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FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES: FISHING OPERATIONS – VESSEL MONITORING SYSTEMS

Summary:

This document is referred to in UNEP/CMS/COP13/Doc.26.2.3 *Bycatch*, and contains 'Vessel Monitoring Systems' (number 1, supplement 1) of the Food and Agriculture Organization of the United Nations (FAO) Technical Guidelines for Responsible Fisheries.

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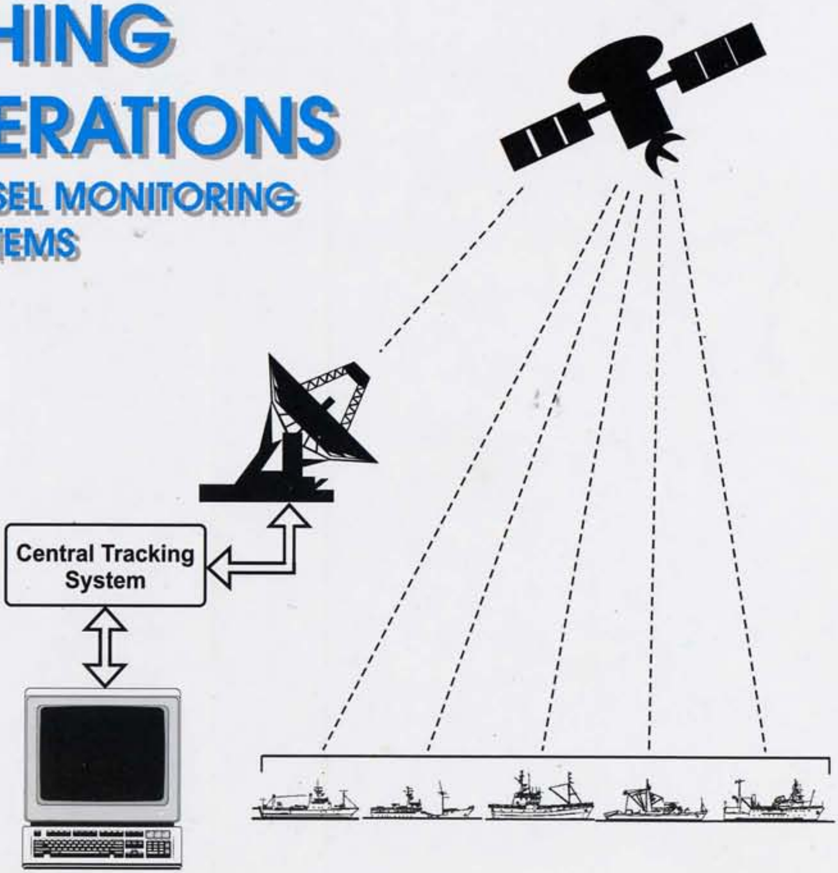
FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

1

Suppl. 1

FISHING OPERATIONS

1. VESSEL MONITORING SYSTEMS



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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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PREPARATION OF THIS DOCUMENT

This document was prepared by staff in the Fishing Technology Service (FIIT), FAO Fisheries Department, based on the text of the principal authors, Mr Phillip Marshall of the Australian Fisheries Management Authority and Mr Robert T. Gallagher of Compleat Services Inc. The preparation for publication was carried out by Messrs Wilfried Thiele and Andrew R. Smith (FIIT). This document is a Supplement to the FAO Technical Guidelines for Responsible Fisheries No. 1 – Fishing Operations.

The principal authors and the FAO Fisheries Department would like to acknowledge the contributions of Jacques Verborgh of the European Commission; Andy Richards of the Forum Fisheries Agency; Jim Coyle of the New Zealand Ministry of Fisheries; Ove Davidsen and Andreas Jaunsen of the Norwegian Directorate of Fisheries; Svien Bertheussen consultant engineer of Tromsø, Norway, and Steve Springer of the United States National Marine Fisheries Agency.

It has to be stressed that these Guidelines and Supplements have no formal legal status. They are intended to support the Code of Conduct for Responsible Fisheries. It should be remembered that, since the Guidelines and Supplements are intended to be flexible and capable of evolving as circumstances change, or as new information becomes available, they may be further revised and complemented by other guidelines, notes, etc., on specific issues. In this regard, readers are invited to collaborate with FAO in providing any information on relevant technical, policy or legal issues which might be useful in updating, evaluating and improving this document as well as in developing more specific information for the promotion of responsible fisheries.

Distribution:

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ABSTRACT

Vessel Monitoring Systems (VMS) have greatly increased the potential efficiency of Monitoring Control and Surveillance of fishing vessels (MCS). In the last few years several countries have introduced VMS which enable the activities of fishing vessels to be monitored and indeed for such vessels to actively report on catches to the fisheries management authority. This document summarizes the state of the art of VMS and gives guidance to fisheries administrators considering implementing VMS in their fisheries management systems and to all other personnel involved in fisheries MCS.

VMS provides another very effective tool for MCS, particularly for some developing countries that lack the financial and physical resources to support an effective conventional MCS capability. In this respect, indications are given for the cost of setting up and operating a national VMS system. For those countries which already have existing MCS, VMS will make those conventional MCS measures more effective and possibly less costly. Attention is drawn to the need for recommendations on common data exchange formats and protocols. This is seen as an immediate problem which needs urgent attention. Eventually these recommendations may be adopted as an international standard for a common international data exchange format in VMS and in catch reporting. Finally, the role VMS will have on the implementation of the UN Fish Stocks Agreement, the FAO Compliance Agreement and the FAO Code of Conduct is also addressed.

Coastal States, which apply VMS to national and foreign fishing vessels licensed to fish in their EEZs, can monitor the activities of such vessels very effectively and economically, thereby increasing the effectiveness of their MCS. On the other hand, the implementation of VMS by Flag States, for vessels authorized to fish on the high seas, is the most effective means of ensuring that vessels flying their flag do not conduct unauthorized fishing within areas under the national jurisdiction of other States.

CONTENTS

List of Abbreviations

AID	Agency for International Development
COFI	Committee on Fisheries (FAO)
EU	European Union
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
FAO	Food and Agriculture Organization of the United Nations
FFA	Fisheries Forum Agency
GIS	Geographical Information System
GMDSS	Global Maritime Distress and Safety System
GMS	Global System for Mobile Telecommunications
GPS	Global Positioning System
HF	High Frequency
ISO	International Standards Organisation
ISDN	Integrated Services Digital Network
LES	Land Earth Station
NAFO	North West Atlantic Fisheries Organisation
NOAA	National Oceanic and Atmospheric Administration
MCS	Monitoring Control and Surveillance
NMEA	National Marine Electronics Association
SAR	Synthetic Aperture Radar
SOLAS	Safety of Life at Sea
UNCLOS	United Nations Convention on Law of the Sea
UNA	United Nations Agreement
VHF	Very High Frequency
VLD	Vessel Location Device
VMS	Vessel Monitoring System

BACKGROUND

1. From ancient times, fishing has been a major source of food for humanity and a provider of employment and economic benefits to those engaged in this activity. However, with increased knowledge and the dynamic development of fisheries it was realized that aquatic resources, although renewable, are not infinite and need to be properly managed, if their contribution to the nutritional, economic and social well-being of the growing world's population was to be sustained.

2. The adoption in 1982 of the United Nations Convention on the Law of the Sea provided a new framework for the better management of marine resources. The new legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction which embrace some 90 percent of the world's marine fisheries.

3. In recent years, world fisheries have become a dynamically developing sector of the food industry and coastal States have striven to take advantage of their new opportunities by investing in modern fishing fleets and processing factories in response to growing international demand for fish and fishery products. It became clear, however, that many fisheries resources could not sustain an often uncontrolled increase of exploitation.

4. Clear signs of over-exploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fish trade threatened the long-term sustainability of fisheries and the contribution of fisheries to food supply. Therefore the Nineteenth Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended that new approaches to fisheries management embracing conservation and environmental, as well as social and economic, considerations were urgently needed. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

5. Subsequently, the Government of Mexico, in collaboration with FAO, organized an International Conference on Responsible Fishing in Cancún, in May 1992. The Declaration of Cancún endorsed at that Conference was brought to the attention of the UNCED Rio Summit in June 1992, which supported the preparation of a Code of Conduct for Responsible Fisheries. The FAO Technical Consultation on High Seas Fishing, held in September 1992, further recommended the elaboration of a Code to address the issues regarding high seas fisheries.

6. The One Hundred and Second Session of the FAO Council, held in November 1992, discussed the elaboration of the Code, recommending that priority be given to high seas issues and requested that proposals for the Code be presented to the 1993 session of the Committee on Fisheries.

7. The Twentieth Session of COFI, held in March 1993, examined in general the proposed framework and content for such a Code, including the elaboration of guidelines, and endorsed a timeframe for the further elaboration of the Code. It also requested FAO to prepare, on a "fast track" basis, as part of the Code, proposals to prevent reflagging of fishing vessels which affect conservation and management measures on the high seas. This resulted in the FAO Conference, at its Twenty-seventh Session in November 1993, adopting the Agreement to Promote Compliance

with International Conservation and Management Measures by Fishing Vessels on the High Seas, which according to FAO Conference resolution 15/93 forms an integral part of the Code.

8. The Code was formulated so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea, 1982, as well as with the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995 (UN Agreement) and in the light of *inter alia* the 1992 Declaration of Cancún, the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

9. The development of the Code was carried out by FAO in consultation and collaboration with relevant United Nations Agencies and other international organizations including non-governmental organizations.

10. The Code of Conduct consists of five introductory articles: Nature and Scope; Objectives; Relationship with Other International Instruments; Implementation, Monitoring and Updating; and Special Requirements of Developing Countries. These introductory articles are followed by an article on General Principles which precedes the six thematic articles on: Fisheries Management, Fishing Operations, Aquaculture Development, Integration of Fisheries into Coastal Area Management, Post-Harvest Practices and Trade, and Fisheries Research. As already mentioned, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas forms an integral part of the Code.

11. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea of 10 December 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with Conservation and Management Measures by Fishing Vessels on the High Seas, 1993.

12. The Twenty-eighth Session of the Conference in Resolution 4/95 adopted the Code of Conduct for Responsible Fisheries on 31 October 1995. The same Resolution requested FAO *inter alia* to elaborate as appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

1. INTRODUCTION

The North Sea, the Northwest Atlantic, the Northeast Pacific, the Bering Sea, the Mediterranean, much of the African coast, much of the coast of South America. The list is a compilation of regions with fisheries in varying states of difficulty. The breadth and global scope of the problem will require a high degree of international cooperation to restore and to assure the health and the sustainability of the natural resource which provides a significant portion of our food supply.

The fact that so many world fisheries are currently in a threatened state is the result of that well documented phenomenon of overfishing. This is caused by the increasing capacity to find and to catch fish stocks which, even under good management are subject to changes in abundance caused by environmental factors. The principal tools at the service of fisheries managers in their efforts to counter overfishing and to protect the stocks are the use of quotas and limitations on fishing effort. While such weapons are theoretically potent, the problem is that no matter how diligent and able the management is in imposing limitations on catch and effort, resources for enforcing those limitations, measured in assets such as personnel, patrol vessels and patrol aircraft, are inadequate.

There seems to be a consensus that Vessel Monitoring Systems (VMS) is one of the keys to redressing this situation. When fisheries managers have timely and accurate knowledge of the movements of fishing vessels, their material resources are in effect increased by the corresponding improvement in the efficiency of their operations. Although VMS schemes established on national and regional levels are admirable initiatives, it must be recognized that, due to the increasing mobility of the world's fishing fleets, the problem is global.

There exists a desire amongst the world's fisheries managers to co-ordinate their efforts so that the world's fish stocks -- which recognize no national or regional boundaries -- can be saved. In order to do so, there will have to be agreement on the methods for implementing VMS on a very detailed level. Only when, for example, a fisheries manager in South America agrees with a fisheries manager in Europe on VMS performance, security and data formats, will a vessel be able to operate under the management of both, moving from one fishery to another both legally and with maximum transparency. Furthermore, only within such a context can the two fisheries managers share data on vessel movements and activities, in order to improve operations on an international scale.

Probably the only way to foster this compatibility is to establish a consultation at the widest possible international level so that fisheries protection officials can express their requirements, preferences and concerns on VMS implementation. This information would form the basis for a world standard in VMS. For many reasons, logistical, political and economic alike, this has not yet been achieved.

If an international standard did exist, then fisheries managers from all regions of the world would be able to set a common goal. Some consensus on VMS implementation, however, might provide some welcome, temporary direction. This may not be enough to keep everyone on the same track, but could be sufficient to keep them moving in the same direction.

2. OBJECTIVES

This document is intended as a working document to generate and facilitate discussion on the use of VMS for the Monitoring, Control and Surveillance (MCS) of fishing vessels. The document is directed at fisheries managers, scientists and others with an interest in improving the sustainable use of wild fish stocks. It seeks to clarify the current status of VMS and allow informed decisions and plans to be made in relation to implementing VMS for MCS purposes in all countries but particularly those actively considering VMS and those with little background in the use of VMS.

It is envisaged that the document will be used in international fora, workshops and seminars on MCS as a discussion document leading to further implementation of VMS and agreement and standardization of VMS.

3. CONTEXT

Advances in electronic, computing and satellite technologies have been moving at an extremely rapid rate over the past 20 years. Tracking of vehicles and animals via H.F. radio and radar became increasingly common during this period. However tracking of fishing vessels did not attract much attention until the mid 1980s when satellite technology became commercially viable for tracking purposes. Applications of this type, and interest in them, continued to be relatively limited until about 1991 when a number of fisheries agencies began investigations and trials.

Subsequent to these trials, a number of countries have implemented VMS on small to medium scales of between 30 to 150 vessels. Australia, New Zealand, New Caledonia, French Polynesia and the USA have all reported on successful implementations of VMS for MCS purposes. Many other countries have conducted trials and most have plans for the introduction of VMS in at least some fisheries as a mandatory legal requirement such as in Australia, New Zealand and the USA. It is of particular note is that the countries of the European Union, where large scale trials have been conducted during 1996 and 1997, are now moving to introduce the mandatory use of VMS on a wider scale, covering all fishing vessels of particular sizes or modes of operation.

In countries where VMS has proven successful there are plans to expand its use. This success has also led to plans to implement systems on a broader regional or sub regional basis. The success of VMS in the Pacific has resulted in the South Pacific Forum deciding to develop a sub regional system which, through the Forum Fisheries Agency (FFA), will serve the interests of the 16 member countries including many which are small, relatively poorly resourced and are classified as developing countries. This system will cover more than 1000 vessels and implementation is scheduled to commence in 1997.

Many other countries have VMS programmes at varying levels of advancement. These include, but are not limited to, Argentina, Chile, South Africa, Morocco, China and Japan.

The implementation of VMS is dependent on the availability of the technology at an affordable price. The availability of the Inmarsat and Argos satellite communications systems globally, and the Euteltracs and Boatracs systems in Europe and the USA respectively, has created a competitive market for tracking vehicles of many types. This has led to improvements in services, software, hardware and reductions in the pricing of all these items. The availability of the Global Positioning System (GPS) has added a new dimension to positioning accuracy and this technology is now pervasive in its use, with hand held GPS now within the economic reach of many individuals.

However, the real motivation to implement VMS comes not from the technology itself but from the benefits it provides for managing fisheries. Variations in global fish catches since 1988, mentioned above, have been well documented. The reasons for these variations are less well understood but it is clear that in many areas there has been a large increase in fishing effort and a decrease in fish stocks. A point of interest so far as this document is concerned, is that the increase in fishing effort has been brought about not only by the fishing technologies used, but also by the use of electronic, computing and satellite technologies. These same technologies are now being seen as one of the tools available to fisheries managers for achieving sustainable harvesting of fish.

VMS technology is seen as meeting two basic functions for the management of fish stocks.

3.1 Compliance with Fisheries Management Rules

Typically, fisheries management rules are designed to achieve sustainable, harmonious and profitable fishing through a variety of methods. This usually includes some form of licensed vessel access to particular areas, restrictions on gear types, restrictions on fishing time, quotas on the amounts of particular species which may be caught, etc. An effective MCS regime must be in place to enable these rules to be a viable management tool. It is this application for which VMS has been targeted mostly through providing information on the position of vessels. Position information is sent from equipment on board licensed vessels to fisheries monitoring agencies at relatively frequent time intervals so that information is available on the activities of those vessels.

3.2 Collection of Fishing Catch and Effort Data, or Other Fishing Activity

Catch and effort data is a primary source of information relating to the status of fisheries. Considerable benefits exist in collecting catch and effort data via VMS. Benefits are derived from improvements in timeliness of delivery of data to the monitoring agency. Reductions in cost of data entry and improvements in accuracy can be achieved through minimising data handling and direct interaction between the vessel operator and the data entry/editing program.

Catch data and other fishing activity data such as reports about a vessel's intentions, may also have a compliance related function. For example, catch reports may be used to monitor a catch quota.

Catch and effort reporting has not been a major focus of VMS implementation to date, the major exception being the VMS implemented by Japan. Further catch and effort reporting via VMS can be expected to develop around the world but this document will only deal with catch and effort reporting as it relates to MCS in keeping with the purpose of the document.

4. DEFINITION OF VMS

In order to discuss the use of satellite navigation and communications systems and their role in fishing vessel monitoring one has to first understand what VMS is. It is often assumed that VMS is a synonym for satellite surveillance. This is not true.

4.1 VMS use in MCS

4.1.1 What VMS does

VMS provides another tool in the MCS kit. It will make many of the currently used conventional MCS measures more effective.

VMS provides monitoring agencies with accurate locations, of fishing vessels that are participating in the VMS. It informs the monitoring agency where a vessel is and where it was at periodic time intervals. The position information can be provided to the monitoring agency in near real time (less than 30 minutes) no matter where the vessel is located in the world. (Note that Inmarsat does not cover the Polar Regions north and south of 75 degrees latitude).

This is simple but powerful information. Prior to VMS, fisheries management agencies have had to rely on information provided by vessel operators, information which may not be reliable, since there are many reasons for the operators giving inaccurate information. Aside from the possibility of illegal fishing, location of successful fishing grounds can be highly valuable commercial information. That VMS can provide this information to a monitoring agency is often the major source of opposition to the use of VMS by the fishing industry.

VMS can also provide a vessel’s speed and heading in either of two ways:

- computed from within the equipment on board the vessel by sampling position fixes; and
- computed at the monitoring station from consecutive position reports.

From the vessel position and speed provided in a number of consecutive position reports, it is possible for the monitoring agency to draw conclusions about the activities of a vessel. A vessel travelling at speeds of less than 3 knots is one indicator of possible fishing activity. For particular types of fishing operations a vessel may show a pattern of positions which also indicate possible fishing activity. For example, in trawling a vessel may show multiple consecutive positions within a relatively small locality and tracks which intersect each other. In long-lining a vessel may show multiple positions in a particular direction for setting the line and the opposite direction for retrieval, or sometimes a circular pattern for setting and retrieving in a consistent direction.

VMS allows the transmission of catch and effort data from the fishing vessel to a monitoring agency in near real time. This information cannot be entered automatically by equipment on the vessel and must be input by the vessel operator. As such, it must assume a lesser degree of reliability. However, it can have a number of uses in the context of MCS.

The vessel operator can nominate commencement and cessation of fishing operations. This may make the task of interpreting the vessel's activities easier for the monitoring agency and allow it to thoroughly investigate suspected fishing operations outside of the nominated operational fishing periods.

Catch data, entered and transmitted at sea immediately after each fishing operation, commits the vessel operator to a specific estimate of catch without the knowledge of whether the vessel will be subject to a boarding inspection at sea or at the landing port. This could be useful in a number of situations such as a quota fishery where more accurate declarations of catch are required.

VMS also allows the transmission of other data to a monitoring agency by the vessel operator. Any unformatted message could be transmitted for a variety of purposes. This could include notification of the vessel's intentions such as entering a port or fishing zone, or could be information about the activity of other vessels. Of course such information could be transmitted by communication systems other than those provided by VMS but the VMS does provide an obvious, reliable, direct and relatively inexpensive means of communication between the vessel and the monitoring agency.

A VMS can also allow for the transmission of information which is not position information and which is not entered by the vessel operator. Such information could be derived from a variety of automatic sensors. Very little practical work has been done with sensors in the fisheries MCS context. The purpose and effectiveness of such sensors will emerge with further development of VMS. Some suggestions as to their purpose are to identify more specifically actual fishing activity through, for example, measuring the load of a trawler's engines or detecting the operation of its winches.

4.2 What VMS Does Not Do

VMS does not replace or eliminate conventional MCS measures such as aerial surveillance, boarding at sea via patrol boats, landing inspections and documentary investigation. Many of these measures may need to be activated as a specific response to information received via the VMS.

VMS, by itself, does not provide evidence of a standard likely to satisfy most criminal courts of an offence that involved fishing activity. VMS indicates probable fishing activity and provides a good and sufficient basis for further investigation by one or more of the conventional MCS measures. In some jurisdictions such as in the USA, many fisheries matters are dealt with in civil rather than criminal courts. A level of credibility may be established for VMS over time, to the extent that VMS evidence may be accepted as *prima facie* evidence of fishing activity by the civil court.

4.3 Application of VMS

4.3.1 Suitable applications

As has been identified above there are clearly functions which a VMS can perform and those which it cannot. The essential components of VMS function are tracking vessel locations, identifying possible fishing activity and providing a means of communication. For effective application of VMS to a fisheries management objective it is obvious that the management rules to achieve that objective must relate to VMS capabilities. Examples of management rules where VMS could be effective will probably include restrictions related to geographic areas. These might include but not be limited to:

- an area which is closed for either fishing or navigation or other activity (e.g. transshipment of fish at sea);
- an area which is closed at particular times;
- an area which is restricted for fishing or other activity, to certain vessels on the basis of nationality, type, size, licence status, etc;
- an area for which the amount of access is to be timed or counted; and
- an area which is subject to quota or other catch restrictions.

The above, or combinations of the above, are quite common in fisheries management practice. VMS may be applied quite simply and effectively in most of these situations. For example, in monitoring whether a vessel conducts fishing activity in a closed area. In other situations, particularly where quota or catch restrictions apply, it may be necessary to modify the management rules to enable VMS to be fully effective in achieving the management objective. For example, in monitoring a catch restriction on a particular area, it may be necessary to restrict vessel operations to that single area for a given voyage (it is easier for VMS to show no fishing in other areas and port inspections to confirm the size of a catch). This may cause some inconvenience to vessel operations and may not be practical as a result. However, in many situations it will be practical to use VMS with some modification of management rules and this should not be overlooked.

4.3.2 Deterrent

One of the major impacts of VMS in MCS usage is its deterrent effect. This has been observed and reported on through practical experience in Australia, New Zealand and the

USA. It has been demonstrated that if fishing vessel operators know that they are being monitored and that a credible enforcement action will result from illegal activity, then the likelihood of that illegal activity occurring is significantly diminished. In this context, VMS is a preventive measure rather than a cure.

The VMS must maintain its credibility in the eyes of the vessel operators and its use must be kept at the forefront of their minds if the deterrent effect is to be maintained. The credibility of the system can only be maintained if all operational issues are followed up, particularly those which effect a vessel such as failure of the vessel to report on schedule. The presence of the VMS equipment on the vessel will be a reminder to operators of its monitoring operation. Use of the system for direct communication between vessel and monitoring agency further strengthens the presence of the monitoring function.

4.3.3 Probable cause and targeted investigations

In an active sense VMS will potentially show monitoring officers many possible breaches of fishing rules. The types of breaches may be fishing in a closed area, fishing in an area for which the vessel is not licensed, or fishing in an area subject to quota restrictions with insufficient quota.

For these types of breaches, VMS can show officers those vessels which are following the rules as well those which are not. In doing so it makes the activities of investigating officers much more cost effective since less time will be spent pursuing false trails and fishing operators who are following the rules.

In many jurisdictions, it may also be a requirement to have established “probable cause” before pursuing some types of investigations, for example, in obtaining a search warrant. VMS may be of assistance in this situation because while not being evidence of sufficient significance by itself to obtain a conviction, it could provide sufficient evidence to lead an officer to believe that an illegal act had occurred.

4.3.4 Targeting landing and at sea inspections

In many fisheries management cases, monitoring officers will have particular vessels or particular situations for which they may wish to conduct an at sea or landing inspection, sometimes without warning to the vessel operator. Prior to VMS it was extremely difficult to determine where a vessel was located at sea or where, and at what time, it might enter port. VMS provides a good and reliable means of achieving this with potential savings in time and other expense in moving officers, aircraft or patrol vessels to the correct location at the appropriate time.

4.3.5 Increasing efficiency of surveillance patrols

Patrols by both sea and air will still be necessary for fully effective MCS even with an effective VMS. Unlicensed vessels must be detected and these may not be participating in a VMS or the VMS position data for some vessels may not be available to a particular nation’s monitoring agency. A patrolling aircraft or vessel can spend considerable time and fuel investigating legitimate fishing vessels that will appear on their radar. Providing access to VMS data to these patrol craft can minimise the effort spent confirming radar contacts of vessels fishing legitimately. Further, identifying legitimate fishing vessels to patrol craft via VMS may help them choose particular contacts for more productive investigation when several contacts are made by radar.

4.3.6 Increasing risk for under declaration of catch

In some fisheries management scenarios catch restrictions or quotas may apply against particular species in particular areas. Operators may under-declare catches for particular areas or misreport catches for areas other than where they were caught. A random inspection system may be part of the MCS regime for such a fishery but often it will be too late to detect the misreporting, or may allow the vessel operators to declare catch accurately in those few situations where an inspection takes place. The communications capability of VMS can be of assistance by assuring that vessel operators declare each catch as it is made. Misreporting catch by this means places the operator at greater risk of detection during the random inspections since the vessel may not have left the area of the reported catch and there will be no opportunity to change the declared catch if the vessel is subject to an inspection.

4.4 VMS Components

At the current state of the art VMS is a “co-operative” system where only participating vessels are monitored. It is a “co-operative” system because each participating vessel must carry an operating transmitter or transceiver (sometimes incorrectly referred to as a transponder) which is capable of fixing a position, (in most cases, calculating its own position and thus the position of the vessel carrying it). An automated reporting system then controls the transmission of the position data and possibly other data via a communications system to a fisheries monitoring station.

The transmitter or transceiver must have an integrated means of fixing a position and hence calculating speed and course. The Global Positioning System (GPS) used so successfully by the fishing industry, is the method generally preferred because of its high level of accuracy, availability and relatively low equipment cost.

The automated reporting system achieves its purpose through a combination of computerised instructions in the transmitter and functions available in the communications system. The automated reporting system is capable of being programmed to send position reports at specified time intervals.

The communications system moves data between the transmitter/transceiver on the vessels and the monitoring agency. This may or may not involve the use of a satellite. Many tracking applications for land based vehicles use cellular phone and H.F. radio. China is trialing a VMS which uses Single Side Band radio as part of the communications system. However, for MCS of fishing vessels, satellite based communications systems are considered the most suitable since they have the advantages of global coverage and high reliability.

In a satellite based communications system, data is transferred from the vessel to a satellite and then to an earth station. The earth station then forwards the data to the monitoring agency via a secure public data network or the telephone network using an international standard data communications protocol such as X25.

Within a fisheries monitoring agency there must be a computerised monitoring station capable of collecting the data received from the earth station, storing that data for subsequent review, analysing the data to detect and highlight exceptional conditions of interest to monitoring officers, and displaying that data in a meaningful way, typically against a background map. A specialised Geographical Information System (GIS) is also a highly desirable element of the monitoring station particularly for historical and statistical analysis of both position and catch data.

4.5 Satellite Surveillance

Within this document VMS does not mean by definition satellite surveillance. It is quite possible. however, that satellite surveillance technology will be used for MCS of fishing vessels in the future. In fact this is already beginning to occur.

Satellite surveillance has a connotation of a non-cooperating target, i.e. the vessel being monitored will not actively be part of the system. The satellite will detect and observe vessels either visually or by radar. Such technology has been typically the preserve of military intelligence agencies. However, satellite imagery has become more accessible and is used now for a variety of commercial and governmental purposes. There are two main types of satellite imagery, optical/infrared such as is provided by Spot and Landsat satellites, and Synthetic Aperture Radar (SAR). Satellites with SAR capability include ERS-1, Radarsat and JERS-1. SAR appears to have more potential for fisheries MCS because it is less affected by cloud cover and darkness. Service providers are now offering software packages that take SAR data, analyse that data, highlighting vessels at geographical locations within the SAR image.

Exploiting satellite surveillance technology for large-scale fisheries MCS purposes has not begun as yet. Some countries, notably Norway and Canada, are trialing the technology but it is still not clear what role it will play in fisheries MCS. It is also uncertain as to whether such technology will be economically viable for fisheries MCS, especially as a broad based fishery management tool.

Satellite surveillance, through technology such as SAR, has the principal advantage that it can detect non-licensed vessels or vessels which are not participating in a VMS. It also has a number of disadvantages for MCS in fisheries.

- The SAR systems have widely varying success rates for detecting vessels depending on the sea state and the angle of the satellite passing overhead relative to a vessel. Enhanced image processing, use of new satellites or other techniques can be expected to improve detection capability.

- Vessels detected by SAR are not identified. They may not be fishing vessels, they may be licensed or unlicensed. Further conventional observation by either a patrol boat or aircraft will always be required.

- The satellites carrying SAR instruments are polar orbiting and only provide limited coverage of any given geographical location, particularly in equatorial regions. The satellite may revisit a given geographical location days or even weeks apart. The SAR satellite will generally cover a 100 kilometre swath and may take a considerable time to provide coverage of large areas through several Earth orbits.

- SAR images are relatively expensive. A single scene (size varies but about 100 km by 100 km) costs between $US2,000 and $US4,000.

In the light of this information, it is clear that SAR is currently somewhat limited in its usefulness as a MCS tool as much activity of fishing vessels will not be observed. However, SAR equipped satellites provide considerable potential as an MCS tool despite their disadvantages. They could be quite useful at monitoring particular areas for illegal activity where weather conditions or remoteness makes conventional surveillance impossible or non cost effective.

The combination of VMS and a SAR satellite surveillance system would be most effective since the systems complement each other in their functional capabilities. A VMS can identify and track licensed fishing vessels where a SAR system simply detects the presence of vessels. Having input from both systems would enable a monitoring agency to focus its attention much more productively on the vessels that may be in breach of management rules. This situation is still a few years away as further development is required before SAR will be fully effective and affordable.

Satellite MCS initiatives will focus on VMS because it is further developed for commercial availability and enables countries to monitor their licensed fishing fleet more cost effectively.

4.6 Other Surveillance Systems

There are a variety of means of monitoring fishing vessels in a non-cooperative manner apart from satellite surveillance and the traditional patrol boats and aircraft. Systems are available which involve use of land based radar or sea based sonar. Such systems tend to be localised in their coverage. They sit at a fixed location and monitor the area in the immediate vicinity. The range can vary greatly from a few kilometres up to more than 300 kilometres for some sophisticated and expensive over the horizon radars.

Fixed surveillance systems can serve a valuable purpose, which will however be limited by their range and in some cases by their expense. They are not an alternative to VMS and the remainder of this document will therefore focus on VMS.

5. SATELLITE COMMUNICATIONS SYSTEMS

5.1 Principles

Satellite communications systems relevant to fisheries MCS use satellites that are either geostationary or orbiting. With a geostationary system the satellite remains in a fixed position relative to a given geographical location (the satellite is actually in a fixed orbit and moves in a consistent relationship to the Earth). With this type of system the satellite can, at all times, receive and transmit messages to any transmitter or transceiver that is within the fixed geographical area visible to the satellite. A communications system based on geostationary satellites may have more than one satellite to cover a greater percentage of the Earth's surface.

An orbiting communications satellite moves in an orbit so that it passes above a given geographical location at periodic time intervals. Such a system means that earth bound transmitters or transceivers come into the satellite's range at these periodic time intervals and transmit or receive only while the satellite is in range or "visible". The transmitter may store messages until the satellite is in range. When messages are transmitted to the satellite, they may also be stored in the satellite until the satellite comes into range of a receiving earth station. Unlike a geostationary system, a single satellite can feasibly cover the whole of the Earth's surface. However, there will be time gaps in coverage when the satellite is not in view of given geographical locations. Increasing the number of satellites will increase the coverage of the system by decreasing the time gaps when a satellite is not in view of a given location.

In both types of system a fixed or mobile transmitter can be used. Such a transmitter is mounted on a vessel, aircraft, building etc. and uses a radio signal to send a message to the satellite mounted transponder. The message can be stored in the satellite for later forwarding or immediately forwarded to a receiver or transmitter with a receiving capability (transceiver) mounted on another vessel, aircraft, building etc. In some cases the receiving station will be a large fixed station (an "earth station") which will link to the normal terrestrial telephone system.

5.2 Factors Affecting Performance

The performance of a satellite system is primarily related to the type and strength of radio signal used between the vessel mounted transmitter and the satellite. The power available in the satellite and the extent to which the satellite can focus on a geographical area are inter related factors and determine the size and power requirements of the vessel transmitter.

The type of radio signal used by transmitters relevant to fisheries MCS is usually within the microwave band and as such is highly reliable and relatively low powered. The signal is not greatly affected by atmospheric conditions.

5.3 Systems Descriptions

The communications systems used for fisheries MCS are primarily Inmarsat, Argos and Euteltracs. Detailed system descriptions are available from the suppliers and will not be documented here, other than in the very broadest terms.

5.3.1 Inmarsat

Inmarsat is a geostationary system that has four operational satellites. One each is mounted over the Pacific and Indian Oceans and a further two cover the Atlantic Ocean. This provides almost universal coverage since the satellites are all close to the equator and have overlapping regions of coverage around the globe, centred along the equator. Coverage of the polar regions is not possible since the height above the Earth's surface of the satellites means that the polar regions are not visible. The area of non coverage is south of 75 degrees South latitude and north of 75 degrees North latitude.

Inmarsat offers a number of different types of service formats using the same satellites. Many large vessels will use Inmarsat A or its digital successor, Inmarsat B. These formats include voice, facsimile and high speed data transmission in both send and receive modes. Inmarsat A or B effectively provide an "end to end", or duplex, communications medium similar to a telephone connection where the sender and receiver are in almost immediate real time contact.

Inmarsat M is a smaller and lower speed format but provides similar services to A and B. Inmarsat A, B and M do not have automated position reporting systems. They provide the equivalent of a telephone line and therefore an "end to end" type of service on which it may be possible to build a position reporting system. Considerable effort would be required to satisfy the security requirements of MCS especially in terms establishing the authenticity of the position source, minimising risk to the integrity of the system from operator interference, and the additional reliability burdens required by end to end systems.

Inmarsat C is substantially different from the other formats offered. Inmarsat C is not an "end to end" system, rather it is a "store and forward" system where the data is not immediately sent all of the way from the sender to the receiver. The message is stored in intermediary locations such as an Inmarsat Land Earth Station (LES) before forwarding to the final recipient. Typically, the transmission time will be about 5 minutes. This is obviously inappropriate for voice communications but it is most appropriate and less costly for Email and telex like messages. Free format messages are sent in a mode called the message reporting mode. Inmarsat C goes further and offers a very inexpensive mode for very small messages. This is called the data reporting mode and allows for transmission of 16 bit packets of data.

Inmarsat C, by definition of the Inmarsat organisation, includes an automatic reporting system making it highly suitable as an off-the-shelf monitoring system used for many monitoring systems in both land and maritime applications. The transceiver can be programmed to report at set time intervals. Programming of the time intervals can be done

remotely from a monitoring station via the satellite communications system. The transceiver can receive and
process other commands such as a request to send the current position of the vessel immediately. Position fixing is done using a GPS receiver integrated into the Inmarsat C transceiver.

5.3.2 Argos

The Argos system is based on the use of dedicated communications sub-systems carried aboard two National Oceanic and Atmospheric Administration (NOAA, USA) satellites that are in polar orbits. A variety of transmitters are available for use with Argos in mobile tracking applications. The system currently operates in send only mode, that is from ship to shore. Receive mode is planned for the turn of the century.

Argos is a store and forward system with messages sent from the ship-based transmitter stored in the satellite until an Argos ground station is in view. Messages are also stored in various Argos processing centres for convenient distribution around the world.

Argos is GPS capable and has an automated position reporting system. GPS positions are fixed at predetermined time intervals within the equipment on board the vessel and are transmitted when the satellite comes into view. The satellite is also capable of fixing a position using a Doppler shift method based on a signal sent from the Argos transmitter on board the vessel.

5.3.3 Euteltracs

The Euteltracs system is based on the use of two geostationary satellites operated by the European Organisation of Telecommunications by Satellite, Eutelsat. The satellites provide regional coverage of Europe and the Mediterranean Basin and Middle East. The technology for the system was conceived by Qualcomm, a USA company which operates the Omnitracs network which is a similar regional satellite network covering the North American area.

The systems services resemble those of Inmarsat C, providing two way communications in a store and forward mode. Euteltracs/Omnitracs provides a variety of ready made tracking applications for the transport industry. Euteltracs has been used in the European Union as part of the development of VMS in Europe. Use of the Euteltracs/Omnitracs technology for VMS has been relatively limited but could expand as Qualcomm and its partners extend coverage from a regional to global system.

5.4 System Compatibility

Though these three specific systems and three types of system are fundamentally different, there is no reason that, from the fisheries manager’s point of view, they cannot be used compatibly so long as their data is aligned with VMS requirements and that the systems each meet the manager’s requirements from the point of view of coverage and performance. This has been demonstrated in Europe, the USA and New Zealand where more than one of the systems have been used, side by side, in the same fishery.

5.5 User Friendliness

Installation of transmitters and transceivers is relatively simple but is best done by experienced or trained technicians such as may be found in many commercial shipping supply businesses. Operation of the equipment by the vessel operator is also relatively simple with guidance from the user manuals and the equipment supplier representatives. The position reporting function will usually require no input from the vessel operator but a catch reporting function will require documentation of the requirements and guidance in its use. Competent instruction will be required where equipment is used also for safety purposes such as part of the Global Maritime Distress and Safety System (GMDSS).

From the monitoring station end of the system the level of user friendliness will be determined by the system interface provided by the satellite service provider and the facilities provided by the software used in the monitoring station. Both are becoming easier to use and are within the capability of most fisheries monitoring agencies given some guidance from supplier representatives.

5.6 Proposed Future Systems

If the current proposed systems all eventuate, in the next few years there will be a plethora of mobile satellite communications systems hoping to provide their services to the fishing industry. All are based on constellations of satellites in one or more of three basic kinds of orbit (i.e. low orbit, medium orbit or elliptical orbit). Some are data only, but the majority are duplex, telephony systems.

The data only systems will almost certainly provide stiff competition for the three existing systems. How useful the telephony systems will be in the context of VMS, however, remains to be seen. Whilst there is significant interest in the fishing community for low-cost, satellite voice communications, one important question must be addressed.

The question that must be asked of them is whether or not, the system is still capable of transmitting a position report and responding to a poll, while the crew aboard a vessel is talking on the telephone. This could take place theoretically using a terminal with dual channel capability or by using the system's signalling channel for continuous position reporting and polling.

The technical solution employed is itself of little importance (although dual channel capability could make the hardware and communications costs unacceptably expensive), but if the response to the question as to whether or not continuous position reporting is available -- even when the system is being used for telephony -- is negative, it would be difficult to qualify such a system for inclusion in a VMS architecture.

5.7 Automatic Ship Identification Systems

As the result of an initiative by the International Maritime Organization an international consultation aimed at establishing a world wide automatic ship identification system is

underway. The motivation for this initiative is essentially to extend further distress and safety capabilities required by the SOLAS (Safety of Life at Sea) convention and GMDSS.

Viewed schematically, the automatic ship identification system would use a ship's own navigation and communications systems to calculate and transmit the ship's position to authorities local to the area where it is operating. Each vessel would have a "black box" aboard which would calculate, given its position, to which authority it would be reporting and the best communications means (VHF, H.F., mobile satellite systems) to get the position data to that authority.

Despite its origin in the world of maritime safety, there is a consensus that such a system, when operational, could be used for other purposes, such as vessel monitoring for customs or fisheries protection purposes. One could envisage that such a system could provide invaluable data on the international movements of vessels, particularly those that, because of their questionable activities, would tend to avoid fisheries which required VMS compliance.

Vessels falling into this category would be those which use registration with flags of convenience to avoid regulation by responsible flag states. In this respect automatic ship identification system would be a valuable tool in the enforcement of the FAO High Seas Fishery Compliance Agreement (See Appendix 1). Other vessels whose movements would attract the attention of authorities, and whose activities could be tracked, at least partially, by automatic ship identification systems, would be those engaging in now illegal activities such as drift net fishing.

Unfortunately, to date, agreement is still required on the necessary approach, technology or standards to implement automatic ship identification services. When these issues are resolved, perhaps the basis will exist for some Cooperation, or even homogenization, of VMS and automatic ship identification, but it is too early to make such an assertion.

6. VMS OPERATIONAL/PERFORMANCE REQUIREMENT

The basic requirements for VMS are quite simple: a vessel must be capable of reporting automatically, accurately and reliably its position to the relevant management authority. In addition to this, there exist a number of ancillary functions which the management authority can designate as requirements or options, as well as a range of performances measured in accuracy, speed of data delivery and system integrity and security.

6.1 The Position Report

For the purposes of this paper we will refer to the shipboard equipment used in VMS as a VLD, or Vessel Location Device. A VLD must be capable of providing positions of the vessel on which it is mounted with a specified level of accuracy, regularity and speed, to be an effective fisheries management tool. The most common accuracy requirement is for a tolerance of ±100 meters. This level has been established, almost de facto, because this is designated accuracy of uncorrected GPS. The European Commission has set its requirement

at a more modest ±500 meters, as has the U.S. National Marine Fisheries Service in its pilot project for the New England groundfish and scallop fishery.

In both cases, this requirement has been relaxed to accommodate the use of Boatracs terminals, as that system's independent positioning system corresponds to this level of accuracy. There is some consensus amongst fisheries managers that the more relaxed level fulfils most VMS requirements.

Furthermore, accuracy is not the only issue. Using GPS the position of a vessel is calculated on board the vessel for transmission to the management authority. This availability of the calculated position aboard the vessel raises a security issue, i.e. the possibility of tampering with that position before it is transmitted (discussed in detail in section 9).

When, on the other hand, the vessel’s position is calculated at the system’s communications hub, this particular tampering problem is obviated. Almost all of the future planned satellite systems, based almost without exception on GMS mobile telephone protocols, will have an independent means of calculating the position of a mobile terminal.

Though these positions will be less accurate than GPS, sometimes significantly so, they may be sufficient for fisheries management. In addition to that they open the way forward to a situation where a GPS position is transmitted by the vessel and the communications system’s positioning capability is used as an integrity check on the GPS position.

6.2 Vessel Speed and Course

A distinct benefit of the use of GPS for positioning is that the receiver, in addition to its position in latitude and longitude, provides its speed and course. The advantage of this data is twofold: while accurate speed information cannot reliably determine whether or not a vessel is fishing, it can, in conjunction with basic information such as the type of vessel that is being monitored and the kind of fishing gear that it is using, give a dependable indication that the vessel is NOT fishing. Reception, for example, of a report from a purse seiner indicating that it is steaming at 12 knots would eliminate the possibility that the vessel was fishing at the time that the report was transmitted.

Course data can be an effective tool in determining the probability of a vessel engaging in illegal fishing, e.g. when it is observed steaming toward a restricted area, and in intercepting a vessel by either patrol vessels or patrol aircraft.

By using an external positioning system, such as those discussed in section 5.1, the availability of independently calculated course and speed is made impossible. The sole alternative is to use two positions to calculate these values by dead reckoning. The accuracy of this operation is a direct function of the interval between the two position reports (the shorter the interval the higher the accuracy) and the accuracy of those reports.

6.3 Frequency of Position Reports

The requirement for frequency of position reports is normally related to the intensity of a given fisheries management regime and the resources available to respond to VMS observations. In general, existing VMS systems require that vessels report their positions up to hourly, i.e. 24 positions per day. In certain situations, normally when a vessel's activity appears to be illegal, authorities call for the ability to receive positions at 15 minute intervals.

As virtually all communications systems offer the ability of this frequency of positions, the only remaining issue is the ability of the fisheries management authority to remotely reprogram the VLD so as to vary the frequency of the position. It is expected that any mobile satellite system which offers dynamic reprogramming will meet a fisheries management scheme's requirement for frequency of reporting. On the other hand, meeting such criteria will often pose difficulties for remote data gathering systems.

6.4 International Data Exchange Formats and Protocols

Exchanging VMS data between national monitoring agencies is foreshadowed in international agreements and is currently being considered within the European Union. A universal standard format has not been agreed for this purpose and neither has a standard communications system or communications protocol for delivering the data. Agreed standards, such as these, would enable monitoring station software providers to develop software which would provide the ability to exchange position data more easily between agencies. The alternative is that each national system would decide its own format and protocol and every other agency exchanging data with that agency would have to support that format and protocol. This could be very expensive and chaotic to administer. Urgent action is required in an international context to prevent this event.

6.5 Catch and Effort Data Formats

Transmitting catch and effort data via VMS is not yet well developed. Japan has made some progress in this area with a reporting system which sends a custom format message over Inmarsat A using the X modem protocol. There have also been trials of catch data reporting using Inmarsat C and Argos in other countries. It is urgent that some attempt is made to standardise both the format and the communications protocol for delivery because of the potential use of VMS for transmission of this data by vessels that move between jurisdictions. If this is not addressed, the support of multiple message formats will lead to expensive software on board vessels and create confusion for vessel operators.

It may not be possible to meet the requirements of all monitoring and scientific agencies with a single message format. However, a basic message structure with some flexibility for supporting different species and fishing methods should at least be sought.

The issue of delivery protocol must also be fully standardised. Simplicity and commonality will lead to less expensive systems development and systems which can be applied in a wider range of countries and monitoring organisations. Similar protocols to those used for the delivery of position reports should be considered.

6.6 Other Data Transmission

Other information may be derived from sensors linked to the VMS equipment. For example, water temperature or information about the operation of various equipment on board the vessel which might provide an indication of environmental conditions or fishing activity. Much of this information will have a specific purpose and it may be difficult to achieve any standardization. However, some consideration should be given to intention messages to ensure that confusion among vessel operators is minimized and ease of use maximized. The issue of sensor data should also be considered in the longer term as use of this technology develops.

6.7 Beginning and End of Operation Messages

It must be assumed that there will be times when a vessel's VLD is legitimately out of operation: when it is in port for prolonged periods or being serviced or refitted, for example. Should a vessel simply stop transmitting its position, this will create an anomaly within the VMS where a position is still expected at regular intervals.

The solution to this potential problem is to program the VLD so that it sends to the fisheries manager a special class of message when the system is turned on or off. The action of turning on the VLD simply formats an "entry into service" message which includes, in addition to the vessel identity, its time and position. Likewise, turning off the VLD formats an "end of service" message with the same variables.

There are two variants on these messages. In the case where the power is suddenly cut and the VLD is unable to send its end of service message, when power is restored, it sends an "interrupted service message" which includes Vessel identity, time, position when power cut occurred and actual position.

The other is that, assuming the VLD has an auxiliary battery power supply (see discussion in section 9.2.1) the switch from principal power supply to battery provokes the transmission of an "emergency operation" message which includes the time and current position

6.8 Two-way Messaging Capability

Most fisheries managers favour systems which provide two-way messaging capability so that they can not only receive their necessary position reports, but have the capability to address operational messages to individual or groups of vessels (changes in regulations, weather reports, safety messages, etc). The addition of a manual input device aboard the vessel (keyboard, hand-held terminal, PC) adds the catch reporting capability to which most fisheries managers aspire.

Table 6.1 VMS performance requirements

Requirement	Measure	Tolerance
Position report	**accuracy in meters**	**±100m to ±500m**
Speed and course	**real or extrapolated**	**real reference is preferable**
Report frequency	**minimum interval**	**15 minutes**
Position delivery speed	**interval between calculation and delivery**	**availability of near real time if required**
Exception messages	**availability of entry to, exit from and interruption of service or power supply**	**availability of near real time for system integrity**

7. PHYSICAL REQUIREMENTS FOR VMS EQUIPMENT

The principal concern regarding the physical characteristics for VLD equipment is that it be reliable and present no obvious weakness that could be exploited by an unscrupulous vessel operator.

7.1 General requirements

Equipment must be sufficiently compact to be easily fitted in a vessel wheelhouse. It must be specifically designed for continuous, reliable marine use and therefore highly resistant to malfunction caused by vibration, physical shock, electrical surge, changes in temperature, moisture and humidity and corrosion. Certification of this resistance needs to be certified either by a competent authority designated by the VMS operator or one of the recognized, international certification services, such as Lloyds, Bureau Veritas, Det Norske Veritas, etc. The standard components (antenna, communications unit and input device) must be securely mounted to the superstructure of the vessel with marine grade components supplied with the units.

7.2 GPS receiver/decoder

When the positioning function is assured by a GPS decoder/receiver that apparatus must be an integrated part of the VLD rather than an external unit. Furthermore, it is essential that the VLD and GPS share a single, integrated antenna.

7.3 Unique identifier

In order to meet the requirements for system security and integrity, it is essential that each VLD carry a unique and unmodifiable identifier that is delivered with every message that it sends. This issue is discussed in a more detailed manner in section 9, Security.

7.4 Installation

That a VLD be properly installed aboard a vessel is a pre-condition for its qualification for use in a VMS scheme. This means that it be capable of continuous, reliable operation. This requires that the fixtures used in the installation be capable of securing the unit so as to neutralize vibration and shaking and that the antenna be installed in a place where it has continuous, unobstructed view of the satellite.

Furthermore, the antenna site must be suitably distant from antennas of other communications systems, navigation antennas or magnetic compass. The antenna cable, must be installed in such a way as to avoid interference with normal ship activity or to be protected by a reinforced conduit if this is impossible.

Finally, the use of an auxiliary power supply is recommended as is the use of waterproof connectors for both antenna and power connections.

8. TYPE APPROVAL PROCESS

The term type approval describes the process of testing and verification which leads to a VLD being accepted for use in a given VMS system. That type approval processes of national and regional agencies be based on certain norms and standards is essential if vessels commissioned for one VMS system are to be accepted with minimum formalities for operation in another.

Essentially, the type approval process is parallel to that cited in section 7.1. The fundamental difference is that this latter process certifies simply that the equipment is suitable for operation in the maritime environment. The type approval process, on the other hand, certifies that the equipment conforms to all of the operational and performance specifications for VMS operation. In addition to meeting the requirements for maritime operation, for example, a rigorous VMS type approval process will insure that the VLD is sufficiently protected against the possibility of tampering to avoid monitoring.

This process is generally executed in two series of tests, one each off-line and on-line. In the former, the VLD is tested using a test-bed, or simulator, of the VMS system. When these trials are successfully completed, the VLD is tested on-line, i.e. as though it were an actual vessel being monitored in real-time.

The basis of the tests are the requirements outlined in section 6. A sequence of operations is carried out to confirm that the equipment sends its entry into service message upon being turned on, that its position reports are delivered in the correct format, that it responds to polls, that its reporting frequency can be reprogrammed remotely, and that it sends a correct end of service message upon being turned off.

8.1 Type Approval Questionnaire

Perhaps the simplest way to create a normalized type approval process would be for monitoring agencies to adopt a standardized questionnaire and to certify that an inspection of each installation they certify would return correct answers to all of the questions. A suitable list of mandatory questions would include:

1. Is the VLD's unique identifier stored in non-volatile memory which constitutes part of the system's unmodifiable firmware?

2. Does the VLD have a clearly visible, irremovable, irreplacable and unmodifiable external serial number or other unique identifier?

3. Is the VLD capable of detecting that it is incapable of sending or receiving messages because of antenna blockage or disconnection?

4. Is the entire communication sequence from the VLD to the VMS monitoring authority, including relay by the satellite service provider, secure and immune to interception, under reasonable circumstances?

5. Does the satellite system employed offer full, continuous global coverage (with the exception of the polar regions) or, as a minimum, continuous coverage of the VMS area?

6. Are the positions received accurate within the specified tolerance?

7. Do received position reports contain, in addition to the position, the VLD's unique identifier and the time of the fix?

8. Is message delivery completed within specified tolerances?

9. Is transmission of position reports unobservable aboard the vessel, under normal circumstances?

10. Is the VLD sufficiently protected against having the automated position reporting function altered or disabled, other than by the monitoring authority?

Depending on a VMS's individual requirements, any or all of the following questions could also be included:

1. Is the VLD capable of providing independently calculated speed and course (if required)?

2. Does the VLD transmit a correctly formatted "entry into service" message upon being turned on?

3. Does the VLD transmit a correctly formatted "end of service" message upon being turned off?

4. Does the VLD transmit an "interrupted service" message when it has been out of service for more than 15 minutes due to abrupt power cut or due to incapability of sending or receiving messages because of antenna blockage or disconnection?

5. Can the frequency of position reports be altered remotely?

6. Does the VLD respond automatically and immediately to a remote request for a position report?

7. Does the VLD have the capability to transmit free-text or pre-formatted messages created on board the vessel?

Positive answers to all of the above questions would certify that a VMS installation met the necessary standards for international operation.

9. SECURITY

Security of VMS data is a major issue for the fishing industry. It is also a major issue for a monitoring agency since it is probable that the agency will have a responsibility to ensure security through legislation, a contract, or an international agreement. Security is broader than protecting data from non-disclosure and its importance in implementing a VMS will therefore be extremely high.

There are a number of concepts that can be included in the general heading of security. Concepts relevant to VMS include the following.

Integrity - whether or not data has been altered or the function of a process is as intended.

Authenticity - whether or not the source of data can be positively identified and accepted as valid.

Privacy - whether or not an unauthorised person can view data.

Non Repudiation - whether or not the sender or receiver of data, can fraudulently deny sending or receiving that data.

Audit Capability - the extent to which all facets of security may be verified by the examination of records.

Without being specific to particular VMS components or functions, all of the above concepts should be considered in the design of a VMS.

Though a paper on VMS norms and standards might seem an unusual forum for a detailed discussion of VMS security, the issue is of vital relevance. If VMS operators are not convinced of the integrity of the data they are receiving during normal operation, the use of VMS for fisheries management will be seriously compromised.

Furthermore, in the context of international operations where the vessels of a given flag state are licensed to operate in the waters of a different coastal state, that state must be assured of the integrity of data coming from any installation aboard a foreign vessel.

Finally, it must be recognized that VMS is most often used as a fisheries protection tool. Fisheries protection is nothing but a specialized variety of police work. A vessel operator might reap substantial monetary awards by avoiding monitoring, therefore it is essential that VLD equipment be designed to be, inasmuch as reasonably possible, invulnerable to wilful corruption of data or other forms of cheating.

The response of some fisheries authorities (e.g. Portugal, Spain, Argentina, Morocco) to this challenge has been to create at VLD which is virtually an armoured unit: it is installed aboard a vessel in a reinforced, metal case and offers a shipboard interface with the minimum functionality necessary to carry out its two-way communication and, perhaps, catch reporting responsibilities.

Whilst this might appear to be a viable solution, it is the opinion of the authors of this paper that such approaches are unsound for a number of reasons. The most important is that the additional security added by such installations fails a fair test of value for additional cost.

The objective of protecting the system in this way, is to render it foolproof, invulnerable to any kind of tampering. Nonetheless, as we shall see below, the most common kind of tampering consists of blocking transmission at the level of the antenna, and no kind of armour or safety device can avoid such action.

Furthermore, each of these VLDs costs several times the price of a standard unit, and the fact that they are built to custom designs means that production will always be small and prices will always be relatively high. In addition, service or replacement is problematical, to say the least, particularly in the context of highly mobile, distant water vessels.

Proponents of this approach will argue that the solution is to develop norms and standards for just such an VLD. However it is difficult to believe that, in a world where fisheries managers have difficulty agreeing upon a simple format for the presentation of position and catch data, they could reach agreement on a project with as many parameters and variables as the new design for a VLD. Furthermore, that hardware would have to correspond to a technological “impossible dream”: the ability operate with all existing and future satellite systems to avoid becoming obsolete in more than a few years.

It must be pointed out that VMS is a means to efficient fisheries management, not an end in itself. By using standard equipment which conforms to reasonable norms of both manufacture and installation, it is possible to hinder all but the most resourceful attempts at VMS cheating, in both the technological and economic sense. One must expect that even the most resourceful will be finally detected by an efficient fisheries protection operation.

With the additional data on the movements of fleets made available through VMS, it should only be a matter of time before someone who is corrupting data transmitted by his VLD will be observed by a patrol vessel or a patrol aircraft in a position very different from that which he is reporting. If the authority responsible for protecting the fishery in which that vessel is operating does not impose penalties of sufficient severity to serve as a deterrent against future contravention of its VMS scheme, the commitment of that authority to assuring the long-term viability of its natural resource must be put into question.

Five forms of action to thwart the normal operation of a VLD can be clearly identified. Each will be described before discussing the kinds of norms and standards that can be imposed upon VLD design, manufacture and installation so as to neutralize such actions.

9.1 Blocking Transmission at the Antenna

This is the most obvious and most common way of neutralizing a VLD. As is the case with many simple techniques, it is highly efficient and difficult to counter. In practice, the blocking most often takes place by covering the antenna with an object built of material that destroys the line-of-sight with the satellite. Almost anything will do, an object in the form of a bucket being the most common.

The sight of a covered antenna could cause unwanted curiosity, so an alternative, more discreet approach, is to coat the antenna with a fluid substance, like metal-based paint. This latter approach does pose, however, the problem of easy removal. Another solution, from the point of view of a vessel operator intent on blocking transmission of his position, is to disconnect the antenna cable from either the antenna or the communications unit.

9.1.1 Defending against a blocked antenna

When an antenna is blocked by any means, transmission of position information is impossible. The key to solving this conundrum lies in configuring the base station to which vessels report in such a way that an expected position report which is not received (the reporting interval is known at the base station) is treated by the base station as an “event”. With the position of the vessel known at its previous report, a broadcast to patrol vessels and aircraft that the vessel in question has ceased reporting, increases the possibility of being observed.

Furthermore, the imposition of "interrupted service" messages as part of the VLD specification give the fisheries manager subsequent input as to the vessel’s movement and the exact time that it was out of contact. While it is overly optimistic to expect that the majority of vessels which block transmission will be observed “in the act”, those which carry on the practice regularly, will be providing data to the fisheries management service that may well be used to discern a pattern.

It is worth noting that triggering the "interrupted service" message should carry a tolerance of, say, 15 or 30 minutes, depending upon the conditions in which the vessel normally operates. This will avoid sending such an alert when the antenna in legitimately blocked by passing under a bridge or steaming next to a tall structure (ship, cliff, etc.).

In the case of disconnecting the antenna, security sealed connectors on the antenna cable can make disconnection impossible without leaving physical evidence of the tampering.

9.2 Disruption of power supply

Disruption of power supply entails interrupting the power necessary for the operation of a VLD in a manner other than turning the unit off in the normal way. The effect of such disruption is similar to that of blocking the antenna in that the monitoring station loses all contact with the vessel.

9.2.1 Defending against disrupted power supply

As the effect of a disrupted power supply is similar to that of a blocked antenna, so is the remedy. Everything said in section 9.1.1 is valid in this case. There is, however, an additional precaution that can dissuade the action of disconnecting the VLD from its power supply. This is to specify in the norms and standards for an installation that there be an auxiliary, battery power supply dedicated to the VLD.

A unit thus installed can send an emergency service message when its power supply is cut, and can, as a function of the power of the battery, continue in service for a considerable time. To specify a 100 amp hour marine battery as auxiliary power supply would assure service for several weeks. Using security connectors (similar to those for the antenna in 9.1.1) would discourage tampering.

The requirement for a complementary power supply has the added advantage of compensating for accidental power outages, a occurrence not uncommon aboard a fishing vessel.

9.3 Physical Removal of VLD

As a VLD transmits its own position, rather than that of the vessel on which it is mounted, physically removing it from a vessel is a very efficient way of separating the real movements of a vessel from its monitored position. The most insidious ramification of this kind of deception is that the operation appears to be completely normal, from the monitoring centre.

9.3.1 Discouraging physical removal of VLD

Once again, the most persuasive deterrent to physical removal of a terminal is the imposition of severe penalties if detected in the course of normal fisheries protection operations. There are means of discouraging this kind of activity by establishing specific norms for the installation of an VLD.

By requiring that both the antenna and the communications unit as well as the antenna connections of the VLD be mounted with security seals (this operation can be as simple as using specially designed security adhesive tape) that must be broken in order to move the elements, and by requiring that the antenna cable pass through an aperture in the vessel bulkhead smaller than either of the elements that it connects, it is possible to assure that the equipment cannot be removed and replaced in an undetectable manner.

Such practice, in the context of a fisheries management operation which requires regular verification of VMS installations and imposes suitable penalties for non compliance, should all but eliminate the probability of physical removal of the antenna.

9.4 Duplication of VLD

This is a practice known as cloning and consists of creating a duplicate VLD which functions like the original. Having done that, the producer of the clone can make it appear to the VMS system as if his vessel is anywhere he would like, so long as he can arrange for the clone to be transported to that position. Functionally, from the VMS point of view, this is the equivalent of removing the VLD from a vessel, but without the inconvenience of having to break the security seals.

9.4.1 Defending against cloning

From the VMS operator's point of view there is some comfort to be drawn from the fact that cloning a satellite communications terminal is no trivial task, either from a technical or an economic perspective. To assure that it is not, is essentially the responsibility of the manufacturer of the terminal and the VMS operator.

The most reliable way of avoiding cloning is for communications in a system by any terminal, both in transmission and reception mode, to be based on unique, internal identifiers that are known only to the terminal manufacturer and the system operator. From the point of view of a VMS operator, it is important to require that this identifier be embedded in the system firmware in unreadable form. If such norms are established, the cloning of a terminal, whilst perhaps not impossible, will not be economically viable as a means of fisheries fraud.

9.5 Transmission of False Position

This is the one that first comes to mind when thinking about possible VMS fraud. A vessel operator finds a way of changing the position that is transmitted by his VLD from the correct one, calculated by his GPS, to the one that indicates where he wants the fisheries managers to think where he is.

There are two ways that one can imagine this happening: in the first, the vessel operator finds a way to effect a manual input of position which is transmitted in the place of the GPS output. In the other, he simulates a GPS signal, using a programmable GPS or some other kind of computer simulation, and substitutes the output signal for that of his VLD's real GPS.

The effect of such action from a VMS point of view is similar to that of a removed or cloned VLD in that the monitoring centre is receiving positions that do not correspond to the monitored vessel's position.

9.5.1 Defending against false position transmission

As is the case with cloning, finding a way to input a false position to a satellite communications terminal designed to resist such tampering is far from a trivial task. Responsibility for defending against this rests, therefore, with the equipment manufacturer, requiring him to shore the defences against tampering on two fronts: system hardware and software.

On the hardware front is essential to assure that the interface between the GPS receiver/decoder is not clearly visible and that the protocol governing the exchange of data not be a standard one. The use of a GPS on a printed circuit board separate from the communications hardware and connected to it through, say, a standard (e.g. NMEA 0183) interface, is simply inviting tampering.

On the other hand, the integration of the GPS components on the same printed circuit board as the communications components and connected to them by a priority interface/protocol, means that a potential tamperer is virtually obliged to reverse engineer the entire VLD. This, once again, would tend to make the cost of the tampering not economically viable .

Likewise, the system software, which will almost certainly permit the manual input of a position for distress and safety reasons, should be written in such a way that the entity receiving a position report is alerted as to when the report is entered by the crew. Embedding this function in the system firmware essentially assures that manual input of position data will not result in successful corruption of VMS data.

From the VMS operator point of view, the necessary action to take is in specifying norms for VLD manufacture that build in sufficient safeguards against this type of tampering supported by the manufacturer’s guarantee. Furthermore, a security seal which restricts opening the VLD coupled with a regulation forbidding such action, will provide added assurance.

Table 9.1 VMS security concerns

Type of security infringement	Remedial action
Blocked antenna	interrupted service message; security seals on antenna connectors
Disconnection from power supply	interrupted service message; auxiliary power supply; security seal on power connectors
Physical removal	strict installation guidelines; security seals on installation
Duplication/cloning	manufacturing standard makes unique code unreadable
Input false position	manufacturing standard makes GPS interface invulnerable; security seal prevents equipment tampering

10. DATA FORMATS

Defining data formats is something like devising a filing system: ask a dozen people to design the most efficient way of arranging the categories and you will end up with a dozen different approaches. Defining data formats for VMS has an added level of complexity: several thousand vessels are already participating in VMS schemes, many of them based on priority data formats. Settling upon norms and standards in this area requires from everyone involved, a combination of technical rigor, flexibility and diplomacy.

The vast majority of current VMS systems are based on the Inmarsat-C system and the position data format used for these terminals is, in turn, based upon recommendations from the International Maritime Organization as part of its work related the SOLAS convention and the resulting GMDSS.

In addition, the data is bit-mapped, a process which attributes specific places in the message to specific data sets, thus keeping the size of the message to a minimum. The way that this works can be illustrated, for example, by the way we must communicate that the position in a given report is expressed in either north or south latitude and east or west longitude.

Taking a normal transmission of unspecified data, it would require at least five bits to express the letters N, S, E or W. If however, we predetermine that the information for which hemisphere latitude and longitude will be transmitted in two specific fields within the message, we require only one bit to distinguish between N and S and a second bit to distinguish between E and W. Other fields can be compressed in a similar way. The result is that bit mapped messages are much shorter than those expressed in free data, are better adapted to automated handling within a VMS system, and keep communications costs to a minimum.

Despite these advantages, it must be admitted that the position report format currently used by Inmarsat is not optimised for VMS as it uses a number of fields that are not relevant to VMS operation. It provides, for example, for macro-encoded messages to communicate parameters which require manual input.

However, despite the fact that this format, not having been developed with VMS in mind, is not specifically adapted to the application, it is only reasonable from the perspective of a VMS operator to include it as one of options for a system under development. This is because so many of the vessels currently participating in VMS are already programmed to transmit this format and that discarding the format would require that current VMS participants, and those carrying Inmarsat-C equipment that might be included in future VMS operations, would all have to be reprogrammed.

On the other hand, it would be a missed opportunity, at this early stage of VMS development, not to define a format optimised to provide the data to a VMS system. Furthermore, it is only prudent to establish a format that gives users some flexibility in the organization of the data. Such reports will be inherently longer, but far less restrictive and should therefore be acceptable to any users who, for one reason or another, find that the bit-mapped approaches are not yet compatible with their operations.

So it would seem that the solution is to qualify three formats as acceptable for VMS reporting and for all VMS operators to program their systems to accept reports in any of those three formats. In so limiting the variables, divergence of national authorities and from one another will be restricted and the stage set for convergence upon a single, world standard, format sometime in the future.

It would be both an egregious error and counter productive not to incorporate existing international standards where applicable. Those that find a natural place in our data formats are the ISO 8859.1 character set; ISO 3166 country codes; ISO 8601 representation of dates and times; and ISO 9735 EDIFACT syntax rules.

10.1 The Inmarsat Position Report

Inmarsat data reports are executed in a series of from one to three 15 byte packets. As is the case with all communications systems, the report begins with the header which is proprietary administrative data identifing the type of message, the sender and the addressee. For this reason the first packet has room for less user designated data and, because the first packet of the standard maritime data report ends with nearly three bytes set aside for a micro encoded message, speed and course data, when used, must be carried over to the second packet.

After the header of the first packet, 39 bits are set aside for position data, organized thus:

Table 10.1 Inmarsat position report, position only

Field	Expression	Data
Hemisphere	North or South	1 bit
Degrees of latitude	whole number 0 to 90	7 bits
Minutes	whole number 0 to 60	6 bits
Fraction of minute	multiples of 0.04	5 bits
Hemisphere	East or West	1 bit
Degrees of longitude	whole number 0 to 180	8 bits
Minutes	whole number 0 to 60	6 bits
Fraction of minute	multiples of 0.04	5 bits

The remainder of the first packet is taken up by the designation of a micro encoded message and its attribute, or variable. The second packet then begins, after its header, with speed and then course data thus:

Table 10.2 Inmarsat position report, course and speed addition

Field	Expression	Data
Speed	number with resolution of 0.2 knots	1 byte
Course	whole number 0 to 360	9 bits

Having added speed and course, there remains 8 bytes of user defined data that could be used to transmit, at no additional transmission charge, other data available on board, such a temperature, wind speed, humidity or water surface temperature.

10.2 Optimized VMS Position Report

On a field per field basis it is impossible to transmit position data more economically than is done within the Inmarsat maritime position report. It is, however, possible to remove extraneous data fields and thus to compress the report as a whole.

If, for example, we allow a full six bytes for header information -- six bits more than Inmarsat requires and likely to meet the needs of any future system -- a 15 byte packet can include all of the data fields, i.e. position, speed and course -- still allowing the necessary two bytes at the end for a check sum, or error correction algorithm.

Table 10.3 Recommended optimized VMS position report

Field	Expression	Data
Hemisphere	North or South	1 bit
Degrees of latitude	whole number 0 to 90	7 bits
Minutes	whole number 0 to 60	6 bits
Fraction of minute	multiples of 0.04	5 bits
Hemisphere	East or West	1 bit
Degrees of longitude	whole number 0 to 180	8 bits
Minutes	whole number 0 to 60	6 bits
Fraction of minute	multiples of 0.04	5 bits
Speed	number with resolution of 0.2 knots	8 bits
Course	whole number 0 to 360	9 bits

The result is that decoding is made simpler because once the header is identified by the receiving system, the active data follows, element by element, until its integrity is verified at the end using the check sum. A desirable byproduct of this approach is that transmission costs of a position report including speed and course are reduced by approximately 20% to 50%.

10.3 Extended Format Position Report

In an ideal world, all VMS position reports would be bit-mapped in an effort to optimize both economy and precision. Whilst such an approach must the be ultimate goal of VMS normalization, it is unrealistic to think that everyone will drop what he is doing and align existing practices to some externally proposed norm. The process will far more likely be one of convergence rather than sudden shifting.

For this reason, the VMS community requires, in addition to a rigorously plotted bit by bit approach, a more flexible report format with data expressed in clear characters with each set of data preceded by an indication of the content of the field. Data presented in such a way could easily and automatically be decoded and then entered into a VMS data base in that system's own, proprietary format.

In recognition of the fact that its member countries had all developed their own, individual preferences for storing data gathered about fishing vessels, the European Commission, as part of its Europe-wide pilot project, developed just such a format which can easily be extended and modified to meet the position requirements covered in the previous sections. Adopting a variant of this format has the advantage of making conformity with it a simple matter for the 13 European Union coastal states as well as those flag states who have vessels fishing in EU waters.

The fields required to compose a report are as follows:

Table 11.4 Extended position report format elements

Element	Code	Width (max characters)	Mandatory	Remarks
Start of record	SR		X	
Type of message	TM	3	X	POS for position; CAT for catch; PLL for poll
Internal number	IR	12	X or RC	VMS vessel ID
Radio call sign	RC	7	X or NA	for vessel ID
Vessel name	NA	40	X + FS	
Flag state	FS	3		mandatory with NA Alpha-3 ISO code
Time	TI	4	X	position UTC hhmm
Date	DA	6	X	position date yymmdd
Latitude	LA	5	X	degrees and minutes Nddmm or Sddmm
Longitude	LO	6	X	degrees and minutes Edddmm or Wdddmm
Speed	SP	3		knots and tenths kkt
Course	CO	3		degrees ddd
End or record	ER		X	

The actual composition of a report is constructed using a double slash (//) and code to indicate the beginning of a field with a single slash (/) separating the code from the data entry.

Expressed using these elements, a position report for an American vessel named Ishmael, reporting its position of 48 degrees 16 minutes North latitude, 33 degrees 51 minutes West longitude, steaming at 9.3 knots on a course of 271 degrees at 8:25 pm on 19 December 1998 would take the following form:

//SR//TM/POS//NA/ISHMAEL//FS/USA//TI/2025//DA/981219//LA/N4816//LO/W3351//SP/093//CO/271//ER

Though a far more substantial message in terms of size -- in ASCII data it works out to approximately 92 bytes or approximately three times the Inmarsat position report and six times the optimized VMS position report, it benefits from the advantages of flexibility and of universality. Even if the order of the elements is scrambled, the report is still easily decoded. It is also worth noting that, were VMS operators able to agree simply on the order of the elements, a certain economy could be realized by eliminating the code designation fields.

Furthermore, it is a simple matter to add new data sets by defining additional elements with the creation new two letter codes. This, as we shall see, makes the approach a useful one in defining an approach to catch reporting. The validity of this approach was apparent when the Norwegian Directorate of Fisheries, in the context of its VMS obligation toward the Northwest Atlantic Fisheries Organization (NAFO) extended the original EU approach to cover virtually all areas of communications with the vessels.

11. CATCH REPORTING

This entire area is fraught with difficulties, both political and technical. One of the political hurdles, is underlined by the fact that near real-time, electronic format catch information is considered, for several reasons, highly sensitive by fishermen. One reason for this sensitivity is the mirror image of what makes the perspective of electronic catch reporting so attractive for fisheries managers and protection officers: that their reports will be subject to a significantly higher degree of scrutiny

Another reason, more sympathetically received by the fisheries manager, is the fear that catch reports, particularly coupled with data on where the catch was caught, constitute commercially confidential information. The fisherman argues that he has, at the very least, a right to assurances that this data will not fall into the hands of his competitors.

Technical difficulties, on the other hand, exist primarily on the international level where there is no standard for the description of a catch in sufficient detail to satisfy the requirements of the fisheries manager. There exist, of course, international standards for the identification of fish species (the FAO three letter codes which are based on biological genus and species nomenclature), and for fishing gear (FAO two and three letter codes), but formats for complementary information such as the size of fish, the condition, storage method and even weight is often specified on either a local or an ad hoc basis.

The view here as to why there is such resistance to replacing the traditional paper catch reports submitted at a later date with a quasi real time electronic method is that the advantages are too one sided, weighted in favour of the government entity which receives the data. Were the fisherman to find his it to his advantage to participate in an electronic reporting scheme this resistance would most likely attenuate, and perhaps even disappear.

One approach capable of changing the equation would be a standard, multi-purpose, electronic logbook. This would give the fishing vessel captain the opportunity of entering catch data systematically and storing it on the disk of the computer connected to his VMS communications terminal. To be acceptable, this log would have to be an easily usable piece of software that would facilitate the entire process of record keeping aboard the vessel, automatically formatting the complex messages inherent in a catch report. Once such a program integrates itself into normal shipboard operations, the whole question of remote, real-time catch reporting is simplified.

Having entered catch data into a shipboard computer as part of daily routine, the ship's captain would then be capable, by selecting various subsets of the raw data that had been entered, to send advance reports of produce that will be for sale to the auction at which he intends to land; to a fish processor or agent to offer produce for sale or to confirm landing; or to the owner of his vessel. In addition to this functionality, the catch data would be available for transmission to the fisheries manager in a standard, catch report format and would remain available for on board interrogation in the case of a boarding or landing control by the relevant inspection authority.

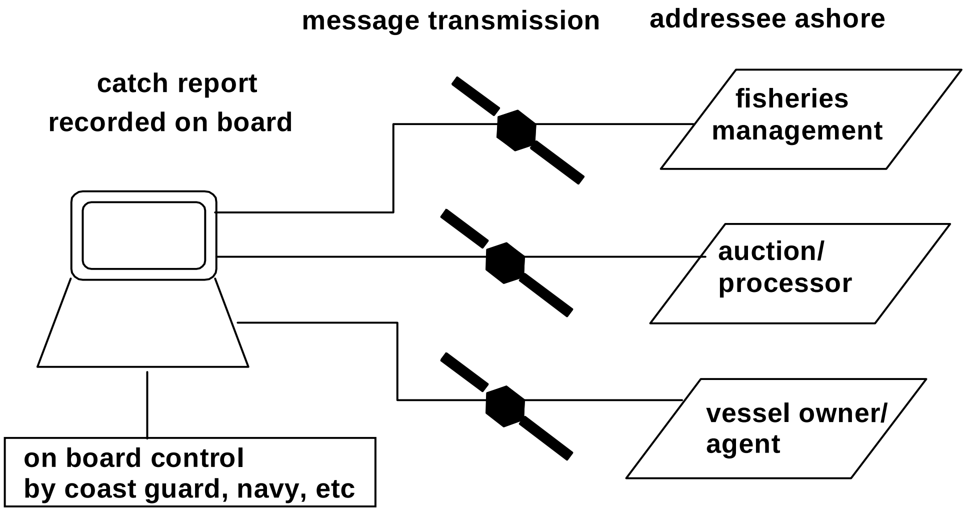

Figure 11.1 Operation of electronic logbook

By conceiving the electronic log as an integrated tool, the concept of catch reporting loses some of its political edge as far as the vessel operators are concerned. In order to achieve this, however, it is necessary to devise a set of common criteria to govern the data entry.

11.1 Electronic Log Data Fields

From a VMS point of view, it would appear that the following elements would meet requirements for an electronic long/catch reporting system:

Table 11.1 Electronic log catch report elements

Element	Code	Example	Source	Mandatory
Vessel ID		Name, Registration, radio call sign	as position report	X
Catch item	CI	cod, herring	FAO species code	X
Weight	KG	kilograms		X or
Weight	LB	pounds		X or
Weight	ST	stone		X
Size of fish	SZ	sole 1 through 5	local standard	
Fishing gear	GE	purse seine, bottom trawl, long line	FAO alpha code[1]	X
Fishing grounds	FG	VIIIbc or latitude and longitude	Regional (ICES) code or FAO grid[2] or HddHddd	X
Preservation	CM	fresh, salted, iced	two digit list	
Delivery	DM	boxes, bulk, storage nets	two digit list	
Condition	CN	gutted, head off, head on	three digit list	
Quality	QX	Extra, A, B	local standard	

11.1.1 Non mandatory data fields

There appear to be no standards for expressing the non-mandatory fields, i.e.preservation methods, delivery methods, condition, size or quality of fish, these being principally a function of local practice. Probably the neatest way of dealing with this is by creating simple tables and assigning a numerical value to each. The following are (non-exhaustive) suggestions for preservation methods, delivery methods and condition.

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[1] see Appendix 4
[2] see Appendix 5

Table 11.2 Preservation Methods

code	Preservation method
0	unspecified
1	fresh/unpreserved
2	frozen
3	iced
4	salted
5	refrigerated sea water
6	sugar cured
7	fresh, boiled in sea water
8	fresh, boiled in salted water
9	dried
10	dried and salted
11	smoked
12	marinated
13	hard salted

Table 11.3 Delivery Methods

Code	Method of delivery
1	storage nets
2	in bulk
3	in tank
4	in boxes/barrels
5	packed for consumption
6	wrapped

Table 11.4 Fish Processing Methods

Code	Processing of fish
100	alive
110	whole/round
111	round, head off
210	gutted, head on
211	gutted, head off
212	gutted, head and collar bone off
213	gutted, head and tail off
310	bellycut
320	sliced
340	peeled
410	split

Because of their specificity, it is possible to deal with delivery and preservation methods with a simple number code. In the case of processing methods, however, there are variations on a number of basic methods. For this reason a three-digit numbering scheme which permits the use of sub-categories is preferable.

11.2 Electronic Log Message Format

There are too many variables not based on standard descriptions to propose a bit mapped format for this message. For this reason, the best place to start will be with a modification of the extended message format elaborated in section 10.3 Because of the possibilities of variables, and because many vessels will be reporting several species per report, catches will be reported in two possible formats, the first with simple expressions of species and quantities.

The format here will use a header identical to that of the position report, followed by a catch item field in which species are followed by their relevant quantity, alternating species and quantity, each element separated by a space until exhausted, followed by fishing gear and fishing grounds. Using this approach, a Belgian vessel named Ostende that had caught 512 kilogrammes of cod, 86 of turbot and 1153 of plaice using beam trawl in ICES zone VIId would file the following report at 11:50 am on 6 June 1997:

//SR//TM/CAT//NA/OESTENDE//FS/BEL//TI/1150//DA/970606//CI/COD 512 TUB 86 PLA 1153//FG/VIID//GE/BT//ER

Such a report would normally be sufficient for fisheries management purposes, but lacks enough specific data about the catch to be very useful on the commercial side of fisheries. Formatting a message which includes information about the preservation method, delivery method and condition of the fish is inherently more complex. The principle is that information specific to a catch item follows that item directly so that the format for catch items reads:

CI/species[space]quantity//CN/designator//CM/designator//DM/designator

This series repeating itself until the catch items are exhausted and then followed by fishing grounds and gear. In this context, a vessel with an internal register number of ZYZ16845 operating near 66 degrees North latitude and 37 degrees West longitude which was reporting a catch of 462 kilogrammes of saithe, gutted with head off to be delivered iced in boxes, and 891 of sole, gutted with head on to be delivered fresh in boxes, both species caught by unspecified trawl, would file the following report:

//SR//TM//CAT//RC/ZYZ16845//TI/0325//DA/971108CI/SAI
462//CN/211//CM/3//DM/4//CI/SOL
891//CN/210/CM/1//DM/4//FG/N66W037//GE/TX//ER

Several points should be noted about these reports. The first is that manual formatting of them aboard a vessel would be a most unreliable process. For this reason, they should be seen as the output of the electronic log software. The second is that the reports are too long, with too many variables, to be dealt with in just a few data packets, as are position reports.

This means that transmission costs will be significantly higher than position reports but can be reduced by the use of data compression. Furthermore, once the format is adopted and the order of elements formalized, it is a small step to move to a bit-mapped format where communications costs could be minimized. In addition, catch reports are filed with far less frequency than position reports.

12. POLLING

Polling a VLD is the capability of remotely controlling it to some degree. This is a valuable tool in fisheries management as it permits the VMS operator to vary the frequency of his position information as a function of the behaviour and whereabouts of a vessel. Whilst in port, for example, the position of a vessel is useful only to confirm that it is still in port. This can be accomplished with a single, daily report. During operation in fishing grounds or, particularly, near sensitive areas, the VMS operator will require much higher frequency data.

In the world of open systems, this means downloading a unique identifier directly into the VLD so that the equipment will recognize that a polling command is being received from an authorized entity. When it receives a correctly formatted command packet which a header including an authorized polling identifier as well as its own identity, it obeys the command which follows.

In the case of a closed system, the process is somewhat simpler. The service provider offers the qualified user a menu of possibilities to be executed from the system base station and, having identified that user, normally through a system of passwords or callback, provides the service or services requested from the menu.

The basic commands required for VMS are to begin reporting, to report position immediately, to modify the reporting frequency or to stop reporting. A number of more advanced commands, relating to micro encoded messages and, perhaps, data gathered from on board sensors, could also be envisaged, but they fall outside our current terms of reference.

It is also beyond our terms of reference to establish formats or methods for establishing control over a terminal, either directly (open system) or through the base station of a closed system. The reason is that such a operation strikes at the very heart of system security. Were an unauthorized entity able to establish control over a VLD, one could imagine that a vessel's direct competitor could observe its movements and use that information to poach on the fishing grounds of the first vessel. The service provider would be held legally responsible were that to happen.

From a point of view of normalization the objective is to establish a set of generic commands for the basic kinds of poll which will be recognized by any service provider, once the issuer of the command has gone through an identification process. Currently, with only three systems on offer, this is not a pressing problem.

A number of fisheries management organizations, particularly in the context of the European Union pilot project, have developed systems that can deal separately with all three systems. The real problem will develop in the next few years, when there may be several times that many systems. For this reason, it is useful to establish some recommended guidelines for polling commands.

In an effort to be as unintrusive as possible as far as current practice is concerned, the actual identifier for these commands will be derived from the existing Inmarsat designations. The reasoning behind this is that these designations are already used for several thousand fishing vessels and it is important to avoid putting the integrity of that operation in jeopardy by developing an approach that would require mass reprogramming. Furthermore, for the two existing closed systems, adding these designations to their list of commands is a relatively straightforward, mostly centralized process.

Table 12.1 Polling codes

Command	Code	Extension
Initiate position reporting	**05h**	reporting interval expressed as hhmm where the maximum value is 2400 and the minimum value is 0015
Report position immediately	**04h**	
Program reporting interval	**04h**	new interval expressed as hhmm where the maximum value is 2400 and the minimum value is 0015
Stop position reporting	**06h**	

In this scheme, the only difference between a command to report immediately and to program the reporting interval is the extension which defines that interval. Upon reception of a 04h command without extension, a VLD which is already programmed to report hourly, will immediately report its position and set the mechanism which times its reports to zero, thus once again reporting hourly counting from the time of the command.

A 04h command with extension functions in the same way, but with the extension defining the interval from the time the polling command is received. Using our extended message format, the command to reprogram the reporting of a terminal to intervals of three hours and 45 minutes would take the following form:

//SR//PLL//04H/0345//ER

A command to stop position reporting would be expressed thus:

//SR//PLL//06H//ER

These commands have the advantage of being short and simple, but they can only be recognized when issued after the VMS system has negotiated the system's proprietary access protocol.

13. DATA EXCHANGE BETWEEN VMS OPERATORS

As VMS systems are introduced, there will be increasing exchanges of data between operators, particularly in terms of position data. For security purposes, it is essential that data transmission services that provide positive identification of both sender and receiver are used. This is most easily accomplished by relying upon X.25 and X.400 services. In the future, even voice band data over standard or ISDN telephone lines will provide suitable security when the telephony service provider transmits the telephone number of the calling party.

Regarding formats, there is no reason to vary from those used for transmission from vessel to VMS operations. As long as VMS stations are programmed to receive all three formats, the data can be transmitted just as received. Because the system used for transmission includes its own protocol to identify the sending party, no modifications need be necessary. The only imperative is that each VMS incorporate a security module which makes impossible reception of data from an unidentifiable source.

14. VMS IN DEVELOPING COUNTRIES

It is an unpleasant fact of life that in developing countries, where VMS could offer fisheries managers a tool of considerable value, the economic and telecommunications infrastructure make its implementation difficult.

The difficulty, in fact, boils down to three specific issues: assuring that the necessary hardware is installed and operational aboard each vessel; obtaining a base station capable of receiving, storing and manipulating the received data; and gaining access to telecommunications of sufficient performance to be able to receive the data and command and interrogate the VLDs. What is more, it is essential that these elements be supplied at a cost level that is acceptable in the developing world.

14.1 Shipboard Equipment

One would hope that a movement toward normalization of VLDs would be the key step in solving the first problem. Currently, it is difficult, from the perspective of a developing country, to judge the quality or performance of a ship's VLD. In a context where there is broad agreement upon the norms that VLDs should meet, officials in the developing countries need only verify that the shipboard equipment corresponds to one of those models certified as meeting the standards.

The question of cost of the VLD is not an issue. The most difficult management task facing developing countries is that of monitoring foreign vessels that fish in their waters under license. Access to the fishing grounds of the developing world is such a precious commodity that in the vast majority of cases it is a simple matter to require fitting of a certified VLD as a condition of that access.

14.2 VMS Base Station

Fisheries management authorities in developed countries are planning and implementing base stations offering increasingly high performance for VMS purposes, including software modules that provide data manipulation facilities that verge on an “artificial intelligence” capability for determining which vessels under monitoring are most likely operating illegally. This is a measure of just how seriously those countries take the potential of VMS in managing their fisheries, but it does not mean that VMS requires this level of sophistication to be a valuable fisheries management tool.

Indeed, a simple PC with a program capable of entering vessel position data in data base, displaying that data on a chart of the waters under management, and manipulating the data in terms of the parameters entered (i.e. position and time as a minimum with optional course and speed), will meet the reasonable needs of most developing countries. Such equipment and software is currently available for less than $US 5000, a moderate amount in the context of any viable fisheries management program.

14.3 Telecommunications Access

By far the greatest of the problems facing developing countries is an extension of their own telecommunications networks and the access that they give to the international services. Until recently this has meant that data reception and VLD control almost always had to be carried out over dedicated satellite links. It is no surprise that this required a high initial level of investment -- often unacceptably high -- and well as significant continuing communications costs.

Developing countries are quickly getting access to the Internet and this will be a great asset. A quick, informal survey shows that upwards of two-thirds of African countries already have Internet access from their capital cities. A number of international organizations are, in addition, executing programs to extend this access. The American non-governmental organization AID, for example, is in the process of implementing a network of 28 V-Sat (fixed point satellite communications) hubs specifically to increase Internet availability in Africa.

A VMS system based on Internet connections will not provide the same performance as one using direct, duplex links. Nonetheless, delivery times over Internet are often accomplished in a matter of minutes, and very frequently within tolerance that would make VMS data received a valuable asset in fisheries management.

It is also worth noting that, given its current world wide success, one can expect that the performance of the Internet will only improve with time. Furthermore this improvement will take place in parallel with the development of the local and international telecommunications available in developing countries. The message is that VMS is a tool that can be put to immediate and practical use in developing countries' fisheries management operations.

15. EVALUATING THE COST/BENEFIT OF VMS

It is not possible to produce a definitive cost benefit study for all potential VMS implementations. The circumstances may vary substantially for particular fisheries. There are many issues which will have an effect on cost benefit, including:

- economic status of the fishery;
- ecological health of the fishery;
- geographical nature of the fishery;
- type of fishing conducted;
- quantity and size of fishing vessels;
- availability and cost of other forms of MCS;
- nature of management arrangements; and
- capabilities and cost of fisheries MCS personnel.

It is possible to take a broad view of the cost benefit of VMS and suggest an approach and some arguments for a cost benefit evaluation. The key question which must be addressed is what constitutes effective management and MCS for a fishery. Having answered this question it is then possible to evaluate whether effective management is being achieved. In the global scenario, the evidence of falling wild fish catch and the failure of major fisheries would suggest that effective management is not being achieved in many cases.

It can be argued that effective management is not possible unless outputs are quantifiable and measurable. In fisheries management terms this means measuring the quantity of fish being caught and identifying the place where the fish are caught. VMS has no solution to the former although it can be used as a means of communicating relevant information. VMS clearly makes it possible to improve the data in relation to the location of fish catches. Catch location and size has largely been provided by vessel operators in the past and has been notoriously unreliable. The single biggest factor which has allowed unscrupulous operators to provide false information and avoid compliance with management measures has been that fishing activity takes place out of view of the management agency or anyone other than the vessel crew. VMS provides relatively reliable and accurate information on the location of vessels and, with a reasonable degree of probability, where fishing activity takes place. VMS is the first practical means of collecting and using such information about all vessels, in the history of fisheries management.

VMS is not the only means to effective management, it is one of several MCS measures and must be used in conjunction with other MCS measures for itself to be effective. A mix of MCS measures will probably be the most appropriate and effective means of achieving effective management.

Some comparison may need to be made against other types of monitoring. One approach to this is to estimate the cost of each type of monitoring against achieving the previously established effective management standard. Types of monitoring that are available include vessel, aircraft, on board observers or VMS. Comparing these different types of monitoring is not comparing like with like since each will have differing monitoring capabilities and levels of effectiveness. The cost of each in meeting all of the requirements can be estimated. The costs and capabilities can then be evaluated against all of the MCS requirements. If effective management has, as one of its MCS requirements, universal monitoring of all vessels in the fishery at all times VMS will have a significant cost advantage as the cost of patrol craft and observers will be very high. However, the degree to which unlicensed vessels (i.e. non-VMS participants) are a factor will have a commensurate effect on the applicability of VMS. Universal use of VMS is highly desirable in terms of the effectiveness of VMS.

The value of the fishery in economic, social and ecological terms should determine how much funding should be available but in reality the level of funding will mostly be determined by political factors. Obtaining the best return on the MCS dollar is critical in a limited funding situation. VMS is highly attractive in this situation particularly if some form of cost recovery can be used to at least cover the cost of the equipment used on board vessels. VMS is attractive because of its low cost. It is possible to set up a monitoring station and establish a VMS system for as little as $US50,000 plus staffing costs. Per vessel costs of $US5,000 for establishment and less than $US1,000 per annum for ongoing costs are also possible.

Another potential argument for the cost benefit of VMS is that through its complete coverage of all vessels in a fishery it will provide more information on the status of MCS effectiveness and also make possible changes in fisheries management rules which may not have been prudent or practical previously. For example, it may be possible to extend fishing seasons or reduce area closures. This could add to the sustainable economic returns from the fishery.

Increasingly, states are making authorisations to fish in waters under their national jurisdiction and on the high seas conditional on the vessel being fitted with VMS and reporting to a monitoring station. Coastal states which apply these measures to national and foreign fishing vessels licensed to fish in their EEZs, can monitor the activities of such vessels very effectively and economically, thereby increasing the effectiveness of their MCS. On the other hand, flag states which take such measures for vessels authorised to fish on the high seas, can ensure that such vessels do not violate the jurisdictions of coastal states. The establishment of VMS is the most effective means of an administration exercising its responsibilities as a flag state in respect of monitoring its fishing vessels. These responsibilities have been laid down in various international fisheries agreements and the extent to which VMS can assist in implementing these agreements is dealt with in Appendix 1.

These guidelines have concentrated on the merits of VMS for fisheries administration and management. Nevertheless, the shipboard equipment used in VMS is generally satellite communications equipment and the advantages of the improved reliability of this new system of communication to the crew in terms of safety (GMDSS) and general information should not be underestimated. The evidence of the importance of this development to the fishing industry is the fact that in 1996, 2,000 fishing vessels were fitted with satellite communications systems - by 1998 this figure had increased to nearly 7,500 fishing vessels. This exponential increase in the number of fishing vessels fitted with satellite communications equipment will mean that most large fishing vessels will be fitted with the shipboard equipment required to report to a VMS within the next few years. It is important that these communications systems are seen in their wider context of their importance to the fishing industry, particularly in increasing safety at sea and increasing the reliability of communication between ship and shore. VMS is only one of the benefits that this emerging technology will have on the fishing industry and on fisheries management and administration.

APPENDIX 1

USE OF VMS IN THE APPLICATION OF INTERNATIONAL FISHERIES AGREEMENTS

1. RELATED CONVENTIONS

1.1 The United Nations Convention on the Law of the Sea (UNCLOS)

UNCLOS is the principal body of law which governs the international use of the seas and oceans. Through UNCLOS, nations have been able to claim exclusive use of resources, including fish stocks, within an Economic Exclusion Zone (EEZ) up to 200 nautical miles from their coastal base line. MCS of EEZs is a major problem for nations as they attempt to ensure that they maintain sovereignty and derive appropriate benefits from their EEZ. For many small island nations the fish resources with their EEZs are the major source of national income. VMS has the potential to protect that income through contributing to increased effectiveness of the MCS programme.

Following the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks in 1995, an Agreement for the implementation of the provisions of UNCLOS relating to the conservation and management of straddling fish stocks and highly migratory fish stocks was opened for signature by nations. This Agreement extends UNCLOS by more specifically defining how fish stocks which straddle EEZ boundaries, or which migrate through EEZs, are to be managed with the aim of conserving those fish stocks while allowing sustainable use of them.

The Agreement (hereafter referred to as the United Nations Fish Stocks Agreement or UNA) has not yet been ratified or acceded to by the 30 nations required to give it binding legal status. However, it is important for the consideration of VMS since it clearly contains a number of provisions that are directly related to the future use of VMS.

1.1.1 Relevant Articles of the UNA

Some of the relevant articles and comments as to their relevance to VMS follow.

Article 5 General principles

In order to conserve and manage straddling fish stocks and highly migratory fish stocks, coastal States and States fishing on the high seas shall, in giving effect to their duty to cooperate in accordance with the Convention:

(j) *collect and share in a timely manner, complete and accurate data concerning fishing activities on, inter alia, vessel position, catch of target and non-target*

species and fishing effort, as set out in Annex I, as well as information from national and international research programmes;

(k) *promote and conduct scientific research and develop appropriate technologies in support of fishery conservation and management; and*

(l) *implement and enforce conservation and management measures through effective monitoring, control and surveillance*

.

Comment:

Timely exchange of vessel position data as required by 5 (j), is an important component of an effective global VMS. Technology is clearly seen as a management tool. Nations are required to implement effective MCS and it can be argued that VMS is a primary vehicle for achieving this.

Article 10 Functions of subregional and regional fisheries management organizations and arrangements

In fulfilling their obligation to cooperate through subregional or regional fisheries management organizations or arrangements, States shall:

(e) *agree on standards for collection, reporting, verification and exchange of data on fisheries for the stocks;*

(h) *establish appropriate cooperative mechanisms for effective monitoring, control, surveillance and enforcement;*

Comment:

While 6 (e) may primarily refer to catch data, VMS is a vehicle for the collection of that data. In addition, VMS position data provides a high degree of verification for catch data in terms of location. Again in subregional or regional organizations VMS has a role in providing effective MCS.

Article 14 Collection and provision of information and cooperation in scientific research

States shall ensure that fishing vessels flying their flag provide such information as may be necessary in order to fulfil their obligations under this Agreement. To this end, States shall in accordance with Annex I.

(a) *collect and exchange scientific, technical and statistical data with respect to fisheries for straddling fish stocks and highly migratory fish stocks;*

(b) *ensure that data are collected in sufficient detail to facilitate effective stock assessment and are provided in a timely manner to fulfil the requirements of subregional or regional fisheries management organizations or arrangements; and*

(c) *take appropriate measures to verify the accuracy of such data.*

Comment:

Again, while Article 14 primarily refers to catch data, VMS is a vehicle for the collection of that data particularly in terms of timely collection and as a means of verifying catch location. In this context VMS has a quality assurance role. Further support for this occurs in Annex 1 of the agreement.

Article 18 Duties of the flag State

1. A State whose vessels fish on the high seas shall take such measures as may be necessary to ensure that vessels flying its flag comply with subregional and regional conservation and management measures and that such vessels do not engage in any activity which undermines the effectiveness of such measures.

2. A State shall authorize the use of vessels flying its flag for fishing on the high seas only where it is able to exercise effectively its responsibilities in respect of such vessels under the Convention and this Agreement.

3. Measures to be taken by a State in respect of vessels flying its flag shall include:

(e) requirements for recording and timely reporting of vessel position, catch of target and non-target species, fishing effort and other relevant fisheries data in accordance with subregional, regional and global standards for the collection of such data;

(g) monitoring, control and surveillance of such vessels, their fishing operations and related activities by, inter alia:

(iii) the development and implementation of vessel monitoring systems, including, as appropriate, satellite transmitter systems, in accordance with any national programmes and those which have been subregionally, regionally or globally agreed among the States concerned;

Comment:

This is the strongest article in the Agreement in terms of support for the use of VMS. It explicitly requires flag States to implement VMS as a means of controlling vessels flying their flag. It also defines the nature of the VMS as being compatible with subregional, regional or globally agreed management measures among the States involved.

This article presents a particularly strong case for VMS to a flag State. VMS may be the only effective means within the budget of many States of monitoring their vessels and hence of satisfying the requirements set out in paragraph 1 and 2 above. Many small and/or developing States will have vessels ranging far from their EEZ. In some cases the vessel may never come to port in the flag State. VMS will enable such States to be informed of the activities of their vessels and to inform coastal States, and subregional and regional organisations of vessel activities relevant to those coastal states or organisations in accordance with their responsibilities under other articles such as 5 (j).

VMS will not by itself enable a flag State to meet its obligations under article 18. As mentioned above, there are scenarios where a vessel does call at port in the flag State and where vessels are fishing at considerable distance from the flag State. While VMS will provide information on those vessels' activities some other more direct investigative or enforcement action will need to be taken. Articles 19, 20, 21, 22 and 23 of the Agreement provide for a variety of compliance and enforcement measures which may be carried out on the high seas or in subregional or regional areas by both the flag State and other States.

Article 25 Forms of cooperation with developing States

3. Such assistance shall, inter alia, be directed specifically towards:

(c) monitoring, control, surveillance, compliance and enforcement, including training and capacity-building at the local level, development and funding of national and regional observer programmes and access to technology and equipment.

Comment:

Article 24 recognises the needs of developing States in terms of the importance of fisheries to those States and their limited capacity to take disproportionate responsibility for conservation and management. Article 25 identifies forms of cooperation with the developing states. Included among the forms of cooperation is in MCS and specifically in relation to technology and equipment. VMS is an area where technological assistance and equipment provision can usefully be supplied for the benefit of the developing States.

STANDARD REQUIREMENTS FOR THE COLLECTION AND SHARING OF DATA

Article 1 General Principles

The timely collection, compilation and analysis of data are fundamental to the effective conservation and management of straddling fish stocks and highly migratory fish stocks…. All data should be verified to ensure accuracy. ….

Article 2 Principles of data collection, compilation and exchange

(b) States should ensure that fishery data are verified through an appropriate system

(c) States should compile fishery-related and other supporting scientific data and provide them in an agreed format and timely manner to the relevant subregional or regional fisheries management organization or arrangement where one exists. Otherwise, States should cooperate to exchange data either directly or through such other cooperative mechanisms as may be agreed among them;

Comment:

VMS is a vehicle for the collection of fishery data particularly in terms of timely collection and as a means of verifying catch location. In this context VMS has a quality assurance role.

Article 5 Reporting

A State shall ensure that vessels flying its flag send to its national fisheries administration and, where agreed, to the relevant subregional or regional fisheries management organization or arrangement, logbook data on catch and effort, including data on fishing operations on the high seas, at sufficiently frequent intervals to meet national requirements and regional and international obligations. Such data shall be transmitted, where necessary, by radio, telex, facsimile or satellite transmission or by other means.

Comment:

Satellite transmission from vessels such as is available via a VMS is specifically recognised as a vehicle for the collection of fishing data.

Article 6 (Data verification)

States or, as appropriate, subregional or regional fisheries management organizations or arrangements should establish mechanisms for verifying fishery data, such as:

(a)   position verification through vessel monitoring systems;

Comment:

The role of VMS as a means of assuring data quality is specifically recognised.

1.1.2 Consequences of the UNA

While the UNA has not yet attained binding status it does provide an insight into the future of VMS on a global basis. UNCLOS and the UNA provide a strong basis for cooperation in fisheries management and conservation via subregional and regional management arrangements. The UNA provides obligations in relation to such management arrangements where VMS plays a significant role. The UNA, either directly or through implication, identifies a role for VMS in MCS and as a means of assuring the quality of catch and effort data. VMS in conjunction with the UNA's compliance and enforcement measures, may represent the only cost effective means of flag States meeting their obligations in ensuring that their vessels do not contravene subregional and regional conservation and management measures.

The UNA foreshadows the use of compatible VMS and the exchange of data between flag States and coastal States or subregional or regional management organisations. There are already examples of how this may work in practice. In the European Union, member States have agreed to implement a national VMS in each state and apply the VMS to most vessels over 24 metres in length. Vessels are to report positions to both flag and coastal States although it not clear how this is to be achieved.

In the Pacific, a subregional organisation, the South Pacific Forum has commenced development of a VMS through its Forum Fisheries Agency (FFA). The small developing island member States will be served by a distributed VMS. Vessels operating in the EEZs of all member States will report to a centralised VMS hub from which appropriate position reports and incident alerts will be sent to relevant national monitoring centres. The VMS hub will automatically notify the national monitoring centre of the appropriate coastal State when a vessel moves into that State's EEZ from an adjoining member State's EEZ.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has called for the voluntary use of VMS by member states as a trial for assessing the effectiveness of monitoring vessel activities in the geographically remote Antarctic area. The USA, South Africa, New Zealand and Australia have agreed to monitor vessels of their flag fishing in the CCAMLR area during the 1997 fishing year. A significant issue in this trial will be the ability of the flag states to effectively control their vessels at such remote localities.

Further similar developments to those planned in the European Union, the FFA and CCAMLR are envisaged as subregional and regional organisations develop their fisheries management arrangements and the UNA comes into force.

1.2 FAO Compliance Agreement

The Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the FAO Compliance Agreement) is an agreement within the framework of the Food and Agriculture Organisation of the United Nations (FAO) and is an integral part of the International Code of Conduct for Responsible Fisheries.

The FAO Compliance Agreement does not specifically refer to VMS but does contain some requirements which are relevant.

1.2.1 Relevant Articles of the FAO Compliance Agreement

Article III FLAG STATE RESPONSIBILITY

(a) Each Party shall take such measures as may be necessary to ensure that fishing vessels entitled to fly its flag do not engage in any activity that undermines the effectiveness of international conservation and management measures.

3. No Party shall authorize any fishing vessel entitled to fly its flag to be used for fishing on the high seas unless the Party is satisfied that it is able, taking into account the links that exist between it and the fishing vessel concerned, to exercise effectively its responsibilities under this Agreement in respect of that fishing vessel.

7. Each Party shall ensure that each fishing vessel entitled to fly its flag shall provide it with such information on its operations as may be necessary to enable the Party to fulfil its obligations under this Agreement, including in particular information pertaining to the area of its fishing operations and to its catches and landings.

Comment:

Similar to the UNA, the FAO Compliance Agreement requires flag states to exercise responsibility for the activities of their fishing vessels. This extends, in paragraph 3, to a requirement to provide information on vessel operations, particularly relating to where a vessel conducts fishing operations. VMS is arguably the most reliable method of providing the required vessel operation information and enabling the flag state to effectively exercise any control over the vessel.

Article V INTERNATIONAL COOPERATION

1. The Parties shall cooperate as appropriate in the implementation of this Agreement, and shall, in particular, exchange information, including evidentiary material, relating to activities of fishing vessels in order to assist the flag State in identifying those fishing vessels flying its flag reported to have engaged in activities undermining international conservation and management measures, so as to fulfil its obligations under Article III.

Comment:

This section requires parties to the agreement to exchange information, particularly evidentiary material relating to the activities of fishing vessels. VMS information is undoubtedly evidentiary material relating to the activities of fishing vessels. For example, it could identify a vessel which may be fishing in a particular EEZ or high seas fishing zone.

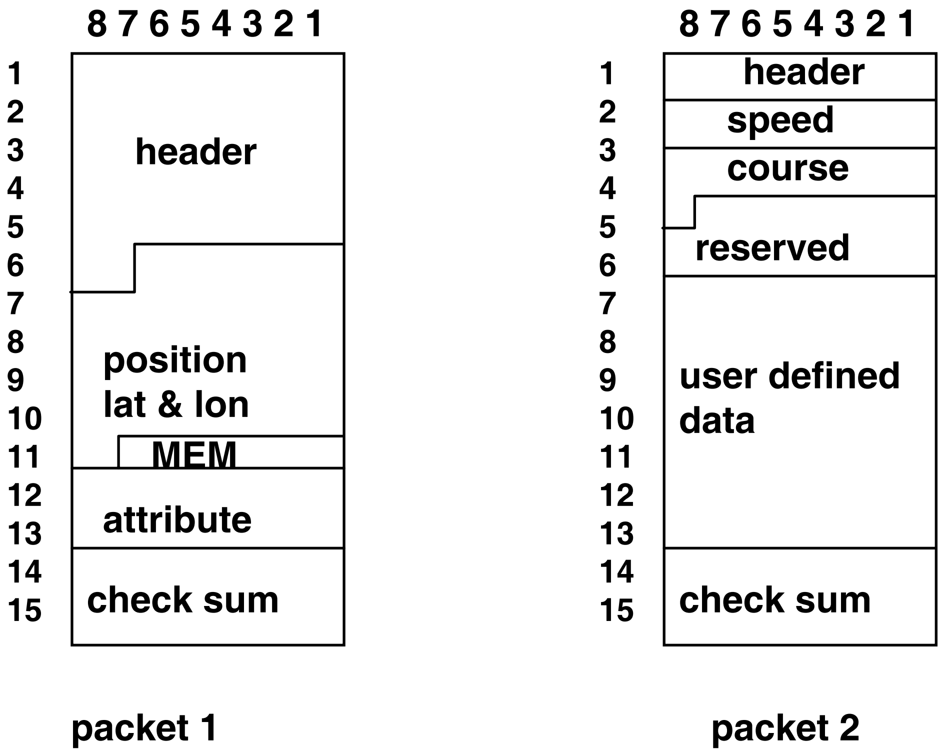
While the text of this paragraph makes exchange of information a requirement in relation to vessels which have been suspected of, or “reported” to be engaged in activities undermining management measures, exchange of VMS information to establish the suspicion would still seem to be a reasonable obligation under this paragraph in view of the overall intention of the FAO Compliance Agreement in preventing activities which undermine conservation and management measures.

1.2.2 Consequences of the FAO Compliance Agreement

The FAO Compliance Agreement has similar implications for the use of VMS as the UNA. VMS would enable parties to the agreement to meet their obligations as a flag state in monitoring the activities of their vessels on the high seas and exchanging VMS information with coastal states, subregional or regional organisations to establish a breach of conservation and management measures. Again similar to the UNA, there are other requirements in the FAO Compliance Agreement which suggest cooperation between flag and port states to effectively take compliance action against vessels.

APPENDIX 2

INMARSAT MARITIME POSITION REPORT

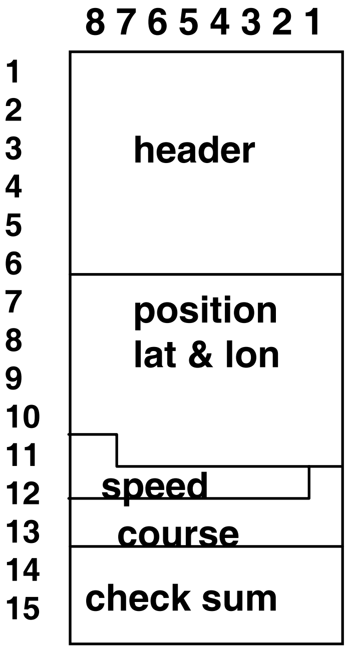


INMARSAT Maritime Positon Report

The Inmarsat Maritime position report uses bit mapping to make optimal use of space within the format of its 15 byte data report packets. Because provision is made for a micro encoded message and its variable (attribute) in the first packet, the addition of speed and course requires a second packet.

APPENDIX 3

OPTIMISED VMS POSITION REPORT FORMAT



Optimized VMS position report format

By removing the micro encoded message from the Inmarsat maritime position report, it is possible to include all of the necessary elements for a complete position report, including speed and course, in a single, 15 byte packet.

APPENDIX 4

INTERNATIONAL STANDARD STATISTICAL CLASSIFICATION OF FISHING GEAR (ISSCFG)

Gear Categories	Standard Abbreviations
SURROUNDING NETS	
With purse lines	PS
- one boat operated purse seines	PS1
- two boat operated purse seines	PS2
Without purse seines	LA
SEINE NETS	
Beach Seines	SB
- boat or vessel seines	SV
- Danish seines	SDN
- Scottish seines	SSC
- pair seines	SPR
Seine nets (not specified)	SX
TRAWLS	
Bottom trawls	
- beam trawls	TBB
- otter trawls[1]	OTB
- pair trawls	PTB
- nephrops trawls	TBN
- shrimp trawls	TBS
- bottom trawls (not specified)	TB
Midwater trawls	
- otter trawls[1]	OTM
- pair trawls	PTM
- shrimp trawls	TMS
- Midwater trawls (not specified)	TM
Otter twin trawls	OTT
Otter trawls (not specified)	OT
Pair trawls (not specified)	PT
Other trawls	TX

[1] Fisheries agencies may indicate side and stern bottom, and side and stern midwater trawls as OTB-1 and OTB-2 and OTM-1 and OTM-2, respectively.
1

Gear Categories	Standard Abbreviations
DREDGES	
Boat dredges	DRB
Hand dredges	DRH
LIFT NETS	
Portable lift nets	LNP
Boat-operated lift nets	LNB
Shore-operated lift nets	LNS
Lift nets (not specified)	LN
FALLING GEAR	
Cast nets	FCN
Falling Gear (not specified)	FG
GILLNETS AND ENTANGLING NETS	
Set gillnets (anchored)	GNS
Driftnets	GND
Encircling gillnets	GNC
Fixed gillnets (on stakes)	GNF
Trammel nets	GTR
Combined gillnets-trammel nets	GTN
Gillnets and entangling nets	GEN
Gillnets (not specified)	GN
TRAPS	
Stationary uncovered pound nets	FPN
Pots	FPO
Fyke nets	FYK
Stow nets	FSN
Barriers, fences, weirs etc.	FWR
Aerial Traps	FAR
Traps (not specified)	FIX
HOOKS AND LINES	
Handlines and pole-lines (hand operated)[1]	LHP
Handlines and pole-lines (mechanised)[1]	LHM
Set longlines	LLS
Drifting longlines	LLD
Longlines (not specified)	LL

[1] Including jigging lines

Gear Categories	Standard Abbreviations
Trolling lines	LTL
Hooks and lines (not specified)[1]	LX
GRAPPLING AND WOUNDING	
Harpoons	HAR
HARVESTING MACHINES	
Pumps	HMP
Mechanised dredges	HMD
Harvesting machines (not specified)	HMX
MISCELLANEOUS GEAR[2]	MIS
RECREATIONAL FISHING GEAR	RG
GEAR NOT KNOWN OR SPECIFIED	NK

[1] Code LDV for dory operated line gears will be maintained for historical purposes
[2] This item includes: hand and landing nets, drive in nets, gathering by hand with simple hand implements with or without diving equipment, poisons and explosives, trained animals, electrical fishing.

APPENDIX 5

THE FAO GEOGRAPHICAL GRID

The FAO geographical grid is a global standard for position reporting commonly used by distant water tuna vessels. It can, however, be used to report the fishing grounds in which any vessel is operating. The grid is based upon the format SQTTGGG where:

- S is the grid size (e.g. 5 for 1 degree * 1 degree),

- Q is one of four quadrants which meet at 0 latitude and 0 longitude (e.g. 1 is Northeast of this),

- TT is the latitude (2 digits) and

- GGG the longitude (3 digits) of the corner of the grid closest to 0 latitude and 0 longitude.

Vessel monitoring systems (VMS) have greatly increased the potential efficiency of monitoring control and surveillance of fishing vessels (MCS). In the last few years several countries have introduced VMS which make it possible to monitor the activities of fishing vessels and enable such vessels to report on catches to the fisheries management authority. This document summarizes the state of the art of VMS and gives guidance to fisheries administrators considering implementing VMS in their fisheries management systems and to all other personnel involved in fisheries MCS. VMS is a particularly effective tool for some developing countries that lack the financial and physical resources to support an effective conventional MCS capability. The publication discusses the cost of setting up and operating a national VMS system. For those countries that already have conventional MCS measures, VMS will make them more effective and possibly less costly. Attention is drawn to the need for recommendations on common data exchange formats and protocols which may eventually be adopted as international standards in VMS and in catch reporting. The future role of VMS in the implementation of the United Nations fish stocks agreement, the FAO Compliance Agreement and the FAO Code of Conduct for Responsible Fisheries is also addressed.

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