VDR - the next generation

The European Maritime Data Management (EMDM) project is an EU initiative that aims to examine, among other things, the capabilities that will be required of the next generation of voyage data recorders (VDR). *S Austin, J-M Forestier, C Winkley*, and *Prof P A Wilson* of the University of Southampton outline the current proposals for enhanced VDR

The European Maritime Data Management (EMDM) project faces the challenge of safe and secure European transport development with the study and development of new applications, functionalities and proposals for Voyage Data Recorders (VDRs) and Electronic Logbooks (ELBs).

EMDM is a consortium of 8 partners including three European VDR and ELB manufacturers (Consilium, Kelvin Hughes, Kongsberg) three SMEs (Avenca, Euroquality, Sodena), the European Commission Joint Research Centre (JRC) and the University of Southampton (UoS).

EMDM is currently evaluating how best to improve on VDR equipment for the next generation of the technology.

The ship VDR is similar in concept to the well-known aircraft 'black box' flight recorder. The VDR records navigational information, internal status information and bridge audio of a vessel in a form designed to survive a catastrophic incident. The record may be used for forensic analysis of incidents whether catastrophic or not.

IMO/IEC presently defines two official flavours of data recorder, VDR and S-VDR. The S-VDR was defined to overcome signal incompatibility problems on existing vessels and the last installations will take place in 2010. All VDR installation thereafter will be on new-builds, so in the EMDM project only VDR has been considered.

The present VDR records a variety of different information. Primary navigational instruments record time, position, heading, COG, SOG, STW, wind direction and speed. Vessel status, such as engine and rudder telegraph, watertight doors, hull openings and alarms are also recorded.

External conditions are recorded by the communications and radar, while bridge audio can record crew perception and actions.

The VDR stores this information in a way that is time stamped, tamperproof and expected to be recoverable even after a fire, explosion or sinking.

Usefulness

The primary reason for the imposition of the regulatory requirement has been seen as the desire to gain knowledge of the events surrounding an incident. Forensic analysis of the record enables safety lessons to be learned about an incident and the maritime community can take steps to avoid a repetition.

Moreover, the UK Marine Accident Investigation Board (MAIB) has highlighted indirect safety benefits available from a regular examination of the record to check company instructions are followed.

These include ensuring that ship's masters are complying with the requirement to proceed at safe speed by random sampling of ship's navigational records; examining safety management systems to ensure procedures are adhered to and the audit processes are sufficiently robust to detect non-conformances; and having shipboard auditing, which should provide enough evidence to verify ship's staff are in compliance with instructions (Recommendations Report 2006, items 109, 208 and 177 respectively, MAIB).

There have been significant changes in technology since the VDR standards were first drawn up

Owners and crews have found benefits too. Examination of the record has shown means of improving the operational efficiency of the vessel as well as data for condition monitoring. It can be used for briefing and analysis of emergency situations.

The ability to replay instrument readout adds to the information available to analyse intermittent faults. For these reasons the VDR installation on many vessels goes beyond the minimum specified by the IEC.

In the early days, crew have regarded the idea of bridge audio monitoring with suspicion, as 'big brother'. Now, in difficult situations, some crew deliberately speak to the microphones in order to ensure there is a clear record of their observations and commands.

However, as Allan Graveson of the maritime union Nautilus UK has made clear, these records may also contain sensitive personal information and the access to them must be restricted and controlled.

Revisiting VDR

The VDR has been around for 20 years, the first installation was by Broadgate in 1988 and was in response to a number of high profile maritime losses in the 1980's - from the Derbyshire bulk-carrier in 1980 to the Herald of Free Enterprise ro-ro ferry in 1987.

The requirement for carriage appeared in 1997 in the form of IMO resolution A.861 (20), followed by the IEC61996 standard that came into force in 2000, but since this standard was drawn-up, there have been significant changes in technology and important experience gained from the assessment of records.

Most of the EMDM proposals are based upon the following sources of industry experience; discussions with individuals in investigation organisations, published documents and comments by members of the industry, and an industry survey by EMDM for which c3800 individuals in over 160 organisations were contacted.

The report has been reviewed by an EMDM Expert Group comprising senior, European, maritime industry representatives from owner/operator, manufacturer, investigation, administration, trade union, legal and insurance and by the EMDM consortium members.

The survey and other information about the project is available at www.euroqualityfiles.net/emdm.

From the survey, the most important features of the VDR are: bridge audio - which is also the one mentioned as having the most problems; radar; ship manoeuvring; and course.

Moreover, the problems commonly encountered when using VDR records were: sensors not working - possibly because VDRs do not alarm in this condition; and data record overwritten - perhaps the crew did not act to preserve the record.

There was clear agreement in favour of: recording more navigational data - ECDIS and more radar; recording the ELB, when available; making the record longer; and defining an open standard for playback - this came into force on 1st June 2008 in a revision of IEC 61996 standard.

No-one in the survey mentioned alarms. The implication is that the operation of the bridge and the vessel manoeuvres are the point of real interest for those other than investigators.

When offered the option to delete from or add items to the record, comments included deleting internal alarms and fire doors, and adding ECDIS, AIS, more Radar, e-logbook data, ballast tank/load monitoring, vessel motion, longer recording, and the ability to select parts of a recording and check that signals are recorded correctly.

It is unlikely that an investigator will agree that internal alarms and fire doors should be deleted, and hopefully nor will the person responsible for auditing conformance to safe operating procedures.

Changes in technology

The changes in technology are twofold - advances in shipborne instrumentation, and advances in the technology that may be employed in the VDR.

The major changes in shipborne instrumentation are AIS, ECDIS, Integrated Navigation Systems, and Integrated Bridge Systems, together with operator choice over display content, including overlay of data from different sources to produce task orientated displays and distribution over multiple high resolution displays.

Most VDRs are based upon PCs, therefore the changes in VDR technology are in the increases in processing power and storage capacity at accessible prices.

The crew perception of a situation can only be understood if both the presentation and selection of information from instruments is available. It may also be important to know what is available but not used.

With respect to the results of the survey, to the advances in the technology and to the required quality of the information, the shortcomings of the minimum VDR as defined by the IEC standard are now reviewed along with the EMDM proposals to overcome them.

Under the present standard the record can be overwritten after 12 hours. This applies to both the protective capsule and the float-free device.

The issues with this short duration include the fact that incidents can have consequences lasting several days. A longer recording period removes the pressure from a master to make a copy of the record whilst perhaps still fully engaged in saving the vessel.

An unscrupulous master might deliberately allow an unfavourable record to overwrite without too much suspicion. However, over a 30 day period this would be difficult to justify as anything other than a deliberate act.

Some incidents are not immediately reported. The loss of the yacht Ouzo in 2006 remained unknown for nearly two days, and only then were vessels contacted for witness information from their VDRs.

Some owners regularly review VDR data as part of their routine safety audits. Others do not, and as a result their crews may be unfamiliar with the copy process, by the time they have received some technical support the opportunity has passed.

Where a vessel is lost, the longer the protected record, the more understanding investigators can have about the way the vessel was operated.

The consensus among the experts is that the record should be longer. EMDM proposes 30 days internal storage and 24 hours in the capsule or float-free.

Proposed improvements

There are a number of areas where EMDM proposes improvements in VDR systems.

Integrity monitoring - There have been cases where data for a particular instrument was not available because an installation fault has developed. This can go undetected for a considerable time

because there is no requirement for integrity monitoring of source data except microphones.

The VDR cannot differentiate between a radar which is switched off because it is not required and a loss of signal because of a fault. There are already sufficient audible alarms on the bridge and false alarms must be avoided, therefore EMDM proposes integrity monitoring of all inputs but with a visual warning indication only.

Bridge audio - The bridge microphones supply a wealth of information on: quality, clarity and appropriateness of commands and communication; location, identity, mood and attitude of a speaker; use of sound signals in poor visibility; audible alarms; public address announcements.

The main issue with this has been the variable quality of the microphone records and the consequent impact on post-incident analysis. This in part due to the inability to isolate a single microphone on playback as a result of recording more than one microphone on a single audio channel.

Alarm, wind, vibration or fault noise on one microphone may mask sound on another. There are also concerns that the possible peak sound levels on the bridge exceed the VDR range, leading to distortion.

Feedback suggests that the existing Installation Guidelines do not cover physical installation of microphone in significant detail and that consideration should be given in the bridge design of a new-build to the acoustics, ambient noise levels and deckhead vibration.

The EMDM proposal is for microphones to be fitted at conning stations, radar displays and other working positions, with only one microphone per recording channel and a higher maximum sound level limit.

Configuration files - Manufacturers' proprietary instrumentation messages, allowed under IEC 61162, are also a problem for investigators, as are alarm messages (ALA) that under IEC 61162-102 have a user-defined meaning.

EMDM proposes that each VDR installation contains a file in standard format that on playback allows these messages to generate a meaningful message directly, for example, an alarm will generate a message saying 'Watertight Door Controller Maintenance Mode', not '901 Other'. The onus is on the installer not the VDR manufacturer.

Radar display - Radar display screen resolution continues to grow, 1600 x 1200 is readily available, and Kelvin Hughes has recently offered 1720 x 1200. Is it necessary to store the full resolution of the

Item	Goal	Summary of proposed changes
Period of Record	Reduce pressure on crew to store a copy of the record during an incident	Increase from 12 hours to 24 hours in the protected capsule float free. Add 30 day internal storage
Integrity Monitoring	Ensure all data items are recorded	Add a variety of signal monitoring functions. Visual Status indication on bridge - not alarm
Date and time (UTC)	Widen range of acceptable sources	Add eLoran as possible source, internal clock to be used only as back-up
Bridge Audio	Overcome quality problems from some installations	Improve average quality; by improved installation and location of microphone; by increased dynamic range allow each microphone to be isolated for playback
Configuration File	Simplify investigator's task of understanding proprietary and user defined messages	Add details on proprietary and user defined messages for automatic use by playback software. Add details of instruments connected
Active control Position	Identify transfer of control	Add indication of active control position
Screen Images	Store more screen images economically Match image interval to rate of change of scene	All images should be restricted to display a palette of no more than 256 colours per image to optimise storage. Store at intervals of 15 seconds except for STW over 40kts when the storage interval shall be 10 seconds
Radar Screen Image	Overcome occasional lack of useful radar image	Record all radar screen images not just primary
AIS	Match data available to crew Ensure Own Vessel is transmitting correctly	Record any screen displaying AIS data except minimum keyboard and display (MKD). The MKD image is not required. Record received Target Vessel, Aid to Navigation and Own Vessel data
ECDIS	To know chart details, ECDIS used correctly, understand passage planning, detect track errors, entry to exclusion zones	Record source: edition, date, update history. Record waypoint locations. Record screen image. Record alarms and settings.
IBS/INS	Record Radar, ECDIS and AIS	Record screen image of any display that includes Radar, ECDIS or AIS data, or all screens if no means available to distinguish
Ballast Water	Monitor compliance with Ballast Water convention	Add: temperature and salinity of ballast water; quantity of water in each tank; pressure in each tank; operation of valves and pumps. Verify with Stress/Motion monitoring where fitted: ship's list and trim; rolling period; longitudinal strength of ship's hull; hull vibration
Additional Alarms	Know when remote Bridge Navigation Watch System alarms are triggered	Add remote alarm signal
Hull Motion	Understand vessel behaviour in flooding conditions	Add Attitude and Heading Reference System
MARPOL	Reduce cost number of record stores	Add to VDR record as it is already tamperproof
Emissions	COx/NOx/SOx monitoring may become a future requirement	Consider adding COx/NOx/SOx instrumentation monitor
Central Alarm Management System	Understand how crew perceive alarms	Add screen image
Integration with Electronic logbook	Provide a secure tamperproof store for ELB data	
Cargo Record	Provide a recoverable Cargo Record in case of vessel loss	

screens or is some resolution loss acceptable in the VDR?

The latest displays on a post-processed short range image are only just adequate to show all the detail from magnetron-based radar. The latest solid-state radar equipment promises higher information content, so the crew perception of an image can only be appreciated at full resolution.

Crew selection of their working radar may change depending on weather, potential hazards or known blind spots or faults. EMDM proposes all radar be recorded at full screen resolution.

Active Steering Position - Whilst the record contains the engine and thruster controller positions and settings, it does not indicate the active control position, nor when it is changed. EMDM proposes the active position and change be recorded.

Proposals for New Technology

New technology is considered as ECDIS, AIS, Integrated Navigation Systems, and Integrated Bridge Systems.

Traditional instrumentation systems offered sensor-based displays. The Integrated Bridge System (IBS) offers task-based displays that can be arranged to suit the user.

The sensor data can be selectively layered on the display, so that, for instance, a chart display may show radar and AIS targets as overlays. For the purposes of investigation, it is vital to have access to the displayed navigational screens.

Automatic Identification System (AIS) does rely upon other vessels cooperating by transmitting accurate data but exposes vessels otherwise hidden from sight or radar.

It supports Aid to Navigation messages such as identifying buoys. The navigator can selectively view the information. It is therefore necessary to know what information was available, whether it is accurate, and what is displayed.

EMDM proposes storage of transmitted and received messages as well as screen image.

To obtain the correct sense of crew perception of navigational information, it is vital to see the screens as they saw them, without loss of detail (excepting that we can only view the screen at intervals).

EMDM strongly suggest that screen images on instruments be restricted to a 256 colour palette on any one image. This reduces the amount of data to be stored and keeps the cost down.

Screen images are presently recorded every 15 seconds, but at this rate the closing distance between high speed vessels diminishes rapidly by several 100 metres per image. It is proposed to decrease the image interval to 10 seconds for craft travelling in excess of 40 knots, speed through water.

The VDR is robust and tamperproof. This makes it a good candidate as a form of electronic strongbox for the storage of important information. EMDM proposes that where ELBs are used, their data should be copied to the protected store.

This might also include copies of records for MARPOL as well as direct monitoring of associated equipment with MARPOL and copies of cargo records for insurance purposes.

Technical feasibility and cost

The storage requirement proposed for VDR is estimated at approximately 600Gbyte for 30 days and 20Gbyte for 24hours.

Whilst the numbers are large, such equipment is readily available to the domestic user as off-the shelf equipment in the form of one Terabyte hard disks and 10Gbyte solid state disks, albeit to a commercial standard.

The processing power requirement, even with 6 large screens and 8 audio channels to compress, is estimated at less than 25 per cent of a typical 2005 desktop PC processing capability.

Only installation in new-builds is considered and this would not be until at least 2010. The installed system constant cost is expected to be approximately 10 per cent more than today's standard VDR. DS

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