort in bridge team resource management training to ensure safe operation. Playback of VDR recording of actual operation data can provide realistic scenario to improve bridge team effectiveness and evaluate procedures for accident prevention. Corrective measures can then be reinforced via training.

EFFICIENCY

Operating efficiency is another important element in the competitive commercial shipping industry. In the long run, only the safe and efficient operator will survive in business. Efficiency can be improved only when the management can compare performance to an established base line standard. Ship operators currently rely on the crew to make observations of time, ship position, speed, engine output and other pertinent voyage data, then record them on a sheet of paper or input them into a computer data base. Uncertainties in weather conditions, effect of current, averaging process used to determine SHP, speed etc on once or twice a day basis degrade the overall data integrity. Since there is no way to check the validity of each input, the data is often of little use in performance monitoring except for record keeping purpose.

The continuous monitoring of navigation and engine data by the VDR creates an ideal database for performance evaluation in an automated fashion. Passage reports can be

generated from past time history records on any selected data fields. Inferences can be made regarding the hull, engine, and propeller efficiencies as well as fuel consumption. The results can assist the management in making optimum dry-docking schedules, choosing fuel types, as well as validating claims of energy saving devices. In the real-time mode the VDR can supply critical engine data to alert operator of abnormal operating conditions before they result in engine damage. The following are a few examples of the use of VDR data in enhancing operation efficiencies:

Engine overload

Ships with low sea margin design of fixed pitch propeller and low speed diesel engine combination can often lead to engine overload when encountering head sea conditions. Monitoring of Shaft horsepower and RPM and displaying them on an engine overload diagram can alert the operator when approaching such conditions. The engineers can then take appropriate actions to minimize the engine wear when operating in restricted zones.

Hull and propeller roughness monitoring

An increase in Hull and propeller roughness can result in a large increase in fuel consumption over time. In the worst scenario, the added resistance will also cause frequent engine overload even in favorable weather conditions resulting in reduction of operating speed. The detailed recording of engine SHP, propeller RPM, and ship speed just after dry-docking can be used as a baseline for comparison with current conditions. Savings in fuel cost can be traded-off between early dry-docking, using long lasting anti-fouling paint and underwater propeller polishing.

Performance evaluation

Ship performance evaluation has been an elusive target due to lack of detailed navigation and engine data. Uncertainties on the effect of weather and ship's loading on fuel consumption plus changes in schedule requirement makes the performance evaluation difficult if not impossible.

With the VDR recording actual ship position, speed, engine RPM, SHP and wind speed, it is possible to compare the performance to a known based line standard. Charter party speed claims can now be based on actual recorded ship speed and wind measurements. For owner operated ships, management can compare performance of sister ships running on the same trade route and identify deficient operating practice to improve efficiency. Historical data can also help the company naval architect in specifying proper sea margin when building new ships.

BEYOND VDR BASICS: ADDED ECONOMIC BENEFITS

Although the primary purpose of VDR is to record data for accident investigation, many real-time applications of the VDR can lead to improved safety by identifying and warning of impending danger or organize the alarms. VDR data could prove valuable for the

training and education of mariners. Real life data of unfolding events could be used to simulate actual problematic situations and the decision of the student could safely be evaluated and guidance provided. Data could be used and reviewed by crews who operate in a problematic area to improve their decisions. VDR data can play a key roll in the education and training of our mariners to enhance the safety of operations.

Companies trying to become more efficient could also use VDR's information. Data collected and analysis performed by companies could be used to increase their competitive advantage. Historical vessel operating efficiency data could be collected and monitored to determine the need for vessel maintenance or modification to reduce operating cost. Performance evaluation could be carried out to identify operating deficiency. By using the VDR data, companies can improve their operating efficiencies. Safer and more efficient operations can be directly translated into cost-saving and increased profitability of those shipping companies utilizing the VDR technology.

CONCLUSION

Carriage requirements for commercial vessels will happen. It is not a question of if there will be a VDR requirement, just when. IMO has passed resolution on Performance Standards of VDR and encourages member states to vote for mandatory carriage of VDR. Discussions are focusing on passenger vessels, which have potentially the greatest impact on human life; followed by vessels which have the potential for environment impacts, such as tankers and chemical carriers, then cargo vessels. Progressive IMO implementation of carriage requirements is expected in the near future.

Currently the IEC is completing the final draft of the technical standard for the VDR. The specifications will have to be consensus standards developed collaboratively by all parties with an interest. They must allow for the cost-effective production VDRs, which can be used by the majority of the commercial shipping industry. In addition, innovative use of VDR data in both real-time and archived mode should be encouraged to bring about added benefits for the owner and operators.

In conclusion, VDRs can positively impact the commercial maritime industry. Safety will be increased just by the awareness of their existence. The utilization of VDR's in the commercial shipping industry will be a plus for the maritime industry. Just through the awareness of their existence, they will heighten operator's diligence in operating their vessels safely and efficiently. With the carriage requirements for the maritime industry coming out in the near term, the industry must be prepared for their implementation. As ships are required to carry such recording equipment, operators should take advantage of the VDR hardware and derive added benefits in enhanced safety as well as efficiency.

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References

Chen, H. Cardone, V. and Lacey, P. "Use of Operation Support Information Technology to Increase Ship Safety and Efficiency", Society of Naval Architect and Marine Engineers, Annual Meeting 1998.

Biographies

Todd Ripley is a Naval Architect at the Maritime Administration under the U.S. Department of Transportation. He is the Maritime Administrations representative for technology development programs involving shipboard information systems and shipboard bridge systems. He is a member of ASTM and ISO and is engaged in shipbuilding and maritime standards development both at the national and international level.

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