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The Influence on Safety at Sea from the Voyage Data Recorder (VDR)

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Abstract

There is no doubt that the use of Shipborne Voyage Data Recorder (VDR) in the commercial maritime industry has made a substantial contribution to the understanding of accident causes and the improvement of safety. 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 of operations. This paper demonstrates the system overview, IMO requirements and some Influence on Safety at Sea from the VDR.

Keywords: *Sea Safety, VDR etc.*

1. Introduction

The air transport industry has led the way with data recorders. The mandatory fitting of flight deck recorders and cockpit voice recorders in most commercial aircraft has made a major impact to the improvement of safety in the air.

Although there are some features that are common to both the air and sea transport industries, there are significant differences. Flights are measured in hours, voyages in days or even weeks. A ship can sink without anyone being aware of it for several days. Integrating a data recorder in the compact environment of an aircraft is one thing, fitting it into a merchant vessel is something entirely different, and the costs of so doing can be great. (Lang, 1999)

International maritime organization IMO made decisions to mandate VDR initially because there are numbers of lives and vessels lost without explanation such as the bulk carrier Derbyshire vanished in 1980, Heraled of Free Enterprise capsized in 1987, Ferry boat Salem Express sank in 1991 and Stonia sank in 1994.

On February 12, 1997, the IMO defined the purpose of the VDR, namely as a means to maintain a store, in a secure and retrievable form, of information concerning the position, movement, physical status, command and control of a vessel over the period up to and following an incident.

The use of Shipborne Voyage Data Recorder (VDR) in the commercial maritime industry has made a substantial contribution to the understanding of accident causes and the improvement of safety. Recorded data has enabled accident investigators to reconstruct events to identify precisely what went wrong and to ensure that effective, rather than convenient, recommendations can be made to prevent the same thing happening again.

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 of operations.

2. Overview of VDR system

It may be useful to start with an overview of a typical VDR system which consists of:

- *Data Acquisition Unit (DAU)*

This is main recording unit, usually located in the vicinity of the bridge. Typically this unit will be capable of recording all information required by IMO plus additional owner-specified data for a rolling period of 24 hours. The DAU has an additional hard drive that can be used for selective retrieval of data. This memory can be also be ‘ripped out’ just prior to abandonment. This unit is not fire or flood proof.

- *Protected data capsule (PDC)*

This is the real ‘black box’, capable of protecting recorded data from fire, impact damage and immersion. This unit is situated typically on the upper deck where in event of the vessel sinking it can be recovered by divers or Remotely Operated Vehicles (ROVs). Only mandatory IMO data is fed to it from the DAU, which is retained on a rolling 12-hour basis.

- *Power supply unit*

Connected to the ship's emergency source of electrical power and with a two hour battery back-up

- *Bridge Alarm Unit (BAU)*

Situated on the bridge

- *An 'interface box'*

Physically the largest part of the system, containing the cable feeds from items being recorded, the interface, and the feeds to the MRU. (Goddard, 2002)

Figure 1: Component of VDR system Source; (Sperry marine, 2006)

The final data storage, medium and capsule requirements

The technology used for the protective capsule is founded on static solid-state memory. The solid-state technology used for 15 years in the well-known aeronautical black box fulfils the fire, shock and immersion extreme conditions met during the explosion, burning and sinking of a ship. (Safety at sea, 1999). The capsule requirements are:

- Recording of last 12 hours. Older data to be overwritten.
- A manual means is required to make the VDR permanently store the latest data after an incident. Push button '' SAVE LATEST DATA''.
- As simple as possible to operate
- A means to make local copies of incident data.
- A fixed or float-free capsule
- Withstand shock (test pulse of 50g during 11 ms).
- Withstand penetration by a 250 Kg pin dropped from 3m height.
- Withstand fire at 260 degrees C for 10 hours.
- Withstand submergence to 6000 meters during a period of 24 hours.
- Fitted with acoustic beacon (Lahalle, 1999)

3. Annual performance test

Regulation 18.8 of SOLAS chapter V requires that:
The voyage data recorder system, including all sensors, shall be subjected to an Annual performance test.
The test shall be conducted by an approved testing or serving facility to verify the accuracy, duration and recoverability of the recorded data.
In addition, tests and inspections shall be conducted to determine the serviceability of all protective enclosures and devices fitted to aid location.
A copy of the certificate of compliance issued by the testing facility, starting the date of compliance and applicable performance standards, shall be retained on board the ship. (Taylor, 2005)

4. Carriage requirements

Even before the regulations was mandatory, some progressive shipping companies installed VDR as part of an advanced Integrated Bridge System (IBS), for example Norwegian company Maris installed its first VDR developed by, Jotron, in November 1999 on a passenger ferry operating between Copenhagen and Oslo. (Safety at sea, 2000)

The mandatory regulations for VDR are contained in Chapter V on Safety of Navigation of the International Convention for the Safety of Life at Sea, 1974 (SOLAS).
Under Reg. 20 adopted in 5th December 2000, which entered into force on 1 July 2002 on Voyage data recorders (VDR).

5. Voyage data recorders (VDR)

The following type of ships are required to carry VDRs:

- passenger ships constructed on or after 1 July 2002;
- ro-ro passenger ships constructed before 1 July 2002 not later than the first survey on or after 1 July 2002;
- passenger ships other than ro-ro passenger ships constructed before 1 July 2002 not later than 1 January 2004; and,
- ships, other than passenger ships, of 3,000 gross tonnage and upwards constructed on or after 1 July 2002. (Safety at sea, 2001).

6. Simplified Voyage data recorders (S-VDR)

The Maritime Safety Committee (MSC) at its 79th session in December 2004 adopted amendments to regulation 20 of SOLAS Chapter V (Safety of Navigation) on a phased-in carriage requirement for a shipborne simplified voyage data recorder (S-VDR). The amendment enters into force on 1 July 2006.

The S-VDR for old cargo ships, it is not required to store the same level of detailed data as a standard VDR, but it should maintain a store, in a secure and retrievable form, of information concerning the position, movement, physical status, command and control of a vessel over the period leading up to and following an incident.

To assist in casualty investigations, cargo ships, when engaged on international voyages, shall be fitted with a VDR which may be a simplified voyage data recorder (S VDR) as follows:

- in the case of cargo ships of 20,000 gross tonnage and upwards constructed before 1 July 2002, at the first scheduled dry-docking after 1 July 2006 but not later than 1 July 2009;
- in the case of cargo ships of 3,000 gross tonnage and upwards but less than 20,000 gross tonnage constructed before 1 July 2002, at the first scheduled dry-docking after 1 July 2007 but not later than 1 July 2010; and
- Administrations may exempt cargo ships from the application of the requirements when such ships will be taken permanently out of service within two years after the implementation date specified above. (International Maritime Organization, 2006)

7. IMO requirements for VDR data

Voyage Data Recorder (VDR), is a data recording system designed for the vessels in order to collect data from various sensors on board the vessel. It then digitises, compresses and stores this information in an externally mounted protective storage unit. The protective storage unit is a tamper-proof unit designed to withstand the extreme shock, impact, pressure and heat, which could be associated with a marine incident (fire, explosion, collision, sinking, etc).

8. IMO requirements for a VDR are that it record the following

- GPS - Date, time and position,
- speed log - Speed through water or speed over ground,
- gyro compass - Heading,
- Radar - As displayed or AIS data if no off-the-shelf converter available for the Radar
  video*,
- bridge audio - Including bridge wings,
- VHF radio communications,
  - Echo sounder - Depth under keel*,
  - Main alarms - All IMO mandatory alarms*,
  - Hull openings - Status of hull's doors as indicated on the bridge*,
  - Watertight and fire doors - Status as indicated on the bridge*,
  - Hull stress - Accelerations and hull stresses*,
  - Rudder - Order and feedback response*,
  - engine/propeller - Order and feedback response*,
  - Thrusters - Status, direction, amount of thrust % or RPM*,
  - Anemometer and weather vane - Wind speed and direction*,

Data marked with * may not be recorded in S-VDR, **except** Radar and Echo Sounder if data & standard interfaces available. (Grey, 2006)

9. Safety

Most people do respond positively to being monitored and the fact that actions may later be analyzed should sharpen the actions and attitude of the bridge and engine room teams. (Safety at sea, 2006)

The ship officers will operate their ship with more attention. They push themselves to establish more formal and better procedures on the bridge. In connection with oil and gas terminal operators the implementation of guidance assistance and VDR has reduced incidents by a factor of about 10. Such a system makes the professional act as professionals. We are here touching the human element of making failures, the majority (68%) of all incidents. (Nielsen, 2002)

The safe and efficient operation of ships is the most important requirement for shipping industry and today's legal liabilities make unsafely and sub-standard operators out of business, therefore ,today the priority is for the tools that encourage and ensure that shipping operations are conducted safely.

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.

It is clear that significant benefits can be derived from post-incident analysis and VDRs can help in improving safety at sea, particularly relating to:

- Accident investigation
- Bridge Team Training
- Promoting best practice and accident prevention
- Assessment of response to safety and environment emergencies
- Reduction in insurance losses (Safety at sea, 2001)

It was also noted, by investigators, that VDRs had just as much value in non-catastrophic incidents where the recorded evidence helped establish the sequence and true cause.

10. Accident Investigation

The marine incident investigations 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.

The professional marine casualty investigators know that, accidents are never caused by a single reason but are a combination of seemingly unrelated events going back over, perhaps, many years. The prime duty of the accident investigator is to find out what happened and why with the sole aim of preventing it happening again. (Lang, 2006).

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.

The first ever underwater recovery of a voyage data recorder took place in February 2006 to help the joint Egyptian-Panamanian investigation into Al Salam Boccaccio 98 ferry disaster in the Red Sea. About 1000 people were lost, when the Egyptian ferry caught fire and sank during a routine crossing between Saudi Arabia and Egypt. The Egyptian authorities sought help via the IMO to recover and analyze its contents, the job was difficult as the ship came to rest more than 800 m deep. (Safety at sea, 2006)

The Registro Italiano Navale and Aeronautin (RINA) have said that the last stability tests on the vessel were carried out in 2003. The last structural inspection was undertaken in June 2005and did not show any problems with the vessel's structure or stability. Water built up on the vessel as a result of attempts to fight the fire, destabilizing it and causing it to sink. (Lloyd's list, 2006)

It is good that the Egyptian ferry disaster is being investigated but was surprised to note that part of the transcript from the recovered voyage data recorder appeared in the media prior to the investigations being completed and the official reports published. It looks suspiciously as if someone was trying to put the blame for what happened on certain individuals rather than identify any systemic reasons behind the accident. It is, in my opinion, essential that all the evidence be evaluated before any conclusions are drawn and that any premature release of evidence, especially a VDR transcript, should be avoided unless a specific safety recommendation is being made. (Lang, 2006). Many lessons were learnt from recover and analyze the VDR contents such as:

- VDR securing device and the need to be afloat
- IMO must introduce standard downloading protocols
- the manufacturer's must carry out the survey responsibility
- Engine room must be involved in the recording process
- The need to raise the training standard for the ship's officers
- More light should be shed on the actions of the crew (Lloyd's list, 2006)

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.

According to Nautic, lessons that can be learned from the VDR information, after a disaster when the ''black box'' is recovered, include:

- What happened?
- How did the officers handle the emergency?
- What can be done to prevent this from happening again?
- And what can be learned from difficult ship handling? (Safety at sea, 2001)

11. Bridge Team Training

Shipping companies spend a great deal of effort in bridge team resource management training to ensure safe operation. Many companies are exploring the potential of VDR data as training material and their fleet safety managers are looking into ways of using VDR for bridge and engine room command and control training.

The companies are particularly interested in exploring how ship's officers communicate while carrying out their duties, especially emphasizing appropriate actions, assertiveness and challenge and response situations.
The company can review the situation, when the ship returns following a difficult crossing, the monitored information could be downloaded for review of the officers's handling of the ship:

- What happened?
- How did the officers handle the situation?
- How can the officers improve their ship handling?
- What can be done in the short as well as the long – term perspective? (Safety at sea, 2001)

Information from voyage data recorders is used to compile training lessons where crew have to deal with real life situations that have actually happened to Star Cruises ships. It is the best source for us to create new training scenarios. (Lloyd's list, 2003)

For bridge team resource management training course the MET institutes can use the Playback of VDR recording of actual operation data to provide realistic scenario to improve bridge team effectiveness and evaluate procedures for accident prevention. Corrective measures can then be reinforced via training.

12. Promoting best practice and accident prevention

In the real-time mode (see Figure 2) 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:

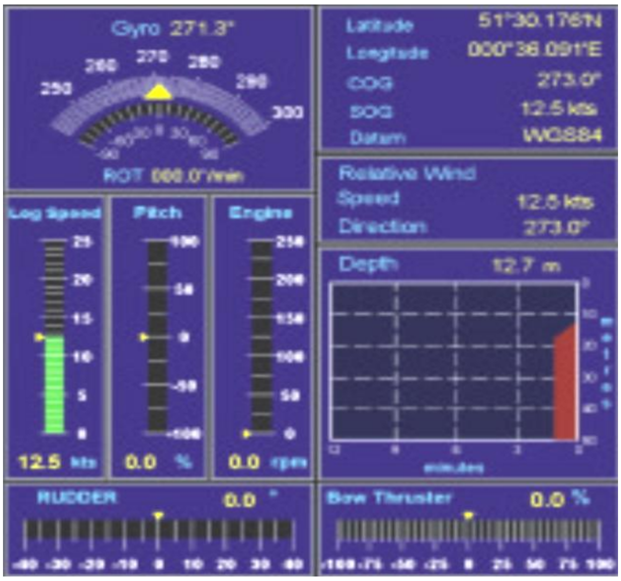

Figure 2: VDR Real Time Display Source; (Taylor, 2005)

12.1 Heavy Weather Damage Avoidance

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. The operator will be able to changing ship speed and heading to reduce motion and stress before it is carried out. The sensors will further confirm the operator's actions.

12.2 Central Alarm Management

Each equipment and sensors on a modern ship have alarm signals with sound and light and that become confusing and unmanageable, also take days for the crew to become familiar with them. 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

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

Conclusion

Maritime accidents continue to result in heavy loss of life and serious damage to the environment. The recurrence of these accidents may be prevented by having a better awareness and understanding of their causes and circumstances in which they occurred. Installation of a voyage data recording system aboard ships will permit the collection of essential data related to an accident in a systematic and reliable manner, thereby enabling the causes and circumstances surrounding an accident to be analyzed. Better awareness in the knowledge of causes and circumstances of maritime events will prevent them to reoccur.

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.

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