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# VDR Technical Data Access and Handling

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# 1. Introduction

This report is deliverable D2 under Work Package 1 of the Framework 6 "European Maritime Data Management" (EMDM) Project.

The objectives of Work Package 1 on the EMDM project include the research, development and production of revisions to existing Voyage Data Recorder standards; and to extend the existing standards to cover simplification of access and availability of data.

In order to be able to identify what revisions may be required, and also assess what is practicable and desirable, it is initially necessary to establish the current situation. This assessment must include a review of what requirements are currently specified, and how those requirements have been met by the Type Approved products which are available today.

This report initially outlines the requirements which have been specified for data storage and transfer, and then assesses the various mechanisms which have been provided by VDR manufacturers for data storage and transfer. The strengths and weaknesses of each mechanism will be reviewed and the number of systems fitted with each type of device considered. Possible enhancements to the storage and transfer of VDR data will finally be discussed.

The report will not study the storage and retrieval of data from the Final Recording Medium (inside the protective capsule), as this aspect appears to be reasonably well specified. In addition, it is generally only necessary to recover data from inside the protective capsule in the event that a ship sinks. The requirement to download data from the protective capsule is made even more unlikely since even if a ship does sink, there is likely to be time to download data using one of the mechanisms considered in this report, in the period between the initial incident and the point at which the Final Recording Medium is submerged. This is corroborated by the fact that since the VDR requirements were introduced up until the start of the EMDM project there had only been one case (the "Al Salam Bocaccio 98" in February 2006) where it has been necessary to retrieve a submerged protective capsule and analyse the data from it. This was achieved successfully.

The relative infrequency with which it is necessary to extract data directly from a protective capsule, combined with the limited use which is currently routinely made of VDR data on a day-to-day basis, suggest that greater benefits could be obtained by reviewing the ways in which data are routinely stored and downloaded from a Voyage Data Recorder with the objective of identifying ways to make the process easier/more efficient. This is therefore the main aim of this report.

The next chapter of this report will outline the current requirements for storing and transferring data. The following chapters will review the mechanisms currently in place for storing and transferring data, before considering possible enhancements.

## 2. Overview of the current requirements

The IMO (International Maritime Organisation) originally specified performance standards for shipborne Voyage Data Recorders in resolution A.861 in 1997. This original VDR specification was applicable to passenger ships. Subsequently in 2004 The IMO introduced another specification for a Simplified Voyage Data Recorder (S-VDR) for cargo ships, as defined in IMO Performance Standard MSC.163 (78).

The International Electrotechnical Commission (IEC) provide a set of specifications (IEC 61996-1 & IEC 61996-2) outlining how to test the performance of VDRs and S-VDRs against the IMO requirements.

More recently, the IMO's Maritime Safety Committee (MSC) have approved amendments to the performance standards for VDRs and S-VDRs to make it easier for accident investigators to retrieve and analyse data quickly following an accident (see IMO Resolution MSC.214(81)). The IEC documents 61996-1 and 61996-2, are currently being updated to reflect these latest amendments to the performance standards.

The specifications detail several requirements relating to the mechanisms for storing and downloading data, including:

- The protective capsule must store at least 12 hours of data. (IEC 61996-1 4.5.4)
- The VDR should save data (without interrupting the storage to the protective capsule for more than 10 minutes) to a separate data source. (IEC 61996-1 4.5.1)
- Recorded data should be checked for integrity. (IEC 61996-1 4.4.4)
- "*The VDR should provide an interface for downloading the stored data and playback the information to an external computer*" by an "*internationally recognised format, such as Ethernet, USB, Firewire etc*" (IMO Resolution MSC.214(81))

The specification of the data items which must be recorded for a full VDR are different to those for an S-VDR. One of the main differences is that the requirements to monitor certain sensors are reduced when the data from those sensors is not available in IEC-61162 format. This is shown in
Table **1**
~~Table 1~~.

Consideration of the above reveals the following points:

- There is little difference in the amounts of data which are required to be stored by VDR and S-VDR systems.
- There is no prescribed maximum duration for the data download process.
- There is only a requirement to store 12 hours of data (even though many systems are likely to have considerably greater capacities of non-protected memory available internally).

From the above analysis of the specifications it is clear that manufacturers can implement almost any mechanism they wish for storing and transferring data under normal circumstances.

| Interface | VDR | S-VDR |
|---|---|---|
| *Date and Time* | ✓ | ✓ |
| *Ship's Position* | ✓ | ✓ |
| *Speed* | ✓ | ✓ |
| *Heading* | ✓ | ✓ |
| *Bridge Audio* | ✓ | ✓ |
| *Communications Audio* | ✓ | ✓ |
| *Radar Data – post-display selection* | ✓ | Unless 'impossible' |
| *AIS* | ✗ | Only if no Radar |
| *Echo Sounder* | ✓ | Only if the data is available in accordance with the international digital interface standard (IEC 61162) |
| *Main Alarms* | ✓ | |
| *Rudder Order and Response* | ✓ | |
| *Engine Order and Response* | ✓ | |
| *Hull Openings (doors) status* | ✓ | |
| *Watertight and fire door status* | ✓ | |
| *Accelerations and Hull Stresses* | ✓ | |
| *Wind Speed and Direction* | ✓ | |

**TABLE 1. TABLE OF DATA ITEMS REQUIRED TO BE RECORDED BY VDRS AND S-VDRS**

The range of mechanisms which have been adopted is reviewed in the remaining chapters of this report, with each chapter considering a different aspect, as outlined below:

**Chapter 3 – Data Quantity and Format:** This chapter considers the quantities of data which may be available, and the data formats.

**Chapter 4 - Data Download Mechanisms – Overview:** This chapter considers the range of download mechanisms currently available, and reviews their relative strengths and weaknesses.

**Chapter 5 – Data Download Mechanisms – Survey Results:** This chapter presents an analysis of the download mechanisms fitted to a range of currently Type Approved VDRs/S-VDRs.

**Chapter 6 - Data Transmission:** This chapter considers some of the options which may be available for the remote transmission of VDR data.

# 3. Data Quantity and Format

## 3.1. Overview

The quantity of data which is produced by a VDR/S-VDR system in a given time period will determine how much storage space is required if data is to be saved/stored, and also what transmission mechanisms may work if the data is to be transmitted elsewhere (e.g. ashore).

The format of the data will in part determine how much space is required to store the data, and also the ease with which it can be used by other third party applications.

## ~~1.2.~~3.2. Data Quantity

There are three basic types of data which VDRs record; Audio, Radar (image data) and Control/Sensor data received via IEC61162 interfaces.

The current performance specifications do not impose any specific format to be used when the data is stored internally to the system.

The exact amount of space required to store data within the system is therefore a function of the number of sensors being used, and any data compression techniques which are used to store the data.

The number of sensors used will vary for each installation, and the compression techniques will vary between manufacturers. It is not therefore possible to state categorically how much memory is required to store a certain period of data.

However, all Type Approved systems must be capable of storing 12 hours of data in the Final Recording Medium (within the Protective Capsule). As most systems use a Protective Capsule which is fitted with around 2GB of memory, it may be concluded that for typical sensor fits and data compression schemes that 12 hours of data must occupy less than 2GB of memory.

Furthermore, from consideration of the various data types, it can also be deduced that the major part of the storage requirements are dictated by the audio and image data, with the sensor data taking up only a small percentage of the total storage required. Figure 1~~Figure 1~~ shows the typical proportion taken up by audio, radar and control/sensor data from one of the VDR models surveyed in Chapter 5. The chart shows how the control/sensor data only uses 2.7% of the entire VDR data. Unlike audio and radar image data (which is often already stored in a compressed format internally), the size of control/sensor data can be reduced further via a compression utility. Figure 3~~Figure 3~~ shows how this reduces the control/sensor data to use only 0.41% on the total usage when compressed.

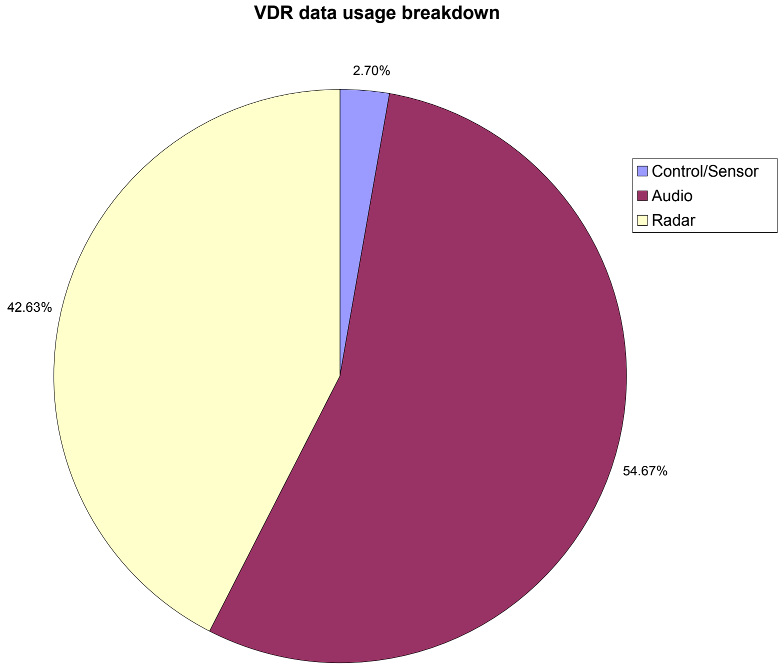


**Figure 1. Breakdown of the space usage of each type of VDR data**

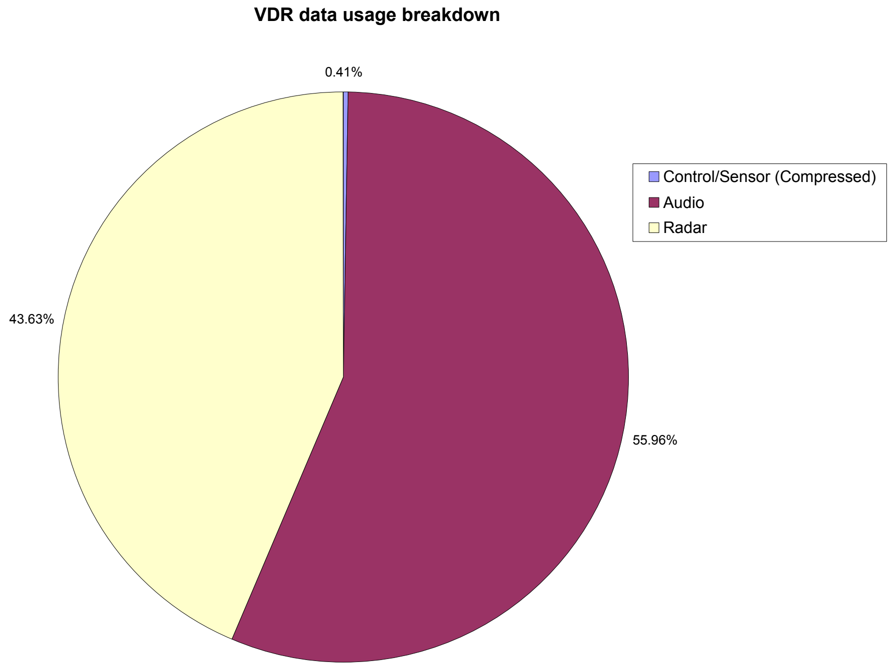


**Figure 3. Breakdown of the space usage of each type of VDR data with control/sensor data compressed**

The other point with regard to data storage which has emerged from the survey of the currently available systems is that although many of the original systems are fitted with internal hard disks that would be capable of automatically storing large quantities of VDR data, only a few manufacturers appear to offer this as standard at present.

## 3.3. Data Format

As stated in the previous section, the original performance specifications for VDR and S-VDR systems do not impose any specific formats on the way in which data is stored internally to the system. Each manufacturer has therefore implemented their own approach to store data.

With the large number of Type Approved systems which are available, it soon became apparent that it was going to be a challenge for accident investigators to download and analyse data from these systems efficiently. Consequently the IMO passed a Resolution (MSC.214(81)), which requires that where manufacturers use proprietary formats to store the data in the VDR, that they provide accident investigators with software to convert the data into "open industry standard formats". It is understood that the IEC VDR and S-VDR test specifications (IEC 61996-1 and IEC61996-2 respectively) are currently being updated to include suitable specification of these industry standard formats.

# 4. Data Download Mechanism

This chapter considers each of the available VDR/S-VDR storage download mechanisms, and assesses their strengths and weaknesses.

The following generic types of storage/download mechanism are covered:

- CD/DVD
- Removable Hard Disk
- Solid State Memory
- PC Connection.

Each of the above is considered in more detail in a separate subsection below.

## ~~1.1.~~4.1. CD/DVD

CDs are flat circular discs, usually 120mm diameter. Data is stored on a spiral groove which covers the entire surface of the disc on a special material (usually aluminium). DVDs are visually almost identical to CDs, but store data at a much higher density which results in a higher storage capacity. With DVDs it is even possible to store data on two layers within the disc increasing the storage capacity further.

### ~~1.1.1.~~4.1.1. Strengths

- A universal (comparatively inexpensive) medium (especially CD) that can be used as standard on most PCs and laptops.
- Rewritable DVD/CDs would probably provide the cheapest option out of all the media outlined in this section.

### ~~1.1.2.~~4.1.2. Weaknesses

- DVDs come in several formats:

  DVD-R, DVD-R DL, DVD+R, DVD+R DL, DVD-RW, DVD+RW, DVD+RW DL, DVD-RAM

  Although most modern drives will be able to write to all of these formats, an attempt to use an unsupported format in an older drive will fail.

- Limited small amount of storage. CDs have a maximum storage capacity of 702 Megabytes by standard, although if the CDRW drive supports 'over-burning', discs which a 870 Megabyte capacity can be used. A single CD is therefore unable to store a full 12 hours of VDR data. This is less of a problem when using DVD media which can have several times more storage space (see Table 3~~Table 3~~), and a single DVD can therefore hold a full 12 hour IMO standard VDR dataset.

| | Single layer capacity DVD+/-R | Dual layer capacity DVD+/-R | Single Layer DVD-RAM v1.0 | Single Layer DVD-RAM v2.0 |
|---|---|---|---|---|
| **Physical size** | **GB** | **GB** | **GB** | **GB** |
| 12 cm, single sided | 4.7 | 8.5 | 2.58 | 4.7 |
| 12 cm, double sided | 9.4 | 17.1 | 5.16 | 9.4 |
| 8 cm, single sided | 1.4 | 2.6 | N/A | 1.4 |
| 8 cm, double sided | 2.8 | 5.2 | N/A | 2.8 |

**Table 3. The storage capacity of DVDs**

- There is a waiting time while the burn process completes, because the transfer rate when burning to a CD or DVD is low when compared to other media. Typically it will take 2 minutes 21 seconds to burn a CD RW (at 32x[1]) whereas a DVD +/-RW will take about 63 seconds (at the current maximum RW speed of 8x[1]) to write the same amount of data. Writing to DVD-RAM media takes over three times as long as DVD +/-RW (3 minutes 20 seconds at the current maximum RW speed of 5x[1]) to write the same amount of data.

  The timings above compare the burn process for 700 MB of data, however as stated in 4.1.2 DVDs can store several times this amount, and it will therefore take significantly longer to burn an entire disc.

  These timings are also impacted by a number of factors. One factor is the speed that the drive is able to write and rewrite at, as well as the maximum speed of the media (CD and DVD media come with ratings declaring their maximum usable speed. Media that can achieve the higher speeds are generally more expensive).

- CDs and DVDs can be prone to scratches. Although it is rare for a CD to be left completely unusable from scratches, it could put critical data at unnecessary risk. This is not an issue for DVD-RAM discs which are available with protective cartridges, and this is the form predominantly used by VDR manufacturers.

- CD/DVDs can degrade over long periods of time (although the life of a disc will be longer if it is stored correctly). "*Historically, manufacturers have claimed life-spans ranging from 50 to 200 years for CD-R discs and 20 to 100 years for CD-RW discs*"[2]. This however greatly depends on quality of the disc and storage conditions, and some users have indicated that the life of a disc could be as low as 2 to 5 years.

- Rewritable CDs and DVDs can only be written a certain number of times before needing to be replaced. The figures in Table 5~~Table 5~~ are from various manufacturers' product technical specifications:

| Media | Rewriting cycles during lifetime |
|---|---|
| CD-RW | 1000 |
| DVD +/-RW | 1000 |
| DVD-RAM 5X | 10,000 |
| DVD-RAM 3X | 100,000 |

**Table 5. Typical amount of rewrites achieved with CD/DVD during media lifetime**

## 4.2. Removable Hard Disk

[1] Note that speed ratings are not equivalent across CD/DVD/DVD-RAM media.
1x CD = 150 Kb/s    1x DVD +/-R = 1.385 Mb/s    1x DVD RAM = 700 Kb/s

[2] Source : Optical Storage Technology Association (OSTA).

When data is stored on a hard disk, it is recorded on magnetic surfaces on high speed rotating platters. There are three main interfaces used to access PC hard disks; IDE, SCSI and SATA. Traditionally the advantage of IDE hard drives have been their low price, whereas the main benefit from using a SCSI has been the high data transfer performance. SATA is the newest interface of the three, and hard drives that use this interface are available at a price comparable to IDE hard drives, with performance comparable to SCSI hard drives.

#### ~~1.1.1.~~4.2.1. Strengths

- Hard Disks provide the largest amount of storage out of the mediums available (The current readily available maximum capacities are 300 GB for SCSI hard drives and 740 GB for IDE hard drives).
- IDE hard drives are currently the cheapest medium per unit of rewritable storage available.
- SCSI drives have the fastest transfer rate of the media available.

#### ~~1.1.2.~~4.2.2. Weaknesses

- SCSI drives are expensive in comparison to IDE drives. SATA is a new cheaper alternative to SCSI with similar performance. Currently a 300 GB SATA drive can cost around 10% of the cost for the SCSI equivalent.
- IDE drives have a slow transfer speed in comparison to SCSI drives.
- Note that is some cases hard drives are placed in ‘caddies’ which provide a USB, Firewire or other interfaces. These caddies provide an easier method of removal and replacement, however they limit any data transfer speed to the speed of the caddy’s interface (e.g. 480 Mbit/s for Hi Speed USB 2.0 and 786.432 Mbit/s for FireWire).
- As a hard drive contains several moving parts, there is an increase in the chance of the medium failing due to mechanical wear. Moving parts also make hard disks vulnerable to shock damage. Most desktop hard disks have a 200-G non operational shock rating (about a 1 inch drop onto concrete), although it is possible to purchase hard disks with ratings G shock ratings as high as 10 000 (or a 30 inch drop onto concrete). In the event of mechanical failure however, it is still often possible for experts to retrieve lost data from the hard drives platters.

### 4.3. Solid State Flash Memory

Several VDR manufacturers have recently started to use solid state flash memory. Flash memory stores data on a microchip in a similar way to computer RAM. The main difference between computer RAM and flash memory is that flash memory is non-volatile, meaning it can retain data without any power source. Flash memory is available in several forms and via several interfaces, however the two main methods used in current VDR systems are USB Flash memory pens and CF (Compact Flash) cards. This report refers to all of these interfaces under single title of ‘Flash memory’, as behind the various interfaces, the data is essentially stored in the same manner.

#### ~~1.1.1.~~4.3.1. Strengths

- Very reliable and robust as unlike CD/DVD drives or hard disks there are no mechanical moving parts (such as spinning discs/platters). This eliminates any chance of data loss due to mechanical failure and also results in a much higher tolerance to shock, vibration and temperature.

- As with hard drives, flash memory is available with several standard interfaces such as USB, CF and PCMCIA.
- Lower latency compared to hard disks (it takes time for hard disks to start spinning before it is possible to read or write).
- Lower weight and noise than conventional hard disks.

#### ~~1.1.2.~~4.3.2. Weaknesses

- Flash memory is expensive and currently costs the most per unit of storage compared to the other mediums detailed in this report. Prices have however been recently reducing dramatically. Once the cost of flash memory becomes comparable to hard disks, it is likely to become the storage medium of choice for VDRs.
- In a similar fashion to DVD-RAM media, manufacturers' technical specifications state that Flash memory only has a lifetime of about 100,000 rewrite cycles.

### 4.4. PC Connection

Connecting a laptop/PC to a VDR, opens up the opportunity to download data directly onto that laptop's/PC's internal hard disk. This is usually achieved via the software supplied by the VDR manufacturer. However due to the nature of some VDRs, this can also be achieved via the standard file sharing functionality built into the PC's operating system.

#### ~~1.1.1.~~4.4.1. Strengths

- May allow recorded data to be seen 'live'.
- Allows for automated data transmission.
- The data can be subsequently transferred by any transfer mechanism available to the PC (e.g. DVD, USB memory stick, or network).

#### 4.4.2. Weaknesses

- It requires an available laptop with the appropriate software installed.
- Data transfer speed is limited to the speed of the interface (100 Mbit/s for Ethernet (or 1000 Mbit/s for Gigabit Ethernet) and 786.432 Mbit/s for FireWire).

### 4.5. Summary

There is a range of different data storage and transfer options available to VDR manufacturers, and the optimum of these depends upon which attributes (capacity, speed, cost and robustness) are considered most important. These are summarised in Table 7~~Table 7~~.

The optimum has probably changed in the 5 or so years that VDRs have been produced, reflecting how technology has progressed in this period. It appears that Flash memory, and PC Links are likely to become the preferred options as they are robust and fast, and the cost per GB for Flash Memory is reducing rapidly.

| | Medium | Max Capacity | Max Speed | | Media Cost | Robustness |
|---|---|---|---|---|---|---|
| Storage Media | CD RW | 870 MB | Slow | 38.4 Mbit/s (32x) | Low | Medium |
| | DVD-RW | 17.1 GB | Slow | 88.64 Mbit/s (8x) | Low | |
| | DVD-RAM | 9.4 GB | Slow | 28 Mbit/s (5x) | Low/Medium | |
| | IDE Disk | 750 GB | Fast | 528 Mbit/s | Low | |
| | SCSI Disk | 300 GB | Very Fast | 5120 Mbit/s | High | |
| | SATA Disk | 750 GB | Very Fast | 3000 Mbit/s | Low | |
| | Flash | 64 GB | Medium | 200 MBit/s | High | High |
| PC Connection Interfaces | USB | N/A | Fast | 480 Mbit/s (High Speed Mode for USBII) | N/A | |
| | Ethernet | | Fast (though Medium in common use) | 1000 MBit/s (though 100 Mbit/s in common use) | | |
| | Firewire | | Fast | 786.432 Mbit/s | | |

**Table 7 Summary table of the different data storage and transfer mechanisms available**

The next Chapter will look at what transfer devices are actually fitted to existing Type Approved VDRs.

# 5. Results of Survey of Download Mechanisms

This chapter of the report presents the relative numbers of each type of storage/download mechanism which are currently fitted to Type Approved VDRs. Thirty-one Type Approved VDR/S-VDRs from the main VDR manufacturers were surveyed to identify which storage/download mechanisms are currently most commonly implemented. The survey has included both currently available systems, and also legacy systems as data will continue to be available from such systems for the foreseeable future.
[Note that the percentages shown on the following pie charts are of the amount of VDR models in the survey and not of the amount of individual units fitted to ships]. Each subsection below considers the results for a particular type of storage/download mechanism.

## ~~1.1.~~5.1. CD and DVD

The relative percentages of the surveyed systems which are fitted with CD and DVD writers are shown in Figure 5~~Figure 5~~ and Figure 7~~Figure 7~~ respectively. The results indicate that less than 20% are fitted with a CD writer as standard, and around 10% are fitted with a DVD writer as standard, although about twice that number of systems offer a DVD writer as an option.

It was notable that the CD writers were generally offered on “first generation” systems, and in some cases were subsequently superseded by a DVD writer.

It should also be noted that if the VDR system supports a PC connection, then it is likely that data could also be transferred to a CD or DVD using a PC which has been connected to the VDR, and is fitted with a CD or DVD writer.

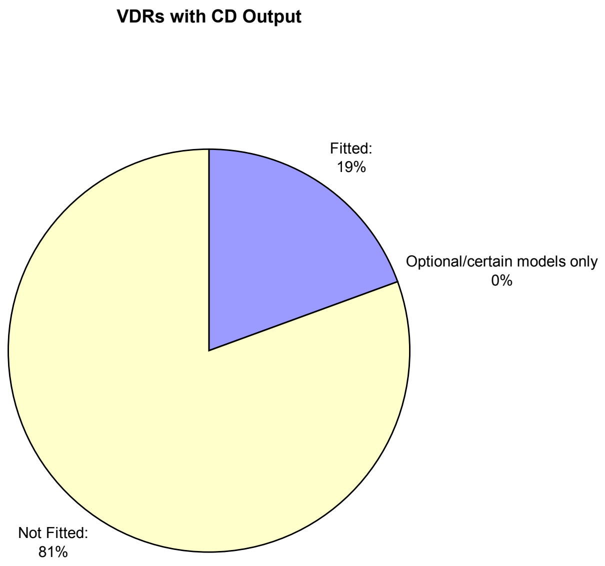


**Figure 5. The relative % of VDRs surveyed which are fitted with a CD writer.**

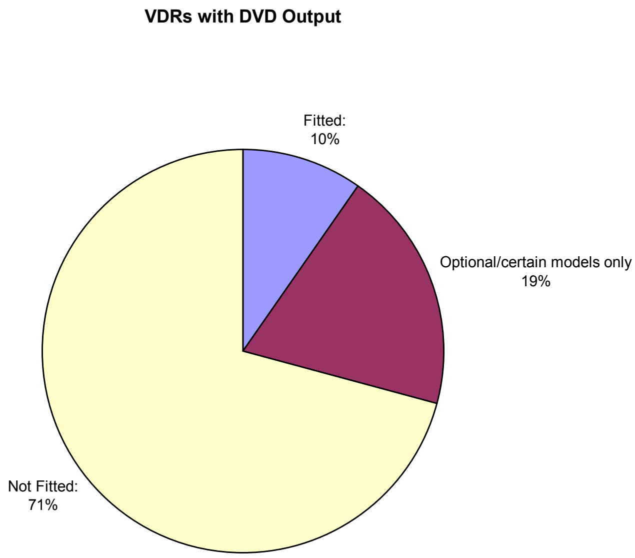


**Figure 7. The relative % of surveyed VDRs which are fitted with a DVD writer.**

## 5.2. Removable Hard Disks

The relative percentages of the surveyed systems which are fitted with removable hard disks are shown in Figure 9~~Figure 9~~. (No distinction is made between SCSI, IDE and SATA disks in this analysis). The results indicate that around a quarter of the systems surveyed are fitted with a removable hard disk as standard, with a further quarter of the systems offering a removable hard disk as an option.

Closer inspection of the results revealed that in some cases manufacturers had offered removable hard disks on their original systems, but that these were not an option on their latest systems, which were primarily targeting the S-VDR market which may be assumed to be particularly cost sensitive. These later systems typically offered Solid State memory devices, and/or PC connection as their storage/download mechanisms.

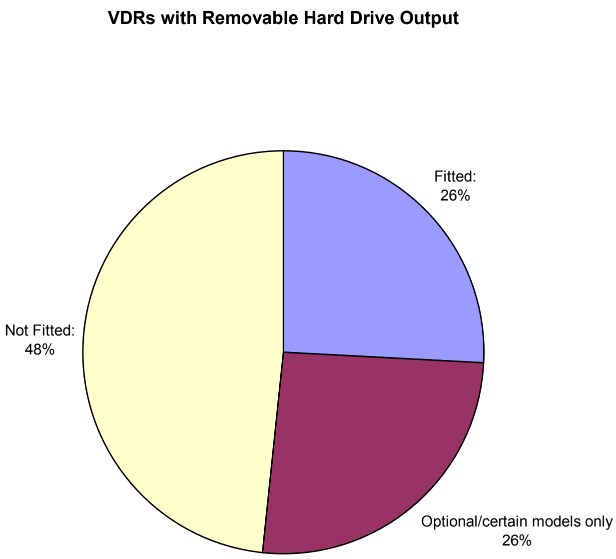


**Figure 9. The relative percentage of systems which are fitted with removable hard disks**

## 5.3. Solid State Memory

The relative percentages of the surveyed systems which are fitted with removable solid state (Flash) memory are shown in Figure 11~~Figure 11~~. (The results for the various types such as Compact Flash(CF), USB, PCMCIA etc. have been aggregated in this Figure).

Although only around 1 in 5 of the systems surveyed offers a solid state memory device as standard, when systems which offer it as an option are included, this rises to almost 1 in 3. Closer inspection of the results indicated that solid state memory was a more common feature on currently available systems than on older systems.

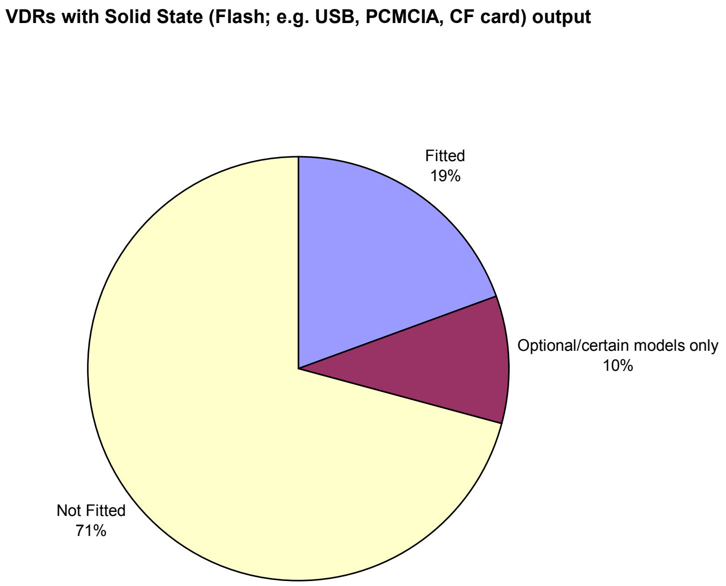


**Figure 11. The relative percentage of the systems which were surveyed which use solid state Flash output devices.**

## 5.4. PC Connection

The relative percentages of the surveyed systems which are able to connect to a PC to download data are shown in Figure 13~~Figure 13~~ independent of the mechanism (i.e. Firewire, or Ethernet) used. These results are very striking when compared to those for the other storage/download mechanisms, since almost all the systems which were surveyed appear to be capable of supporting a PC connection. Indeed, the only systems which didn't support a PC connection are no longer in production. So based upon the systems surveyed, it appears that *every* system currently available is likely to support a PC connection as a storage/download mechanism.

Figure 15~~Figure 15~~ analyses the relative percentage of the systems which use Ethernet compared to Firewire as the means to enable the PC connection. From these results it is immediately apparent that Ethernet is by far the most common mechanism, with only one of the surveyed manufacturers offering a Firewire connection.
One of the other advantages of the PC connection, is that once the data is available on a PC, then it is likely that PC can be used to either store the data to PC-compatible media (e.g. CD, DVD, memory stick etc.), or transfer it elsewhere (e.g. via the Internet).

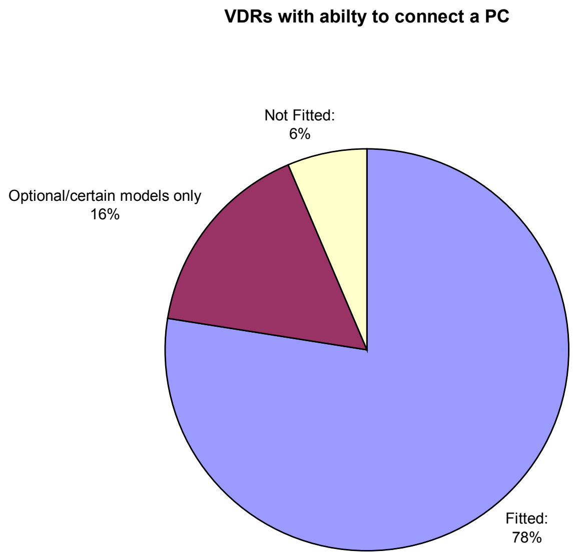


**Figure 13. Relative Percentage of Systems which support a PC Connection.**

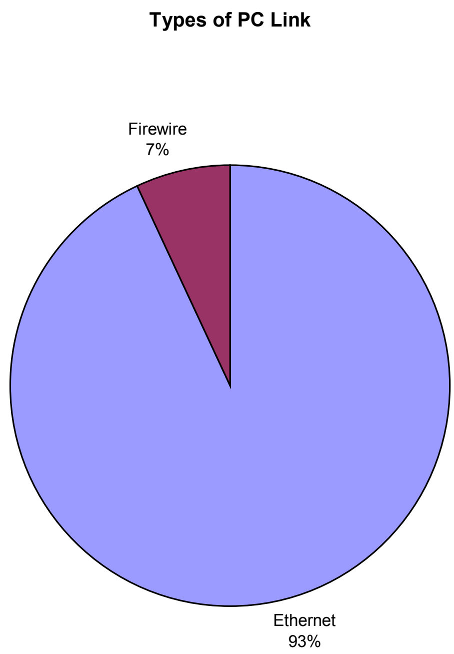


**Figure 15. Relative Percentage of Ethernet vs. Firewire as the mechanism for PC Connection.**

## 5.5. Summary

Figure 17Figure 17 shows the above results summarised in a single chart. The chart shows how removable hard drives are the most commonly used storage mechanism (available on almost half the VDR/S-VDRs surveyed) with flash and DVD both being available on approximately one third of all VDR/S-VDRs.

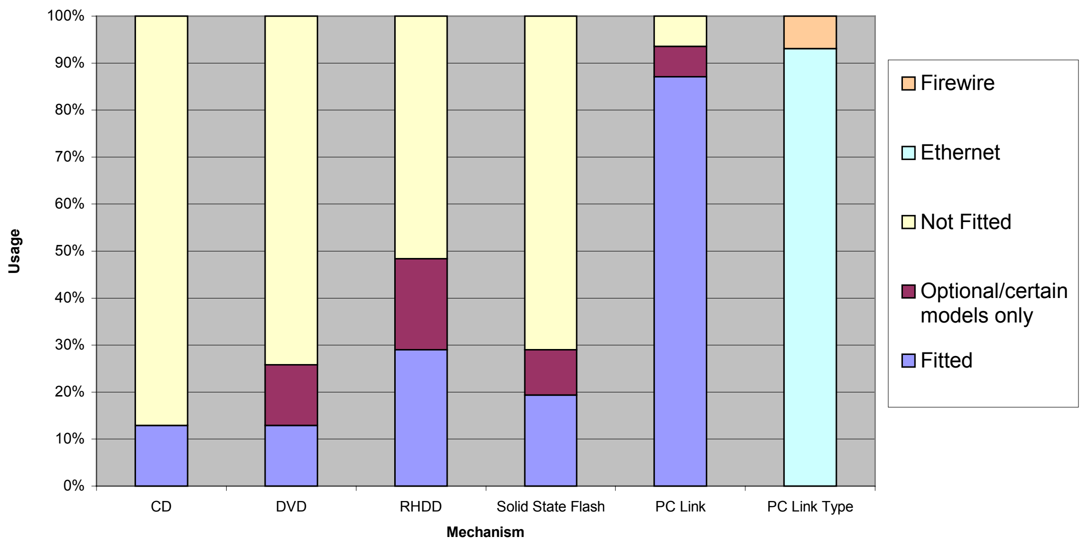


**Figure 17. Download mechanisms used by all VDR/S-VDR systems surveyed**

Comparison of the results in Figure 19Figure 19 with those in Figure 21Figure 21 reveals how the download mechanisms used by VDR manufacturers in currently available systems are progressing compared to the legacy systems. Figure 19Figure 19 shows how in current systems, flash memory is becoming the preferred storage medium, whereas optical CD/DVD storage is no longer widely used.

Removable hard disks appear to still be used in many systems (about 40%); however it is more common for them to be optional extras rather than the main storage medium for downloaded data.

Another clear progression is that all of the current available systems surveyed feature the ability to connect an external PC to download data. Ethernet is the mechanism used by the majority of manufacturers to achieve this. The widespread availability of Ethernet in the latest systems, is probably a reflection that it is likely to be a standard feature on most commercially available processor boards, and is therefore a very cost effective mechanism to provide bulk download capability. However, it also means that the currently available systems should meet the requirements of IMO Resolution MSC.214(81) "*The VDR should provide an interface for downloading the stored data and playback the information to an external computer*" by an "*internationally recognised format, such as Ethernet, USB, Firewire etc*".

Another visible trend is that there is a lot less variety of storage mechanisms fitted as standard on the newer systems. 33% of the legacy VDR systems surveyed would have more than one download mechanism (other than PC link) available and in 60% of these cases, the extra download mechanisms were fitted as standard. Only 12.5% of the currently available systems surveyed offer multiple download mechanisms and none of systems have multiple mechanisms fitted as standard. This could reflect the introduction of SVDRs, and the drive to produce cheaper systems.

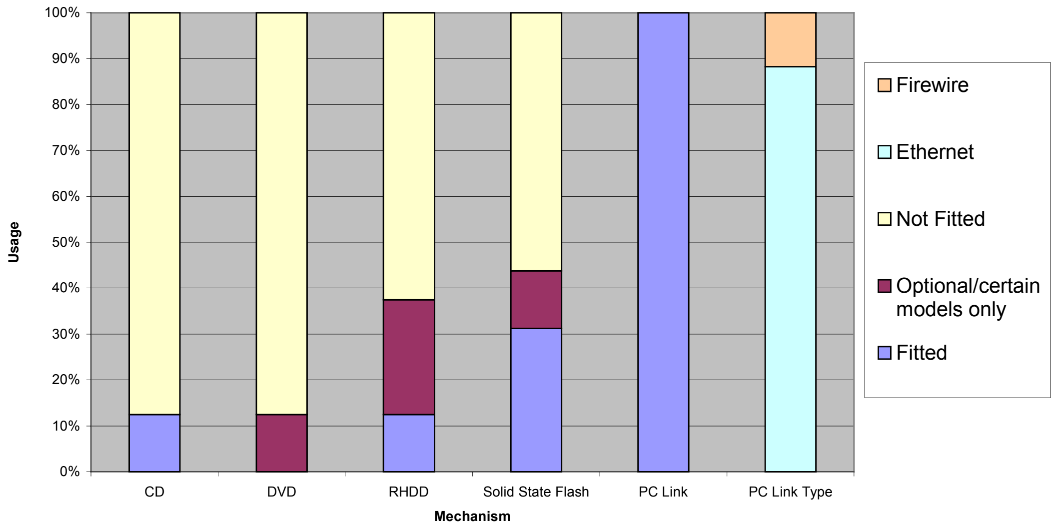


**Figure 19. Download mechanisms used by currently available VDR/S-VDR systems surveyed**

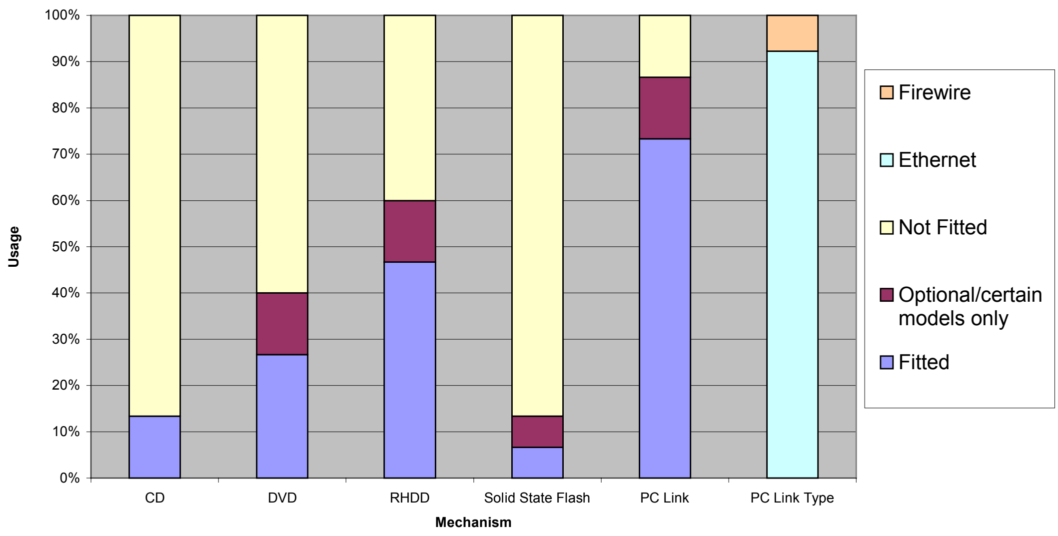


**Figure 21. Download mechanisms used by legacy VDR/S-VDR systems surveyed**

# 6. Data Transmission

The ability to remotely transmit data back to shore not only provides an extra level of offsite data backup, but opens up the possibility of using VDR data for day to day analysis. Automating this process would allow these benefits to be gained without affecting current operations. This section looks at the possible data transmission options for achieving this.

The optimum transmission solution for any given application is likely to be determined by two major factors:

- **The type of shipping operation:** If the vessel is operating in coastal waters, or on short crossings, then downloading/transmitting the data should be comparatively easy – since the vessel is likely to be in port fairly regularly, and hence the amount of data which has been acquired since the last download will not be too great. Also higher data transfer rates are likely to be available in port, or coastal waters, compared to the data transfer rates which are available mid-ocean.

- **The data to be transmitted:** The majority of space occupied by VDR data is taken up by audio and radar (image) data. If this data is not transmitted, and only the control/sensor data is required, then the transmission requirements are considerably reduced.

This chapter of the report considers various data transmission options which are currently available, and assesses their suitability for use in the transmission of VDR data.

## ~~1.1.~~6.1. Remote Transmission via Satellite Internet

For long haul shipping operations, onboard Internet access would likely be required to ensure data can be transmitted before the VDR runs out of internal storage space and overwrites data. Currently the only Internet access medium with sufficient ocean coverage is via satellite communications.

### ~~1.1.1.~~6.1.1. Inmarsat

Inmarsat currently offers 3 different Maritime Internet packages which provide different data transfer speeds:

| | |
|---|---|
| **FLEET F33** | **9.6KBPS** |
| **FLEET F55** | **64KBPS** |
| **FLEET F77** | **128KBPS** |

The Inmarsat service provides an almost global coverage. The only areas that it does not cover are the Polar Regions (see Figure 23~~Figure 23~~).

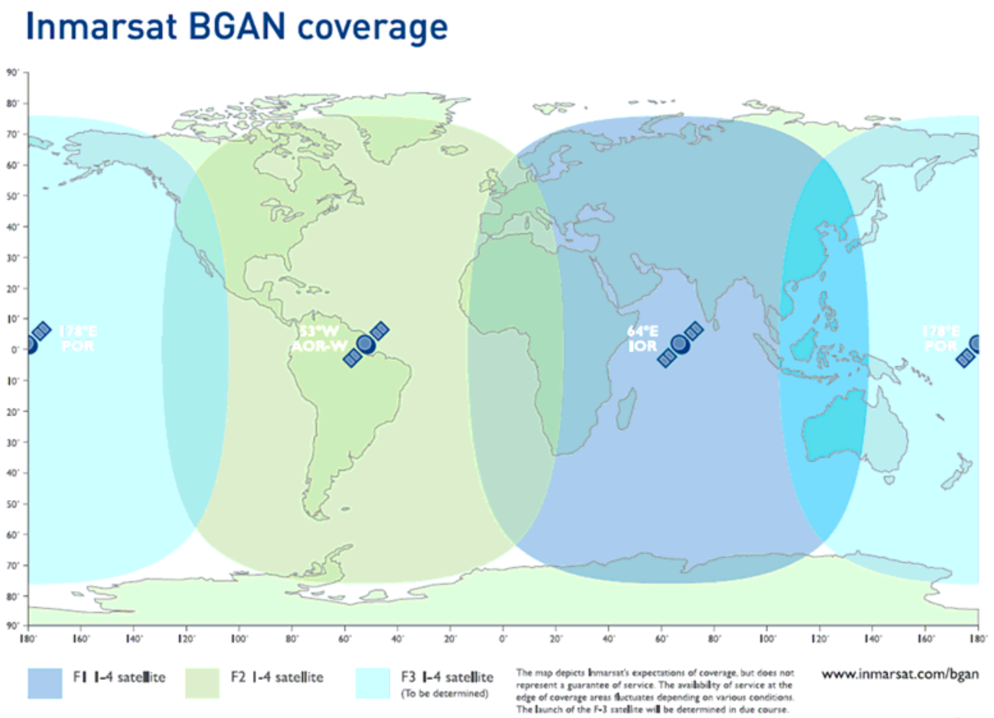


**Figure 23 : Inmarsat Coverage (Courtesy of Inmarsat Ltd)**

It is unlikely that these transfer speeds are fast enough to transmit radar and audio data to shore in real time, however they should be sufficient to transmit control/sensor data in real time (see 6.5)

Kelvin Hughes currently offers remote downloading of data from their VDRs via the Inmarsat service.

### 6.1.2. Telenor

Telenor's "*Sealink Entry*" service can provide data download speeds of 512 Kbit/sec and upload speeds of 64 Kbit/sec. Coverage for this service is global (see Figure 25~~Figure 25~~)

Again, these upload speeds are not fast enough to transmit radar and audio data from ship to shore in real time, but may be suitable if only control/sensor data is required to be transmitted.

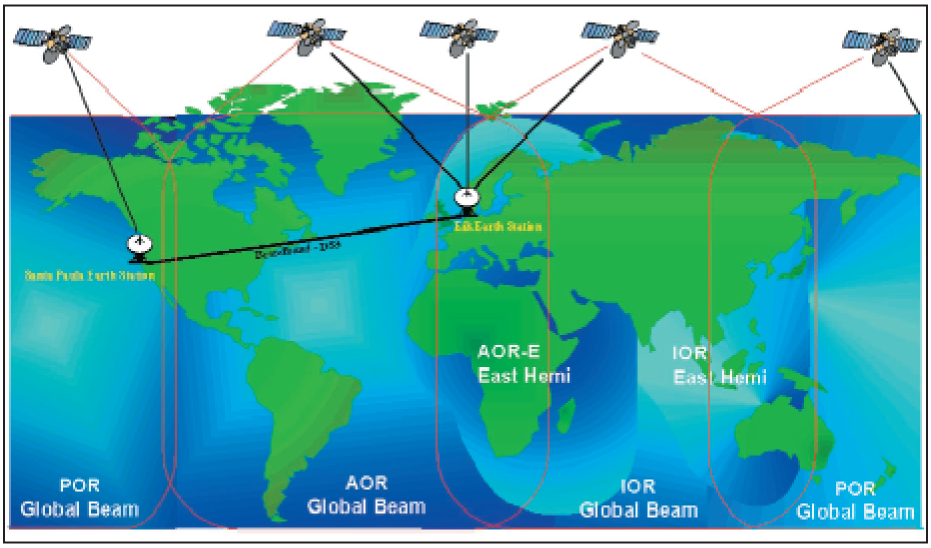


**Figure 25 Telenor's "*Sealink Entry*" service coverage (Courtesy of Telenor Satellite Services)**

Another maritime Internet service provided by Telenor is called "*WaveCall*". This service provides download speeds of up to 1 Mbit/sec and upload speeds of up to 256 Kbit/sec.

This service would more than sufficient to send control/sensor data in real time; however it is unlikely that it would be possible to send all VDR data in real time at this speed (see 6.5 ).

Despite the WaveCall service having very high land coverage across America, the coverage only goes as far as coastal American waters. The WaveCall service also has coverage in European waters and the Mediterranean (identical to the Telenor DVB-RCS coverage shown below).

Telenor also provide a service called "*DVB-RCS*" which uses two-way satellite communication to provide download speeds of 2Mbit/sec and upload speeds of 512 Kbit/sec. The coverage for this service (see Figure 27~~Figure 27~~) unfortunately only includes European waters and the Mediterranean.

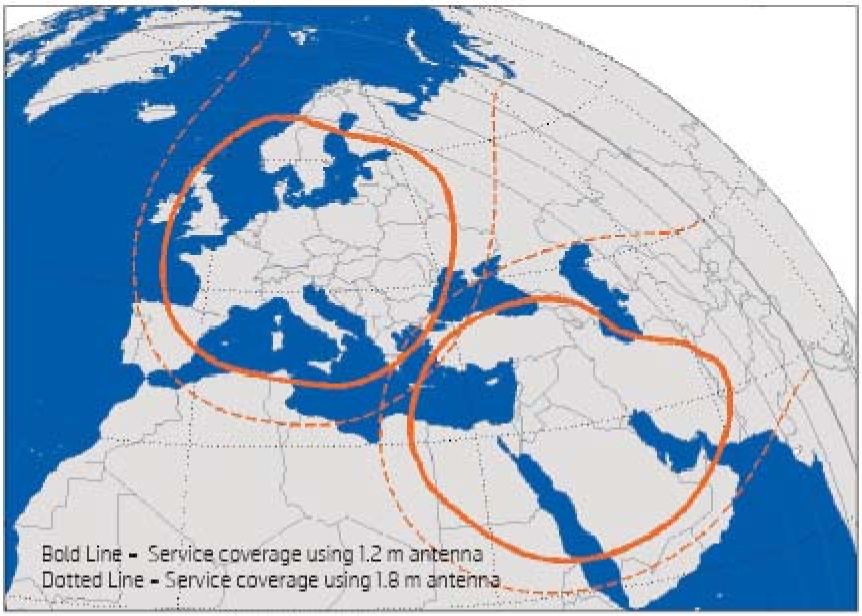


**Figure 27 Telenor's "*DVB-RCS*" service coverage (Courtesy of Telenor Satellite Services)**

The 512 Kbit/sec upload speed provided by this service is potentially fast enough to transmit all VDR data in real time (see 6.5)

### 6.1.3. Globalstar

Globalstar provides a service to access the Internet via a Globalstar satellite phone, which is connected to a pc or laptop. This service has a regular data transfer speed of 9.6 kbps, but using Globalstar's compression software can result in effective speeds of up to 56 kbps (the same speed as traditional landline modem dial up).

The Globalstar service has coverage across most of the globe's landmass, however the ocean coverage is less extensive (see Figure 29~~Figure 29~~). Coverage does not include vast regions of the Pacific and Indian oceans, or African and Asian coastal waters.

Its comparatively slow data rates, and limited coverage, mean that the Globalstar service would have limited use for VDR data transmission. It would not be sufficient to send large files (i.e. audio and radar), but should still be able to send control/sensor data (see 6.5).

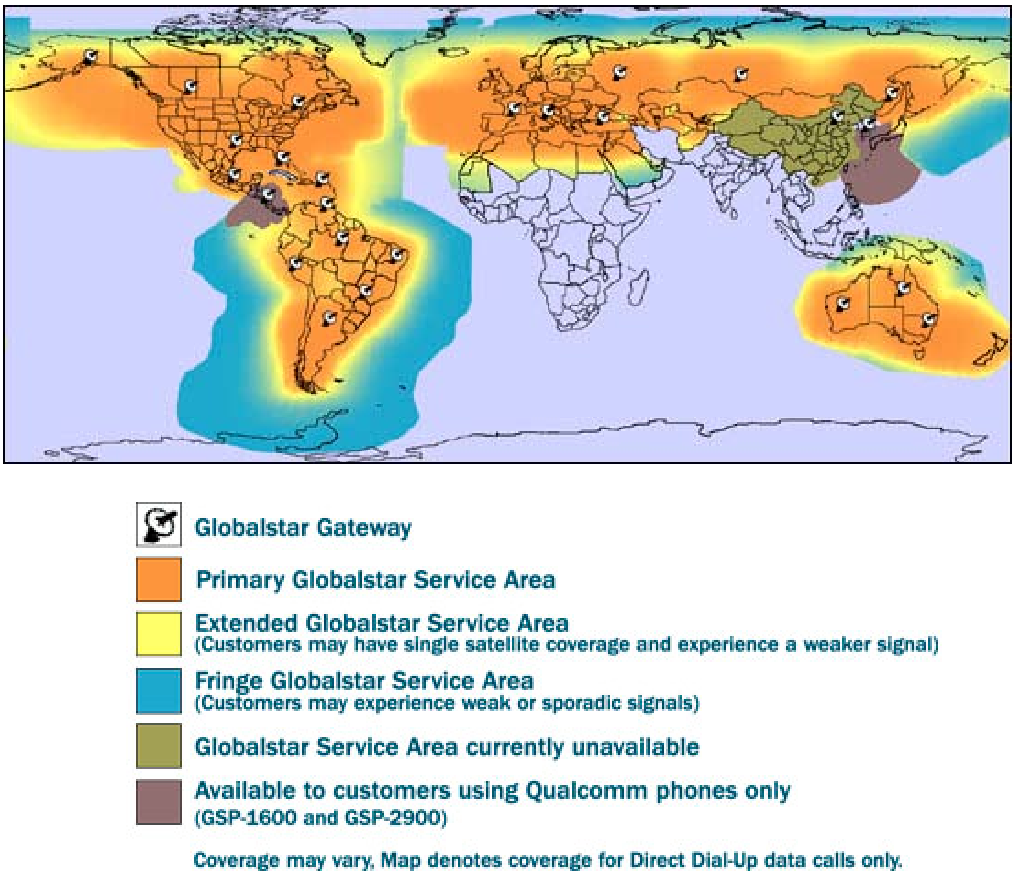


**Figure 29 : Globalstar Coverage (Courtesy of Globalstar)**

### 6.1.4. Iridium

Iridium provides two services to receive internet access via low level satellites. The packages are: Dial-Up Data and Direct Internet Data. Like the Globalstar service, this is achieved via a satellite telephone, connected to a PC or laptop. Both services provide a data transfer rate of 2.4kbps, however the Direct Internet Data utilises transparent server side compression which will improve the transfer rates for certain data types (e.g. control/sensor data, but not already compressed JPEG radar data etc.). Nevertheless this is by far the slowest option and certainly wouldn't be sufficient for large data file transfer.

The main advantage of the Iridium service is that it has 100% global coverage (including oceans, airways and Polar Regions) and is considered more reliable than the Globalstar service.

#### 6.1.5. Thuraya

Thuraya provides a service which covers Europe, the Middle East and North Africa (see Figure 31~~Figure 31~~). In terms of ocean coverage, this service would be most applicable to any operations in the Mediterranean Sea, or European coastal waters. The upload and download transfer speed of the service is up to 144 Kbps, which makes it comparable to Inmarsat Fleet F77).

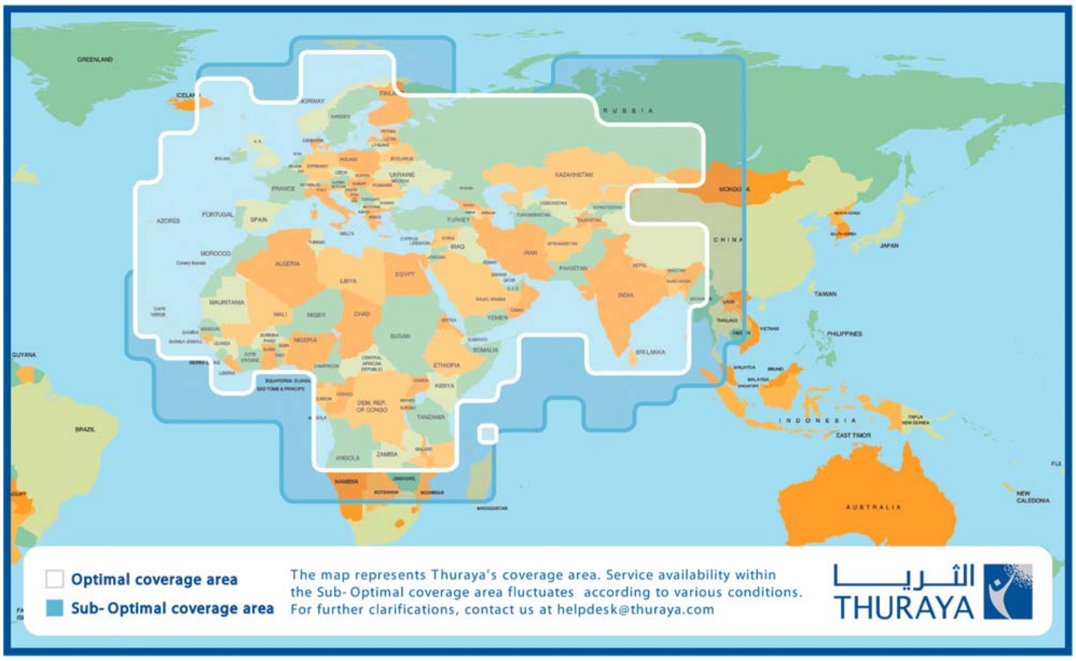


**Figure 31 : Thuraya Coverage (Courtesy of Thuraya Satellite Telecommunications Company)**

### 6.2. Future Satellite Communication Services

#### 6.2.1. Inmarsat

Planned to be released in the second half of 2007, Inmarsat's 'Fleet Broadband' service should provide high speed Internet access to maritime vessels. The service will offer the same coverage as existing services, however it will provide much faster transfer rate.

The service would be available in two different packages. The details are shown in Table 9~~Table 9~~.

| | FB250 | FB500 |
|---|---|---|
| STANDARD IP | UP TO 284KBPS | UP TO 432KBPS |
| STREAMING IP | 32, 64, 128KBPS | 32, 64, 128, 256KBPS |
| ISDN | - | 64KBPS |
| VOICE | 4KBPS AND DIGITAL 3.1KHZ AUDIO | |
| FAX | GROUP 3 FAX VIA 3.1KHZ AUDIO | |
| SMS | STANDARD 3G (UP TO 160 CHARACTERS) | |

**Table 9 : Details of Inmarsat's Proposed "Fleet Broadband" Service.**

## 6.3. In-port WiFi

WiFi is currently the standard medium used on traditional wireless local area networks, although it has been known to reach ranges over 100 miles. Despite this being too short to reach ships on long haul operations, it could be used to transmit VDR data once a ship is in port. If complete coverage of VDR data was required, this would only be applicable on operations whereby the ship's entire journey could be stored in the VDR before reaching the destination port.

Currently the fastest WiFi standard available is the IEEE 802.11g which can theoretically reach speeds of 54Mbit/sec. Many manufacturers produced hardware that can theoretically boost the speed to that equal to that of traditional wired Ethernet (100 Mbit/s), however this boosting technology is unsupported by the IEEE 802.11g standard. At these speeds data representing entire journeys could be downloaded very quickly once a ship was in range.

At 100Mbit/s transfer speed, 1.5 GB of data (approximately 12 hours of radar, audio and control/sensor data) would take 2 minutes to transfer to shore, however in reality 802.11g transfer rates only typically reach about 60Mbit/s when boosted, or 24Mbit/s as standard. These typically slower speeds are caused by network overheads, environment (e.g. obstacles) and distance from the wireless access point. At these speeds, a 1.5 GB file would take 3 minutes 20 seconds (boosted) or 8 minutes 20 seconds (standard), however, these speeds are likely to decrease over longer ranges increasing the time required to transfer the data.

The next IEEE standard is 802.11N, which is estimated for publication in October 2008. This standard will allow for maximum transfer rates of 540 Mbit/s with typical transfer rates of 200 Mbit/s.

## 6.4. Security

It is important to consider security when transmitting sensitive VDR data wirelessly. Secure communication can be preformed via a Virtual Private Network (VPN). VPNs allow private networks to be securely accessed over a public network such as the Internet. This is achieved via a number of cryptographic tunneling protocols including SSL (Secure Socket Layers) which is better known as the encryption technique used by almost all e-commerce sites when processing credit/debit payment via the Internet.

There are also several systems (such as WPA) associated with securing a private WiFi networks. WPA not only encrypts data between the client and wireless access point, but also provides authentication, by requesting a pass phrase from users requesting to access the network.

## 6.5. Summary

The automatic download of all VDR data from any ship would require the equivalent of 1.5GB/12hrs (around 284 Kbit/s) and global coverage.

The latest generation products are just about achieving these rates of throughput and coverage. However it is unlikely that these services would only be used to transmit VDR data, but would primarily be installed for voice and e-mail communications so there would be inadequate remaining bandwidth for the VDR data. A service with higher bandwidth than required would not only account for this, but could also help overcome situations where full bandwidth is not available, for example, when on the fringes of coverage areas, or when a shared service is at a higher contention.

If only control/sensor data is to be transferred then the quantities are considerably reduced, and real time transmission is a more practicable proposition with speeds of only around 9 Kbit/s required or even possibly as low as 1.5 Kbit/s if the data is compressed before transmission (note that slightly higher speeds would be recommended to take account for any overheads). It is likely that many vessels that currently already possess a satellite communication service will have sufficiently high bandwidth to achieve this.

For short journeys, WiFi would probably be the best option due to its high speed and low cost. Unlike the Satellite Internet options described, WiFi does not have an associated monthly cost which makes it by far the cheapest option in the long run. Due to its short range, it would be less suitable for long haul routes, however with some systems now storing in excess of 30 days as standard, it is becoming possible to backup longer journeys using this method.

Table 11~~Table 11~~ provides a summary of the services described in this section.

| Supplier | Max Upload Speed | | Coverage |
|---|---|---|---|
| Inmarsat | 128Kbit/s | Fast | Global except polar regions |
| Telenor | 512 Kbit/s | Very Fast | Europe and Mediterranean |
| | 64 Kbit/s | Medium | Global |
| GlobalStar | 9.6 Kbit/s (up to 56 Kbit/s possible with compresion software) | Medium | Majority of the globe however focused on land. Little coverage of Pacific, African Indian or Asian waters |
| Irridium | 2.4 Kbit/s | Slow | Global |
| Thuraya | 144 Kbit/s | Fast | Europe and Mediterranean |
| Inmarsat Broadband | 372 Kbit/s | Very Fast | Global except polar regions |
| WiFi | 24Mbit/s (60Mbit/s when boosted) | Ultra Fast | Short range area around location of the wireless access point. |

**Table 11. Overview of available remote data transmission services**

## 7. Conclusions

~~1.1.~~7.1. The current IMO and IEC specifications detail several requirements relating to the storage and download of data from VDRs and S-VDRs. However they do not specify the mechanisms to be used.

~~1.2.~~7.2. Current Type Approved VDR and S-VDR systems use several different storage and download mechanisms with Flash memory the most commonly used storage mechanism in currently available VDRs. As the price of Flash memory decreases, it is expected that the presence of Flash memory in the VDR market will continue to grow.

~~1.3.~~7.3. All the current VDR/S-VDR systems which were surveyed provided a facility to download data directly to a PC using a cable connection. Ethernet is by far the preferred method of connecting VDRs to external PCs/Laptops. This is not expected to change in the foreseeable future.

~~1.4.~~7.4. The current performance standards do not specify any specific file formats for radar, audio or control/sensor data while the data is stored internally, but recent amendments to the specifications do specify that it must be possible to export the data to an open format.

~~1.5.~~7.5. The vast majority of VDR data is made up of audio and radar data. In comparison, control/sensor data takes up a very small amount of space (~3%) and could take up even less space if compressed (0.5%).

~~1.6.~~7.6. Remote VDR data transmission would bring several benefits such as an extra level of offsite backup. Automating this service would allow it to be transparently integrated into systems without affecting current operations. If data is transmitted in real time, this would also provide an almost instant copy of the VDR data in the event of a disaster without having to retrieve the ship's protective capsule.

~~1.7.~~7.7. It is likely that most vessels which already possess a satellite communication service have sufficient bandwidth to transmit control/sensor data on its own to shore in real time. To achieve real time transmission of audio and radar data as well would require one of the latest services with at least 284 Kbit/s download speed.

~~1.8.~~7.8. Ships on short voyages could make use of WiFi in port to routinely download data. This would prove to be much more cost-effective compared to a satellite service. As internal storage space of VDRs increase, this becomes are more feasible solution for longer haul voyages.

## 8. Recommendations

~~1.1.~~8.1. It is recommended that in any future new VDR specification, consideration is given to specifying the format to be used for storing data and the mechanisms for downloading data. This would enable a more standard download/analysis procedure across all VDRs manufactured to that specification, and make it easier for accident investigators to analyse the data.

~~1.2.~~8.2. It is recommended that a remote VDR data backup procedure is trialled. A feasibility study would help establish the viability of the technique. The study should encompass trialling long haul voyages (backups via satellite communications using a VPN) as well as short haul voyages (backups via in port WiFi encrypted and authenticated by WPA)

~~1.3.~~8.3. The significant on-going reductions in the cost of memory, and the increasingly widespread availability of digital outputs from marine electronics mean that consideration should be given to the feasibility of developing a very simple, low-cost VDR which could be used upon smaller vessels, such as fishing boats and recreational pleasure craft. Development, manufacture and testing costs of such a product should be significantly reduced by the following strategies :

- Removal of the requirement to store radar or audio data would significantly reduce storage requirements (in addition to considerably simplifying the data acquisition and installation aspects of the system). A current-generation VDR/S-VDR system typically requires a 2GB protective capsule to store 12hrs of the full IMO-specified dataset. However, if only control/sensor data was required, only around 100 to 200MB of storage would be required for 12 hours of data. Alternatively 2GB memory would enable more than 18 days of control/sensor data to be stored, or if the control/sensor data is compressed, this could increase to ~120 days worth of data.

- Reduced requirements for the protective capsule (in terms of fire protection and/or penetration) would also have a significant impact on overall system costs.

~~1.4.~~8.4. It is recommended that VDR manufacturers are encouraged to make use of any large capacity media available in their VDRs to store more data than the required 12 hours as standard. This maximises the chances of data being available following an incident, should action not have been taken to preserve it from being overwritten within 12 hours of the start of the incident.