

REPORT ITU-R M.2027*

**Engineering guidance for operators to upgrade shore based facilities
to operate the Global Maritime Distress and Safety System
in the A1, A2 and A3/A4 sea areas**

(2001)

1 Overview

In order to establish a new A2, A3, or A4 sea area it is necessary to gain some knowledge of how the propagation conditions vary. A2 coverage is by groundwave, which is stable, enabling the extent of the service area to be confirmed by measurement before committing capital expenditure, which is recommended by the IMO. A3 and A4 coverage is by skywave which depends upon the condition of the ionosphere which varies with solar activity. Since this follows an 11-year cycle, the extent of the service area cannot be confirmed by performing a new measurement study, and administrations wishing to join the HF shore station network may require methods to verify feasibility and size the equipment required in order to confidently establish a project budget.

The extent of the sea areas A2, A3, and A4 are specified by the IMO in Annex 3 to their resolution A.801(19), and § 3.4.1 of this Report provides charts for rapid assessment of the extent of the A2 sea area using this data, and also guidelines to enable administrations to make their own assessment of potential A3 and A4 coverage using HF prediction software in the context that each shore station is a member of a community of HF stations working together to provide the required grade of service.

- Section 2 defines the functional requirements, and describes the equipment required.
- Section 3 defines single sideband (SSB) carrier/noise ratio and useable signal level, outlines the grades of service, presents performance criteria, reviews the software tools available and provides guidance on determination of receive ranges and transmitter power requirements.
- Section 4 covers site engineering issues: including selection of good receive sites, isolation between sites, protection of watch frequencies, station earthing and lightning protection.

2 The Global Maritime Distress and Safety System (GMDSS)**2.1 Statutory requirements**

The GMDSS came into force in February 1992 under the international convention for the Safety of Life at Sea (SOLAS) amended in November 1988 and is intended for setting up a global communications network to support search and rescue activities from land, air and sea for rapid rescue for ships in distress.

* This Report should be brought to the attention of the International Maritime Organization (IMO).

The GMDSS allows shore based search and rescue (SAR) authorities as well as ships in the immediate vicinity of the ship in distress to be rapidly alerted to the distress incident so that they can assist in coordinated search and rescue operations with a minimum delay.

The GMDSS substantially expands the SAR communications coverage to the global sphere using the VHF, MF and HF bands as well as satellite communication systems using digital selective calling (DSC) which allows a ship in distress to rapidly transmit information on its situation to a shore-based coast station in a simple, secure way. The coast station that has received a distress alert can easily access the ship for SAR communications.

In addition, the GMDSS NAVTEX system provides automatic broadcasting of maritime safety information, navigational and meteorological warnings and SAR information to all ships in a coastal area of up to 500 nautical miles offshore.

Full GMDSS coverage is provided by dividing the oceans of the world into four different areas in which ships are expected to operate:

Area	Definition of sea area	Means of coverage	Typical range
A1	An area within radiotelephone coverage of at least one VHF shore station, in which continuous DSC alerting is available	<i>Permanent VHF coverage</i> Within line-of-sight of antenna, extended when ducting persists	<i>Short range</i> 15 to 30 nautical miles offshore
A2	An area, excluding sea area A1, within radiotelephone coverage of at least one MF station, in which continuous DSC alerting is available	<i>Permanent MF coverage</i> Groundwave propagation over the horizon with some patches fading at night	<i>Medium range</i> 100 to 300 nautical miles offshore
A3	An area, excluding sea areas A1 and A2, within which the elevation of an INMARSAT geostationary satellite is 5° or more	<i>Alternative to INMARSAT</i> Using skywave propagation on 5 HF bands	<i>Long range</i> Mainly between latitude 70° N and latitude 70° S
A4	An area outside sea areas A1, A2, and A3	<i>Primary HF coverage</i> Shared between network of participating shore stations by skywave on 5 HF bands	<i>Long range</i> Beginning north of 70° N south of 70° S

2.2 Operational requirements

2.2.1 Basic operator functions

Shore-based coast stations providing ships at sea with VHF, MF or HF radiocommunication services for use with the GMDSS have to incorporate the following functions.

Reception of distress alerts. The shore station is required to keep continuous watch for distress alerts transmitted from ships using DSC. The distress alert identifies the ship in distress, its position, the nature of the distress, the type of assistance required and the time of recording of the information.

Transmission of acknowledgement. The shore station which has received a distress alert is required to send back an acknowledgement signal to the ship in distress, to cease any transmission which may interfere with distress traffic, and to continue to watch distress traffic.

Re-transmission of the distress alert. The shore station is required to have the means to re-transmit the received distress alert to all the ships navigating in the vicinity of the ship in distress.

Dissemination of maritime safety information. To support SAR operations, shore-based coast stations are expected to disseminate maritime safety information including navigational and meteorological warnings and other urgency and safety messages. The NAVTEX information is transmitted on 518 kHz by means of narrow-band direct printing (NBDP) telegraphy in forward error correction (FEC) mode.

2.2.2 Functional roles played by shore-based facilities

Although arrangements differ from country to country, shore-based facilities generally comprise radio stations and SAR forces under the supervision of one or more rescue coordination centres (RCC), and rescue missions commonly employ facilities from more than one country, calling for a high degree of international cooperation. Annex 2 of document COM33/2/3 (July 1987) – Input from IMO subcommittee on Life Saving Appliances, Search and Rescue to IMO subcommittee on Radiocommunication concerning SAR communications on Long Ranges in GMDSS, describes how the search and rescue operations are coordinated by the international RCC community with direct assistance from shore-based radio facilities, and lays out some basic guidelines for international cooperation.

The shore station nearest to the reported distress position should acknowledge the alert. Other shore stations receiving the alert should acknowledge if the nearest station does not appear to respond, which may be due to the variability of HF skywave communications. The shore station which acknowledges the alert is then expected to establish and maintain communications with the casualty until relieved by the affiliated RCC which bears responsibility for all subsequent coordination of SAR measures, unless and until responsibility is accepted by another RCC better able to take action.

2.2.3 Initial operator response to a distress alert

The loss of life resulting from any accident or disaster is reduced by the speed of response from the rescue service. The prime directive should therefore be to enable the shore station operator to implement the fastest possible response, summarized as:

- recognizing the nature of the distress and notifying the affiliated RCC;
- establishing initial contact with the distressed vessel or task force;
- accepting responsibility for and initiating transmission of the DSC acknowledgement;
- patching the RCC through by radio to the distressed vessel or task force if required.

The operator response software should be designed to immediately invoke an appropriate human response, minimizing the amount of time which the operator should spend correlating data, deciding

what action to take, and performing subsequent actions like dialling telephone numbers and setting up equipment.

The ship's crew-member raising the alert has the option to request the use of NBDP for follow-on communication, mandatory if in A4 waters. The operator workstation should therefore be equipped to double as an NBDP chat-mode terminal.

2.3 Equipment required for distress response

2.3.1 Basic equipment required for short-range communication (A1)

A country with an extended coastline may need a number of VHF base stations for effective radio coverage, as shown in Fig. 1, in which one RCC supervises a number of geographically based subsystems, each with its own operator. As a call may be picked up by more than one base station, each subsystem would use a voting system to decide which base station to use, and these would be linked between sites to decide which operator would be responsible for overlapping calls.

FIGURE 1
Typical system covering a complete coastline

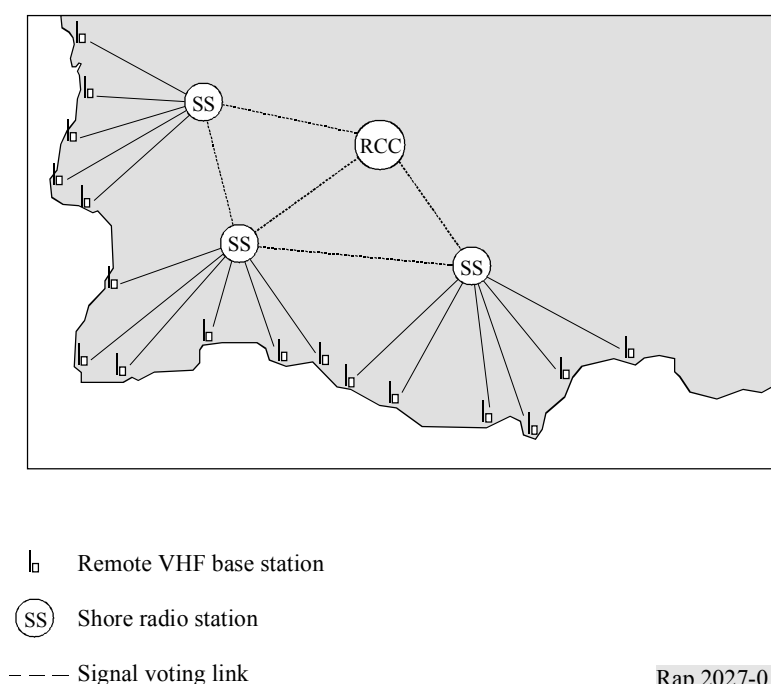
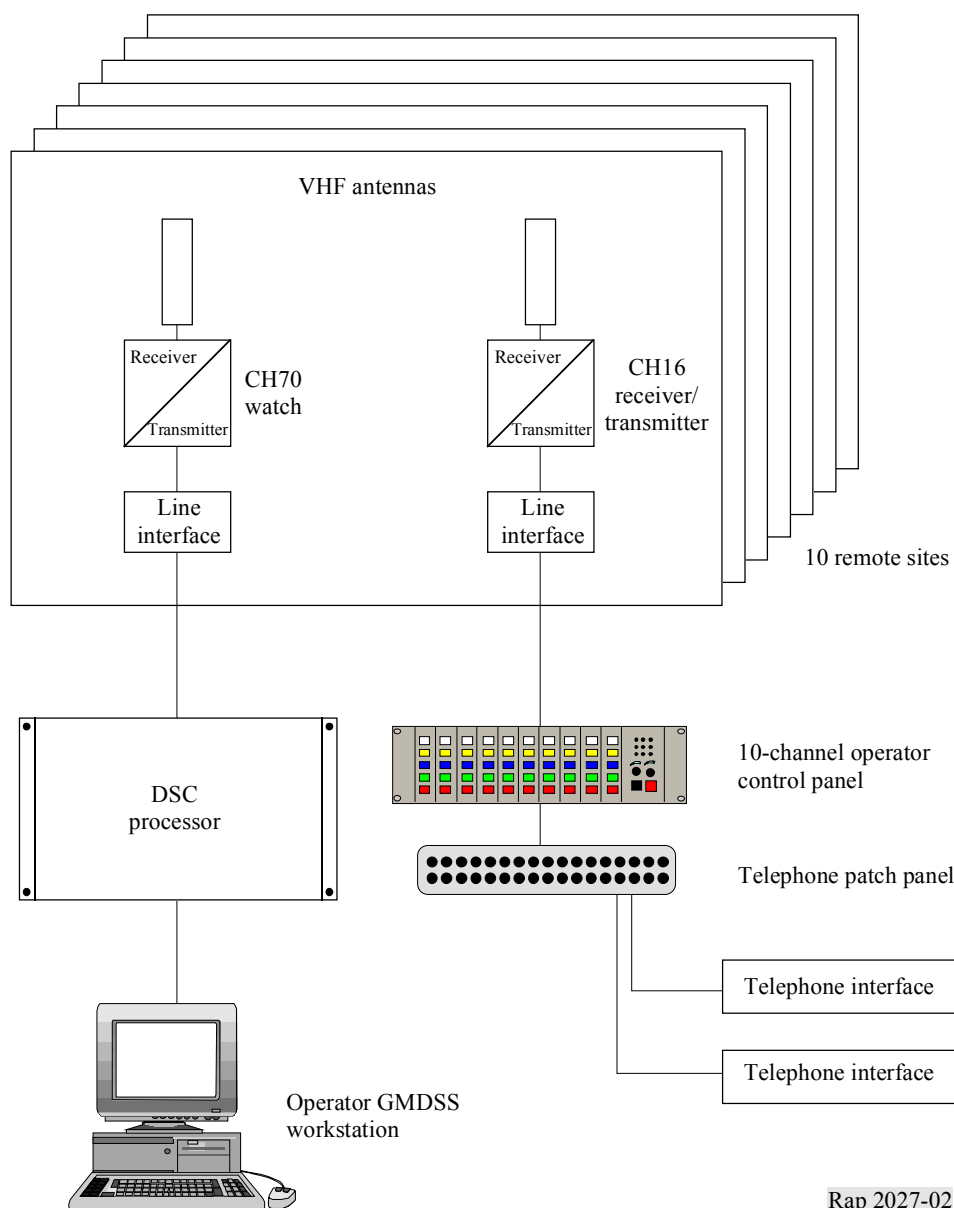


Figure 2 depicts the basic equipment required in each subsystem to provide a response to an A1 distress alert, showing 10 remote VHF base stations under the control of a single DSC processor and operator.

2.3.2 Basic equipment for medium-range communication (A2)

Figure 3 shows the basic equipment required for providing a response to an A2 distress alert, configured to enable the transmission of the distress acknowledgement and provision of manual response using SSB radiotelephony to be accomplished using a single transmitter.

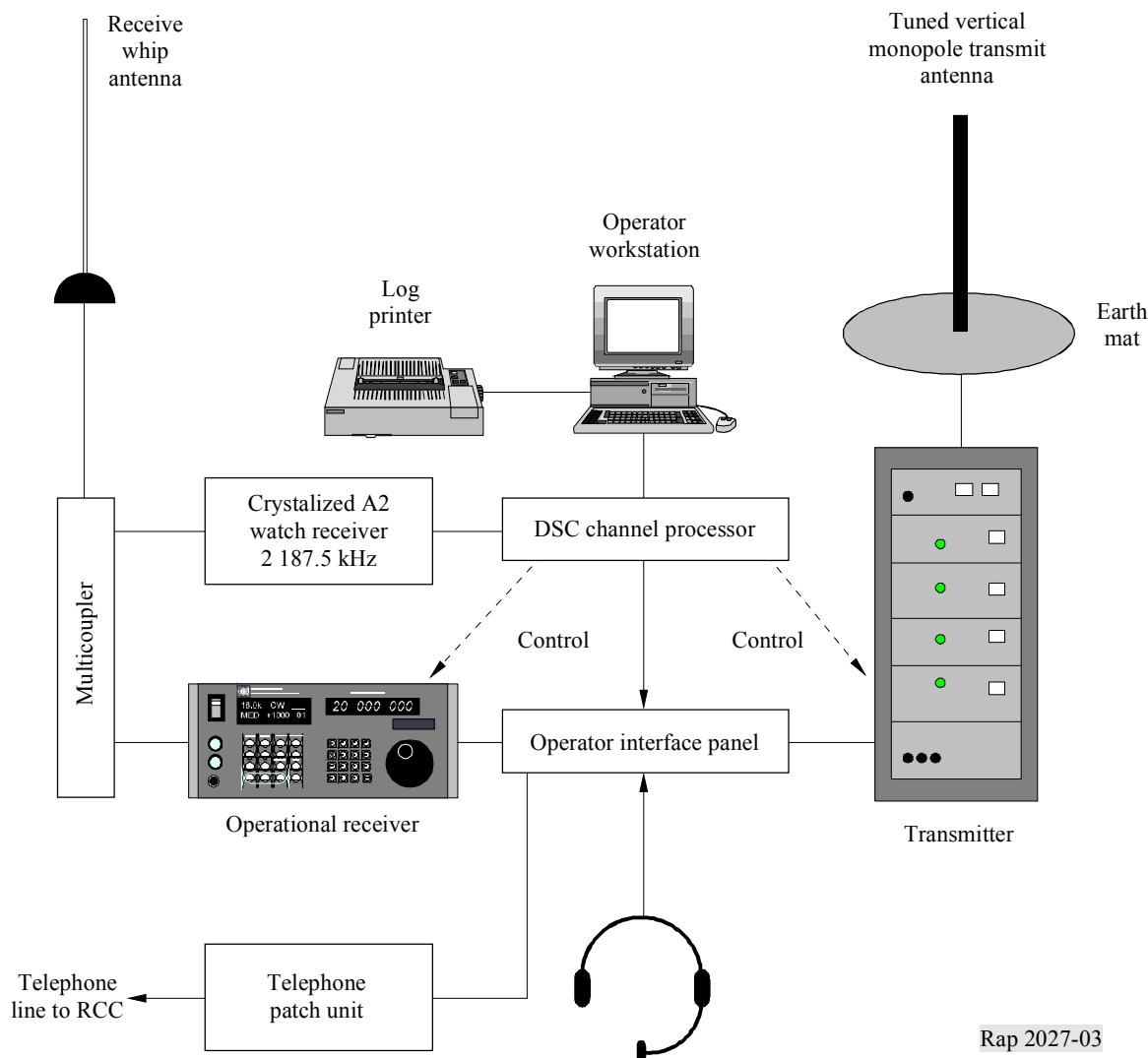
FIGURE 2
Basic GMDSS A1 subsystem



A short whip receive antenna is connected to a crystallized A2 watch receiver and an operational receiver via a multi-coupler. The watch receiver output is connected to DSC processor modem input, the modem audio frequency and PTT outputs being connected to the transmitter via an interface panel to enable the DSC acknowledgement to be routed to the transmitter when required. The interface panel enables the operator to establish a radiotelephony circuit with the ship, and provide the necessary connection to the RCC, and to maintain control of the transmitter and receiver.

The transmit antenna is a vertically polarized tuned monopole antenna, capable of launching a groundwave for A2 response. The size of transmitter required will depend upon the antenna efficiency, which depends upon the antenna length, and the size of the earth mat, and for output powers below 500 W it would be possible to combine the transmitter and the operational receiver into a single transceiver. More information on antenna efficiency is given in § 4.5.1.3 below.

FIGURE 3
Basic GMDSS MF DSC system



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The transmitter and operational receiver can be set to the appropriate mode and frequency by the DSC processor, either directly, or indirectly via the operator workstation.

Additional equipment which may be used, but is not shown, include modems to enable the equipment to be installed on separate sites, and a call logger to enable the radiotelephony messages and DSC signals to be recorded.

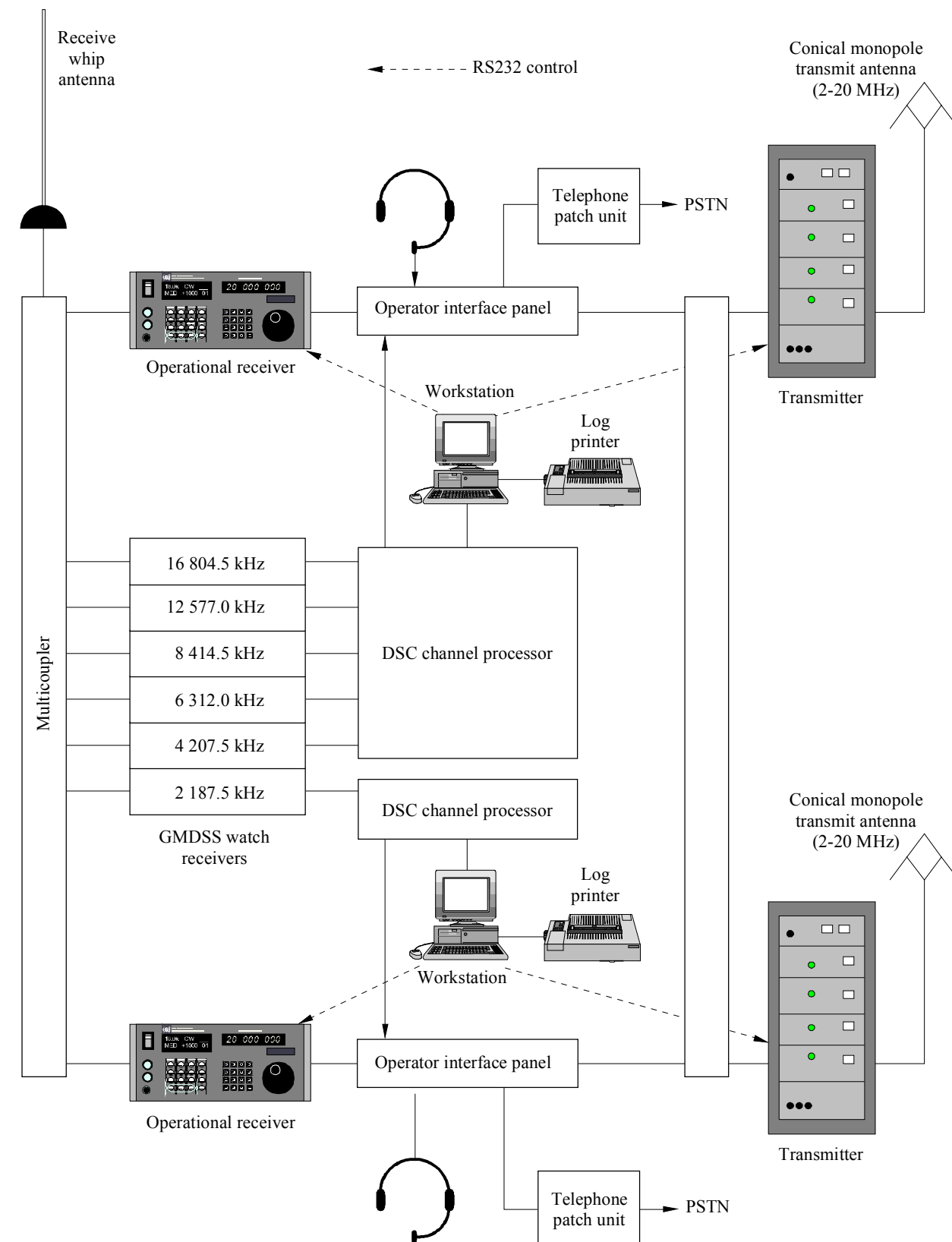
2.3.3 Basic equipment for medium- and long-range communication (A2/A3)

Figure 4 shows the additional equipment required to the basic configuration in Fig. 3 for a second channel providing A3 coverage, comprising watch receivers and DSC modems to cover the five HF bands, operational receiver, transmitter, and transmit antenna.

Both transmitters connect to their own wideband conical monopole antenna suitable for initiating groundwaves for MF A2 coverage, and low angle skywaves for HF A3 coverage, and a transmitter crosspatch ensures that if one transmitter fails the remaining transmitter can be used on either

service. Additional redundancy could be provided by doubling the number of watch-keeping receivers, providing two identical subsystems each capable of operating on either A2 or A3.

FIGURE 4
Basic GMDSS MF or HF DSC system

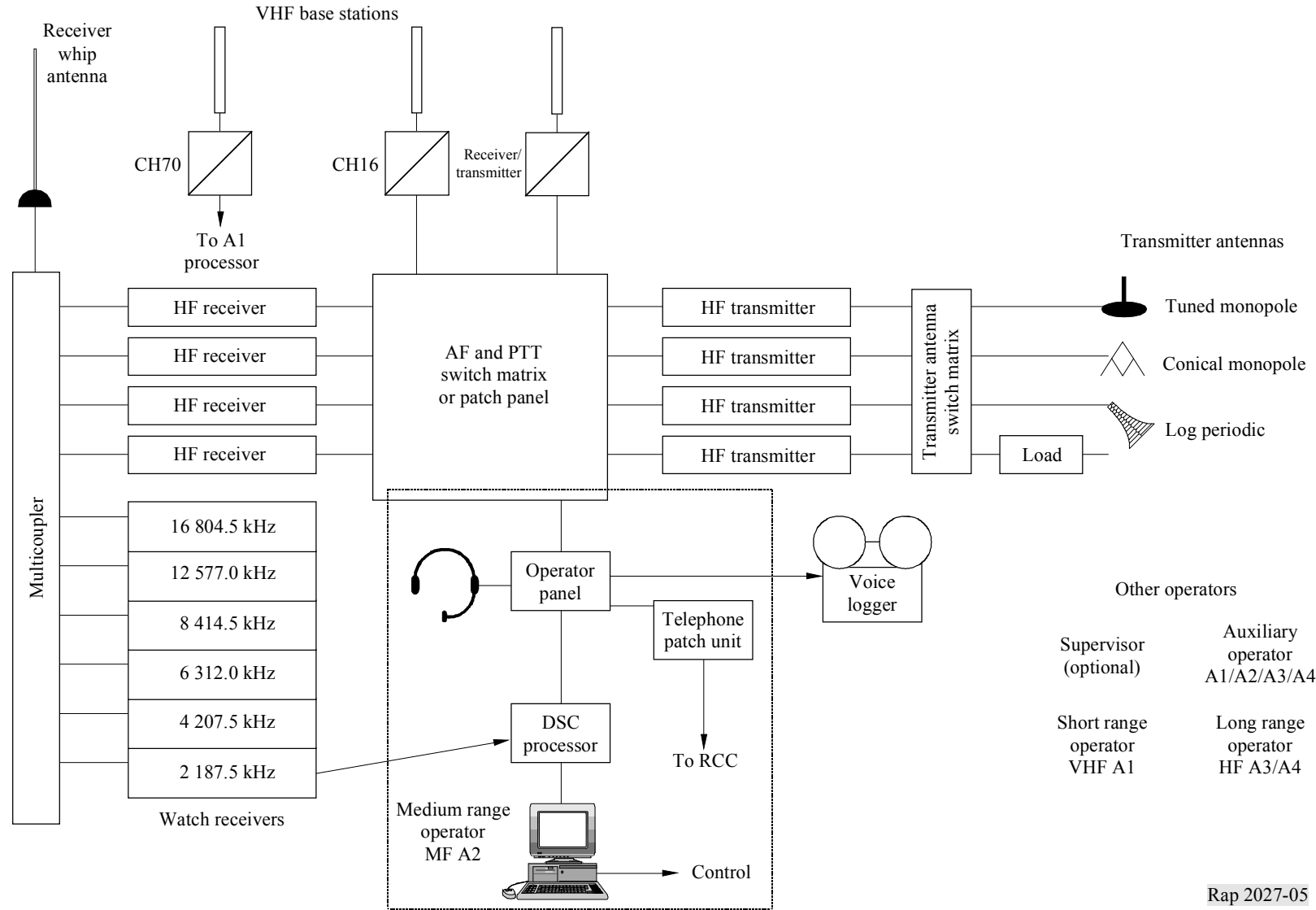


PSTN: public switched telephone network

2.3.3.1 Typical system providing full cover on A2, A3, and A4

FIGURE 5

Typical system providing full GMDSS A1, A2, and HF coverage

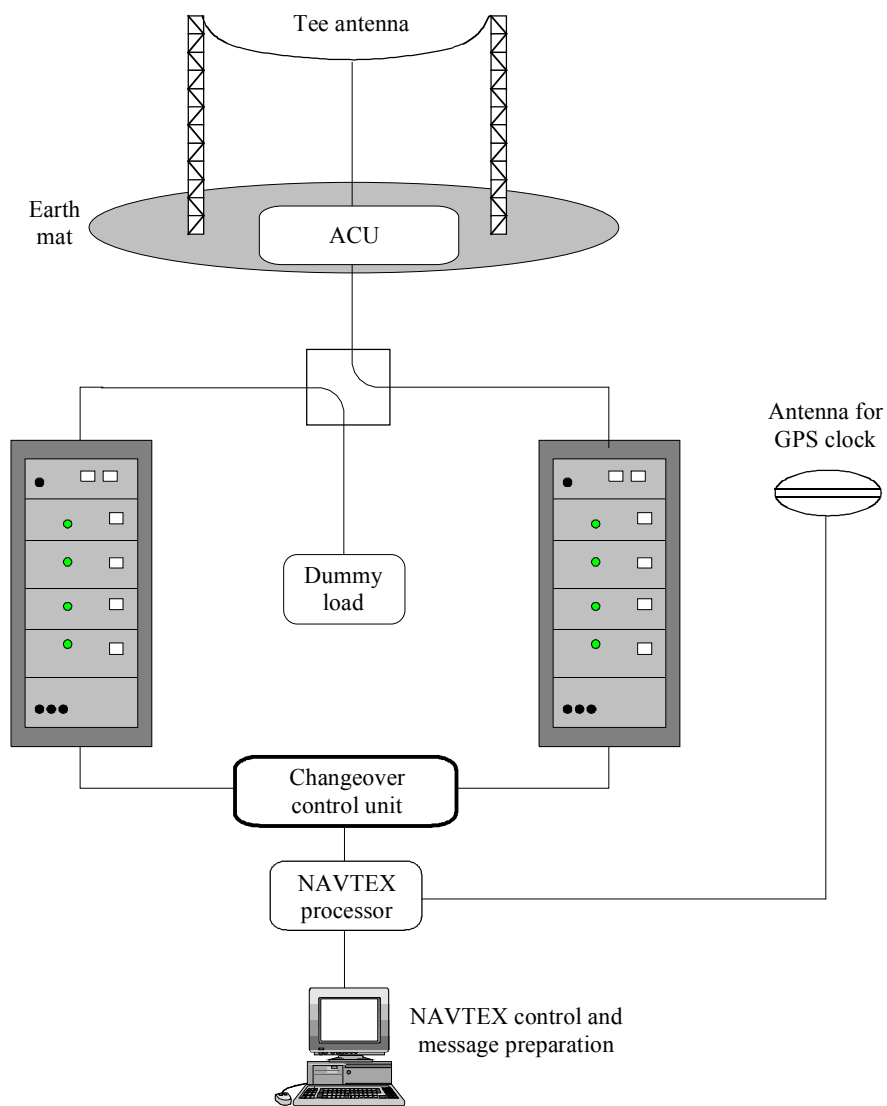


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2.3.4 NAVTEX system

The NAVTEX system can store broadcast messages in advance and automatically send them out on a pre-set broadcast timetable. The 518 kHz transmitter is designed to operate in the F1B mode in order to transmit NAVTEX information in the FEC mode through the NBDP system.

FIGURE 6
Basic NAVTEX system



ACU: antenna command unit

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3 System planning

3.1 Planning objectives

Shore-based GMDSS stations have to provide short-range, medium-range and/or long-range services using VHF, MF and HF bands, respectively. Whereas an A1 sea area may require a large number of VHF stations at intervals along the coastline, NAVTEX and A2 sea areas can each be covered from a single shore station, which should be designed to provide a grade of service offering 95% availability for A2, and 90% for NAVTEX broadcasts. The responsibility for covering A3 and A4 sea areas is shared between a number of shore stations working together to provide a joint availability of 90%, i.e. a 90% probability that a call will be picked up by any one shore station.

The range achieved depends upon the transmitted power, the propagation loss, and the ability of the receiver to discriminate between the wanted signal and the unwanted noise or interference. The level of each component in the received signal will drift as the propagation conditions change with time, and therefore arrive at the receive antenna in varying proportions, and the final system design should ensure that the level of the signal will exceed the level of the noise by an adequate amount for an adequate proportion of the time. This proportion is called the availability, and is determined by quantifying the behaviour of the signal and the noise with time.

3.2 Planning criteria

3.2.1 Performance criteria for VHF services

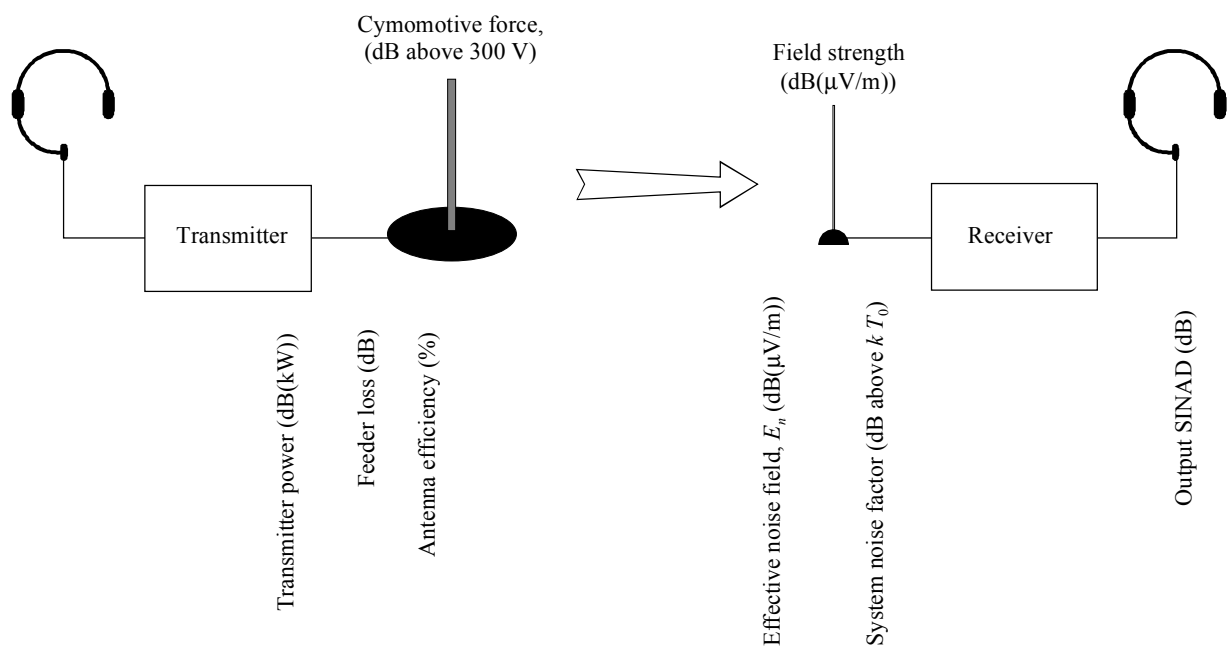
Annex 3 of IMO resolution A.801(19) provides the following formula for calculation of range A :

$$A = 2.5 \times (\sqrt{H} + \sqrt{h}) \quad \text{nautical miles}$$

where H and h are heights of shore and ship antennas (m) above mean sea level, and $h = 4$ m.

3.2.2 Performance criteria for groundwave services

FIGURE 7
A simple SSB radiotelephony system



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The IMO define the range for an A2 shore-based radio station by the ability of the station to hold effective communications with a ship transmitting 60 W into a 25% efficient antenna on SSB radio telephony, for which the essential system elements are shown in Fig. 7. Since this power is much less than the level usually transmitted from the shore station, the first step is to check the sensitivity of the receive site, secondly to determine the amount of power required to return the call, and then to protect the integrity of the DSC distress watch-keeping channels. The IMO recommend a measurement study to provide assurance of the range achieved.

TABLE 1

Performance criteria for groundwave services

Distress channel	Receiver/ transmitter	DSC	ARQ NBDP	NAVTEX
Frequency (kHz)	2 182	2 187.5	2 174.50	490 and 518
Bandwidth (Hz)	3 000	300	300	500
Propagation	Ground wave	Ground wave	Ground wave	Ground wave
Ships power (W)	60	60	60	
Ships antenna efficiency (%)	25	25	25	25
RF full bandwidth signal/noise ratio, S/N (dB)	9	12	18	8
Mean transmitter power below peak (dB)	8	0	0	
Fading margin (dB)	3	Not stated	9	3
IMO reference	res. A.801(19)	res. A.804(19)	Rec. ITU-R F.339	res. A.801(19)
Percentage of time (%)	95 ⁽¹⁾	Not stated	Not stated	90

ARQ: automatic error correction

- ⁽¹⁾ This figure is suggested by the Danish Post and Telegraphs administration in their paper "Calculation of GMDSS ranges for selected parts of the world" dated 30 December 1987.

3.2.3 Performance criteria for skywave services**3.2.4 Frequencies used**

TABLE 2

Frequencies for GMDSS transmissions

Band (MHz)	NBDP distress	GMDSS distress	Receiver/ transmitter distress
4	4 177.50	4 207.50	4 125
6	6 268	6 312	6 215
8	8 376.50	8 414.50	8 291
12	12 520	12 577	12 290
16	16 985	16 804.50	16 420

TABLE 3

Performance criteria for various HF transmissions

Distress channel	Receiver/ transmitter	DSC	ARQ NBDP
Bandwidth (Hz)	3 000	300	300
Ships power (W) ⁽¹⁾	60	60	60
Ships antenna efficiency	Not stated	Not stated	Not stated
RF full bandwidth signal/noise ratio, <i>S/N</i> (dB)	9	12	12
Mean transmitter power below peak (dB)	8	0	0
Fading margin (dB)	3	Not stated	Not stated
IMO reference	res. A.806(19)	res. A.806(19)	res. A.806(19)

(1) IMO resolution A.806(19) states that higher powers may be required in some areas of the world.

3.3 Planning tools

3.3.1 ITU software

3.3.1.1 NOISEDAT

Recommendation ITU-R P.372 provides a complete method for determination of the levels of radio noise to be expected at any location, in any season, and during any period of the day. The method is based around use of the ITU-R noise maps, which were originally produced for inclusion in HF prediction packages. The basic method included in the Recommendation has been encapsulated in the “NOISEDAT” program, which runs under DOS.

3.3.1.2 GRWAVE

Calculates groundwave field strength curves used in Recommendation ITU-R P.368, and runs under DOS.

3.3.1.3 Recommendation ITU-R P.533

Predicts signal strengths in accordance with Recommendation ITU-R P.533, and runs under DOS.

3.3.1.4 HFANT

This program embraces analytical models of the antennas contained in Recommendation ITU-R BS.705 enabling the gain and radiation patterns for a large number of antennas to be modelled.

3.3.1.5 The ITU International Frequency List CD-ROM

This is available from the ITU in Geneva, and provides an invaluable listing of sites by station type and frequency registration. It is of especial use in determining the locations of other shore stations for frequency planning and coordination purposes.

3.3.2 Institute of Telecommunication Sciences (ITS) of the National Telecommunication and Information Administration (NTIA)/ITS software

The following programs are available from NTIA/ITS in the United States of America for prediction of communications and coverage by HF skywave. They are configured to run under DOS, Windows 3.1, Windows 95, or Windows NT.

Origin of model used	Point-to-point package	Area coverage package	Interference analysis package
Recommendation ITU-R P.533	REC533	RECAREA	–
IONCAP	ICEPAC	ICEAREA	S/I ICEPAC
IONCAP	VOACAP	VOAAREA	S/I VOACAP

Each package contains a useful database of world locations and antennas, and is supported by an extended version of HFANT which enables the library of antenna radiation patterns to be viewed or new ones synthesized in accordance with Recommendation ITU-R BS.705. Area coverage maps are created from an integral world coastline database, over which a wide range of contours can be plotted, including maximum useable frequency (MUF), signal strength, noise power, signal-to-noise ratio, reliability, and required antenna elevation angle. ICEPAC and VOACAP use the same basic model, but ICEPAC has been enhanced to account for geomagnetic activity.

3.3.3 IPS software

IPS is the Australian Department of Administrative Services, who operate a wide range of propagation prediction service. Their “ASAPS” (advanced stand alone prediction system) package is well established, and is a frequency, HF skywave prediction, management and engineering system, and is well known for its “Grafex” frequency predictions. For groundwave predictions they offer their “GWPS” (groundwave prediction system) package which models coverage by groundwave.

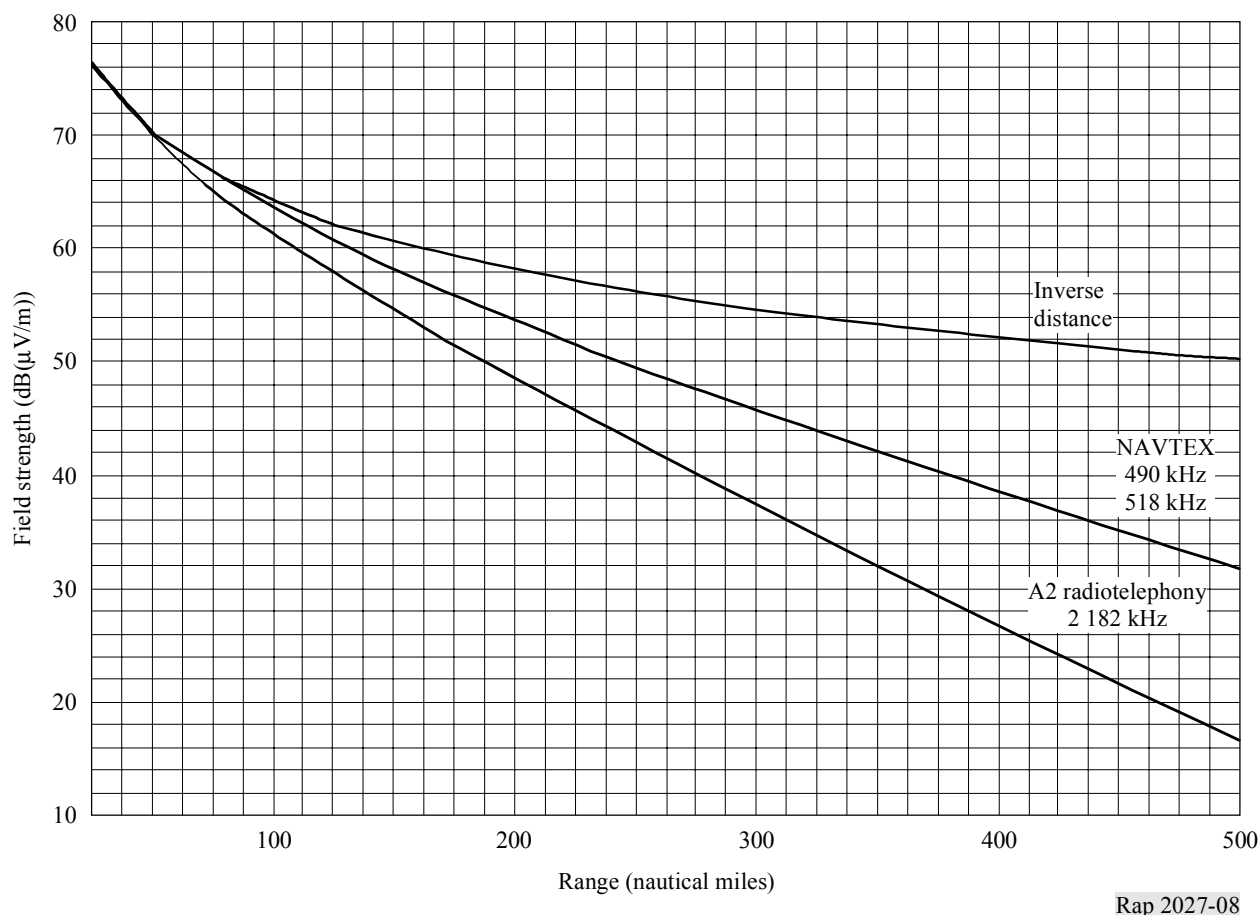
3.3.4 Choice of software

For use in implementing the following guidelines, the ITU program NOISEDAT is recommended for determination of external noise levels for planning the A2 groundwave service, and the NTIA/ITS version of Recommendation ITU-R P.533, RECAREA, and HFANT are recommended for planning the A2 and A3 skywave services. However, administrations may well find that the alternative programs covered above better suit their needs, such as GWPS for modelling within the A2 service area.

3.4 Planning guidelines

3.4.1 Establishing an effective groundwave service area

FIGURE 8
Groundwave propagation curves for A2 and NAVTEX, extracted from Rec. ITU-R P.368



3.4.1.1 Determination of extent of A2 service area

The extent of the A2 service area is determined by the range over which SSB communication is effective at 2 182 kHz between ship and shore. The ship is considered to be fitted with a 60 W transmitter, feeding a short monopole antenna with an efficiency of 25%. The range is fixed by the maximum distance at which the ship can be from the shore station to produce a S/N of 9 dB in a 3 kHz bandwidth, out of the receive antenna at the shore station which must be equipped with a transmitter of sufficient power to return the same S/N at the output of the ship's receive antenna. The range in both directions depends upon the sensitivity of the receive antenna, which depends upon the levels of natural and man-made noise present, the quality of the receive antenna installation and earthing, and the ability of the antenna to discriminate between the wanted signal and the unwanted noise. The noise factor of the receive system connected to the receive antenna can be ignored at 2 182 kHz. It is assumed that the shore-based receive antenna can be correctly installed and subject to periodic maintenance, and therefore free from serious corrosion.