Makaira – versatile communications for coastal and archipelago protection vessels

A. Bell

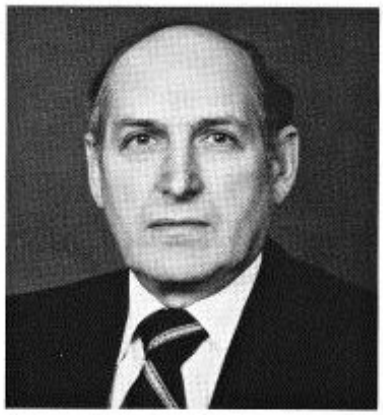
Summary Agreements reached by the Third United Nations Law of the Sea Conference provide coastal, island and archipelago states with extended legal rights for the utilization, management and protection of natural resources in coastal and offshore areas. Many such states also find it necessary to provide increased protection against illegal entry and smuggling.

To achieve the necessary surveillance and protection, these states need to provide a cost effective policing system of aircraft, ships and command centres ashore. To ensure effective and efficient co-ordination within this organization will require comprehensive communications networks.

The article describes how the new Makaira radio system, which covers all naval, marine, military and aircraft frequency bands between 1·6MHz and 400MHz, can provide a relatively unsophisticated but compatible communications package for small patrol craft employed on surveillance and protection duties.

A. Bell

Alan Bell joined the Marconi Company in January 1953, having previously served in the Communications and Radio Electrical Branches of the Royal Navy. During his 31 years with the Company he has held a number of appointments concerned with the System Engineering, Installation and Marketing of naval and maritime communications, radio location and radio navigational aids. Prior to October 1981, when he was appointed Business Development Manager (Naval), he was, for a number of years, responsible for naval sales. His current assignments include the planning and promotion of new products.



Introduction

In an era of declining terrestrial resources and increasing population the need for new and larger national resources is globally manifest. Agreements reached by the Third United Nations Law of the Sea Conference provide coastal, island and archipelago states with new legal rights for the utilization and protection of resources within both inshore and offshore areas. The consequential rights and obligations placed upon such states include responsibility for the surveillance and control of territorial waters (12 miles) and Exclusive Economic Zones (EEZs) (200 miles) to protect fish and mineral resources and energy supplies, and to provide support and rescue services. In most states there also exists the need to protect against illegal entrants, infiltration of subversives, and smugglers of currency, drugs, firearms and other contraband goods. Thus the civil and military authorities of coastal and archipelago states have become increasingly involved with coastal and offshore defence and protection.

Rationale of surveillance and protection

The responsibilities of protecting coastal borders and offshore resources are substantial as the areas involved are, in many instances, much larger than the land areas of the countries possessing them. Rigorous enforcement is not only a right but a responsibility that must be implemented. Enforcement entails continuous policing, not only to apprehend offenders but also to acquire knowledge of what is going on and to provide a deterrent against infringements. Covering the needs of such surveillance, protection, rescue and, if necessary, arrest requires:

a) patrol aircraft, including helicopters,
b) surface vessels, including patrol craft,
c) communication networks,
d) command and control centres ashore.

Communications are somewhat complex because of the variety of units involved. These may include civil, police/coastguard and/or naval vessels; civil, military and/or naval aircraft; shore stations and/or offshore rigs, many of which are probably equipped to operate only within their own specific frequency bands assigned according to the International Radio Regulations.

Neither aircraft nor ships can alone carry out all the tasks. Obviously aircraft can best provide reconnaissance of large areas of sea whereas only surface units can carry out on-the-spot interrogations and, if need be, arrest offenders. Ship's commanders therefore must have contact both with the patrol aircraft and with the national authorities ashore. In the event of accidents to ships or to oil or gas rigs, rescue operations are likely to involve both civil and naval aircraft and ships plus, possibly, units ashore. It is therefore important that surface units are provided with reliable, comprehensive and compatible communications.

Development of patrol craft capability

The design and deployment of naval vessels has evolved throughout history but traditionally these developments have been mainly directed towards the operational roles and requirements of major warships – frigates, destroyers and capital ships. However the increasing costs in building and

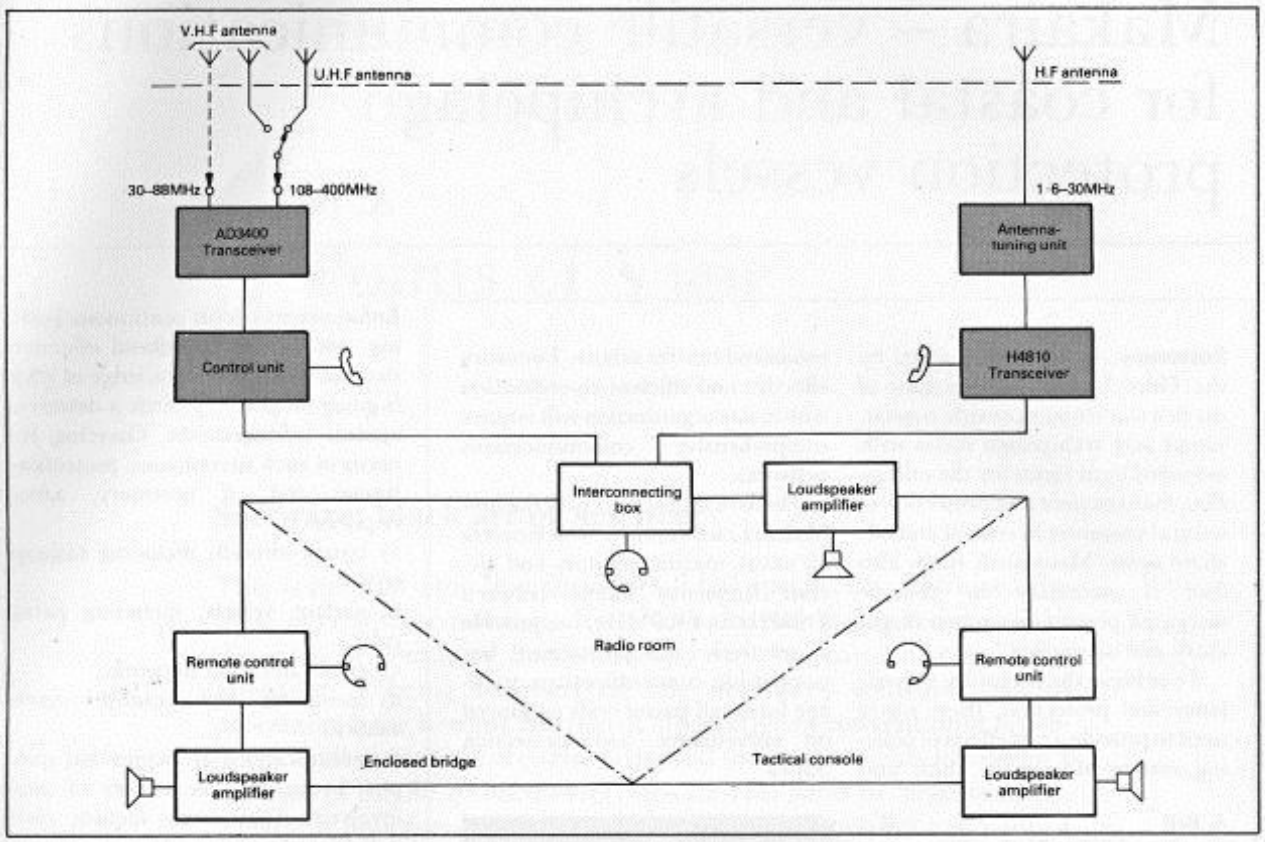


Fig. 1. Makaira system with two radios and three positions

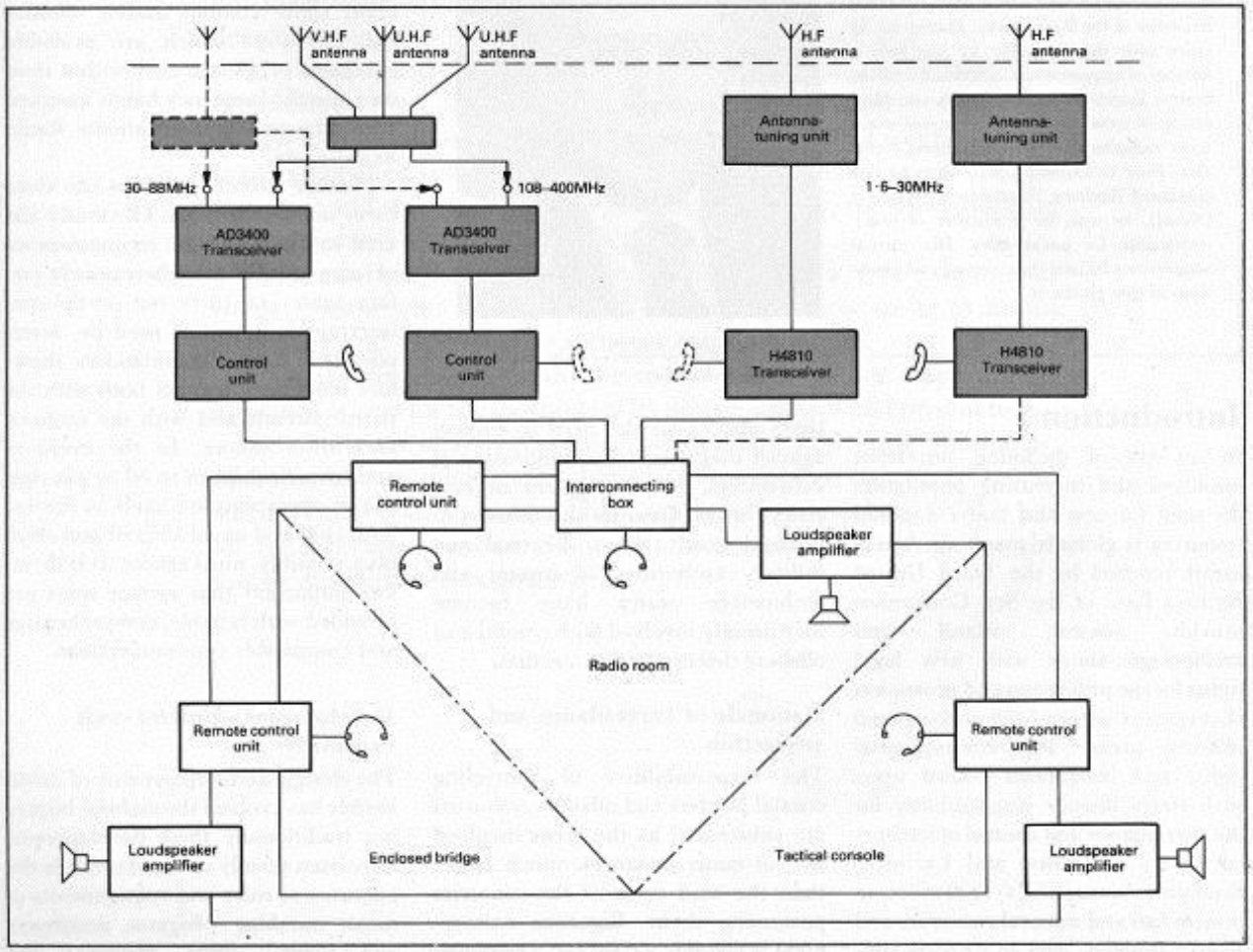


Fig. 2. Makaira system with four radios and four positions

operating such ships, combined with recent evolutions in weapons systems, electronics and communications, have led to increasing interest in the employment of much smaller patrol craft for many roles in coastal and archipelago areas. Fortunately many of the new policing and rescue duties and defence roles in these waters can be undertaken by patrol craft manned by coastguards or police-type organizations, as well as by naval forces.

To match these changes over the last decade or so, Marconi Communication Systems in the early 1970s developed ICS3 for major warships, followed in the late 1970s by NTC1 for light naval forces – e.g. light frigates, corvettes and offshore patrol vessels – and also for submarines. Now Marconi has introduced Makaira, a relatively unsophisticated but comprehensive communications package for small patrol craft and the like, engaged on surveillance, protection and rescue duties in coastal, offshore and archipelago areas.

Several constraints are placed on the design and cost of complex communication sytems for small vessels, where both space and crew are very limited. While providing high performance and multi-band, multi-mode operation, the system must be compact and lightweight in order to be accommodated onboard, simple to operate and highly reliable. In addition its cost must not be out of proportion with that of other onboard systems. Makaira provides a solution which meets all these constraints.

Makaira tactical radio system

Using only two transceivers, as shown in figure 1 (typical basic system), Makaira provides for communication in the naval, international maritime, military and aeronautical frequency bands between 1·6MHz and 400MHz. H.F Transceiver H4810 covers the frequency band 1·6MHz to 30MHz and V.H.F/U.H.F Transceiver AD3400 covers three ranges, 30MHz to 88MHz, 108MHz to 174MHz and 225MHz to 400MHz. The AD3400 also incorporates a guard receiver for simultaneous monitoring of 243MHz or 121·5MHz according to the frequency band in use. Subject to possible operating restraints, either one or both transceivers may be duplicated. Each transceiver may be operated locally, or remotely through a radio control ring. Selection of the working frequency, emission mode and transmitter power is normally made locally at each equipment but optionally these facilities can be provided at an extended position. The number of control and loudspeaker units incorporated in the ring can be varied to meet individual needs but it is anticipated that the example shown in figure 1 will fulfil many requirements. The remote control units (two-radio) enable each operator, or user, to select and operate either of the radios and to monitor the other. Additionally, the remote control units (two-radio) provide for intercom between the users/operators with simultaneous monitoring of one radio. Thus, for example, while investigating a report of illegal fishing, the commander on the bridge could have u.h.f radio contact with a patrol aircraft and intercom with the tactical console operator who is tracking the offending vessel by radar. Simultaneously, a radio operator using the h.f radio could be in contact with a command centre ashore and/or another patrol vessel.

When duplicate h.f or v.h.f/u.h.f transceivers are installed, a radio ring as figure 2, employing remote control units (three-radio) that provide access (operating and monitoring) to three radios plus intercom facilities, may be fitted. The remote control units (two-radio) may also be used in conjunction with a three-radio ring installation to provide operation and monitoring of either radios A+B or radios A+C. The radios are linked to the ring at the inter-connecting box by means of simple plug and socket connections so the selection of the radios may be changed easily and quickly at any time.

Interception and ECM protection

Interception and monitoring of ship-to-aircraft and ship-to-shore communications can prove extremely useful to intruders and offenders, enabling them to take appropriate action to evade interrogation and possible detention. The advantage of such intelligence can readily be denied by the use of secure voice communication. Both of the transceivers can be provided, optionally, with voice encryption modems. These modems first convert speech into digital format which is then encrypted according to a previously stored customer code. This is changed periodically and every new transmission is encrypted by a different part of the code sequence – thus even the same message, if repeated, would be encrypted differently each time. At the receiver the encrypted message is converted back to clear speech by combining it with the same customer code sequence.

Although perhaps of greater importance to vessels deployed in truly naval roles during times of tension or hostilities, circumstances may arise when it is necessary to minimize the possibility of detection and location, e.g. by direction finding or interruption of signals by jamming. Effective jamming of communications could prove catastrophic since disruption of command and control links would result in either aborting an operation or significantly reducing its effectiveness. Optionally available for both transceivers are modems to provide a frequency-hopping capability thus making signals extremely difficult to detect and jam.

Transceiver H4810

Transceiver H4810 (figure 3) is based upon the recently developed military combat net h.f radio, Scimitar H, which covers the 1·6MHz to 30MHz frequency range in 284,000 synthesized 100Hz steps. Operation is either single or two frequency simplex with a receiver clarifier facility accurate to 1Hz steps. Up to ten channels, each containing the transmit and receive frequency or frequencies and the operating mode, can be preset and stored. A choice of seven emission modes is provided – u.s.b, l.s.b, a.m, c.w, secure, a.j (anti-jam) and secure+a.j. The transmit/receive frequencies, the 10 channels, clarifier, emission modes and built-in test facilities are selected and displayed by a keypad and liquid-crystal alphanumeric display incorporated in a detachable control panel which may be used at up to 10m cable length from the transceiver.

A receiver/exciter drives a 100W broadband power amplifier, the output of which is connected to a microprocessor-controlled automatic antenna-tuning unit (a.t.u). The a.t.u is mounted adjacent to the antenna which may be a whip of between 3m and 8m in length or a wire antenna of similar impedance. Tuning is rapid, with tuning information being automatically stored in the microprocessor.

A built-in, slow-speed frequency-hopping capability may be used to

Fig. 3. Transceiver H4810 (Scimitar H)

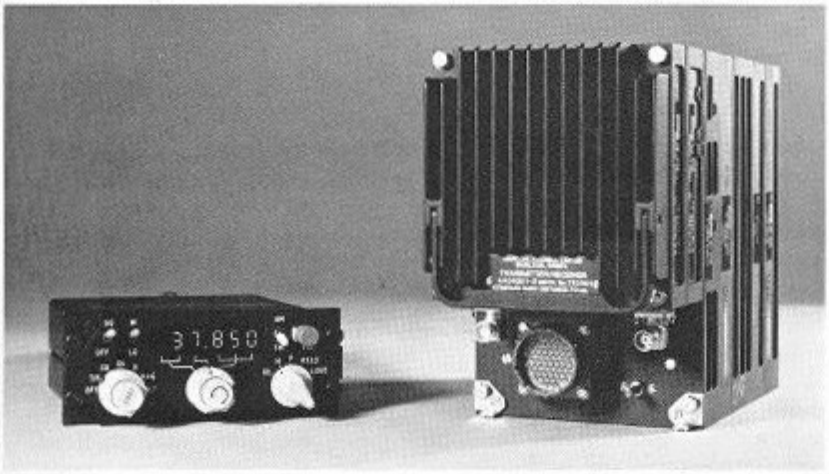


Fig. 4. Transceiver AD3400 with control unit

provide protection against interception by fixed-frequency receivers and jamming by fixed-frequency transmissions. An optional modem provides speech security and a more sophisticated frequency-hopping capability.

A built-in-test-equipment (BITE) facility provides a high degree of operator confidence in the correct operation of the radio, together with rapid fault diagnosis. A microprocessor continually scans the BITE from each major module and indicates any fault condition on the liquid-crystal display. A 'test' key on the control panel enables off-air checks down to printed-circuit board levels. Individual printed-circuit boards are plug-in and fully interchangeable without realignment.

The H4810 operates from a 28V d.c supply but full performance is maintained within the limits of 24V to 32V d.c. With a power supply outside these limits, the equipment continues to function but with a reduced performance.

Transceiver AD3400

Multimode Transceiver AD3400 (figure 4) conforms to standard aeronautical (ARINC) characteristics and provides for a.m or f.m voice communications in the following frequency bands with 25kHz spacing throughout:

30–88MHz	f.m	Military tactical
108–156MHz	a.m	Civil/military air
156–174MHz	f.m	International maritime
225–400MHz	a.m/f.m	Naval/military air and ship

The transmitter is inhibited between 108MHz and 118MHz and between 162MHz and 174MHz. An integral guard receiver provides for simultaneous monitoring of 243MHz or 121·5MHz according to the band in operation.

Up to 20 channel frequencies may be preset and stored. A.M or f.m may be used in the 225MHz to 400MHz band, otherwise modulation is automatically set according to the band in operation.

Transceiver AD3400 comprises two units, a transmitter-receiver and a control unit. The transmitter-receiver is of modular slice construction incorporating a synthesizer together with a transmitter, main receiver and a guard receiver. A power amplifier provides an output of 10W on a.m and 15W on f.m through switched harmonic filters for each of the operating frequency bands. Two separate antenna connectors are provided for 30MHz to 88MHz and 108MHz to 400MHz, respectively.

All functions and facilities, including operating frequencies and modes, provided by the AD3400 are selected and displayed at the Control Unit which, in the case of Makaira, is incorporated with the radio/control interface circuitry in a bench-mounting unit. An alternative control unit may be located up to 20m from the transmitter-receiver unit.

Optional modems are available to provide for secure speech or frequency hopping.

While the equipment is operating, microprocessor-controlled BITE circuitry carries out continuous monitoring of selected parameters, and a warning of incorrect operation is immediately displayed on the control unit. A more detailed diagnostic check is initiated when the test position is selected on the mode switch. Failure of any module is indicated by illumination of the appropriate module number on the control unit display. A 'no malfunction' condition is indicated by the word PASS on the display. Defective modules may be replaced without the need for internal adjustment.

The AD3400 operates from a 28V d.c supply but full performance is maintained within the limits of 24V to 29V d.c. With a power supply outside these limits the equipment continues to function but with a reduced performance. Protection circuits prevent damage in the event of short circuits, reverse polarity, or over-voltage input surges.

Radio control ring

The radio control ring used in the Makaira system is derived from a range of interconnecting, control, operating and other ancillary audio units, which are selected and interconnected by a cable harness according to the number of radios fitted, the number of operator/user positions and the facilities required (figures 1 and 2). These units permit the use of one, two or three radios and also provide for intercom between the operator/user positions. See Table 1 for a summary of operating facilities.

The Interconnecting Box (figure 5), provides:

a) operator/user access to the radios,
b) a local operator position,
c) the intercom amplifier,
d) 18V power supply to the remote control units.

The local operator may work one radio and monitor another and also have intercommunication with other operator positions. This unit operates from a 28V d.c supply.

The Remote Control Unit (two-radio) (figure 6) enables each operator/user to use one radio, to monitor another and to use intercom. The operating facilities are independently selectable at each position.

The Loudspeaker Amplifier (figure 7) selects either a radio or intercom

Table 1: Summary of facilities selectable independently at each operator/user position using microphone/telephone headset

Facility	Signal destination
Operate v.h.f/u.h.f or h.f radio	both ears
Operate v.h.f/u.h.f or h.f radio	left ear
monitor other radio	right ear
Operate intercom	both ears
Operate intercom monitor radio	left ear right ear
Intercom with override (automatically reverts to normal intercom)	all operators, at any switch setting
Loudspeaker reception of radio or intercom signals (optional)	

Most of these facilities are available also when using a handset and a loudspeaker at an operating position.

Fig. 5. Interconnecting box (two-radio)

Fig. 6. Remote control unit (two-radio)

Fig. 7. Loudspeaker amplifier

signal and amplifies it sufficiently to drive four 1W loudspeakers. The amplifier may also be used with audio signals from a radio or other source outside the system. This unit also requires a 28V d.c supply.

The loudspeaker (figure 8) may be connected direct to a Remote Control Unit in quiet conditions or to the Loudspeaker Amplifier in noisier conditions or when a greater output is required.

All units are sealed and only routine checks and cleaning are necessary for preventive maintenance. Except in an emergency, the units should normally be opened, repaired and resealed only in controlled workshop conditions.

The units will operate with a power supply from 21V to 33V d.c and will withstand switching surges and pulses without malfunction.

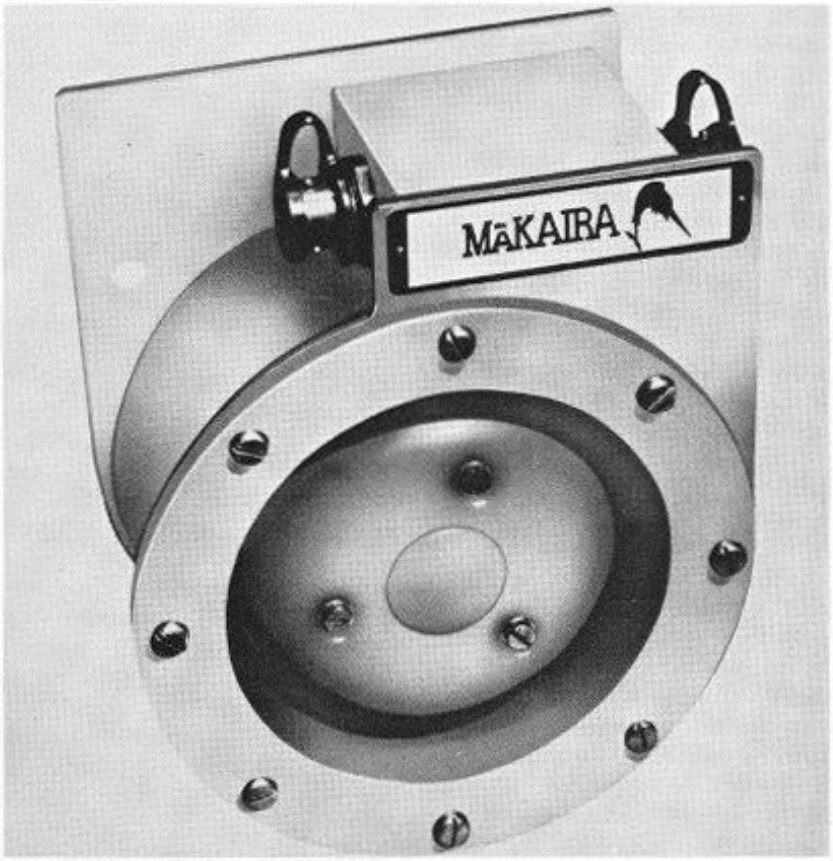


Fig. 8. Loudspeaker

Conclusions

The comprehensive multi-frequency band coverage (1·6MHz to 400MHz), plus the multi-mode operating capabilities (c.w, a.m.e, u.s.b, l.s.b, a.m and f.m) combined with equipment compactness and an intercom facility, make Makaira a most suitable communication system for both new construction and refitted patrol craft deployed on coastal and offshore policing and rescue duties. Makaira will provide such craft with compatible and inter-operable communications with the existing and new types of radio equipment likely to be used by other patrol craft, rescue vessels, naval vessels, fishing and other mercantile vessels, civil and military helicopters, military and naval aircraft and both civil and naval shore stations.

These equipments can also be used for other applications thus extending compatibility of both communications and logistics. An alternative version of Transceiver H4810 is the Scimitar H which is used for both conventional and secure military tactical communications. Transceiver AD3400 is used in aircraft and helicopters, and has already been ordered by three of the world's major air forces and also for a number of Royal Navy aircraft.

RÉSUMÉ

Les accords qui ont été pris à la troisième conférence des Nations Unies sur la loi de la mer accordent aux états îles côtières et archipels des droits légaux accrus pour l'utilisation, la gestion et la protection des ressources naturelles dans les zones côtières et maritimes. Parmi ces états, il en est beaucoup qui se voient obligés d'exercer une protection accrue contre les entrées illégales sur leur territoire et la contrebande. Pour assurer la surveillance et la protection qui sont nécessaires, ces états doivent établir un système économique de contrôle et de gestion des trafics d'avions et de navires et des postes centraux de commande à terre. Pour assurer une coordination efficace et rentable de l'organisation, il est nécessaire de disposer d'un réseau de communications complet.

L'article décrit comment le nouveau système radio Makaira qui couvre toutes les bandes de fréquences navales, marines, militaires et avions entre 1,6MHz et 400MHz peut offrir un ensemble de communications relativement simple mais compatible pour petites unités chargées de missions de surveillance et de protection.

ZUSAMMENFASSUNG

Entsprechend den durch die dritte Konferenz der Vereinten Nationen über das Seerecht festgesetzten Abkommen, verfügen Küsten-, Insel- bzw. Inselmeerstaaten jetzt über erweiterte Rechte zum Ausbeuten, Verwalten sowie zum Schutz der Naturreserven in Küsten- und küstennahen Gebieten. Viele dieser Staaten müssen jetzt auch erhöhten Schutz gegen illegale Einwanderung und Schmuggeln vorsehen.

Um notwendige Überwachung und Schutz zu erreichen, benötigen diese Staaten jetzt ein kostenwirksames Überwachungssystem mit Flugzeuge, Schiffen und Befehlszentren am Land. Wirksame und leistungsfähige Zusammenarbeit innerhalb dieser Organisation benötigt vollständige Kommunikationsnetze.

Dieser Aufsatz beschreibt, wie das neue Marconi-Radiosystem Makaira, welches alle Frequenzbänder der Kriegs- und Handelsmarine, des Militärs und der Luftfahrt zwischen 1,6 und 400MHz deckt, ein verhältnismäßig einfaches jedoch verträgliches Kommunikationspaket für kleine Streifenschiffe bietet, die für Überwachung und Schutz eingesetzt werden.

RESUMEN

Los acuerdos a que llegó la Tercera Conferencia de las Naciones Unidas sobre la Ley Marítima, proveen a estados de islas costeras y archipiélagos de derechos para la utilización, administración y protección de recursos naturales en zonas costeras y de mar adentro. Muchos de estos estados observan que es necesario también proveer de mayor protección contra las entradas y contrabandos ilegales.

Con la finalidad de lograr la vigilancia y protección necesarias, estos estados necesitan proporcionar un sistema de vigilancia a costo rentable de aeroplanos, buques y centros de mando en tierra. Para asegurar coordinación efectiva y eficiente dentro de esta organización, se requerirán redes amplias de comunicación.

El artículo describe cómo el nuevo sistema de radio Makaira, que abarca todas las bandas de frecuencia navales, marítimas, militares y aeronáuticas entre 1,6MHz y 400MHz, puede suministrar un conjunto ofrecido a precio global de comunicaciones relativamente insofisticado pero compatible para buques patrulleros pequeños empleados en servicios de vigilancia y protección.