VOYAGE DATA RECORDER - VDR. IMPLEMENTATION AND PERSPECTIVES

[1]Cdr. Neculai C. TATARU[1]
[2]Cpt. Gabriel MOISE[2]
[3]Ens. Florin ALBICI[3]
[1] "Mircea cel Bătrân" Naval Academy, Constanța, Romania

Abstract: *Fly Data Recorder - FDR and Cockpit Data Recorder - CVR are successfully used to study aircraft incidents for a long time. These "black boxes" have a role in aircraft accident investigation, the maintenance, research and development of new technology. In the 80's, several major naval sinister officials led IMO - International Maritime Organization to consider the adoption of similar technologies for ships. As a result, in the 90's have developed technical specifications for "ships black boxes ", which allow recovery of important data for marine accident investigators. Voyage Data Recorder records and stores data in a secure capsule essential for any investigation. This capsule can be floating or submersible. Currently VDR plays an important role in maritime safety, providing important analysis for diving, stranding, collision, capsizing and other event and help owners to increase crew training and implementation of naval safety procedures. Relatively recent introduction of these very useful tools in the investigation requires a careful analysis of ergonomics and system maintenance but also offers great opportunities for improvement.*
Keywords: *capsizing, collision, VDR, Voyage Data Recorder*

1. INTRODUCTION

The VDR's purpose is to create and maintain a secure, retrievable record of information indicating the position, movement, physical status, and command & control of a vessel for the period covering the most recent 12 hours of operation. Analogous to a flight data recorder or Black Box, and is designed to aid in maritime casualty investigations aboard ships engaged on international voyages.

It is a commercial carriage requirement for all existing passenger vessels and new vessels over 3000 GT built on or after July 1 2002 and a useful data source for crew training and warehousing operational "best practices" for the vessel owner / manager.

There is no requirement at present for ships under 3000 GT, or for existing ships other than passenger ships, to be fitted with VDRs. Owners are, however, encouraged to fit VDRs - Simplified Voyage Data Recorder, when practicable to do so, in order to assist in the investigation and identification of the causes of accidents and other incidents.

The IMO is in the process of reviewing the need for existing ships and certain classes of smaller vessels to carry VDRs. Performance standards for a suitable device for these vessels are being drafted.

Applicable International Standards:

IMO A.861:1997, Performance standards for shipborne voyage data recorders;

IEC 61996, Maritime navigation and radiocommunication equipment and systems -Shipborne voyage data recorder (VDR) -Methods of testing and required test results.

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 servicing 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, stating the date of compliance and the applicable performance standards, shall be retained on board the ship.

2. DATA ITEMS THAT MUST BE RECORDED BY THE VDR

Date and time: Date and time referenced to UTC, shall be obtained from a source external to the ship (for example, an electronic position fixing system or radio time signal if available), or from an internal clock at least once per hour. The recording shall indicate which source is in use. The recording method shall be such that the timing of all other recorded data items can be derived on playback with a resolution sufficient to reconstruct the history of the incident in detail, not worse than 1 s.

Ship's position: Latitude and longitude, and the datum used, shall be derived from a designated electronic position fixing system or integrated navigation system if available. The recording shall ensure that the identity and status of the source can always be determined on playback. The ship's position shall be recorded, as available on the ship, up to a resolution of 0.0001 min of arc.

Speed: (Speed through the water, or speed over the ground (transverse as well as longitudinal in either case, as available on the ship), including an indication from which it is, derived from the ship's designated speed and distance measuring equipment, shall be recorded, as available on the ship, up to a resolution of 0,1 kn.

Heading: As indicated by a designated ship's compass. The ship's heading shall be recorded, as available on the ship, up to a resolution of 0,1°.

Bridge audio: One or more microphones positioned on the bridge shall be placed, such that conversation at or near the conning stations, radar displays, chart tables etc., may be adequately recorded. As far as is practicable, the positioning of microphones shall also capture the input and output of intercom, public address systems and the audible alarms on the bridge. The audio signals at all work stations shall be recorded continuously. Optionally, means may be provided so that the originating work station can be identified with the audio signal being analyzed during playback of the recorded information.

Communications audio: VHF communications relating to ship operations shall be recorded, independently of the bridge audio. The recording shall include both transmitted and received audio signals and shall be continuous from a directly connected fixed VHF radio to be designated at installation of the VDR.

Radar data - post-display selection: This shall include electronic signal information from within one of the ship's radar installations which records all the information which was actually being presented on the master display of that radar at the time of recording. This shall include any range rings or markers, bearing markers, electronic plotting symbols, radar maps, whatever parts of the electronic chart or map that were selected, the voyage plan, navigational data, navigational alarms and the radar status data that were visible on the display. The recording method shall be such that, on playback, it is possible to present a faithful replica of the entire radar display that was on view at the time of recording, albeit within the limitations of any bandwidth compression techniques that are essential to the working of the S-VDR.

AIS data: Where there is no commercial off-the-shelf interface available to obtain radar data then AIS target data shall be recorded as a source of information regarding other ships; otherwise AIS information may be recorded additionally as a beneficial secondary source of information on both other and own ship. The VDM (AIS - VHF data link) message shall be recorded in such a way, that all target data available from the onboard AIS are acquired. If the VDO (AIS - VHF data link own-vessel) message is recorded, this shall be additional to the recording of individual sensor data.

Other items: Any additional data items listed by IMO with the requirements set out in resolution A.861 (20) shall be recorded where the data is available in accordance with the international digital interface standards using approved sentence formatters.

Echo sounder: This shall include depth under keel up to a resolution of 0.1 m as available on the ship. The depth scale currently being displayed and other status information shall be recorded where available.

Main alarms: This shall include the status of all IMO mandatory alarms on the bridge. The status of all IMO mandatory alarms shall be recorded by the bridge audio and as a data parameter where practicable.

Rudder order and response: Both rudder order and response angles shall be recorded up to a resolution of 1º as available and permitted on the ship. Status and settings of heading or track controller, if fitted, shall also be recorded.

Engine order and response: This shall include the positions of any engine telegraphs or direct engine/propeller controls, including shaft(s) (revolutions or equivalent), and feedback indications, if fitted, including ahead/astern indicators. This shall also include status of bow and stern thrusters if fitted. Revolutions shall be recorded up to a resolution of 1 rpm and pitch shall be recorded up to be solution of 1º.

Hull openings (doors) status: This shall include all IMO mandatory status information required to be displayed on the bridge.

Watertight and fire door status: This shall include all IMO mandatory status information required to be displayed on the bridge.

Accelerations and hull stresses: Where a ship is fitted with IMO mandated hull stress and response monitoring equipment, all the data items that have been pre-selected within that equipment and are available shall be recorded.

Wind speed and direction: This shall be applicable where a ship is fitted with a suitable sensor. Both relative or true wind speed and direction may be recorded, but an indication of which it is shall be recorded.

3. VOYAGE DATA RECORDER SYSTEMS DIAGRAM

Most items of navigational equipment will already have the standard IEC 61162 (NMEA 0183) interface and so interfacing will be possible. For those that have some other form of electrical / electronic interface, it should be possible to interface to the VDR via an interface box.

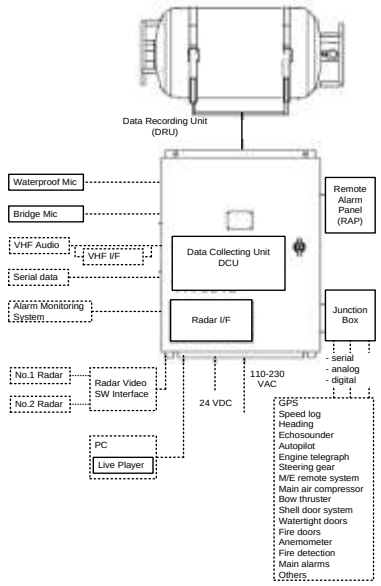

Figure I System configuration

4. PROTECTIVE MEMORY CAPSULE

The final recording medium shall be installed in a protective capsule. The capsule may be designed to remain fixed to the ship in all circumstances. Alternatively, it may be designed to float free automatically if the ship sinks.

To permit subsequent analysis of factors surrounding an incident, the method of recording should ensure that the various data items can be co-related in date and time during playback on suitable equipment.

The final recording medium should meet all of the following requirements:

- be capable of being accessed following an incident but secure against tampering;
- maximize the probability of survival and recovery of the final recorded data after any incident;
- be of a highly visible color and marked with retro-reflective materials; and be fitted with an appropriate device to aid location and marked with the legend: "VOYAGE DATA RECORDER - DO NOT OPEN REPORT TO AUTHORITIES"
- be fitted with means to facilitate grappling and recovery and be designed with due regard to preventing it from being fouled during release;
- be so constructed as to minimize the risk of loss or damage to the final recording medium during recovery operations;
- be capable of transmitting an initial locating signal and a further locating and homing signal for at least 48 hours over a period of not less than 7 days/168 hours.

The equipment should be so designed that, as far as is practical, it is not possible to tamper with the selection of data being input to the equipment, the data itself nor that which has already been recorded. Any attempt to interfere with the integrity of the data or the recording should be recorded.

The recording method should be such that each item of the recorded data is checked for integrity and an alarm given if a non-correctable error is detected.

To ensure that the VDR continues to record events during an incident, it should be capable of operating from the ship's emergency source of electrical power.

If the ship's emergency source of electrical power supply fails, the VDR should continue to record Bridge Audio from a dedicated reserve source of power for a period of 2 h. At the end of this 2 h period all recording should cease automatically.

Recording should be continuous unless interrupted briefly. Time for which all stored data items are retained should be at least 12 h. Data items which are older than this may be overwritten with new data.

The submersible capsule containing the final recording medium shall be designed to be installed on the external deck of the vessel.

The capsule shall be designed to protect the stored data against the following:

a) Shock: A half sine-wave pulse of 50 g, with duration of 11 ms;

b) Penetration;

c) Fire: A low temperature fire of 260º C nominal for 10 h and a high temperature fire of 1 100º C nominal for 1 h;

d) Deep-sea pressure and immersion, in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m);.

The fixed capsule shall have a release mechanism to facilitate recovery under water both by a diver or a remotely operated vehicle (ROV). Possible items to be considered are:

a) the use of break-away bolts;

b) release levers; or

c) twist lock.

Figure II Testing the temperature

To ensure that the capsule may be retrieved safely after release, suitable large pad eyes or handles shall be incorporated.

Float-free capsule: The capsule shall be designed to ensure that the data held in the final recording medium, shall be retrieved without loss after it has been deployed and subjected to salt water exposure and shall be fully operational for at least 7 days;

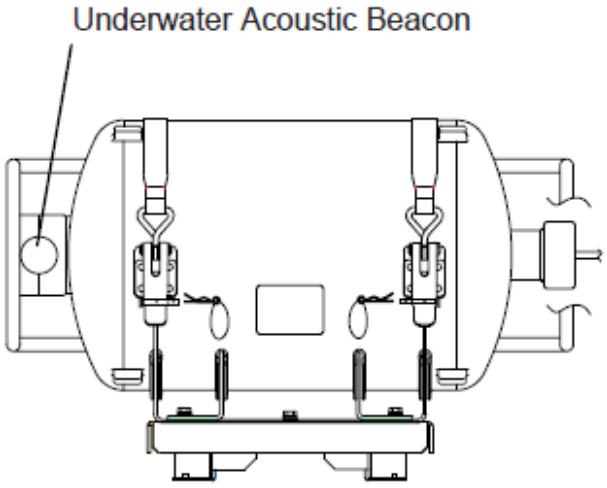

Figure III Data Recording Unit

Data integrity under float-free operation: The float-free capsule shall be tested to verify that the data stored up to the moment of releasing the capsule is not corrupted by the deployment of the capsule or by the transmission of locating and homing signals.

a) Performance checks shall be performed on the capsule after being released under different deployment scenarios, including:

- having been manually released after manually set to the transmission mode;

- having been manually released without being set to the transmission mode;- automatic release; and with different sequences of disconnecting data and power inputs, if relevant.

b) The equipment, with a full set of data stored, shall be set into the test transmission mode: in a suitable arrangement in order not to alert SAR (Search and rescue) facilities and not floating in water, in order to represent the worst case condition. The beacon transmissions shall be maintained for duration of 7 days.

5. TESTING A VDR

In this clause, except where specifically stated otherwise, any reference to the equipment under test (EUT) shall be interpreted as comprising all the parts of a shipborne VDR configuration including:

a) listener port(s);

b) microphone(s) and associated self-test device;

c) communications audio input(s) unit;

d) radar input unit;

e) control and display unit(s);

f) the final recording medium in its protective capsule;

g) power supply unit(s);

h) all other item(s) declared by the manufacturer; and

i) manufacturer's documentation.

The EUT shall be installed in the test facility using interconnection and input cabling and methods representative of a normal installation, but this material and installation shall not be considered part of the EUT.

6. INTERCONNECTION THE EQUIPMENT

Modern satellite communications allow data transmission of fleet management systems, so that it can be easily optimized to work ships at berth basis.

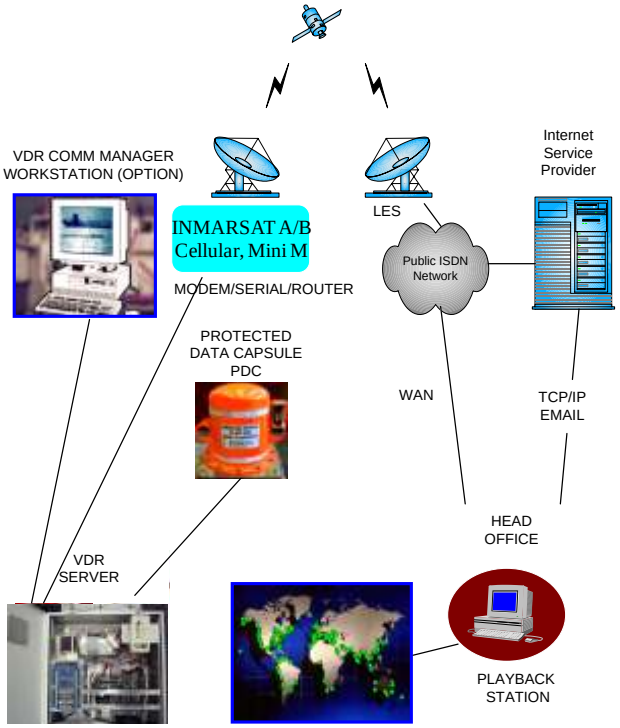

Figure IV Interconnects the VDR

7. CONCLUSION

Being introduced shortly, this equipment requires special attention on board, observance of the instructions for operation and maintenance.

To develop and improve systems requires cooperation from the board officers working with these systems and especially the marine incident investigation teams that can produce higher requirements for these tools:

- Introduction of additional data protected memory;

- Deployment of new programs and improve the playback data of existing already for simulation as realistic a situation during or before a naval accident.

We think this idea extremely useful coupling VDR with ECDIS and ECDIS image capture in the same technical conditions of registration at this time the radar image. Replacing traditional paper charts with modern electronic chart system offers great opportunities for work recording officers in watch.

Capture images from electronic charts allows analyzing the following elements:

- Making corrections and additional map and information systems for safe navigation;
- Making proper navigation plan;
- Proper use of alarms and warnings operational;
- Proper use of ARPA and AIS information overlaid on the navigation map;
- Consultation of various windows to see weather data on actual wind direction and speed by the officer on watch;
- Consultation by the officer on watch on the information systems of safety of navigation of the route march.

REFERENCES:

[1] Alecu "Accidentele de navigaţie maritimă. Prevenire şi cercetare" Editura Fundaţiei "Andrei Şaguna", Constanţa 1997
[2] N. Tataru "Contributions to the modernizations of naval black boxes" BULETINUL INSTITUTULUI POLITEHNIC DIN IA?I; ISSN 1223 - 8139; Oct 2006 Tomul LII (LVI) Fasc.5B;
[3] N. Tataru; A. Anghel "Determination of wave elements by using laser-based distance measurements". 6th International Conference on Electro-mechanical and Power System - SIELMEN 2007: ANALELE UNIVERSIT??II DIN CRAIOVA, SERIA: INGINERIE ELECTRIC?; anul 31, nr.31, 2007, Vol II, ISSN 1842-4805;
[4] IMO A.662(16): Performance standards for float-free release and activation arrangements for emergency radio equipment
[5] IMO A.861(20): Performance standards for shipborne voyage data recorders (VDRs)
[6] IMO : 1974, Convention on Safety of Life at Sea (SOLAS), as amended
[7] http://www.imo.org
[8] http://webstore.iec.ch