Recommendations on the Proactive Use of Voyage Data Recorder Information

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The OCIMF mission is to be the foremost authority on the safe and environmentally responsible operation of oil tankers, terminals and offshore support vessels, promoting continuous improvement in standards of design and operation.
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1 Introduction

All tankers in excess of 3,000 gt on international voyages are required to be fitted with a Voyage Data Recorder (VDR) or a Simplified Voyage Data Recorder (SVDR). Data from the recorders is typically only reviewed reactively following an incident or accident. Often the data is found to be incomplete, reducing the potential benefits of having the equipment installed.

It is recommended that greater attention is given to the recording and analysis of VDR information so that undesirable events are recognised and corrective action is taken to prevent recurrence. The proactive analysis of data on a regular basis could provide an important tool for use in accident prevention and the reinforcement of a positive operational safety culture.

2 Background

Despite the advances made in bridge training and the provision of technological aids, analysis of tanker incidents during the period 1978 to 2011 indicates that navigational incidents involving collisions,contacts or groundings have consistently accounted for around half of all incidents, as depicted in Figure 1 below:

![Graph showing distribution of tanker incidents by type 1978-2011](image)

*Figure 1: Distribution of Tanker Incidents by Type 1978–2011 (Source: Intertanko)*

Over the same time period, collisions and groundings accounted for an even larger percentage of significant oil spills, as shown in Figure 2.
It is important to note that a causal analysis of incidents indicates that most are due to human factors, as opposed to issues such as equipment failure or weather. Attention is properly being paid to improved training but it should also be recognised that there is the potential to learn lessons from other industries, particularly aviation, by improving the analysis and assessment of available data.

3 Data Analysis in the Aviation Industry

Flight Data Recorders (FDRs) have been fitted to aircraft since the 1950’s and many airlines have been routinely analysing their FDR information since the 1970’s. As a result, the aviation industry now has considerable experience of analysing FDR data.

Research by an insurance company in 1996 revealed that the accident rate was significantly lower for those operators that had been analysing their FDR data for the longest period of time. In the 1990’s, the US Federal Aviation Authority (FAA) also sponsored a research programme to establish the safety and cost benefits that could derive from implementing a programme of routine analysis of FDR data. They established that, in addition to safety-related benefits, there were also significant maintenance and fuel-saving cost benefits.

As a result of the demonstrable positive benefits derived from the routine analysis of FDR data, the International Civil Aviation Organization (ICAO) required that from January 2005, operators of aircraft of a maximum certificated take-off weight in excess of 27,000 kg should establish and maintain a flight data analysis programme as part of their accident prevention and flight safety programme.

From the above, it is apparent that it took the aviation industry some 20 to 30 years to fully appreciate and realise the potential benefits from routine analysis of FDR data. It is believed that similar benefits are available to the maritime industry through the analysis and assessment of Voyage Data Recorder information.

4 VDR Information Analysis and Assessment

Software associated with VDR analysis may be programmed with a range of ‘rules’ to detect ‘events’ within the VDR data. The rules can range from fairly simple ones which check the value of a single variable, such as the depth below the keel is less than a defined limit or the rate of turn or applied
rudder angle at full sea speed exceeds a defined limit, to more complex ones which may require significant processing/fusion with other data sources. For example, checking that the ship has followed the correct procedure for a particular Traffic Separation Scheme or has not deviated from the approved voyage plan may require links to data from charts and route plans.

The following table provides examples of ‘events’ which are indicative of poor practice, that may be programmed for identification when analysing VDR data:

<table>
<thead>
<tr>
<th>Events</th>
<th>Examples of checks using proactive indicators from a VDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Keel Clearance at Speed</td>
<td>Check for UKC &lt; 10% draft when SOG &gt; 3 knots</td>
</tr>
<tr>
<td>High Rate of turn at Speed</td>
<td>Check for ROT &gt; 15 deg/min when SOG &gt; 3 knots</td>
</tr>
<tr>
<td>Engines Full Astern</td>
<td>Check for engine order</td>
</tr>
<tr>
<td>Excessive Rudder Angle</td>
<td>Check for Absolute Rudder Angle &gt;20° when SOG &gt; 70% of service speed</td>
</tr>
<tr>
<td>Telegraph Delay</td>
<td>Check for Engine response &lt;&gt; (Engine Order ± 10%) within 30 seconds of a change in Engine Order</td>
</tr>
<tr>
<td>Traffic Separation Scheme (TSS) Adherence</td>
<td>Check that ship is adhering to TSS ‘Rules’, eg:</td>
</tr>
<tr>
<td></td>
<td>• Ensure that it is going in correct direction for lane</td>
</tr>
<tr>
<td></td>
<td>• Check that it has entered TSS at an entry point</td>
</tr>
<tr>
<td></td>
<td>• Check for any speed or depth restrictions</td>
</tr>
<tr>
<td>Close Encounter</td>
<td>Check AIS data for any ships where:</td>
</tr>
<tr>
<td></td>
<td>CPA&lt;0.5 nm and TCPA &lt; 10 minutes</td>
</tr>
</tbody>
</table>

Table 1: Examples of Typical ‘Events’ Associated with Safety of Navigation

The following describes actual examples of VDR data analysis.

**Example 1: Analysis of Depth Below Keel**

A tanker operator’s procedures stated that the depth below the keel should not be less than 5 metres at normal service speed. Figure 3 shows an illustrative event that was automatically detected through analysis of the VDR data. The depth below keel (blue line) may be seen to remain at about 3 metres for a period of about 20 minutes while the ship’s speed, shown as over the ground (pink line) and through the water (red line) remains consistently high.

![Figure 3: Example Analysis of Depth Below Keel (Source: Avenca)](image)
The data illustrated in Figure 3 related to a single arrival at a particular oil terminal. In order to determine what action should be taken it was necessary to undertake further analysis to identify, for example, whether this was a normal or exceptional event at the terminal and whether it only occurred with certain pilots/Masters or during particular combinations of weather and/or tidal conditions.

**Example 2: Incorrect Manipulation of Bridge Controls**

A ferry company introduced a VDR analysis ‘rule’ to monitor whether Masters were allowing sufficient time for a bridge control command, for example, propeller pitch or rudder movement, to take effect before the order was countermanded. A Response Deviation Indicator (RDI) was included in the VDR analysis software to enable cases where this was happening to be automatically identified. A high RDI value indicated that insufficient time was being allowed for the system to respond to a command before it was countermanded.

The results of processing the VDR data from eight consecutive entries to a particular port are shown in Figure 4. The higher RDI values for alternate entries to the port indicate that the bridge controls were not being used effectively for those arrivals.

![Figure 4: Response Deviation Indicator (RDI) for Eight Port Entries (Source: Avenca)](image)

The ‘A’ and ‘B’ annotation of the results depicted in Figure 4 identifies the Master in charge of the ship and clearly shows the high incidence of mis-operation of the controls by Master B.
It transpired that Master B had previously been in command when the same ship had run aground at the port. The cause of the grounding had been identified as inappropriate use of the bridge controls at a time of high tidal flow and strong winds.

Prompted by the results of the VDR analysis, the ferry company arranged for Master B to receive suitable re-training. Without the information provided by the VDR analysis, there was no appreciation that the problem still existed, risking the possibility of further incidents.

5 Challenges Associated with Using VDR Data

5.1 VDR-Related
VDRs are relatively sophisticated monitoring devices which continuously log key parameters such as position, course/heading and speed, as well as the radar display and bridge audio and radio communications.

Due to restricted data storage, some VDRs only receive data from a single unit of each type of equipment, such as one of the radars or one VHF set, when multiple units are installed. Consideration should be given to providing separate feeds to the VDR from each item of equipment.

Typically, the VDR data is only examined following an incident or accident. As a result, when an incident does occur, it is not uncommon to find that the VDR was not fully operational at the time of the incident and that some or all of the data was not recorded correctly.

The current performance specification for VDRs only requires that the data is stored for a minimum of 12 hours before being overwritten. Since many existing VDRs simply meet the required 12 hours, if no action is taken to preserve the recorded VDR data within 12 hours of the start of an incident, the data will be lost or overwritten, thereby negating the purpose of having a VDR installed.

Onboard procedures should address the requirements for retaining and preserving VDR data post-incident.

5.2 Ship-Related
A good approach to analyse VDR data is to undertake a central assessment of information from all ships in a fleet. This enables the correlation of occurrences of ‘events’ which may be associated, for example, with particular ports, Masters, pilots or weather conditions.

As most voyages are in excess of 12 hour’s duration, if VDR data is only downloaded and analysed at the end of each voyage, typically only the data from the last 12 hours will be available. The ‘standard’ VDR therefore does not lend itself to facilitate the implementation of comprehensive voyage assessment and analysis.

6 Extended Recording and Remote Transmission of Data
To address issues associated with short VDR recording times, advanced technology has resulted in options now being available that can significantly increase the duration for which VDR information is available before being overwritten.

Systems are available at relatively low cost (approx. US$3,000/ship) and extended recording durations in excess of 90 days are not uncommon. The extended recording option normally takes the form of an additional unit, an example of which is depicted in Figure 5. The unit may have a removable hard disk or support a separate network connection to enable data to be downloaded for analysis. The remote downloading of selected data to a central processing facility via satellite broadband internet is a practical option.
Routine downloads and transmission of VDR data, excluding voice records and radar images, would amount to some 20-30 MB/day. The regular download of data also has the benefit of providing a check that all data inputs are functioning correctly.

![An Example of a VDR Extended Recording System (Source: Avenca)](image)

### 7 Central Analysis and Reporting

The maximum benefit from analysing VDR data may be obtained by reviewing data from a fleet of vessels in order to have the greatest amount of information available to identify trends and their causes. The analysis may also be useful when identifying training requirements for individuals or across a fleet.

Given the worldwide nature of shipping operations, it is recommended that the VDR data is processed centrally with the results being made available securely over the internet.

The system can be set up to generate regular feedback on ‘events’ and their frequency to relevant managers. Such reports could also identify any VDR data channels that may not be recording properly in order that corrective action or repair can be instigated.

### 8 Summary of Recommendations

The installation of Voyage Data Recorders provides the facility for ship operators to take proactive measures to improve operational safety by analysing reported data to identify undesirable events or occurrences and best practices worthy of replication.

It is recommended that consideration be given to the following:

- Extending the means of retaining VDR data beyond the minimum 12 hours in order to encompass full voyages or longer calendar periods, for example, 90 days
- Implementing regular checks on VDR operation to ensure that the complete dataset is being correctly recorded
- Facilitating remote data transmission to a central source
- Undertaking centralised assessment and analysis of VDR information against parameters established by operators
- Identify appropriate follow-up actions in response to recorded ‘events’.

The following graphic provides an overview of a suggested process:
Recommendations on the Proactive Use of Voyage Data Recorder Information

Figure 6: Summary of VDR Analysis Process

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