The FFA Member Countries' Vessel Monitoring System (FFA VMS)

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Summary

Since the mid-late 1980s, the member countries of the Forum Fisheries Agency (FFA) have been considering the use of a satellite-based fisheries vessel monitoring system to enhance the effectiveness of several other compliance measures in the lucrative tuna fisheries of the western and central Pacific. After the 1996 cancellation by the European Union of a programme to fund the research and development of a vessel tracking system in the region, the FFA, with assistance from Australia and New Zealand, has developed the FFA member countries' vessel monitoring system that assists with monitoring the position, speed and direction of fishing vessels in the EEZs of FFA member countries. While the FFA Secretariat provides technical, administrative, and management support, and legal advice for the system, the FFA member countries are individually implementing the system in their EEZs to conserve and manage their tuna resources.

The FFA member countries' vessel monitoring system (FFA VMS)

Getting started – the business problems

The concept of a satellite-based vessel monitoring system (VMS) for the use of Forum Fisheries Agency (FFA) member countries[1] in their Exclusive Economic Zones (EEZ) was under discussion in the mid-late 80s, as an example of non-traditional hardware that may be used in the function of fisheries surveillance (Aldous, 1986). The basis of this approach was that FFA member countries were becoming increasingly aware of the value of such systems to improve compliance, surveillance and data retrieval in the field of fisheries management. The 6th Regional Fisheries Surveillance Meeting in January 1991 directed the FFA Secretariat "…to seek funding to implement a vessel location and catch data acquisition system…" (Anon., 1991), leading to further development of the concept by staff at the FFA Secretariat (Brown and Allinson, 1991).

With the aim of identifying an appropriate VMS to be used in the EEZs of FFA member countries, the FFA Secretariat convened a series of annual technical consultations on vessel tracking, the first being held at Suva, Fiji in 1991. From 1991 to 1996, six technical consultations on fishing vessel monitoring systems were held on a regular basis in order to exchange information on national and sub-regional VMS programmes as they were developed and implemented, and to promote the standardisation and harmonisation of VMS as it is introduced to the commercial tuna fleet operating in the western and central Pacific (WCP) (Anon., 1995a).

FFA member countries faced two main business problems in relation to the operations of fishing vessels from distant water fishing nations (DWFN) - illegal fishing, and mis-reporting

[1] Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

and/or under reporting of catches of tuna in their EEZs, that total approximately 30 million square kilometres of ocean (Anon., 1995b).

The tuna resources of, and tuna fisheries operating in, the WCP

The WCP region is host to the most productive tuna fishing grounds in the world, supplying over 50 per cent of the world's canning tuna. The annual catches of the four principal species - skipjack, bigeye, yellowfin and albacore – consistently total around 1.3 million metric tonnes. In recent years, the annual value of the unprocessed tuna catch has fluctuated between USD1.5 to 1.7 billion (Anon., 1998c).

The WCP region's tuna fisheries are complex in nature. There is a range of target species (tuna), in some cases captured at different stages of their life by three fishing gears (purse seining, longlining and pole-and-lining) operated by several fishing nations. A variety of other non-target species (by-catch), some of considerable economic value, are also landed. The situation is further complicated by the tunas' migratory nature, in that each stock may migrate through numerous national jurisdictions and areas of high seas. Approximately 50-60 per cent of the total catch is taken within the EEZs of FFA member countries, the remaining 40-50 per cent being caught in high seas areas and in the waters of non-FFA members. The tuna resources of the region, if managed effectively, are capable of generating sustainable revenues over time (Richards, 1997).

Tools with which to achieve compliance

Effective management by FFA member countries of fishing activity in their EEZs needs to be based on the best available scientific advice, built around a sound legal and policy framework, and enforced through a comprehensive monitoring, control and surveillance (MCS) programme. Past efforts to establish administrative arrangements for foreign fishing vessels operating in the region have proven difficult. This has largely been a function of the

size of the region, combined with the fact that the small island States in the WCP have only limited personnel and financial resources to apply to this effort.

In recognition of these constraints, FFA member countries have adopted some innovative procedures to assist their fishing vessel administration and monitoring efforts that combine legal and technical elements that are applied at either the national level, or regionally in co-operation with other island States, and in some cases, supra-regional agencies. They include air and sea surveillance, regional and national observer programmes, the Regional Register of Foreign Fishing Vessels and agreements on cooperation in surveillance between the FFA member countries. A satellite-based VMS is seen as a cost-effective tool to enhance these compliance measures (Anon., 1994).

A false start – the EU funding experience

In February 1994, after almost two years of effort by the FFA Secretariat, Papua New Guinea, on behalf of the eight Pacific ACP States, signed a Financing Agreement for the Integrated Regional Fisheries Surveillance and Management Programme (IRFSMP), to be funded from the European Union's (EU) European Development Fund (EDF) Pacific Regional Programme. With total funding amounting to ECU4.65 million over 5 years, the Programme included support for a position of Fisheries Management and Law Adviser (FMLA), a monitoring, control and surveillance programme including support for the manager of that Programme, and the research and development of a vessel tracking system for the region.

In June 1994, the EU arranged a restricted tender to select a consultancy firm to implement the Programme. However, because the financial bids of all prospective tenderers significantly exceeded the budget provided for personnel support in the Financing Agreement, the EU eventually cancelled the tender in late 1994. Simultaneously, an EU-selected VMS consultant was contracted on a short-term assignment to assess the technical

feasibility of the implementation of a regional VMS. Based at FFA headquarters, Honiara, the consultant was to conduct trials of various commercially available tracking systems. Shortly after commencing the assignment, the consultant advised a VMS Steering Committee at the FFA that to his knowledge, there were no technical impediments to the introduction of VMS in the WCP.

The consultantt worked with the Steering Committee to highlight several other issues, that would require detailed consideration prior to regional application of VMS in the WCP. The Committee noted that there existed several potential constraints to regional application, including the multinational and multicultural composition of fleets licensed in the region, the relatively poor degree of harmonisation of national licensing conditions among FFA member countries, the national VMS programmes planned by nations responsible for fleets operating in the WCP that may not be compatible with even the minimum expectations of FFA member countries, the diversity of vessel types and variation in the degree of technical sophistication among fleets and gear types in the region and limited resources at the FFA Secretariat. The Committee also noted that dedicated technical personnel to manage a VMS would be an essential key to its success.

As a result, the EU revised the consultant's Terms of Reference to enable him to design a programme that could assess the feasibility of the introduction of VMS to the region, including a cost/benefit analysis and trial of available technology, and review legal issues that would require consideration at both national and regional scales as VMS is implemented in the region.

Following the submission of the consultant's report, the EU decided that the studies must be concluded, and the recommendations considered, before any technical assistance would be provided to the FFA Secretariat under the Lomé IV Programme. Since this meant that the Agency would have no staff to apply to the implementation of the studies supported by the

EU, in January 1995 the EU agreed to offer a short-term consultancy to assist the FFA Secretariat carry out the implementation (Anon., 1995c).

On a firmer footing – assistance from Australia

Anxious that the delayed implementation of the EU Programme should not jeopardise the entire MCS programme at the FFA Secretariat, the Agency approached Australia for support of some key components of that programme. As a result, the Australian Government agreed to provide funding for several components of the MCS programme, including funding for the position of Manager Monitoring, Control and Surveillance and support for the research and development of a VMS for FFA member countries, including technical support for programme management.

Concurrently, the FFA Secretariat explored opportunities for a collaborative arrangement with the EU for further development of the MCS programme at the Agency. In May 1995 the Agency advised FFA member countries that there would be a major initiative during 1995 to research, design and implement a satellite-based VMS at national and regional levels, to be achieved by close collaboration between the FFA, Australia and the EU (Anon., 1995d).

Regional VMS Business Plan Consultancy

In early June 1995, the FFA Director advised that a regional VMS Business Plan was to be prepared that would provide guidance on how a VMS for FFA member countries' (FFA VMS) could be implemented. Following a restricted tender, a contract for consultancy services to prepare a VMS Business Plan was awarded in July 1995 to an Australian company, Telstra Applied Technologies Limited. A three man consultancy team worked closely with FFA Secretariat staff and several member country fisheries MCS personnel to prepare a draft report that was used as a basis for discussion at the 5th VMS Technical Consultation in late September 1995 (Anon., 1995a).

The consultancy report provided a system design overview, business analysis and the business requirements of, and a proposed implementation plan for, the FFA VMS. The report stated that, in its basic form, and in accordance with the stated preference of many FFA member countries, the FFA VMS would provide position data of DWFN vessels moving across the waters of the WCP, thus allowing individual member countries to track the movements of vessels in their EEZs. At the next level of evolution, the FFA VMS would provide support to existing surveillance and monitoring programmes by integrating fishing vessel position reports with air-sea surveillance patrol units, to target potentially suspicious behaviour and reduce search time. Ultimately, the FFA VMS would also include provision for catch data and effort reporting.

Given the operational and logistical challenges envisaged for the FFA VMS project, the consultancy report suggested that the implementation of the FFA VMS be undertaken in a planned and phased manner, to ensure its successful introduction. A series of confidence, technical and pilot trials were suggested to progressively gain confidence in the technical and operational performance of the FFA VMS, and also to test logistical and procedural plans. Following the successful outcome of these trials, full implementation of the FFA VMS would commence. The report estimated that the project duration would be between 2 to 2.5 years, with completion in mid to late-1998 (Anon., 1995b).

It is important to note that the VMS Business Plan is a generic document that did not recommend a particular satellite system for the FFA VMS. The business requirements of the FFA member countries provided the basis for which system would eventually be selected.

Withdrawal of EU support

At the 5th VMS Technical Consultation held at Honolulu, Hawaii in September 1995, the FFA member countries represented at the consultation approved a set of functional business requirements for the FFA VMS and agreed that they would introduce a system of full cost

recovery to support the system. Costs would be recovered on a 'user-pays' basis from vessels participating in the tuna fishery in the region, with the cost of purchase and fitting of transponders being the responsibility of vessel operators (Anon., 1995a). The EU regarded the decision on cost-recovery as a breach of the agreement between itself and the FFA member countries because that agreement included the provision of VMS equipment for a VMS pilot project. In late 1996 it canceled the Financing Agreement for the IRFSMP, leaving Australia as the main source of funds for the development and implementation of the FFA VMS.

Getting it built – the FFA VMS Implementation Plan

In early February 1996, following the acceptance by the FFA of the VMS Business Plan, a draft Request For Tender (RFT) document for implementation of the FFA VMS, based on the Business Plan, was discussed at a workshop held at the FFA Secretariat, Honiara. The workshop, involving representatives from the FFA Secretariat, and VMS and contract specialists from Australia and New Zealand, produced a final VMS RFT document that was published and dispatched to six prospective tenderers at the end of February 1996. The prospective tenderers were the same six companies that had originally been invited to prepare tender proposals for the FFA VMS Business Plan. A briefing on the FFA VMS RFT document was held for prospective tenderers at Canberra, Australia on Tuesday 19 March 1996.

The FFA Secretariat prepared a FFA VMS Tender Evaluation Plan in early April 1996 consisting of a series of tables designed to assist in determining those tenders that clearly complied with FFA's VMS business requirements and those that did not. Tender proposals were received from three of the six companies before the closing date of the tender on 31 May 1996 while the other three prospective tenderers formally indicated that they would not be submitting a response to the RFT. The FFA VMS tender evaluation team, comprising five

FFA staff members, met in Canberra from 17-21 June 1996, during which time it interviewed representatives from several of the tenderers. Aspect Computing Pty Ltd of Canberra, Australia, in conjunction with Absolute Communications Ltd of Christchurch, New Zealand was selected by the tender evaluation team as the preferred tenderer.

Following contract negotiations between the preferred tenderer and the FFA at the FFA Secretariat, Honiara in late October 1996, a contract for the FFA VMS Project was signed on 4 November 1996 between the FFA and Aspect Computing Pty Ltd. Participants at the 6th VMS Technical Consultation held at Nadi, Fiji from 13-15 November 1996 were advised that the FFA VMS would be completed within a year to 18 months from contract signature (Anon., 1996).

Technical Development of the FFA VMS under the VMS Project Contract

Almost immediately following contract signature, representatives of the VMS Project contractor and sub-contractor visited the FFA Secretariat, Honiara to commence project implementation, beginning with design specification. With the completion of design specification on 14 April 1997, the FFA VMS Project Team conducted a specification review.

Three trials were conducted during the project – the Confidence Trial, the Technical Trial and the Acceptance Trial. The Confidence Trial enabled FFA VMS Project staff to establish familiarity with the functionality of the FFA VMS and to develop solutions to several technical problems that arose during the trial. The trial built confidence in the FFA VMS throughout the FFA Secretariat, with the FFA VMS Contractor and with the vessel operators in several FFA member countries that kindly volunteered the use of their vessels for the trial.

The Technical Trial was principally a laboratory trial at the FFA VMS Contractor's office in Canberra, Australia where the functionality of the VMS hardware was tested. The FFA

Secretariat's VMS Project staff developed a Technical Trial Plan that was used during the entire Technical Trial period.

The final trial was the Acceptance Trial that commenced in May 1998 and continued until late August. The delay in completing the Acceptance Trial was caused by technical difficulties in the FFA hub-site FFA VMS computers. A solution to this difficulty was identified in early 1999, thus providing the FFA Director with the opportunity to sign off on the project on 17 March 1999. In doing so, the FFA Director acknowledged that the hub-site FFA VMS equipment at the FFA Secretariat is fully operational. In those FFA member countries where in-country FFA VMS equipment has communications links to the hub-site, member country FFA VMS equipment can down-load fishing vessel position information from the hub-site computers, as required.

FFA VMS type approval for Automatic Location Communicators

To properly manage the FFA VMS, the FFA Secretariat has to manage the means by which Automatic Location Communicators (ALC) generate information, the receipt of that information by satellites and the re-transmission of the information from satellite to Land Earth Station (LES) and to the FFA Secretariat. Two formal documents have been published by the FFA Secretariat that describe the FFA VMS Type Approval Process. In order for an ALC to qualify for type approval, it must first meet the FFA VMS performance specifications (Anon., 1997a). These requirements are designed to ensure that any ALC offered up for certification meets the stringent standards necessary for the operation of an effective surveillance system. The identification and definition of the responsibilities of the various parties involved with the type approval, purchase, installation, operations and management of the ALCs within the FFA VMS are also documented (Anon., 1999).

Project Management

Very early in the FFA VMS Project, a committee was established within the FFA Secretariat with the aim of managing the project. The FFA VMS Committee facilitated input to the project from all divisions of the Agency and permitted it to liaise effectively with the FFA VMS Contractor's project management team. The operation of the FFA VMS Committee was one of the key elements to the success of the FFA VMS Project. Project Management meetings between the FFA Secretariat and the FFA VMS Contractor, held either in Canberra or Honiara, were also useful in identifying potential problem areas in the FFA VMS Project.

Capabilities of the FFA VMS

The baseline form of the FFA VMS enhances the effectiveness of several other measures being implemented to assist with the sustainable development and management of the tuna resources of the WCP. The FFA VMS assists with monitoring the position, speed and direction of DWFN vessels that are fitted with ALC devices.

The system is capable of simultaneously monitoring the position, speed and direction of up to 1,000 fishing vessels at any one time with the potential to monitor up to 2,000 vessels. A computer based at the FFA Secretariat headquarters in Honiara, Solomon Islands, known as the "FFA VMS Decision Engine" identifies those vessel position reports that violate a set of rules stored in the computer. Exception and alert reports are generated accordingly by the computer and sent to the FFA member country in whose EEZ the vessels are operating. The FFA Secretariat and each FFA member country are equipped with a graphical monitoring facility to view the exception and alert reports and other position data against a display of the member country's defined geographical areas. The FFA VMS is also capable of securely transferring vessel positions to each FFA member country, as required, enabling individual FFA member countries to track the movements of vessels in their EEZs (Figure 1).

The FFA VMS is not currently capable of transmitting fish catch data, though it has been designed with the flexibility to handle catch data transmission as an enhancement to the baseline FFA VMS. This is consistent with the FFA member countries' requirement to address the issue of illegal fishing in the first instance.

Advantages to FFA member countries and DWFN fishing vessel operators

The advantages of the FFA VMS to FFA member countries include a cost effective method of providing support to the region's compliance and monitoring programme, targeting of selected vessels by patrol boats and surveillance flights, fostering of regional solidarity, improved communications within the WCP with both DWFNs and other FFA member countries, and increased safety at sea and improved response time to emergency calls by FFA member countries.

The main benefits of the FFA VMS to fishing operators include ship to shore communication at all times that is not dependent on radio frequencies being available, provision of a communication method whereby a fleet of vessels can be contacted and directed to target aggregations of fish, increased safety at sea whereby any distress signal is transmitted over the entire FFA VMS network, and increased and more timely weather information available more consistently than with existing systems.

Security and confidentiality

Confidentiality of FFA VMS data is a major issue, both for the FFA member countries and the DWFNs. To ensure that the position data is held securely, the FFA Secretariat has implemented a comprehensive security system, based on a report prepared by independent security consultants in early 1998. In the passage of FFA VMS information to and from the FFA VMS hub-site to FFA member countries, all incoming and outgoing information is encrypted by "Smart Crypt", an encryption system that is near military grade.

Training of VMS Officers

Under the FFA VMS Project, comprehensive training programmes have been made available for FFA member country VMS Officers and FFA Secretariat personnel. The FFA VMS Training Course for FFA member country VMS Officers took place at Canberra, Australia from 1-5 September 1997 and refresher training was provided by FFA VMS Project staff in-country during 1998 and early 1999.

Development of the legal basis for the FFA VMS

The legal basis for the FFA VMS as a compliance tool in the EEZs of FFA member countries derives from the sovereign rights and enforcement powers of coastal States in their EEZs, as granted by the United Nations Convention on the Law of the Sea. During the life of the FFA VMS Project, the FFA Secretariat's Legal Division provided advice to FFA member countries, on request, as to how to implement the FFA VMS at the national level. The bulk of this work was carried out by the Fisheries Law Adviser, Dr Martin Tsamenyi, who was attached to the Legal Division for two years from May 1997.

Two workshops were held to examine the legal aspects of the FFA VMS. The first such workshop held at Nadi, Fiji from 20-26 September 1997 provided the basis of several decisions made by the 34th meeting of the Forum Fisheries Committee with regard to amendments to the Harmonised Minimum Terms and Conditions of Fisheries Access (MTCs) (Anon., 1997b). A follow-up workshop was held at Nadi, Fiji from 16-18 February 1998 to consider other priority legal issues that must be addressed to fully implement the FFA VMS, including the need to devise guidelines on VMS information security, ownership of VMS information and evidentiary issues in relation to prosecution of VMS-related offences (Anon., 1998a). The two workshops provided a foundation for work on the legal aspects of the FFA VMS.

At the country level, the Fisheries Law Adviser kept regular contact with counterpart lawyers from the Attorney-General's offices to monitor legislative implementation of the FFA VMS. Suggested strategies to deal with the FFA VMS in access negotiations and bilateral access agreements were also prepared for use by FFA member countries.

Cost-recovery scheme for the FFA VMS

The FFA member countries have agreed that the FFA VMS operates on the principle of 'user pays' or cost-recovery. The cost of type-approved ALCs to be fitted to fishing vessels is the responsibility of individual vessel operators. Currently, the cost of a type-approved ALC is USD2,800-3,100, with an extra USD1,700-2,000 for a mobile data terminal for attachment to the ALC for messaging purposes. The modest, on-going operational cost of the FFA VMS, estimated at USD845 per vessel, is being recovered annually from the tuna fisheries operating in the WCP by means of an FFA VMS Register Fee, that is paid when a type-approved ALC is registered with the FFA Secretariat. The FFA VMS Registration year runs from 1 September in any year to 31 August in the following year.

Publicity

To keep FFA member countries apprised of developments with the FFA VMS Project, an FFA VMS Newsletter has been published on an irregular basis throughout the life of the project. The newsletter is an effective means of disseminating information about the FFA VMS Project to a wide target audience in FFA member countries. A region-wide publicity campaign was also conducted, comprising radio interviews, and full-page spreads in the regional press and international fisheries publications.

FFA VMS guidelines for DWFN fishing operators

The FFA Secretariat publishes and distributes a set of guidelines for the DWFN fishing operators relating to the installation and registration of ALCs (Anon., 1998b). This key document sets out in six easy steps the process for ALC installation and registration. It also

provides details of the four types of ALC that have been type approved and contact details of ALC fitting agents in American Samoa, Australia, Federated States of Micronesia, Fiji, Guam, Hong Kong, Japan, Kiribati, Korea, Maldives, Marshall Islands, New Zealand, Papua New Guinea, Samoa, Singapore, Solomon Islands, Taiwan and Vanuatu.

Political support for the FFA VMS

All FFA member countries have expressed their support for the FFA VMS through the annual meetings of the Forum Fisheries Committee. Strong support has also been forthcoming from the Forum Leaders at the South Pacific Forum meetings held at Rarotonga, Cook Islands in 1997 and at Pohnpei, Federated States of Micronesia in 1998. In communiqués issued following both meetings, the political leaders of the region have urged the DWFN operating in the WCP to support the VMS initiative of FFA member countries.

Implementation of the FFA VMS in FFA member countries

Though the FFA Secretariat provides technical, administrative and management support for the FFA VMS, the FFA member countries have agreed that they will be individually responsible for informing their bilateral fishing partners about the timetable for implementing the FFA VMS in their respective EEZs. Vessels applying for licences to fish in the EEZ of a particular FFA member country may be advised by the national licensing authority that a pre-condition of obtaining a licence is that the vessel must first be registered on the FFA VMS Register. The decision to require a fishing vessel to register on the FFA VMS Register is therefore the responsibility of FFA member countries, not the FFA Secretariat.

Solomon Islands, Papua New Guinea, Vanuatu and Nauru have been actively implementing the FFA VMS in their EEZs and several other FFA member countries have included VMS as part of their fisheries access agreements with their bilateral fishing partners. In many cases, fisheries access agreements in place in FFA member countries call for the fitting of ALCs on fishing vessels during 1999. Under the terms of the U.S. Multilateral Fishing Treaty

administered by the FFA Secretariat, U.S. purse seiners are fitting and operating FFA VMS ALCs in the EEZs of those FFA member countries that require operation of the FFA VMS as part of their national fisheries legislation. There are currently 45 vessels of several types and flags registered on the FFA VMS Register.

The two major obstacles to timely implementation of the FFA VMS are opposition by DWFNs, and administrative and logistical difficulties for FFA member country fisheries administrations and vessel operators. Several attempts have been made, and will continue to be made, to understand the precise difficulties that DWFNs have with their vessel operators fitting the FFA type approved systems to their vessels. The FFA Secretariat is actively engaged in addressing the latter issues through the continuing supply of a wide range of technical and legal support, and advisory services.

The future

The use of the FFA VMS to minimise mis-reporting, under-reporting and non-reporting of fish catches is a stated business requirement of FFA member countries. The ready availability of timely catch data will assist them to effectively implement their in-zone tuna management plans. Addressing the business requirement of FFA member countries relating to mis-reporting, under-reporting and non-reporting of fish catch will require enhancements to the baseline FFA VMS. The system has been built to be sufficiently scaleable and flexible to accommodate the monitoring of fish catches using electronic catch data forms.

Conclusion

The FFA VMS has developed from the first discussions about fishing vessel tracking in the late 80s and early 90s to the stage where it is being implemented in the WCP by each FFA member country, based on their individual implementation schedules. The FFA VMS Business Plan that laid the groundwork for the implementation of the FFA VMS, estimated

that the project would be completed in mid-late 1998, a prediction that has proved to be substantially correct.

In hindsight, the withdrawal of the EU from the project proved fortuitous, since this permitted the FFA VMS to develop along strictly business lines, with the business requirements of FFA member countries determining the way forward. The timely application of financial support and technical advice from Australia and New Zealand permitted the construction of a VMS for FFA member countries that satisfies the FFA VMS business requirements while minimising on-going costs.

The implementation of the FFA VMS reflects the determination of FFA member countries to ensure the sustainability of the tuna resources in the WCP. The FFA VMS is based on well proven technology and by adopting a common standard, it has been designed to be efficient and beneficial for both FFA member countries and DWFN fishing partners alike. It is also consistent with similar developments worldwide. Despite this, there remains a persistent resistance by some DWFN to accept the sovereign rights of FFA member countries to implement such a system within their respective EEZs.

It is clear that top level political commitment in FFA member countries will be required if FFA VMS implementation is to be taken forward. The greatest tuna fishery in the world and the WCP region's largest renewable resource will rely on the vision of the region's leaders to maintain this commitment.

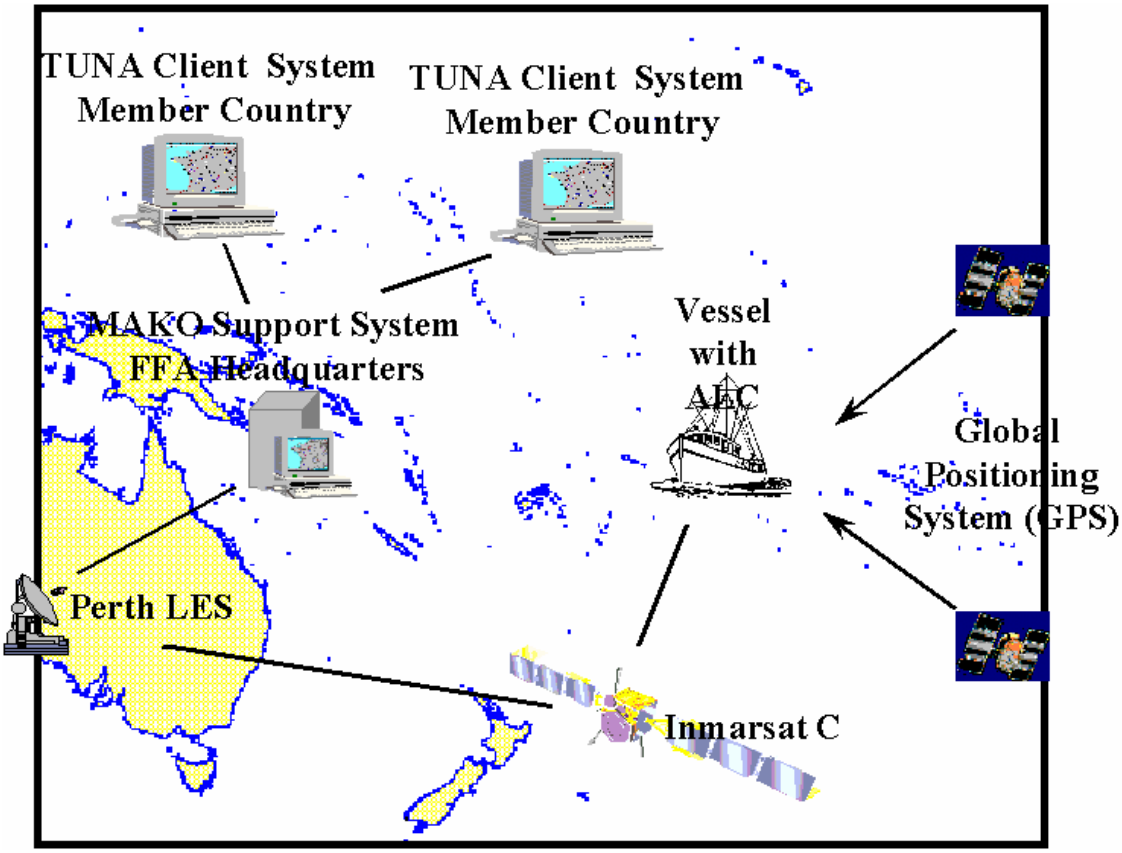

Figure 1. Main components of the FFA VMS

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