NO.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DIRECTORATE GENERAL OF SEA COMMUNICATION, MINISTRY OF COMMUNICATIONS (DGSC), THE REPUBLIC OF INDONESIA

THE STUDY FOR THE MARITIME TRAFFIC SAFETY SYSTEM DEVELOPMENT PLAN IN THE REPUBLIC OF INDONESIA

FINAL REPORT

FEASIBILITY STUDY REPORT VOLUME IV

PART 4. : GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS)

June 2002

THE JAPAN ASSOCIATION OF MARINE SAFETY (JAMS)

JAPAN AIDS TO NAVIGATION ASSOCIATION (JANA)

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Exchange Rate in the Study:

1 US$ = Rp. 10,000 = 130 Japanese Yen

（based on the approximate rates of February 2002）

PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a study on Maritime Traffic Safety System Development Plan in the Republic of Indonesia and entrusted the study to Japan International Cooperation Agency.

JICA selected and dispatched a study team headed by Mr. Kunio Tashima (until September 4th 2001) of The Japan Association of Marine Safety (JAMS) and Mr. Shingo Tsuda (from September 5th 2001) of JAMS, to Indonesia, three times between April 2001 and March 2002. In addition, JICA set up an advisory committee headed by Mr. Tamotsu Ikeda (Director, Radio Aids Division, Aids to Navigation Department, Japan Coast Guard) between March 2001 and March 2002, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Republic of Indonesia and conducted field surveys at study areas. Upon returning to Japan, the team conducted further studies and prepared this Final Report.

I hope that this report will contribute to the promotion of the projects and to the enhancement of friendly relationship between the two countries.

Finally, I wish to express my sincere appreciation to the officials concerned with the Government of the Republic of Indonesia for their close cooperation extended to the study.

June 2002

川上隆朗

Takao Kawakami
President,
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

June 2002
Mr. Takao Kawakami
President
Japan International Cooperation Agency

Dear Mr. Kawakami

It is my great pleasure to submit herewith the Final Report of the Study for the Maritime Traffic Safety System Development Plan in the Republic of Indonesia.

The study team of the Japan Association of Maritime Safety (JAMS) and Japan Aids to Navigation Association (JANA) conducted surveys in the Republic of Indonesia over the period between April 2001 and March 2002 as per the contract with Japan International Cooperation Agency.

The findings of this study, which are compiled in this report, were fully discussed with the officials of the Ministry of Communications of the Indonesian Government and other authorities concerned to formulate the Maritime Traffic Safety System Development Plan in the Republic of Indonesia for the period up to the year 2020.

On behalf of the study team, I would like to express my heartfelt appreciation to the Government of the Republic of Indonesia, the Ministry of Communications and other authorities concerned for their diligent cooperation and assistance and for the heartfelt hospitality which they extended to the study team during our stay in the Republic of Indonesia.

I am also deeply indebted to “Japan International Cooperation Agency”, “The Ministry of Foreign Affairs of Japan”, “The Ministry of Land, Infrastructure and Transport of Japan” and “Embassy of Japan in Indonesia” for giving us valuable suggestions and assistance during the preparation of this report.

Yours faithfully,

津田真吾

Shingo Tsuda
Team Leader,
The Study for the Maritime Traffic Safety System
Development Plan in the Republic of Indonesia

INDONESIA

Legend: ◎ 1st Class Coast Station ● 2nd Class Coast Station

GMDSS Equipment Installed by Maritime Telecom Phase-III Project

Kupang Transmitting Station 【2nd Class】

GMDSS at Kupang Receiving Station

Benoa Station 【3rd Class】

GMDSS at Benoa Station

Aged Equipment to be Replaced

Antennas at Banjarmasin Transmitting Station

E/G at Makassar Transmitting Station

New Sites

Teluk Bayur Transmitting Site (already purchased) & its Station Building

Makassar Transmitting Site (under negotiation with land owner)

ABBREVIATIONS

B	BAPPENAS	Badan Perencanaan Pembangunan Nasional (National Development Planning Agency)
	BASARNAS	Badan SAR Nasional (National SAR Agency)
C	COSPAS/SARSAT	Space System for Search of Distress Vessels/ Search and Rescue Satellite-Aided Tracking
	C/S	Coast Station
D	DGSC	Directorate General of Sea Communication
	DSC	Digital Selective Calling
E	E/G	Engine Generator
F	FIRR	Financial Internal Rate of Return
G	GDP	Gross Domestic Product
	GMDSS	Global Maritime Distress and Safety System
	GOI	Government of the Republic of Indonesia
H	HF	High Frequency
I	IMO	International Maritime Organization
	INMARSAT	International Mobile Satellite Organization
J	JBIC	Japan Bank for International Cooperation
	JICA	Japan International Cooperation Agency
L	LUT	Local User Terminal
M	MF	Medium Frequency
N	NAVIGASI	Directorate of Navigation
	NAVTEX	Navigation Telex
	NBDP	Narrow Band Direct Printing

O	ODA	Official Development Assistance
P	PC	Personal Computer
R	RCC	Rescue Coordination Center
	RX, Rx	Receiving or Receiver
S	SAR	Search And Rescue
	SOLAS	International Convention for Safety Of Life At Sea
T	TX, Tx	Transmitting or Transmitter
U	USD	US Dollar
V	VHF	Very High Frequency

Feasibility Study Report for
GMDSS Expansion and Improvement

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Feasibility Study Report for GMDSS Expansion and Improvement

1. Introduction

(1) Requirements of SOLAS Convention

Although the conventional maritime distress and safety communication system, mainly using Morse codes such as SOS, TTT, has contributed to the safety of life at sea for a long time, some problems have been pointed out. The conventional system is inadequate for long-distance communication, and no distress signal is transmitted if a vessel is capsized abruptly.

To solve these problems, International Maritime Organization (IMO) and other related organizations have developed the Global Maritime Distress and Safety System (GMDSS) using digital and satellite communications technologies.

GMDSS allows a vessel in distress in any sea area to make a quick and secure request for rescue to maritime search and rescue (SAR) authorities and vessels passing in the vicinity. In addition, the GMDSS allows the vessels in the vicinity to obtain maritime safety information available from the shore at any time with high accuracy using the automatic receiving system.

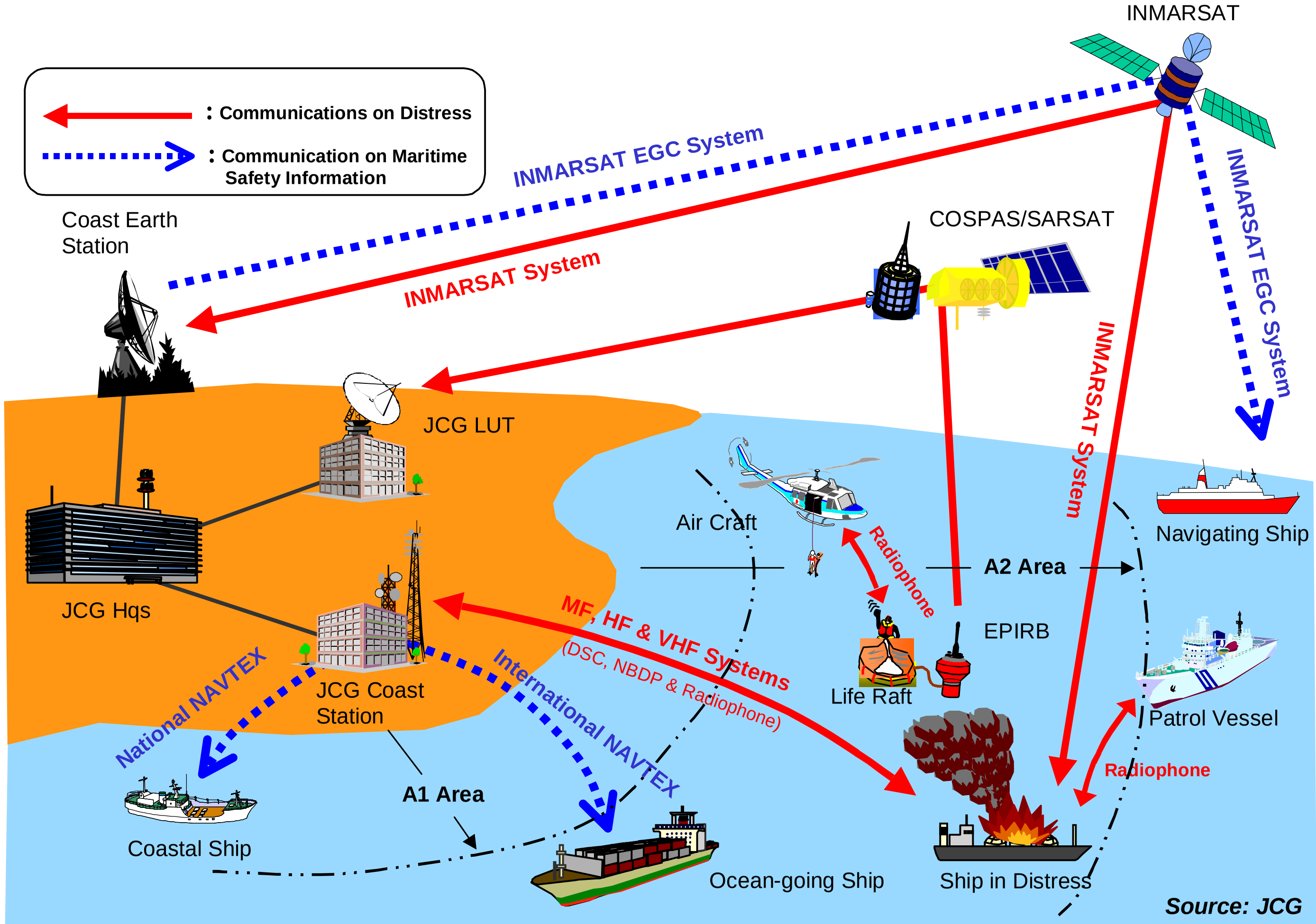
For the full coverage by the GMDSS, the sea areas in the world are divided into four ship's areas of operation as follows:

Sea Area A1 – within range of shore-based VHF coast stations (about 25 nautical miles)
Sea Area A2 – within range of shore-based MF coast stations (about 150 nautical miles)
Sea Area A3 – within range of service by INMARSAT, which covers the whole globe except polar regions
Sea Area A4 – the remaining sea areas outside areas A1, A2 and A3

GMDSS was put into service in February 1992 and fully implemented in February 1999 in accordance with the regulations under the International Convention for Safety Of Life At Sea (SOLAS Convention). **Figure 4.1.** shows the concept of GMDSS.

Accordingly, the vessels that required under SOLAS Convention shall install with GMDSS equipment corresponding to their navigating sea area.

Figure 4.1. Concept of GMDSS



For shore-based facilities, Amendments to the 1974 SOLAS Convention concerning GMDSS, Chapter IV (Radio communications), Part B (Undertaking by Contracting Governments), Regulation 5 (Provision of Radio Communication Service) stipulates;

> "Each Contracting Government undertakes to make available, as it deems practical and necessary either individual or in cooperation with other Contracting Government, appropriate shore-based facilities for space and terrestrial radio communication services having due regard to the recommendations of the organization".

The Republic of Indonesia, as a big maritime state in the world, has a vital responsibility for an early establishment of maritime distress and safety telecommunication system, i.e. GMDSS throughout Indonesian waters.

(2) Current Situation of GMDSS Coverage

In accordance with the requirements of SOLAS Convention, BASARNAS established COSPAS/SARSAT Local User Terminal (LUT) at two sites in Jakarta and Ambon, while DGSC is also promoting to provide the required coast stations with GMDSS equipment such as digital selective calling (DSC), narrow band direct printing (NBDP) and navigation telex (NAVTEX) equipment.

So far, DGSC installed HF DSC at 12 stations, MF and VHF DSC at 30 stations and NAVTEX transmitters at 4 stations under the Maritime Telecommunication System Project Phase Ⅲ and other projects.

Table 4.1. shows the list of GMDSS coast stations at present and **Figure 4.2.** shows the locations of those stations.

a. HF DSC for Sea Area A3

Twelve (12) coast stations are installed with HF DSC equipment and are keeping watch for whole Sea Area A3.

There are no more needs to deploy HF DSC stations for Sea Area A3.

b. MF DSC for Sea Area A2

Thirty (30) coast stations are installed with MF DSC equipment and are keeping watch for Sea Area A2.

There still remain blind zones in Sumatra, Kalimantan, Sulawesi and Irianjaya which need to be covered by MF DSC.

c. VHF DSC for Sea Area A1

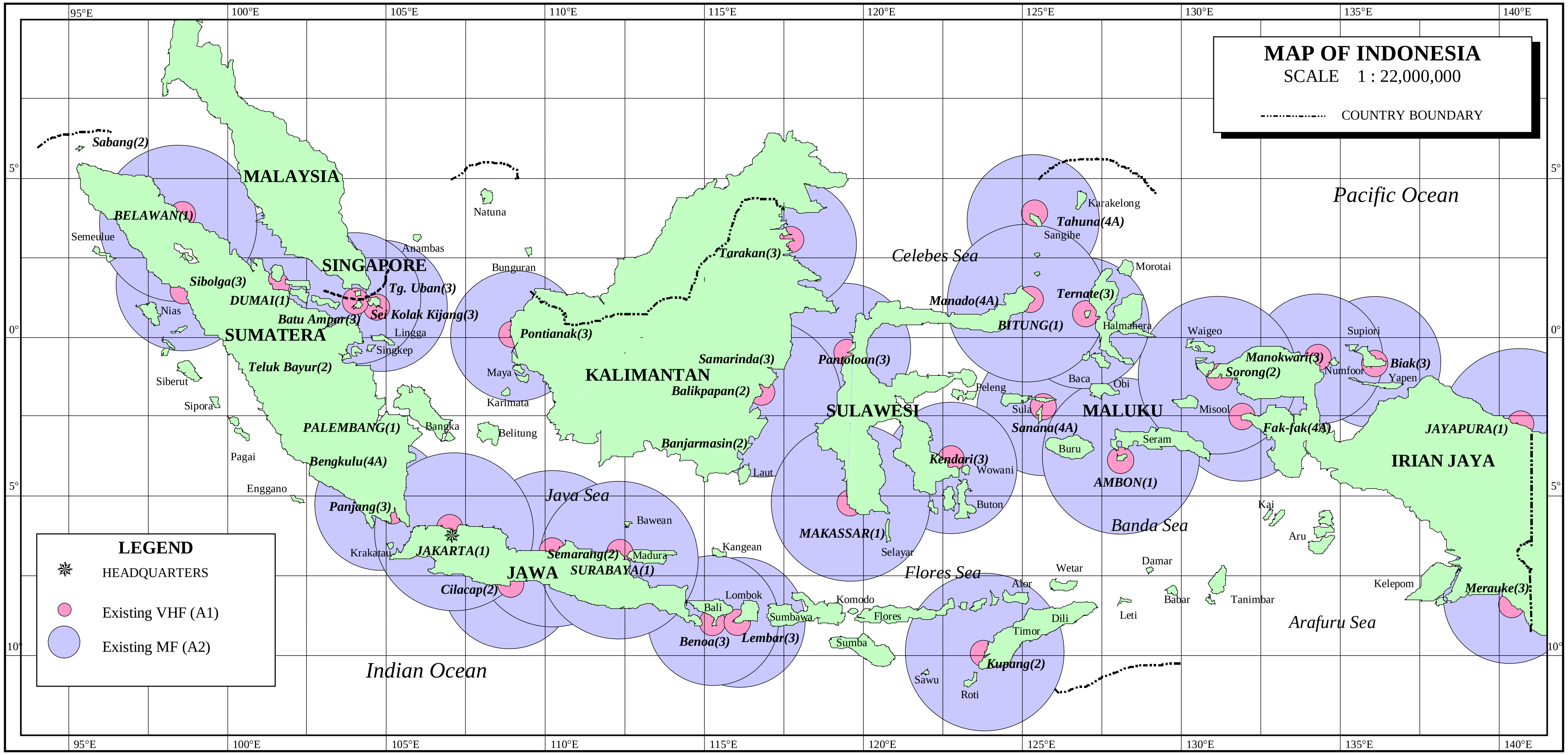
Thirty (30) coast stations are installed with VHF DSC equipment and are keeping watch for Sea Area A1.

There still remain a number of coast stations for main ports, major feeder ports and important navigation waters which need provision of VHF DSC equipment.

Table 4.1. GMDSS Coast Stations at Present

Class			A3 HF DSC	A2 MF DSC	A1 VHF DSC	NAVTEX	Remarks
I	1	Belawan	O	O	O		
	2	Dumai	O	O	O		
	3	Jakarta	O	O	O	O	
	4	Surabaya	O	O	O		
	5	Makassar	O	O	O	O	
	6	Bitung	O	O	O		
	7	Ambon	O	O	O	O	
	8	Jayapura	O	O	O	O	
II	1	Semarang	O	O	O		
	2	Cilacap		O	O		
	3	Kupang	O	O	O		
	4	Balikpapan	O	O	O		
	5	Sorong	O	O	O		
III	1	Sibolga		O	O		
	2	Batu Ampar		O	O		
	3	Sei Kolak Kijang		O	O		Eq'pt from Tg.Pinang
	4	Panjang		O	O		
	5	Benoa		O	O		
	6	Lembar		O	O		
	7	Pontianak		O	O		
	8	Tarakan		O	O		
	9	Kendari		O	O		
	10	Pantoloan		O	O		
	11	Ternate		O	O		
	12	Manokwari		O	O		
	13	Biak		O	O		
	14	Merauke		O	O		
IV	1	Tahuna		O	O		
	2	Sanana		O	O		
	3	Fak-fak		O	O		
Total No. of Station			12	30	30	4	

Figure 4.2. GMDSS Coverage Area (at Present)



Remarks: A3 area is covered by Belawan, Dumai, Jakarta, Surabaya, Makassar, Bitung, Ambon, Jayapura, Semarang, Kupang, Balikpapan and Sorong.

d. NAVTEX

International NAVTEX using English are being serviced from Jakarta, Makassar, Ambon and Jayapura coast stations, and their coverage areas are shown in **Figure 4.3.**

However, National NAVTEX which are being serviced in many non-English countries in order to secure the safety of navigation for coastal and inter-islands shipping, has not been established yet in Indonesia.

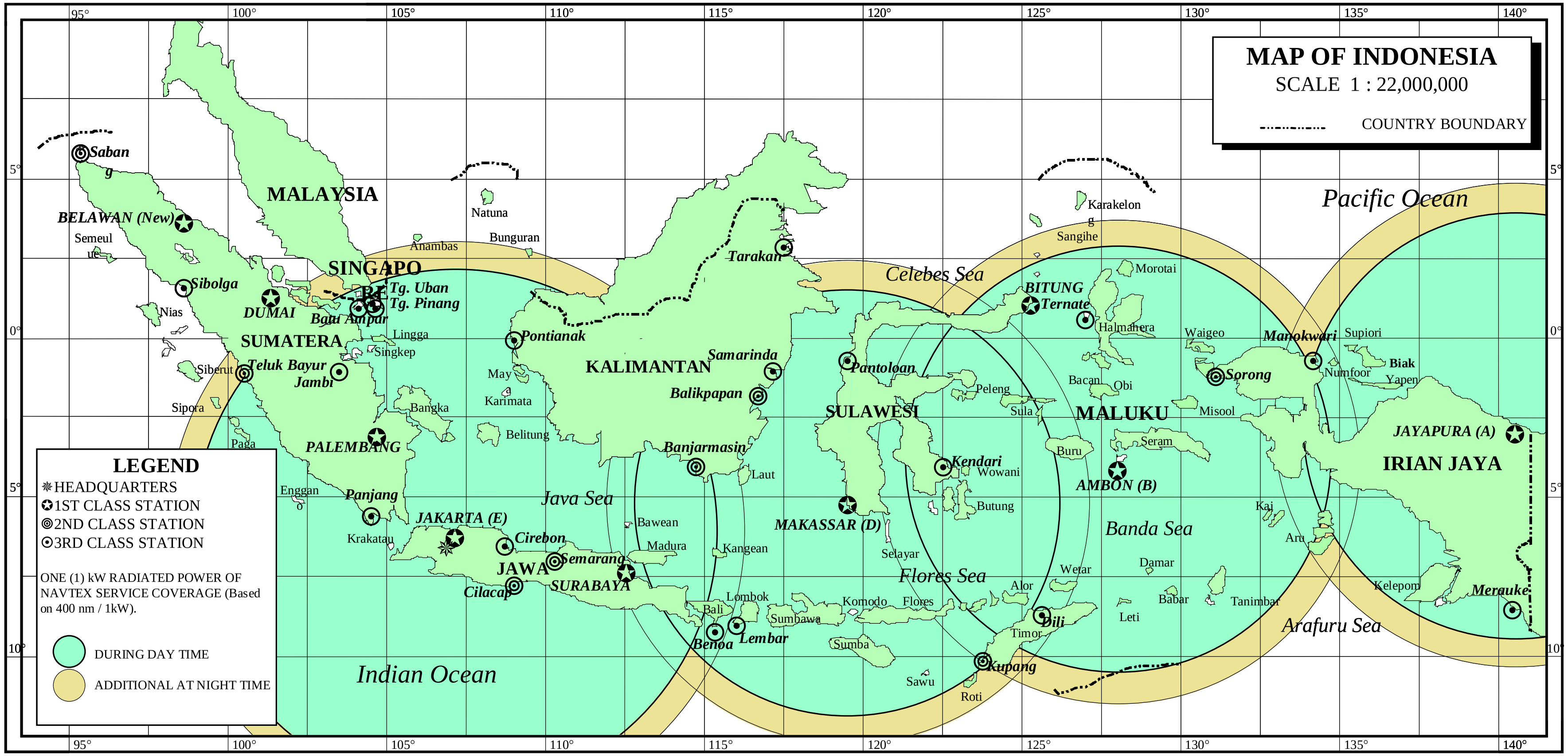
Table 4.2. shows NAVTEX services in the world where national language is provided.

Table 4.2. NAVTEX Services in the World where National Language is Provided

NAV/MET Area	Country	Frequency		Language		Status	Remarks
I	Iceland	518 kHz		English		Operational	
			490 kHz		Icelandic	Operational	
	UK	518 kHz		English		Operational	
			490 kHz		English	Trial	
II	France	518 kHz		English		Operational	
			490 kHz		French	Trial	
	Spain	518 kHz		English	Spanish	Operational	
III	Greece	518 kHz		English	Greek	Operational	
	Italy	518 kHz		English	Italian	Trial	
VI	Argentine	518 kHz		English	Spanish	Operational	
	Uruguay	518 kHz		English	Spanish	Operational	
			490 kHz		Spanish	Operational	
IX	Egypt	518 kHz		English		Operational	
			4 MHz		English	Operational	0750, 1150 UTC
XI	China	518 kHz		English	Chinese	Operational	
	Japan	518 kHz		English		Operational	
			*424 kHz		Japanese	Operational	* specially assigned
	Korea	518 kHz		English		Operational	
			490 kHz		Korean	Operational	
	Vietnam	518 kHz		English		Operational	
			490 kHz		Vietnamese	Operational	0340, 1540 UTC
			4 MHz		English	Operational	
XV	Chile	518 kHz		English	Spanish	Operational	English 3 times/day Spanish 3 times/day
XVI	Peru	518 kHz		English	Spanish	Operational	

Source: IMO GMDSS Master Plan (Feb 28, 2001)

Figure 4.3.   NAVTEX Coverage Area (at Present)



2. Necessity of GMDSS Expansion and Improvement

(1) GMDSS was developed by IMO, and put into service in February 1992 and fully implemented in February 1999. As for shore-based facilities, Amendments to the 1974 SOLAS Convention concerning GMDSS, Chapter Ⅳ (Radio Communications), Part B (Undertaking by Contracting Governments), Regulation 5 (Provision of Radio Communication Service) stipulates;

> "Each Contracting Government undertakes to make available, as it deems practical and necessary either individual or in cooperation with other Contracting Government, appropriate shore-based facilities for space and terrestrial radio communication services having due regard to the recommendations of the organization".

(2) Accordingly, so far DGSC installed HF DSC for Sea Area A3 at 12 coast stations and MF DSC for Sea Area A2 / VHF DSC for Sea Area A1 at 30 coast stations, and International NAVTEX transmitters at 4 stations.

However, there still remain many blind zones for Sea Area A2 and Sea Area A1, and National NAVTEX service has not been established yet in Indonesia.

The Republic of Indonesia, as a big maritime state in the world, has a vital responsibility for the establishment of maritime distress and safety telecommunication system in accordance with the SOLAS Convention and the related international regulations.

(3) A lot of human lives have been lost every year in Indonesian waters by serious marine accidents. Recent accidents for example;

① June 29th 2000, ferry boat "Cahaya Bahari" sank at the off of Manado in Sulawesi island, in which the passengers and crews of more than 500 lives have been missing.

② A passenger ship "Restu Ilahi" which sank at the Makassar Strait on May 27th 2001 with 93 persons, though 44 persons were rescued within 9 days, but 49 persons are still missing.

These accidents especially pointed out the lack of maritime telecommunication system. The probability of lives to be rescued becomes much higher after the completion of GMDSS.

(4) Today, the countermeasures against piracy and armed robbery are the urgent issue for the coastal waters of Indonesia. It is pointed out that one of the

reasons why the measures against piracy and armed robbery do not work effectively is the delay in information transmission.

IMO recommends all ship masters that if they are or may be subject to piracy and armed robbery, they should quickly report the fact to the nearest Rescue Coordination Center (RCC) or coast station. GMDSS is an effective means in piracy report from ship's master to nearby RCC or coast station.

(5) A lot of domestic and international vessels are engaging in transportations and fishing activities in Indonesian waters. GMDSS provides many favorable effects and impacts on Indonesian social and economic activities by securing maritime safety and protecting marine environment as follows:

[GMDSS effects and impacts]

As for International Responsibilities as a Maritime State

Rescue and Ensuring Safety of Life
Rescue and Preservation of Ships and Property
Marine Environment Protection
Safety of sea lanes

As for Promotion of Economic Activities

(Direct)

Maritime Transportation
Fishery Activities
Exploitation of Ocean Resources

(Indirect)

Development of National Economy by Efficient Maritime Traffic
Promotion of Local Industries
Exploitation of Sea-bed Mines
Promotion of Shipping Industries

(6) GMDSS was developed with the aim that a distress vessel in any sea area can make a quick and secure request for rescue to maritime SAR authorities.

Therefore in principle, the whole Indonesian waters should be covered by GMDSS. However, as Indonesia shall hasten to establish GMDSS shore-based facilities and notify the coast stations list of GMDSS to IMO, the following GMDSS expansion and improvement should be implemented as an urgent project:

- To cover major blind waters by MF DSC,

- To cover waters in and around main ports and important navigation waters by VHF DSC,
- To commence National NAVTEX service using a frequency and transmitters for International NAVTEX.
- To improve coast stations having problems for enabling them to cover GMDSS

(7) Budget from Light Dues has been allotted to DGSC from 2001, thereby the maintenance and training fee for the maritime telecommunication system have been substantially increased and the maintenance conditions will be greatly improved hereafter.

3. Concept of GMDSS Expansion and Improvement

The concept of GMDSS expansion and improvement that should be executed as an urgent project is as mentioned below.

Figure 4.4. shows the role of coast stations for maritime distress and safety, and **Figure 4.5.** and **4.6.** show the typical radio equipment for GMDSS.

(1) Expansion of GMDSS Coverage
   a. To cover major blind waters by MF DSC for Sea Area A2
   b. To cover waters in and around main ports and important navigation waters by VHF DSC for Sea Area A1

(2) Commencement of National NAVTEX service
   a. To introduce and commence National NAVTEX service in Indonesian language using a frequency and transmitters for existing International NAVTEX

(3) Improvement of coast stations for enabling them to cover GMDSS
   a. Separation of transmitting and receiving stations
      Teluk Bayur and Benoa stations
   b. Improvement of environment for coast stations
      Surabaya and Makassar stations
   c. Improvement of VHF coverage
      Dumai and Samarinda stations
   d. Improvement of engine-generators
      1^{st} and 2^{nd} class stations
   e. Replacement of old antennas
      1^{st} and 2^{nd} class stations

Figure 4.4. Role of Coast Station

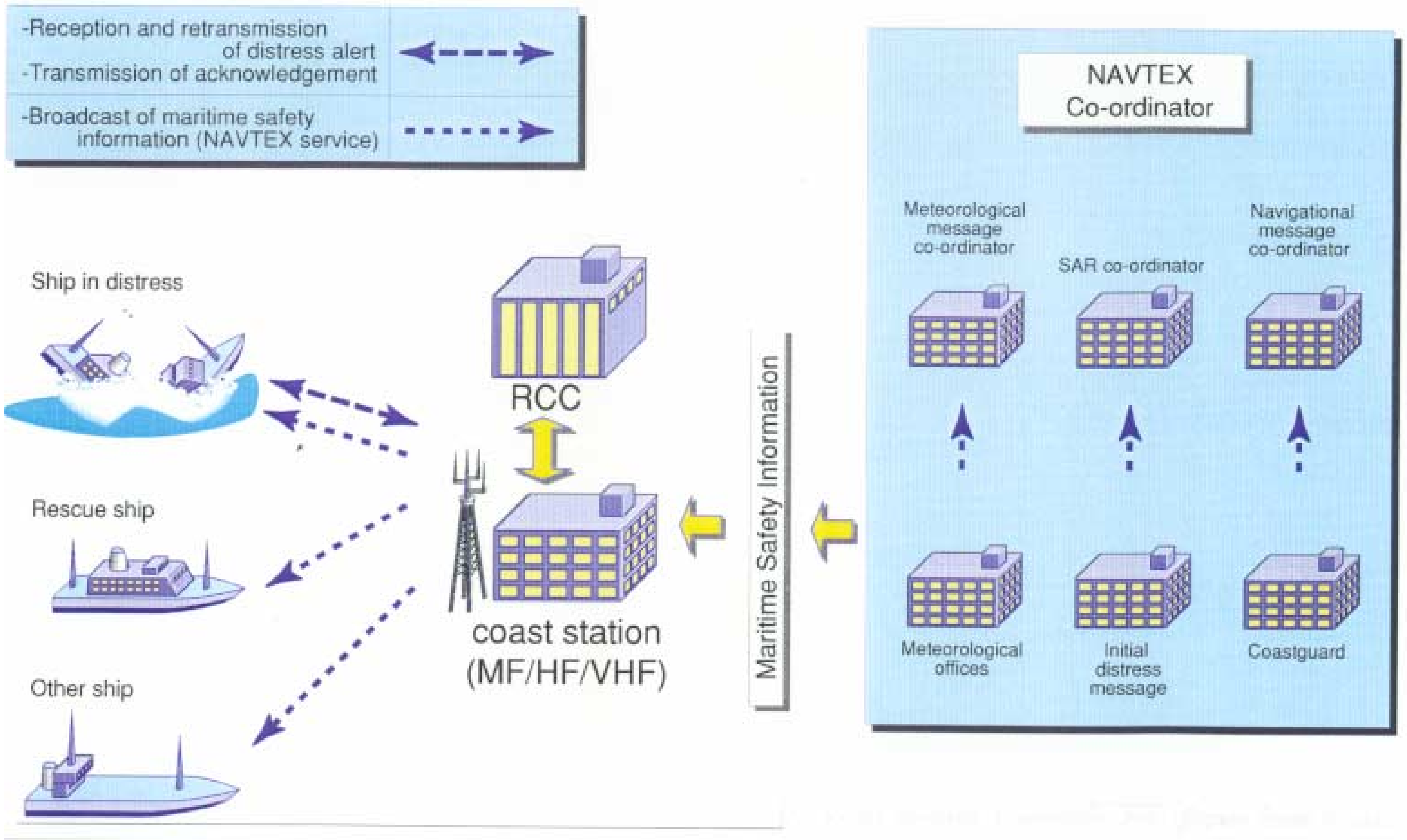


Figure 4.5. Radio Equipment for GMDSS (Area A2)

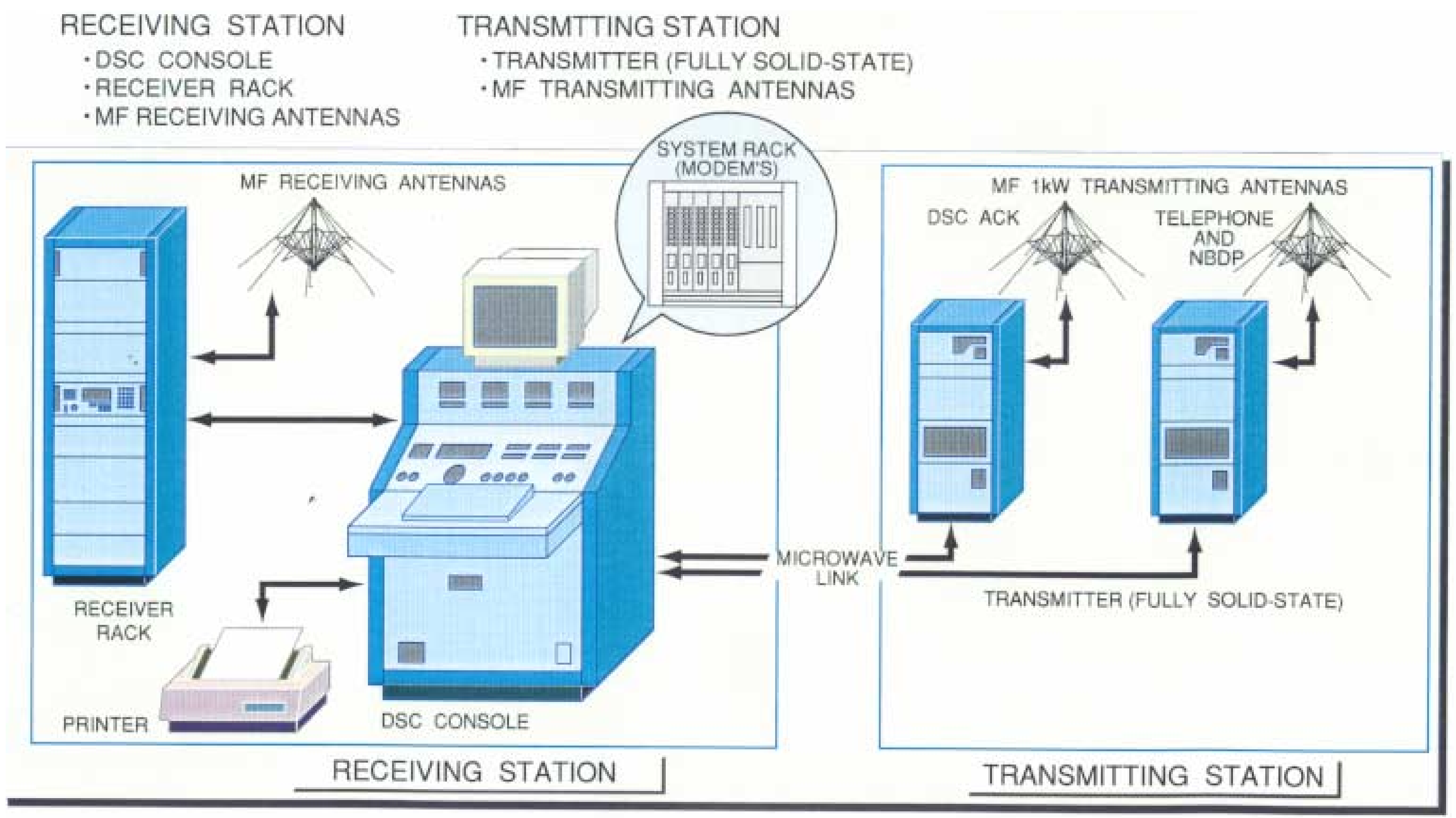
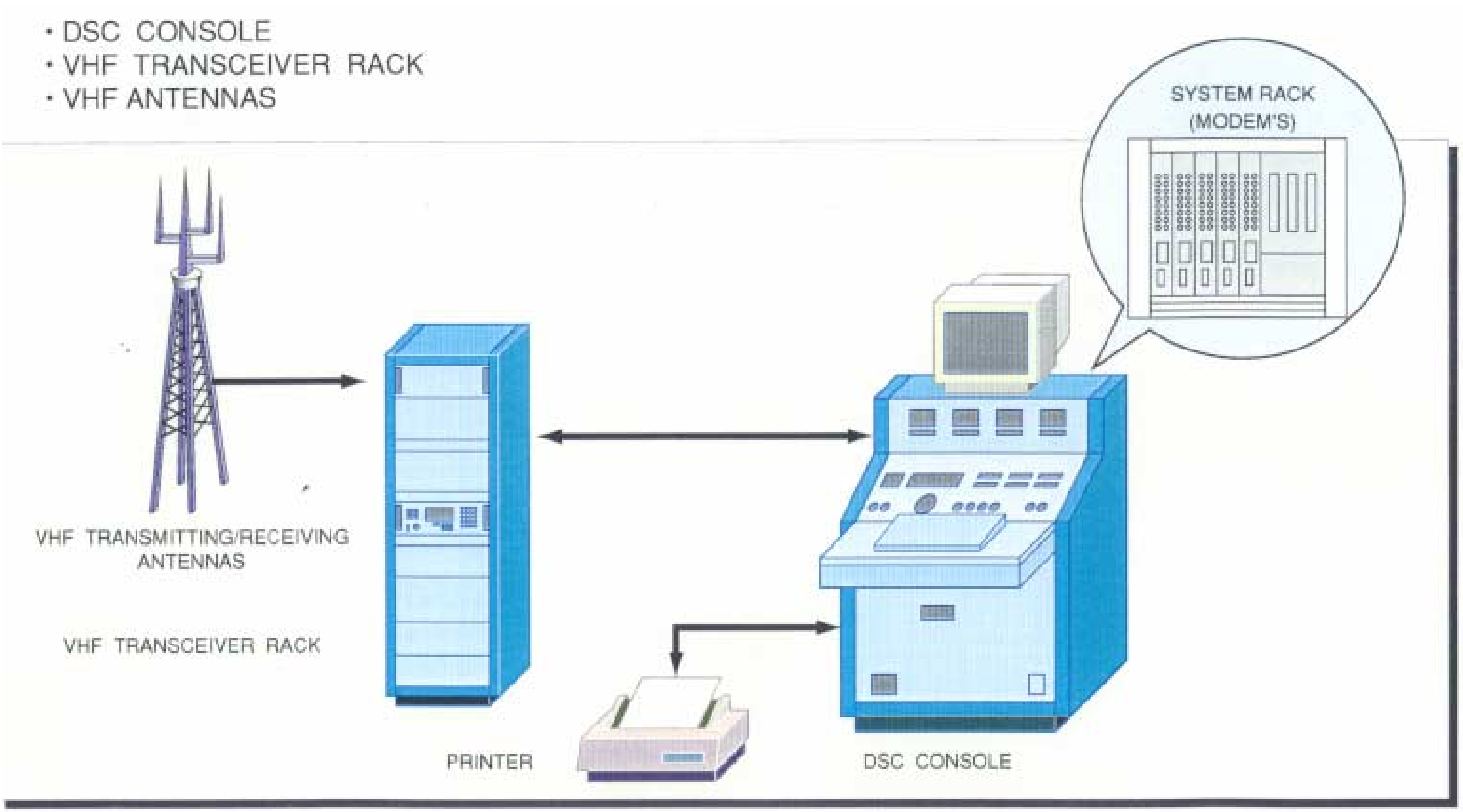


Figure 4.6. Radio Equipment for GMDSS (Area A1)



4. Contents of the Project

4.1. Expansion of GMDSS Coverage

(1) Installation of MF DSC for Sea Area A2

The following existing stations should be installed with MF DSC equipment to cover major blind waters for Sea Area A2:

1st class	:	1 station	(Palembang)
2nd class	:	3 stations	(Sabang, Teluk Bayur and Banjarmasin)
3rd class	:	2 stations	(Samarinda and Bau-bau)
4th class	:	13 stations	(Tapaktuan, Natuna, Pangkal Balam, Bengkulu, Ende, Bima, Ketapang, Sampit, Poso, Toli-toli, Tual, Saumlaki and Agats)

Figure 4.7. shows the expansion coverage for Sea Area A2.

(2) Installation of VHF DSC for Sea Area A1

The following existing stations should be installed with VHF DSC equipment to cover waters in and around main ports and important navigation waters for Sea Area A1:

1st class	:	1 station	(Palembang)
2nd class	:	3 stations	(Sabang, Teluk Bayur and Banjarmasin)
3rd class	:	5 stations	(Tg Uban, Jambi, Cirebon, Samarinda and Bau-bau)
4th class	:	24 stations	(Tapakutuan, Lhokseumawe, Kuala Tanjung, Kuala Enok, Natuna, Pangkal Balam, Muntok, Bengkulu, Cigadang, Klianget, Meneng, Bima, Ende, Mumere, Ketapang, Sampit, Kumai, Batulicin, Pare-Pare, Poso, Toli-toli, Saumlaki, Tual and Agats)

Figure 4.8. shows the expansion coverage for Sea Area A1.

4.2. Commencement of National NAVTEX

A frequency for International NAVTEX, 518 kHz, will be utilized for National NAVTEX service. The use of this frequency is limited to the message only in the “VITAL” or “IMPORTANT” categories. However, message can be received by the receivers of International NAVTEX without any modification, as the Indonesian alphabet is the same as English.

The present International NAVTEX stations (Jakarta, Makassar, Ambon and Jayapura) are used for the above purpose.

Figure 4.7.   GMDSS Coverage Area (A2, Expansion)

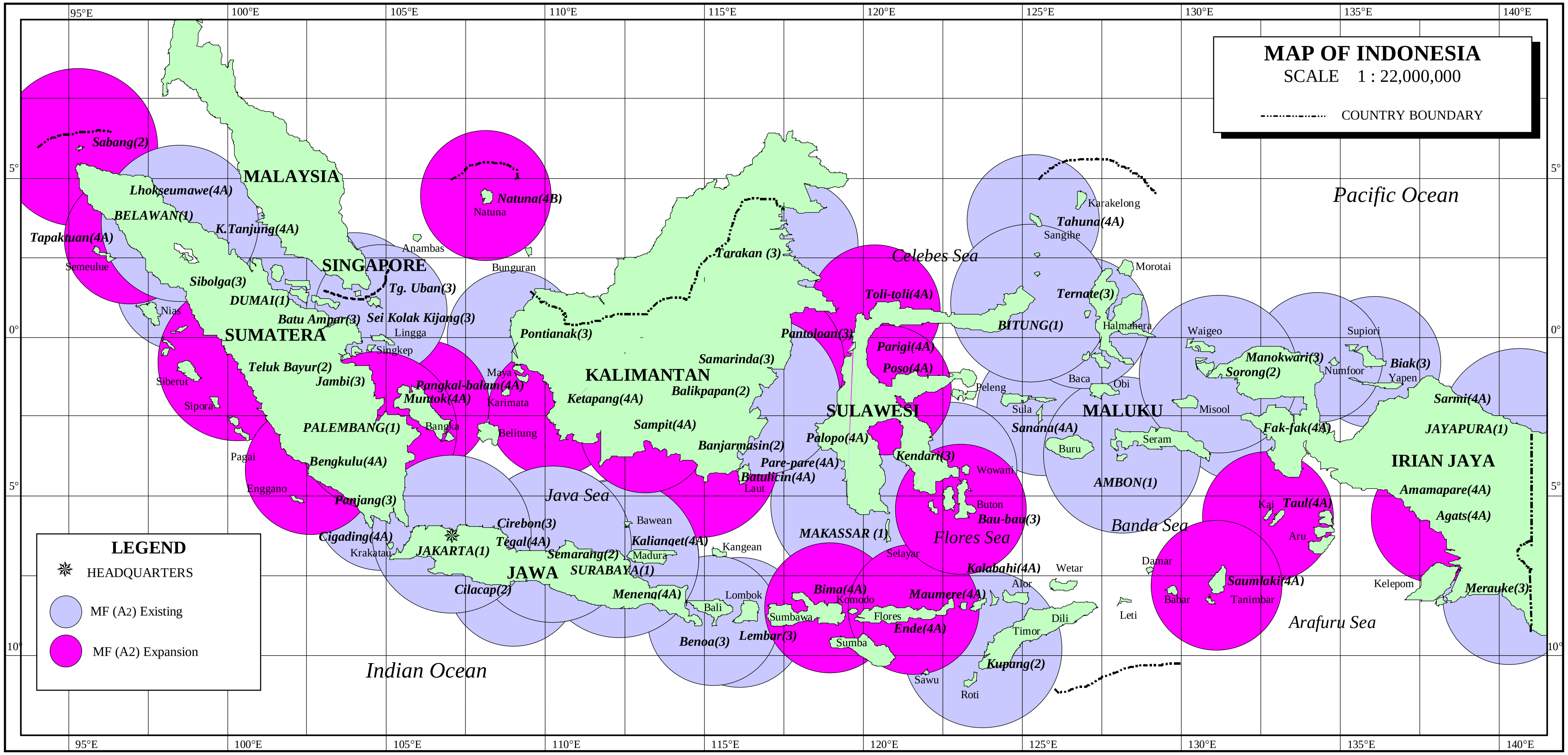
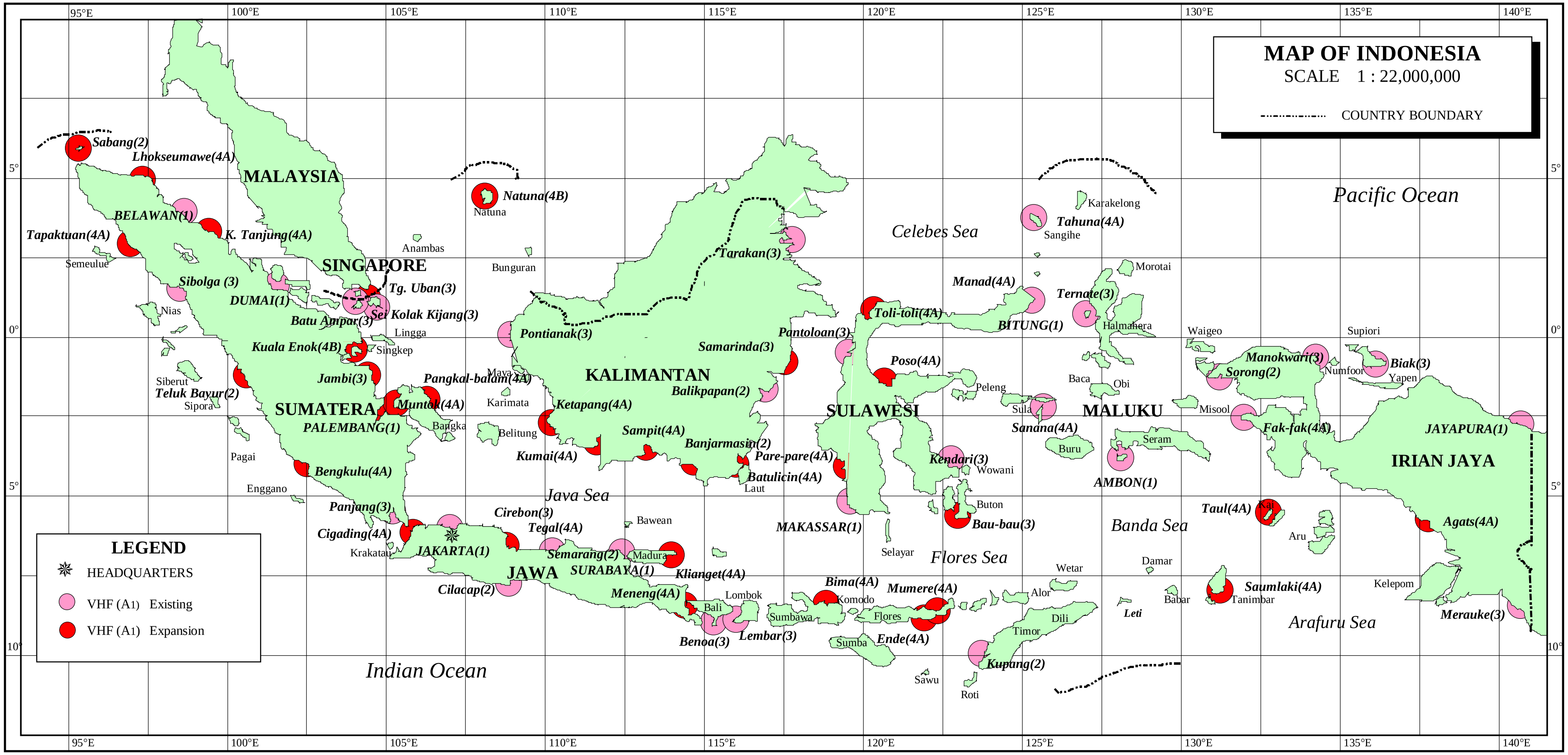


Figure 4.8. GMDSS Coverage Area (A1, Expansion)



The coverage areas of National NAVTEX using 518 kHz is the same coverage as existing International NAVTEX and shown in **Figure 4.3.**, and **Table 4.3.** shows an introduction schedule of the National NAVTEX.

Table 4.3. Introduction Schedule of National NAVTEX

	Service	Frequency	Transmitting Station	Remarks
1st Stage	Limited to use only for "Vital" or "Important" message	518 kHz	Existing 4 stations Jakarta Makassar Ambon Jayapura	Common use of International NAVTEX equipment
2nd Stage	Full implementation of National NAVTEX	490 kHz	Existing 4 stations Jakarta Makassar Ambon Jayapura And new one station Belawan	To be developed ship's receiver for National NAVTEX

4.3. Improvement of Coast Stations for Enabling to Cover GMDSS

The following improvement for coast stations should be executed urgently in synchronization with the GMDSS expansion in order to enable them to secure GMDSS coverage:

(1) Separation of transmitting and receiving station

Although Teluk Bayur (2nd) and Benoa (3rd) stations are located at key spots for maritime safety and has many links with other lower class coast stations, both stations have been operated at a single site where the transmitters and receivers are collocated.

Those stations should be separated into transmitting (Tx) and receiving (Rx) stations. In addition, Benoa station should be classified as the 2nd class station.

In promoting of the separation plans, **Appendix 4.1.** and **4.2.** should be taken into consideration.

(2) Improvement of environment for coast stations

In Surabaya (1st) and Makassar (1st) coast stations, noises caused by city activities are very big, these are unsuitable for the environment of receiving stations. Furthermore, the transmitting and receiving sites of Surabaya station and the receiving site of Makassar station are too limited in space to ensure the antenna system of the 1st class station.

For both Surabaya and Makassar stations, the Tx station should be moved to new site, and new Rx station should occupy the existing Tx station site.
In promoting of the relocation plans, **Appendix 4.1.** should be taken into consideration.

(3) Improvement of VHF coverage

Dumai station (1st) can not communicate with the vessels passing the Strait of Malacca by VHF because of a big Rupat island existing in front of Dumai port. Samarinda station (3rd) is located about 50 km upriver from the sea and VHF radio wave cannot reach to the coastal line.

These VHF coverages of Dumai and Samarinda coast stations should be expanded.
In promoting of the VHF expansion plans, **Appendix 4.3.** should be take into consideration.

(4) Improvement of engine-generators

Most engine-generators of the 1st and 2nd class coast stations are old, and no spare parts are available at the site or market.

A set of engine-generators with automatic start/stop function should be provided in each of the Tx and Rx stations at the 1st and 2nd class stations in substitute for old ones.

(1) Replacement of old antennas

Most antennas of the 1st and 2nd class coast stations are old, and should be replaced.

All the items planned in urgent project and its related stations are shown in **Table 4.4.**

Table 4.4. Expansion and Improvement Plan for GMDSS

Class		Name	A3	A2	A1	NAVTEX		Improvement				
			HF DSC	MF DSC	VHF DSC	International	National	Separation	Relocation	VHF Area	E/G	Antenna
I	1	Belawan	▲	▲	▲						◎	◎
	2	Dumai	▲	▲	▲					◎	◎	◎
	3	Palembang		◎	◎						◎	◎
	4	Jakarta	▲	▲	▲	▲	◎				◎	◎
	5	Surabaya	▲	▲	▲				◎		◎	
	6	Makasar	▲	▲	▲	▲	◎		◎		◎	
	7	Bitung	▲	▲	▲						◎	◎
	8	Ambon	▲	▲	▲	▲	◎				◎	◎
	9	Jayapura	▲	▲	▲	▲	◎				◎	◎
II	1	Sabang		◎	◎						◎	◎
	2	Teluk Bayur		◎	◎			◎				
	3	Semarang	▲	▲	▲						◎	
	4	Cilacap		▲	▲							
	5	Kupang	▲	▲	▲							◎
	6	Banjarmasin		◎	◎						◎	◎
	7	Balikpapan	▲	▲	▲						◎	◎
	8	Sorong	▲	▲	▲						◎	◎
III	1	Sibolga		▲	▲							
	2	Batu Ampar		▲	▲							
	3	Tg. Uban			◎							
	4	Sei Kolak Kijang		▲	▲							
	5	Jambi			◎							
	6	Panjang		▲	▲							
	7	Cirebon			◎							
	8	Benoa		▲	▲			◎				
	9	Lembar		▲	▲							
	10	Pontianak		▲	▲							
	11	Samarinda		◎	◎					◎		
	12	Tarakan		▲	▲							
	13	Kendari		▲	▲							
	14	Bau-bau		◎	◎							
	15	Pantoloan		▲	▲							
	16	Ternate		▲	▲							
	17	Manokwari		▲	▲							
	18	Biak		▲	▲							
	19	Merauke		▲	▲							
IV	1	Tapaktuan		◎	◎							
	2	Kuala Tanjung			◎							
	3	Lhokseumawe			◎							
	4	Kuala Enok			◎							
	5	Natuna		◎	◎							
	6	Muntok			◎							
	7	Pangkal Balam		◎	◎							
	8	Bengkulu		◎	◎							
	9	Cigading			◎							
	10	Kalianget			◎							
	11	Meneng (Banyuwangi)			◎							
	12	Bima		◎	◎							
	13	Ende		◎	◎							
	14	Maumere			◎							
	15	Ketapang		◎	◎							
	16	Sampit		◎	◎							
	17	Kumai			◎							
	18	Batulicin			◎							

Note: ▲ Existing
◎ New (Urgent)

Table 4.4. Expansion and Improvement Plan for GMDSS

Class		Name	A3	A2	A1	NAVTEX		Improvement				
			HF DSC	MF DSC	VHF DSC	International	National	Separation	Relocation	VHF Area	E/G	Antenna
	19	Pare-pare			◎							
	20	Poso		◎	◎							
	21	Toli-toli		◎	◎							
	22	Tahuna		▲	▲							
	23	Tual		◎	◎							
	24	Saumlaki		◎	◎							
	25	Sanana		▲	▲							
	26	Fak-fak		▲	▲							
	27	Agats		◎	◎							
Total Existing			12	30	30	4	-					
Total Expansion (Urgent)			**-**	**19**	**33**	**-**	**4**	**2**	**2**	**2**	**14**	**12**
Grand Total			12	49	63	4	4	2	2	2	14	12
IMO Master Plan (*)			13	84	84	4	0					

Note: * IMO Master Plan means the GMDSS Master Plan published by IMO, in which those number of Indonesian stations are listed based on the information form GOI.

Note: ▲ Existing
◎ New (Urgent)

4.4. Establishment of Comprehensive Maintenance Function

In order to cope with the increase of sophisticated equipment, comprehensive maintenance function should be established in Jakarta, which intends to reinforce practical and effective maintenance system for maritime telecommunication system with fully prepared spare parts, maintenance goods, personal computer (PC) networks with 1st/2nd coast stations, etc and high-level staffs.

A proposed plan of the comprehensive maintenance function is shown in **Appendix 4.4.**

4.5. Reinforcement of Training Function

Present training equipment installed at Tg. Priok, Jakarta is mainly for the staffs at the 1st and 2nd class coast stations. According to extensive deployment of numbers of different types of equipment for GMDSS and other communication purposes, necessity of practical training on operation and maintenance for whole DGSC's coast stations has been significantly increase.

Therefore, a comprehensive training function should be established, introducing all-round of equipment, instruction materials, simulators, etc. in addition to the present equipment.

5. Review of Classification and Operation-hours of Coast Stations

The 221 coast stations of DGSC are classified into 5 classes: Ⅰ,Ⅱ,Ⅲ, Ⅳ-a and IV-b by service type and operating hour. The present classification is based on **Table 4.5.**

Table 4.5. Present Classification of Coast Stations

Class	Service Type	Operation Hours
I	Maritime Mobile Service Fixed Service	24 h
II	Maritime Mobile Service Fixed Service	16 – 24 h
III	Maritime Mobile Service Fixed Service	12 – 16 h
IV-a	Maritime Mobile Service Fixed Service	8 – 12 h
IV-b	Fixed Service	8 h

However, in parallel with the enforcement of GMDSS, the classification and the operating hours of coast stations are recommended to review in accordance with **Table 4.6.** Thereby, increase and/or reshuffle of stations staffs will be needed.

6. Implementation schedule

Implementation time of this Project is estimated for 50 months and the schedule is shown in **Table 4.7.**

7. Project Cost Estimate

7.1. Project cost and Financing

The required cost for this project consists of foreign currency portion and local currency portion with details as follows:

(1) Foreign currency portion will be used for:

a. Supply of the equipment
   - Equipment and materials
   - Ocean freight and insurance

b. Consulting services:

c. Training and test (at factory)

d. Contingency

(2) Local currency portion will be used for:

a. Supply of the equipment
   - Local equipment and material
   - Installation and local transportation

b. Consulting services

c. Training and test (in Indonesia)

d. Contingency

7.2. Project Cost

a. Expansion of A2 and A1	:	US$ 22,014,300
b. National NAVTEX	:	(not required)
c. Improvement of coast stations	:	US$ 17,787,000
Total		US$ 39,801,300

Table 4.8. shows the estimated project cost for GMDSS Expansion and Improvement.

Table 4.6. Recommended Classification of Coast Station

Class of Station	1st Class		2nd Class	3rd class [1]	4th-A class [2]	4th-B class [3]
	Jakarta	Other				
GMDSS	A1, A2, A3, A4			A1, A2	A1	-
Service area	A1: 25NM A2: 150NM			A1: 25NM A2: 125NM		-
Frequency band	MF, HF, VHF				VHF	-
Transmitter's output for MF, HF	5kW	1kW		1KW or 500W	-	-
Transmitter's output for VHF	50W					-
NAVTEX Broadcast	Jakarta	Makassar, Ambon, Jayapura				
Fixed Communication						
Frequency band	HF					
Transmitter's output	5kW or 1kW	1kW		500W		100w
Operating Hour	24H					8H
Station Building for Tx and Rx	Separated [4]			Collocated		
Remarks			[4] Except for: Sabang, Cilacap	[1] Benoa is recommended upgrading to 2nd class.	[2] Tapaktuan, Pangkal Balam, Bengkulu, Bima, Ende, Ketapang, Sampit, Poso, Toli-toli, Tahuna, Taul, Samulaki, Sanana, Fak-fak, Agats is recommenced upgrading to 3rd class.	[3] Natuna is recommeded upgrading to 3rd class.

Table 4.7. Implementation Time Schedule for GMDSS

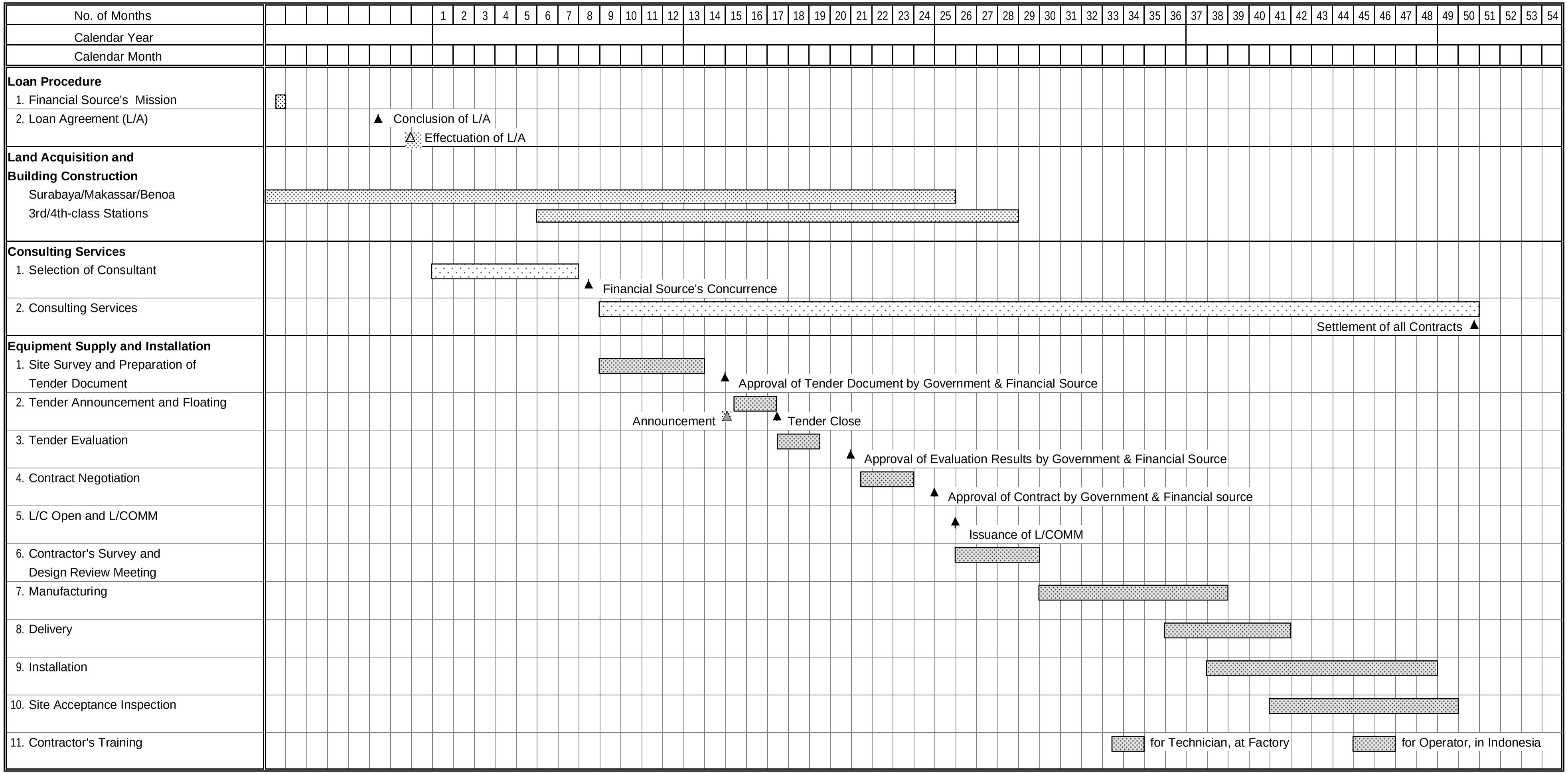


Table 4.8. Estimated Cost for GMDSS Expansion and Improvement

Unit: US$

		Cost						Remarks
		Unit amount	Q'ty	Sub-total	Total	*Foreign*	*Local*	
A	EQUIPMENT AND SERVICES							
1	Improvement of stations to meet GMDSS				16,610,000	*14,118,500*	*2,491,500*	
	1st class: (add DSC/NBDP)	670,000	1	670,000				Palembang
	2nd class: (add DSC/NBDP)	670,000	2	1,340,000				Sabang, Banjarmasin
	3rd class: (MF&VHF GMDSS and Fix HF)	600,000	15	9,000,000				Samarinda, Bau-bau, Tapaktuan, Natuna, Pangkal Balam, Bengkulu, Bima, Ende, Ketapang, Sampit, Poso, Toli-toli, Taul, Samulaki, Agats
	4A class: (VHF GMDSS and Fix HF)	400,000	14	5,600,000				Tg.Uban, Jambi, Cirebon, Kuala Tanjung, Lhokseumawe, Kuala Enok, Muntok, Cigading, Kalianget, Meneng, Maumere, Kumai, Batulicin, Pare-pare
2	Separation of Tx & Rx stations (up-grade to 2nd class)	4,500,000	2	9,000,000	9,000,000	*7,650,000*	*1,350,000*	Teluk Bayur, Benoa
3	Relocation of station	1,500,000	2	3,000,000	3,000,000	*2,550,000*	*450,000*	Surabaya, Makassar
4	Improvement of VHF coverage area	440,000	2	880,000	880,000	*748,000*	*132,000*	Dumai, Samarinda
5	Replacement of aged E/G (at 1st & 2nd class)	120,000	14	1,680,000	1,680,000	*1,428,000*	*252,000*	Belawan, Dumai, Palembang, Jakarta, Surabaya, Makassar, Bitung, Ambon, Jayapura, Sabang, Semarang, Banjarmasin, Balikpapan, Sorong
6	Replacement of aged Antenna (at 1st & 2nd class)	70,000	12	840,000	840,000	*714,000*	*126,000*	Belawan, Dumai, Palembang, Jakarta, Bitung, Ambon, Jayapura, Sabang, Kupang, Banjarmasin, Balikpapan, Sorong
7	Reinforcement of Maintenance function	1,000,000	1	1,000,000	1,000,000	*850,000*	*150,000*	
8	Reinforcement of Training function	1,000,000	1	1,000,000	1,000,000	*850,000*	*150,000*	
9	Training of DGSC staffs	450,000	1	450,000	450,000	*382,500*	*67,500*	
	Equipment and Services Total (1)				34,460,000	*29,291,000*	*5,169,000*	
B	CONSULTING SERVICES (2) (1) x 10%				3,446,000	*3,446,000*		
C	CONTINGENCY (3) [(1)+(2)] x 5%				1,895,300	*1,895,300*		
	PROJECT TOTAL (1)+(2)+(3)				39,801,300	*34,632,300*	*5,169,000*	

Foreign and Local Costs	
a. Foreign Cost	34,632,300
b. Local Cost	5,169,000
	39,801,300

8. Operation and Maintenance Cost

All of GMDSS equipment will be installed at existing coast stations. Accordingly, most proportion of running cost is used for the following purposes:

a. Repairing and/or purchasing spare unit/parts
b. Delivering the above goods to/from Jakarta and/or manufacturer's country
c. Purchasing consumable spares
d. Electricity, fuel, etc.

Total running cost of this project is estimated US$ 360,000 per year.

However, as **Table 4.9.** indicates, running cost after 15 years becomes higher. The lifetime of telecommunication equipment is usually 15 years or so after installation, because the provision of spare parts/units by manufacturers expires. Therefore, around half of equipment will be replaced after 15 years of so.

Table 4.9. Initial and Running Cost for GMDSS

Unit: Thousand US$

		Initial Cost			Running Cost		
	Calendar year	Consultant	Contractor	Total	Repairing	Electric & others	Total
	2002			0.0			
	2003	689.2		689.2			
	2004	861.5		861.5			
	2005	861.5	13,784.0	14,645.5			
	2006	689.2	15,507.0	16,196.2			
1	2007	516.9	6,892.0	7,408.9	310.1	50.8	360.9
2	2008			0.0	310.1	50.8	360.9
3	2009			0.0	310.1	50.8	360.9
4	2010			0.0	310.1	50.8	360.9
5	2011			0.0	310.1	50.8	360.9
6	2012			0.0	310.1	50.8	360.9
7	2013			0.0	310.1	50.8	360.9
8	2014			0.0	310.1	50.8	360.9
9	2015			0.0	310.1	50.8	360.9
10	2016			0.0	310.1	50.8	360.9
11	2017			0.0	310.1	50.8	360.9
12	2018			0.0	654.7	50.8	705.5
13	2019			0.0	740.9	50.8	791.6
14	2020			0.0	7,632.9	50.8	7,683.6
15	2021			0.0	8,408.2	50.8	8,459.0
16	2022			0.0	4,014.6	50.8	4,065.3
17	2023			0.0	310.1	50.8	360.9
18	2024			0.0	310.1	50.8	360.9
19	2025			0.0	310.1	50.8	360.9
20	2026			0.0	310.1	50.8	360.9
21	2027			0.0	310.1	50.8	360.9
22	2028			0.0	310.1	50.8	360.9
23	2029			0.0	310.1	50.8	360.9
24	2030			0.0	310.1	50.8	360.9
25	2031			0.0	310.1	50.8	360.9
26	2032			0.0	310.1	50.8	360.9
27	2033			0.0	310.1	50.8	360.9
28	2034			0.0	310.1	50.8	360.9
29	2035			0.0	310.1	50.8	360.9
30	2036			0.0	310.1	50.8	360.9
		3,618.3	36,183.0	39,801.3			30,727.2

9. Economic Analysis

(1) Purpose

To plan effective use of limited resource (human resources, commodities, currency), cost benefit analysis should be implemented quantitatively as far as possible on the viewpoint of effective utilization of resources. The items, which cannot be converted into currency, will be implemented by qualitative analysis.

(2) Specification of the project

It is to install MF DSC for Sea Area A2 at 19 coast stations and VHF DSC for Sea Area A1 at 33 coast stations, and to commence national NAVTEX services at 4 coast stations.

(3) Evaluation Periods of Projects

The evaluation periods of projects should be normally the same as the loan reimbursement periods. In case of ODA loans, loan period is 30 years, grace period of the principal is 10 years.

a. The periods for analysis

The periods of analysis are basically settled on termination of year of use.

b. Termination years for use

Termination years for use of almost half of the equipment used in the project are around 15 years.

(4) Approach and Methodology of the Economic Analysis

Purpose of GMDSS is to establish the distress and safety communication system in Indonesian waters. GMDSS put into service in February 1992 and fully implemented in February 1999 according to the regulations under SOLAS Convention and mandatory system for vessels.

① Benefits and costs

By expansion and improvement of GMDSS, benefits and costs are analyzed qualitatively in **Table 4.10**.

Table 4.10. Benefits and Costs for GMDSS

	Items	Contents	Party to be belonged
Benefits	・Increasing probability of rescue	・Mainly in Area A1, A2, A3, ships at sea can get reliable transmitting measures for rescue and victims will decrease.	Ship's owner, crew, crew's family, GOI
	・Increasing navigational safety	・Ships at sea can get lots of necessary information systematically, such as weather forecast, navigational information, pirates attack information, etc by national NAVTEX	
	・Decreasing search costs in distress	・Rescue station can know the ship's position in distress early, therefore rescue ship can arrive the scene at the early stage.	GOI
	・Decreasing social unrest due to incorrect news	・By reliable transmitting measure, crew's family do not influence due to incorrect news.	Crew's family
Costs	・Occurrence of installation costs	・Installation costs for the project occur.	GOI
	・Increasing rescue costs due to mishandle the equipments.	・Rescue station order that rescue team go to the scene by incorrect information and increase unnecessary rescue costs.	GOI
	・Occurrence of education and training costs	・Education and training cost occur by installation of new equipments.	Ship's owner, crew, GOI
	・Campaign costs to the public	・Campaign cost to the public occur.	GOI

② "With" case and "Without" case

By expansion and improvement of GMDSS, "With" case and "Without" case for benefits are analyzed qualitatively in **Table 4.11**.

Table 4.11. "With" Case and "Without" Case for GMDSS

Items	"With" Case	"Without" Case
Probability of rescue	Increasing ・Mainly in Area A1, A2, A3, ships at sea can get reliable transmitting measures for rescue. Probability of rescue will increase and victims will decrease.	No change ・Mainly in Area A1, A2, A3, ships can not get reliable transmitting measures for rescue. Probability of rescue will maintain the present condition.
Navigational safety	Increasing ・Ships at sea can get lots of necessary information by Indonesian sentence, such as weather forecast, navigational information, pirates attack information, etc, systematically by national NAVTEX. Navigational safety will increase.	No change ・Ships at sea can not get lots of necessary information which mentioned in "With" case systematically. Navigational safety will maintain the present condition.
Search costs in distress	Decreasing ・Rescue station can catch the ship's position in distress early, therefore rescue ship can arrive the scene early. Search costs in distress will decrease.	No change ・Rescue station may not know the ship's position in distress early, therefore rescue ship have to waste a time for search the ship in distress. Search costs in distress will maintain the present condition.
Social unrest due to incorrect news	Decreasing ・By reliable transmitting measure, crew's family do not influence due to incorrect news. Social unrest due to incorrect news will decrease.	No change ・By unreliable transmitting measure, crew's family will influence due to incorrect news. Social unrest due to incorrect news will maintain the present conditions.

③ Evaluation of Benefits and costs

Considering **Table 4.10.** and **Table 4.11.**, the items are very hard to convert into currency. But it has potential for saving human lives at sea and navigational safety. A lot of human lives have been lost every year in Indonesian waters by serious marine accidents. These accidents especially pointed out the lack of maritime telecommunication system. The benefits for decreasing loss of human lives and increasing navigational safety are fully worth the projects costs.

10. Financial Analysis

(1) Purpose

For this project, light dues will be available to cover the operation and maintenance cost. The financial analysis has been assessed in terms of FIRR (Financial Internal Rate of Return).

(2) Total amount of investment

Total amount of investment for this project is estimated in **Table 4.12.**

Table 4.12. Total Amount of Investment for GMDSS

Unit: Thousand US$

Items	Foreign Cost	Local Cost	Total
GMDSS	34,632	5,169	39,801

(3) Raising funds for investment

The hypothetical terms and conditions the study team has implemented are to use official development plan (ODA) and market rate. ODA can be broadly divided into bilateral ODA and multilateral ODA. Bilateral ODA consist of bilateral grants and ODA loan. In this case, ODA loan that is the best terms and conditions among soft loans should be used.

The principal terms and conditions for ODA loan and market rate are as follows;

a. ODA Loan

① 15% of total amount of investment (foreign cost + local cost) should be paid from funds of GOI as a down payment.

② 85% of total amount of investment (foreign cost + local cost) should be loaned to GOI.

③ Loan period is 30 years, grace period of the principal is 10 years and interest rate is 1.8%.

b. Market Rate

① 15% of total amount of investments (foreign cost + local cost) should be paid from funds of GOI as a down payment.

② 85% of total amount of investments (foreign cost + local cost) should be loaned to GOI.

③ Loan period is 10 years and interest rate is 6 %.

(4) Calculation for revenue

Light dues shall be applied to civil works, facilities, machineries, consulting services and other project needs including operating costs, maintenance costs.

According to Communication Bureau of BAPPENAS, 50 % of light dues would be used for Aids to Navigation, supporting facilities and maritime telecommunication. Total amount of light dues are shown in **Table 4.13**.

Table 4.13. Forecast of Total Amount of Light Dues

Units: US$

	Likeliest Case	Optimistic case	Pessimistic case
2001	13,094,871	13,094,871	13,094,871
2002	13,994,919	14,299,280	13,693,165
2003	15,175,099	15,840,522	14,529,724
2004	16,457,496	17,552,026	15,418,950
2005	17,851,062	19,452,916	16,364,140
2006	19,365,604	21,564,506	17,368,926
2007	21,011,787	23,910,529	18,437,133
2008	22,801,228	26,517,322	19,572,836
2009	24,746,609	29,414,371	20,780,317
2010	26,861,736	32,634,381	22,064,230
2011	28,511,141	35,219,045	23,028,102
2012	30,262,043	38,008,812	24,034,193
2013	32,120,739	41,019,967	25,084,356
2014	34,093,864	44,270,169	26,180,527
2015	36,188,427	47,778,381	27,324,760
2016	38,411,972	51,565,123	28,519,104
2017	40,772,431	55,652,583	29,765,799
2018	43,278,280	60,064,632	31,067,147
2019	45,938,441	64,827,119	32,425,552
2020	48,762,475	69,967,924	33,843,512

(5) Consideration of FIRR

a. FIRR by ODA loan

The initial costs, operating costs, maintenance costs and financial analysis are shown in **Table 4.14.**

Necessary light dues to achieve 1.8% of FIRR (GDP: Likeliest Case) are 10.49% of light dues.

Necessary funds and light dues(GDP: Likeliest Case) are shown in **Table 4.15.**

Table 4.14. Financial Analysis for GMDSS

Light Dues 10.49% Units : Million US$

period	No	Year	TTL Cost (GMDSS)							Revenue					
			Civil	Consultant	Initial Cost Total	Operating & Maintenance	Grand Total	Funds (Initial Cost) 15%	Grand Total-Funds	GDP: Likeliest Case		GDP: Optimistic Case		GDP: Pessimistic Case	
										Light Dues		Light Dues		Light Dues	
			1	2	3=1+2	4	5=3+4	6=3 x 0.15	7=5-6	8	9=8-7	10	11=10-7	12	13=12-7
	1	2000													
	2	2001													
	3	2002													
	4	2003		0.689	0.689		0.689	0.103	0.586	1.591	1.006	1.661	1.075	1.524	0.938
	5	2004		0.862	0.862		0.862	0.129	0.732	1.726	0.994	1.841	1.108	1.617	0.885
	6	2005	13.784	0.862	14.646		14.646	2.197	12.449	1.872	-10.577	2.040	-10.409	1.716	-10.733
	7	2006	15.507	0.689	16.196		16.196	2.429	13.767	2.031	-11.736	2.261	-11.505	1.821	-11.945
1	8	2007	6.892	0.517	7.409	0.361	7.770	1.111	6.658	2.203	-4.455	2.507	-4.151	1.933	-4.725
2	9	2008				0.361	0.361		0.361	2.391	2.030	2.781	2.420	2.053	1.692
3	10	2009				0.361	0.361		0.361	2.595	2.234	3.085	2.724	2.179	1.818
4	11	2010				0.361	0.361		0.361	2.817	2.456	3.422	3.061	2.314	1.953
5	12	2011				0.361	0.361		0.361	2.990	2.629	3.693	3.332	2.415	2.054
6	13	2012				0.361	0.361		0.361	3.174	2.813	3.986	3.625	2.520	2.160
7	14	2013				0.361	0.361		0.361	3.368	3.008	4.302	3.941	2.631	2.270
8	15	2014				0.361	0.361		0.361	3.575	3.214	4.643	4.282	2.745	2.385
9	16	2015				0.361	0.361		0.361	3.795	3.434	5.010	4.650	2.865	2.505
10	17	2016				0.361	0.361		0.361	4.028	3.667	5.408	5.047	2.991	2.630
11	18	2017				0.361	0.361		0.361	4.276	3.915	5.836	5.475	3.121	2.761
12	19	2018				0.706	0.706		0.706	4.539	3.833	6.299	5.593	3.258	2.552
13	20	2019				0.792	0.792		0.792	4.817	4.026	6.798	6.007	3.400	2.609
14	21	2020				7.684	7.684		7.684	5.114	-2.570	7.337	-0.346	3.549	-4.134
15	22	2021				8.459	8.459		8.459	5.428	-3.031	7.919	-0.540	3.704	-4.755
16	23	2022				4.065	4.065		4.065	5.762	1.696	8.548	4.482	3.866	-0.199
17	24	2023				0.361	0.361		0.361	6.116	5.755	9.226	8.865	4.035	3.675
18	25	2024				0.361	0.361		0.361	6.492	6.131	9.958	9.597	4.212	3.851
19	26	2025				0.361	0.361		0.361	6.892	6.531	10.748	10.387	4.396	4.035
20	27	2026				0.361	0.361		0.361	7.316	6.955	11.601	11.240	4.589	4.228
21	28	2027				0.361	0.361		0.361	7.766	7.405	12.522	12.161	4.789	4.429
22	29	2028				0.361	0.361		0.361	8.244	7.883	13.516	13.155	4.999	4.638
23	30	2029				0.361	0.361		0.361	8.751	8.390	14.589	14.228	5.218	4.857
24	31	2030				0.361	0.361		0.361	9.289	8.929	15.747	15.386	5.446	5.085
25	32	2031				0.361	0.361		0.361	9.861	9.500	16.998	16.637	5.685	5.324
26	33	2032				0.361	0.361		0.361	10.468	10.107	18.348	17.987	5.934	5.573
27	34	2033				0.361	0.361		0.361	11.113	10.752	19.805	19.444	6.194	5.833
28	35	2034				0.361	0.361		0.361	11.797	11.436	21.378	21.017	6.465	6.104
29	36	2035				0.361	0.361		0.361	12.524	12.163	23.077	22.716	6.748	6.387
30	37	2036				0.361	0.361		0.361	13.295	12.934	24.911	24.550	7.044	6.683
			36.183	3.618	39.801	30.727	70.529	5.970	64.559	198.016	133.458	311.798	247.239	127.978	63.420
						FIRR					1.80%		3.47%		-0.04%

Table 4.15. Necessary Funds and Light Dues (Likeliest Case)

Unit: Million USD

	Loan	Necessary Funds of GOI	Total Initial Costs	Necessary Light Dues
	1	2	3=1+ 2	
GMDSS	33.831	5.970	39.801	10.49%

b. FIRR by Market Interest Rate (6%)

Necessary light dues to achieve 6.0% of FIRR are shown in **Table 4.16.**

Table 4.16. Necessary Light Dues by Market Interest Rate

	Necessary Light Dues					
	GDP: Likeliest Case		GDP: Optimistic Case		GDP: Pessimistic Case	
Evaluation Period	10 years	30 years	10 years	30 years	10 years	30 years
GMDSS	32.40%	22.82%	27.46%	17.29%	38.07%	29.46%

(6) Sensitive Analysis for ODA loan

Sensitive analysis for ODA loan should be implemented among three GDP cases. To implement GMDSS, necessary light dues are 10.49% in likeliest case, 7.00% in optimistic case, 15.37% in pessimistic case. It is shown in **Table 4.17.**

Table 4.17. Sensitive Analysis

Unit: %

	Necessary Light Dues		
	Likeliest Case	Optimistic Case	Pessimistic Case
GMDSS	10.49	7.00	15.37

Appendix 4.1. Recommended Standard Facilities for DGSC's Coast Stations

DGSC's Coast Stations		Site		Floor Space		Equipment List	Required Persons
		Area (m/m)	Layout	Main Bldg (m/m)	Power Bldg (m/m)		
1st Class	TX	25,000 ~ 40,000	Fig 1	90	45	Table 1	Table 2
	RX	15,000 ~ 22,500	Fig 2	120	30		
2nd Class	TX	20,000 ~ 36,000	Fig 3	70	45		
	RX	15,000 ~ 22,500	Fig 2	80	30		
3rd Class		3,600	Fig 4	25	20		
4th Class		3,000	Fig 5	25	20		

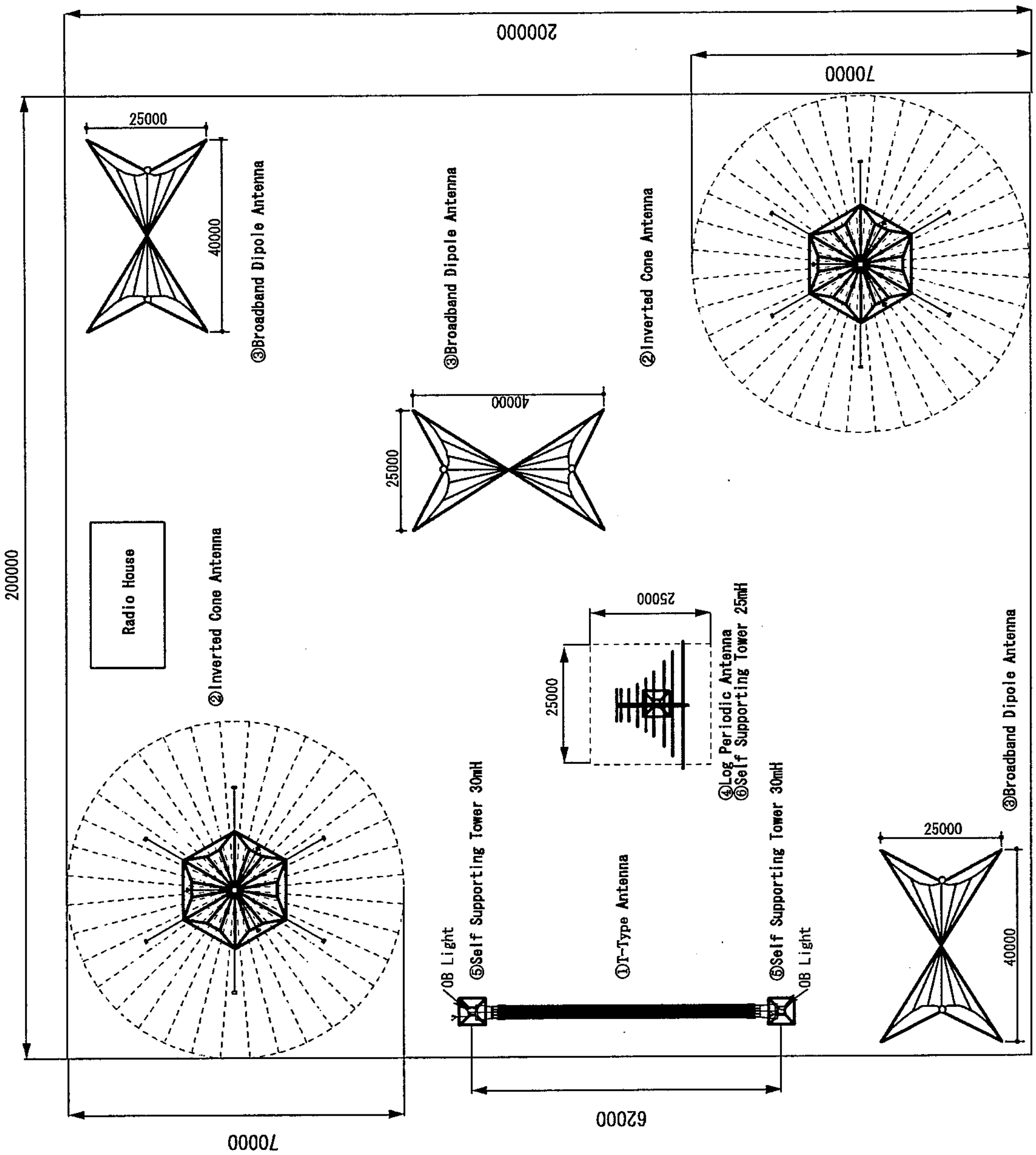
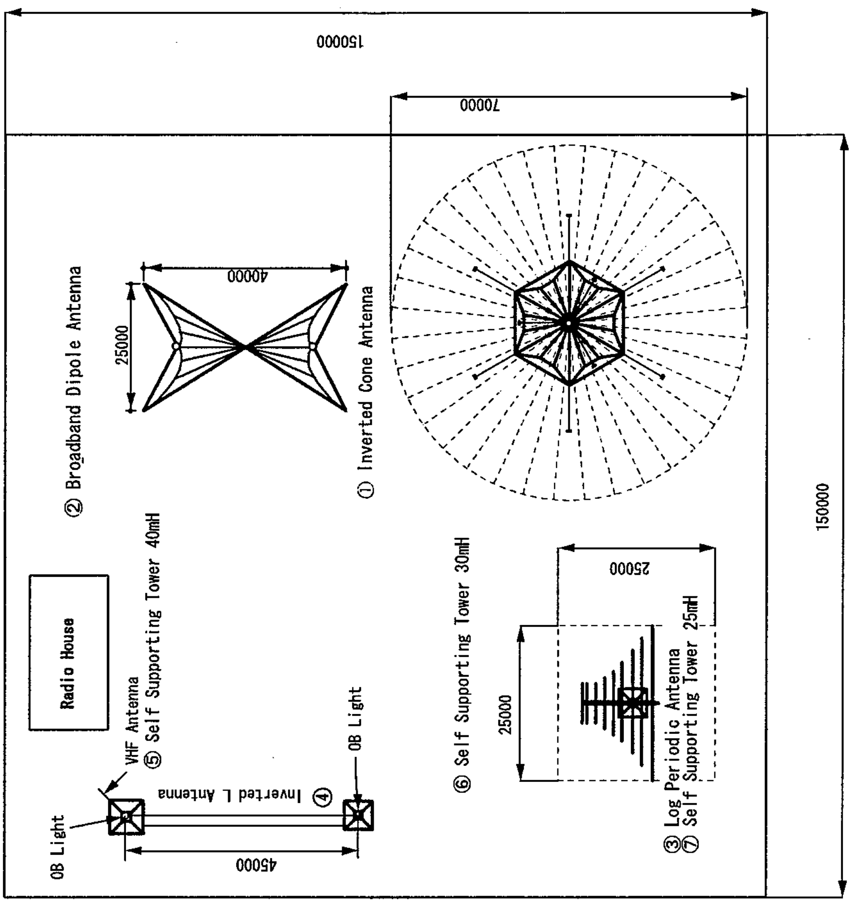


Fig.1 1ST Class Tx Station Antenna Layout

LEGEND:

①	T-Type Antenna	x 1 Set.
②	Inverted Cone Antenna	x 2 Sets.
③	Broadband Dipole Antenna	x 3 Sets.
④	Log Periodic Antenna	x 1 Set.
⑤	Self Supporting Tower 30mH	x 1 Set.
⑥	Self Supporting Tower 25mH	x 1 Set.



LEGEND:

① Inverted Cone Antenna x 1 Set.
② Broadband Dipole Antenna x 1 Set.
③ Log Periodic Antenna x 1 Set.
④ Inverted L Antenna x 1 Set.
⑤ Self Supporting Tower 40mH x 1 Set.
⑥ Self Supporting Tower 30mH x 1 Set.
⑦ Self Supporting Tower 25mH x 1 Set.

Fig.2 1ST・2ND Class RX Staition Antenna Layout

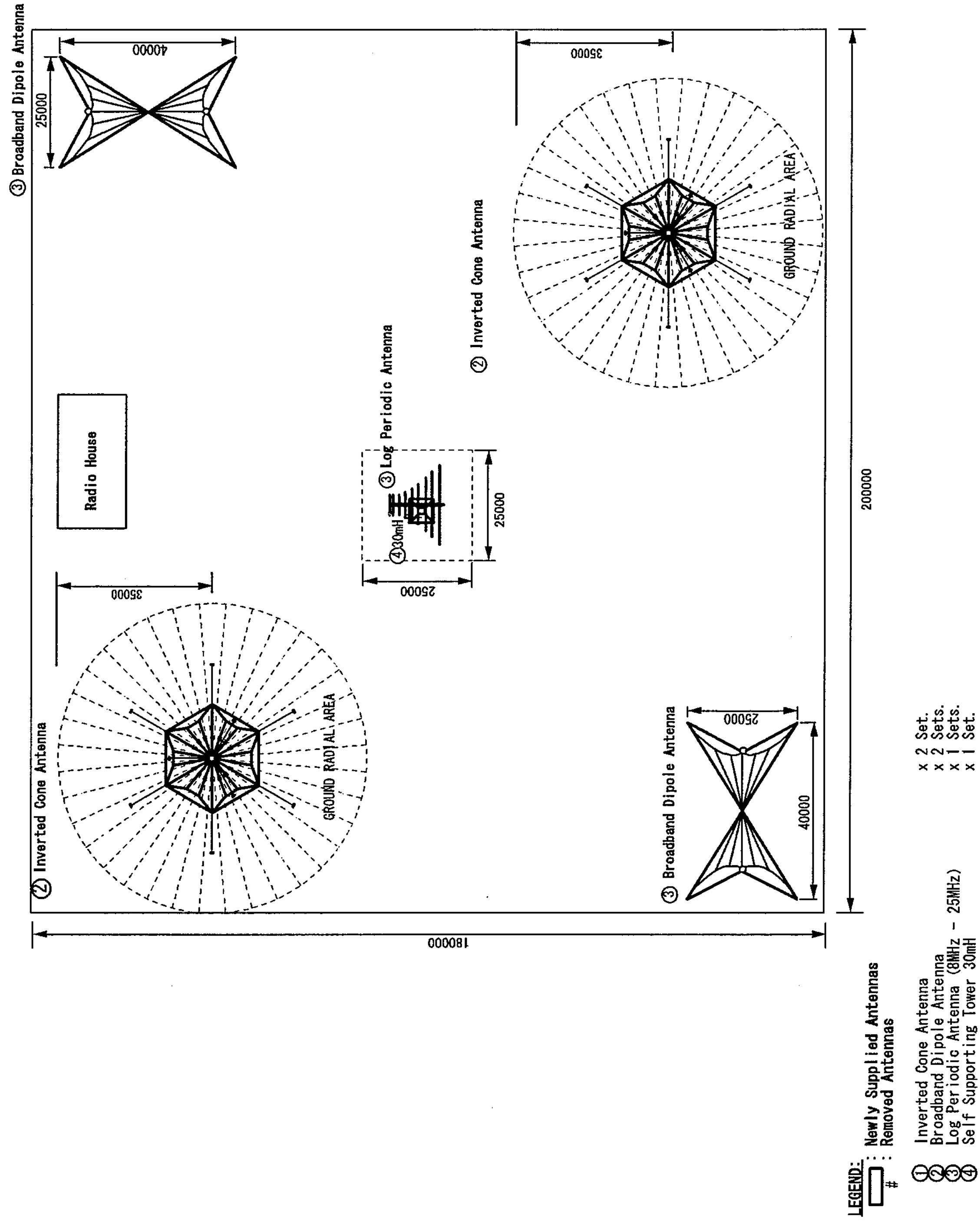


Fig.3 2 nd class TX Station Antenna Layout

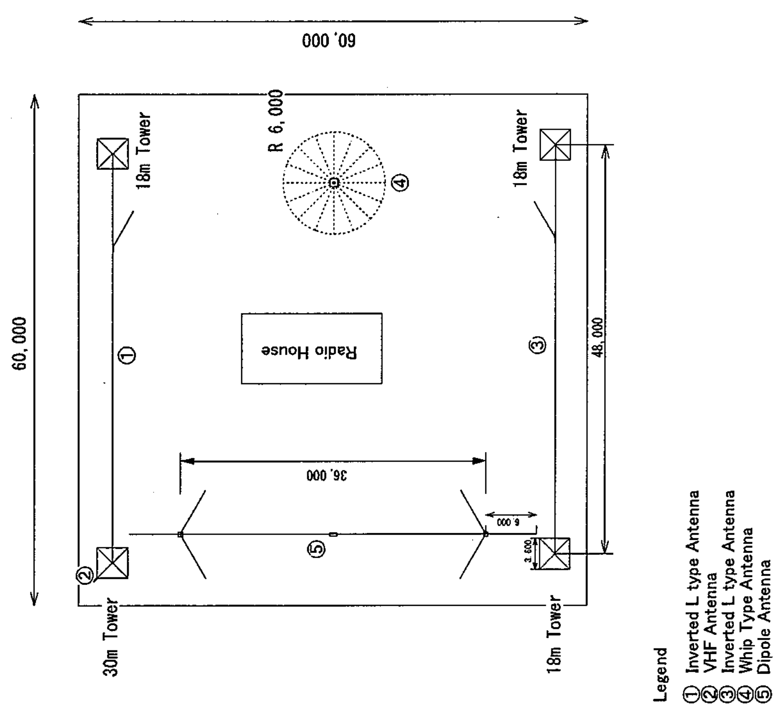


Fig.4 3rd Class Radio Station Antenna Layout

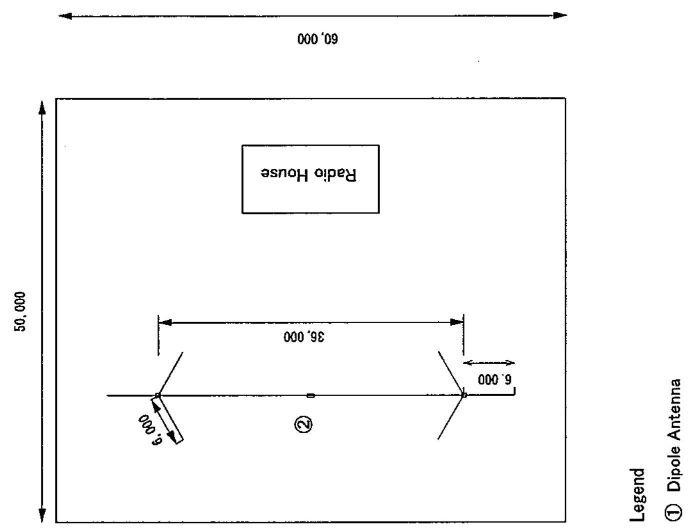


Fig.5 4th Class Radio Station Antenna Layout

Table 1. Recommended Number of Main Equipment

Use or Services		1st class		2nd class	3rd class	4thA class	4thB class
		with NAVTEX	without NAVTEX				
MF or HF Transmitter		**9**	**7**	**6**	**2**	**1**	**1**
		(1 kw Tx)	(1 kw Tx)	(1 kw Tx)	(500 w Tx)	(500 w Tx)	(100 w Tx)
General	TP(TG), DSC, NBDP	2	2	2	2	n.a.	n.a.
Distress	DSC, NBDP, TP	1	1	Common	Common	n.a.	n.a.
Ship Reporting		1	1	1	Common	n.a.	n.a.
Spare		1	1	1	—	—	—
Fixed Com (Internal Telecom)		2	2	2	Common	1 *	1 *
NAVTEX	(518KHz)	2	n.a.	n.a.	n.a.	n.a.	n.a.
MF/HF Tx Antenna		**7**	**6**	**5**	**2**	**1**	**1**
General	Inverted Cone	1	1	2	—	n.a.	n.a.
	Broad-band Dipole	1	1	—	—	—	—
	Wide-band Dipole	—	—	—	1	—	—
	Inverted L -Type	—	—	—	1	—	—
Distress	Inverted Cone	1	1	Common	Common	n.a.	n.a.
Ship Reporting	Broad-band Dipole	1	1	1	Common	n.a.	n.a.
Fixed Com	Log-periodic	1	1	1	Common	—	—
	Broad-band Dipole	1	1	1	—	—	—
	Wide-band Dipole	—	—	—	—	1	1
NAVTEX	T-type	1	n.a.	n.a.	n.a.	n.a.	n.a.
MF/HF Receiver		**24**	**24**	**14**	**2**	**0**	**0**
All wave-type Receiver		10	10	8	2	—	—
Spot-type Receiver		12	12	4	—	—	—
Spare of Spot-type Receiver		2	2	2	—	—	—
MF/HF Rx Antenna		**4**	**4**	**4**	**2**	**0**	**0**
Commonly	Inverted Cone	1	1	1	—	—	—
used	Broad-band Dipole	1	1	1	—	—	—
	Wide-band Dipole	—	—	—	—	—	—
	Inverted L -Type	1	1	1	1	—	—
	Log-periodic	1	1	1	—	—	—
	Whip	—	—	—	1	—	—
VHF Transceiver		**4**	**4**	**4**	**3**	**3**	**0**
General		2	2	2	1	1	n.a.
Distress (Ch16 & Ch70)		2	2	2	2	2	n.a.
VHF Antenna		**4**	**4**	**4**	**3**	**3**	**0**
Operator Position		**6**	**5**	**4**	**1**	**1**	**0**
General	(including VHF ope.)	2	2	1	1	1	n.a.
Distress	(including VHF ope.)	1	1	1	Common	Common	n.a.
Ship Reporting		1	1	1	Common	n.a.	n.a.
Fixed Com		1	1	1	Common	Common	n.a.
NAVTEX		1	n.a.	n.a.	n.a.	n.a.	n.a.

Note: n.a.: Not applicable
Common : The upper column's equipment will be commonly used for this services.
* : Transceiver-type equipment.

Table 2 Required Persons for DGSC's Coast Stations (1/2)

1st Class Coast Station (except Jakarta Station)

Note: ( ) indicate the persons required for NAVTEX stations.

	Receiving Station		Transmitting Station	
	No.	Basis of Estimation	No.	Basis of Estimation
Chief	1			
Operator	27	4×5 shifts 20 Stand-by 4 Office hours 3		
(NAVTEX)	(6)	(1×5 shifts 5) (Stand-by 1)		
Technician	3	Workshop 3	11	1×5 shifts 5 Stand-by 1 Workshop 5
Administrator	3			
Sub Total	34 (40)		11	
Total	45 (51)			

2nd Class Coast Station

	Receiving Station		Transmitting Station	
	No.	Basis of Estimation	No.	Basis of Estimation
Chief	1			
Operator	20	3×5 shifts 15 Stand-by 3 Office hours 2		
Technician	2	Workshop 2	9	1×5 shifts 5 Stand-by 1 Workshop 3
Administrator	2			
Sub Total	25		9	
Total	34			

Table 2 Required Persons for DGSC's Coast Stations (2/2)

3rd Class Coast Station

	No.	Basis of Estimation
Chief	1	
Operator	14	2×5 shifts 10 Stand-by 2 Office hours 2
Technician	3	
Administrator	2	
Total	20	

4th-A Class Coast Station

	No.	Basis of Estimation
Chief	1	
Operator	7	1×5 shifts 5 Stand-by 1 Office hours 1
Technician	2	
Administrator	1	
Total	11	

Appendix 4.2. Separation of TX/RX

1. Necessity of Separation

1.1. From the Operational Aspect

	Teluk Bayur	Cilacap	Benoa	Sabang
Maritime Safety	Important	Important	Important	Important
Internal Telecomm	Many Links 5-IV	Less Links	Many Links 1-III, 9-IV	Many Links 8-IV
Necessity of Separation	Urgent	Next Stage	Urgent	Next Stage
Class	II	II	III→II	II

1.2. From the Technical Aspect

(Interference matrix at a single site where TX/RX are collocated.)

		Receiving						
		2MHz	4MHz	6MHz	8MHz	12MHz	16MHz	VHF
Transmitting	2MHz	×	×	×	×	×	×	○
	4MHz	×	×	×	×	×	×	○
	6MHz	×	×	×	×	×	×	○
	8MHz	×	×	×	×	×	×	○
	12MHz	×	×	×	×	×	×	○
	16MHz	×	×	×	×	×	×	○
	VHF	○	○	○	○	○	○	○

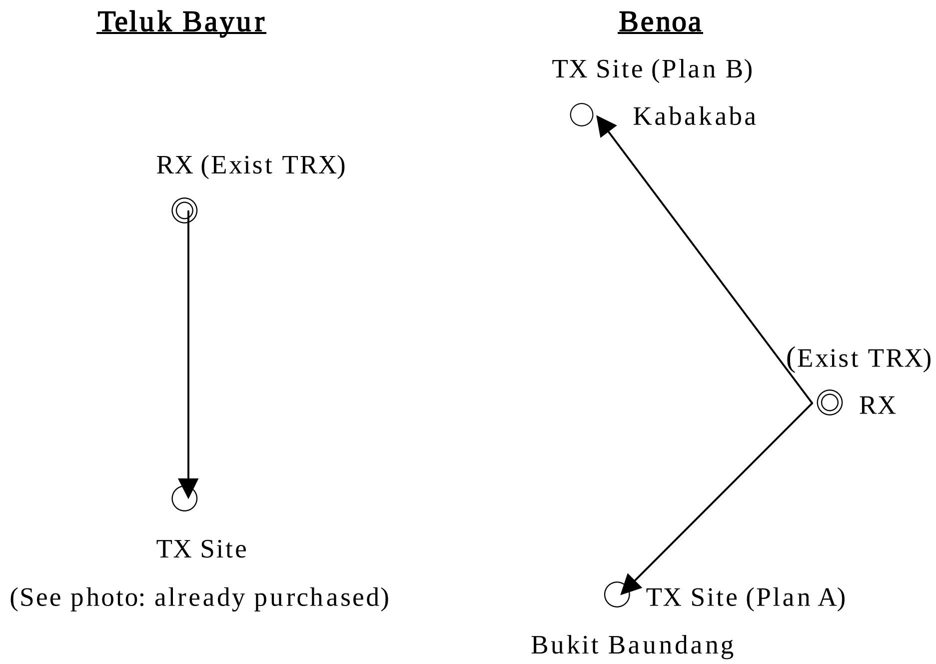
Legend:

○ means simultaneous TX/RX possible.

× means simultaneous TX/RX impossible due to interference.

Note: The calculation examples on the possibilities of interference between 8 MHz to 8 MHz and 2 MHz to 16 MHz are stated in the attached paper.

2. Separation Concept for Teluk Bayur and Benoa



Attached to Appendix 4.2.

Subject: Radio-Wave Transmission Interference

Mutual radio-wave interference between transmitting antenna and receiving antenna in the same site has been studied. The results are described below.

Condition:
1. Transmitting power: 1 kW
2. Transmitting and Receiving frequencies:
   1) 8.291 MHz & 8.4145 MHz
   2) 2.182 MHz & 16.420 MHz

Under the above conditions, studies have been performed about two items:
1) Effects on other transmitting antennas (at antenna-to-antenna intervals of 100 m and 50 m)
2) Effects on receiving antennas (at antenna-to-antenna intervals of 100 m and 50 m)

1) - 1: Effects on other transmitting antennas at an antenna-to-antenna interval of 100 m

The VSWR value that has been obtained from our calculations is from1.1 to 1.44 and there are no problems. An alarm, however, may occur since the effects of interfering waves on the impedance detector of the transmitter which undergoes induction cannot be estimated. The situation, of course, changes according to the particular combination of frequencies. It is more desirable for the coast station to separate transmitting antennas each other.

1) - 2: Effects on other transmitting antennas at an antenna-to-antenna interval of 50 m

The VSWR value that has been obtained from our calculations is from1.21 to 2.12 and there are no problems. An alarm, however, may occur since the effects of interfering waves on the impedance detector of the transmitter which undergoes induction cannot be estimated. The situation, of course, changes according to the particular combination of frequencies. It is more desirable for the coast station to separate transmitting antennas each other.

2) - 1: Effects on receiving antenna at an antenna-to-antenna interval of 100 m
According to our calculation results, a voltage of 10.56 to 40.15 Vrms is applied to the input end of the receiver. In the case of normal receiving, maximum 1Vrms(120dBƒÊ) is applied the input end of the receiver. Therefore, there occurs problems such as the suppression of the receiver gain and cross modulation.

2) - 2: Effects on receiving antenna at an antenna-to-antenna interval of 50 m
According to our calculation results, a voltage of 21.13 to 80.29 Vrms is applied to the input end of the receiver. In the case of normal receiving, maximum 1Vrms(120dBƒÊ) is applied the input end of the receiver. Therefore, there occurs problems such as the suppression of the receiver gain and cross modulation. Besides, more than 50Vrms of input voltage damages the receiver. In the case that the transmitting antenna and the receiving antenna are installed at the same site, a break-in relay is usually inserted at the input end of the receiver so that the RF line from the receiving antenna is disconnected during transmission.

The above results indicate that although the differences between the antenna-to-antenna intervals of 50 m and 100 m are not too significant, it is usually not possible to avoid the effects on the receiver. Therefore, since no receivers operate during transmission from either transmitter, other communications cannot be performed. In other words, only one type of communication (simplex communication) per station is possible.
If the receiving site and the transmitting site are separated, receiving at every frequency is possible, even during transmission. Multiple communications can be simultaneously performed at one station. We propose that the receiving site and the transmitting site be separated considering the traffic volume and importance of that station.

Mutual interference between transmitting antennas cannot be avoided, even if the receiving site and the transmitting site are separated. According to the calculation results mentioned above, simultaneous emission at two frequencies creates no problems. However, an SWR alarm and/or MF detuning are likely to occur under a combination of different frequencies or according to the particular environmental conditions.
In the past, at a number of coastal stations, partial interference has occurred

because of many antennas having been arranged on narrow land. This problem, however, has been properly handled in operational aspects and has not become a big problem in terms of practical usage. Even so, it is a fact that increasing the antenna-to-antenna interval to its maximum is the absolute requirement for avoiding interference.

1. Calculation of electric field strength

Transmission end：Transmitting antenna
Receiving end (the equipment that undergoes induction) ：Receiving antenna

Parameters:

Wavelength	λ（m）
Effective length of the half-wavelength dipole antenna	ｌｅ（m）
Impedance at the power supply point	Ｒｒ（Ω）
Current at the power supply point	Ｉｏ（A）
Output power	Ｐｔ（W）

Electric field strength"Ｅ"（Ｖ／ｍ）at a distance of "ｄ"（ｍ）from the transmitting antenna can be calculated as follows from bibliography:

$$E = \frac{60 \times \pi \times Io \times le}{\lambda \times d} \quad \ldots\ldots \qquad (1)$$

where "le" and "Io" can be expressed as follows:

$$le = \frac{\lambda}{\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

$$Io = \sqrt{\frac{Pt}{Rr}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

Assignment of these expression (1) above, therefore yields:

$$E = \frac{60}{d} \times \sqrt{\frac{Pt}{Rr}} \qquad (4)$$

2. Calculation of the power available for receiving

When the power available for receiving is taken as Pr(W), and the receiving release voltage, as Vo(V), and the impedance of the receiving antenna, as Rr(Ω), the value of Pr can be calculated as follows from bibliography:

$$Pr = \frac{Vo^2}{4 \times Rr} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

Also, since

$$Vo = E \times le = E \times \frac{\lambda}{\pi} \quad \cdots\cdots \quad (6)$$

assignment of expression (6) to expression (5) above yields:

$$Pr = \frac{E^2 \times \lambda^2}{4 \times \pi^2 \times Rr} \quad \cdots\cdots\cdots \quad (7)$$

Further, assignment of expression (4) to expression (7) above yields:

$$Pr = \frac{\lambda^2}{4 \times \pi^2 \times Rr} \times \frac{60^2}{d^2} \times \frac{Pt}{Rr}$$
$$= \left(\frac{30 \times \lambda}{\pi \times d \times Rr} \right)^2 \times Pt \quad \cdots \quad (8)$$

3-1 For the current subject, the condition

Pt＝1000W

d＝100m

The transmitting and receiving frequencies are as follows:

Transmitting frequency f_1＝2.182 MHz ：Wavelength λ_1＝137.49m

Receiving frequency f_2 ＝ 16.420MHz ： Wavelength λ_2 ＝ 18.27m

The gain of the antennas:

Transmitting antenna ：2.15dBi（=0 dBd）

Receiving antenna ：2.15dBi（=0 dBd）

3-1-1 Effects on the receiving antenna

It follows from expression (8) above that:

$$Pr = \left(\frac{30 \times \lambda}{\pi \times d \times Rr} \right)^2 \times Pt$$
$$= \left(\frac{30 \times 137.49}{\pi \times 100 \times 73.13} \right)^2 \times 1000$$
$$= 32.23(W)$$

Therefore, since the input impedance of the receiver is 50ohms the input voltage Vr of the
receiver is:

$$Vr = \sqrt{\Pr \times Z} = \sqrt{32.23 \times 50} = 40.15Vrms$$

According to the above calculations, since the frequency is quite separate from the other, the performance of the receiving antenna against the transmitting wave is same as that of the transmitting end on the supposition of the broadband antenna.

3-1-2 Effects on other transmitters:

The output of the transmitter which undergoes induction is 1000W. If an induction wave of 32.23 W is received for 1000W. the VSWR value in terms of the output of the transmitter which undergoes induction is:

$$VSWR = \frac{\sqrt{Pt} + \sqrt{Pr}}{\sqrt{Pt} - \sqrt{Pr}}$$
$$= \frac{\sqrt{1000} + \sqrt{32.23}}{\sqrt{1000} - \sqrt{32.23}}$$
$$= 1.44$$

3-2 For the current subject, the condition

Pt＝1000W

d＝50m

The transmitting and receiving frequencies are as follows:

Transmitting frequency f_1＝2.182MHｚ：Wavelength λ_1＝137.49m

Receiving frequency f_2＝16.420MHｚ：Wavelength λ_2＝18.27m

The gain of the antennas:

Transmitting antenna ：2.15 dBi（=0 dBd）

Receiving antenna ：2.15 dBi（=0 dBd）

3-2-1 Effects on the receiving antenna

It follows from expression (8) above that:

$$Pr = \left(\frac{30 \times \lambda}{\pi \times d \times Rr} \right)^2 \times Pt$$
$$= \left(\frac{30 \times 137.49}{\pi \times 50 \times 73.13} \right)^2 \times 1000$$
$$= 128.93(W)$$

Therefore, since the input impedance of the receiver is 50ohms the input voltage Vr of the
receiver is:

$$Vr = \sqrt{\Pr \times Z} = \sqrt{128.93 \times 50} = 80.29Vrms$$

According to the above calculations, since the frequency is quite separate from the other, the performance of the receiving antenna against the transmitting wave is same as that of the transmitting end on the supposition of the broadband antenna.

3-2-2 Effects on other transmitters:

The output of the transmitter which undergoes induction is 1000W. If an induction wave of 128.93 W is received for 1000W. the VSWR value in terms of the output of the transmitter which undergoes induction is:

$$VSWR = \frac{\sqrt{Pt} + \sqrt{Pr}}{\sqrt{Pt} - \sqrt{Pr}}$$
$$= \frac{\sqrt{1000} + \sqrt{128.93}}{\sqrt{1000} - \sqrt{128.93}}$$
$$= 2.12$$

3-3 For the current subject, the condition

Pt＝1000W

d＝100m

The transmitting and receiving frequencies are as follows:

Transmitting frequency f_1＝8.291MHｚ：Wavelength λ_1＝36.18m

Receiving frequency f_2＝8.4145MHｚ：Wavelength λ_2＝35.65m

The gain of the antennas:

Transmitting antenna ：2.15 dBi（=0 dBd）

Receiving antenna　　　：2.15 dBi（=0 dBd）

3-3-1 Effects on the receiving antenna

It follows from expression (8) above that:

$$
\begin{aligned}
Pr &= \left(\frac{30\times\lambda}{\pi\times d\times Rr}\right)^2 \times Pt \\
&= \left(\frac{30\times 36.18}{\pi\times 100\times 73.13}\right)^2 \times 1000 \\
&= 2.23(W)
\end{aligned}
$$

Therefore, since the input impedance of the receiver is 50ohms the input voltage Vr of the
receiver is:

$$
Vr = \sqrt{\Pr\times Z} = \sqrt{2.23\times 50} = 10.56 Vrms
$$

According to the above calculations, since the frequencies are close, the effective length of the receiving antenna is the same as that of the transmitting antenna

3-3-2　Effects on other transmitters:

The output of the transmitter which undergoes induction is 1000W.　If an induction wave of 2.23 W is received for 1000W. the VSWR value in terms of the output of the transmitter which undergoes induction is:

$$
\begin{aligned}
VSWR &= \frac{\sqrt{Pt}+\sqrt{Pr}}{\sqrt{Pt}-\sqrt{Pr}} \\
&= \frac{\sqrt{1000}+\sqrt{2.23}}{\sqrt{1000}-\sqrt{2.23}} \\
&= 1.10
\end{aligned}
$$

3-4　For the current subject, the condition

Pt＝1000W

d＝50m

The transmitting and receiving frequencies are as follows:

Transmitting frequency f_1＝8.291MHz：Wavelength　λ_1＝36.18m

Receiving frequency　　f_2＝8.4145MHz：Wavelength　λ_2＝35.65m

The gain of the antennas:

Transmitting antenna　：2.15 dBi（=0 dBd）

Receiving antenna　　　：2.15 dBi（=0 dBd）

3-4-1 Effects on the receiving antenna

It follows from expression (8) above that:

$$
\begin{aligned}
Pr &= \left(\frac{30 \times \lambda}{\pi \times d \times Rr} \right)^2 \times Pt \\
&= \left(\frac{30 \times 36.18}{\pi \times 50 \times 73.13} \right)^2 \times 1000 \\
&= 8.93(W)
\end{aligned}
$$

Therefore, since the input impedance of the receiver is 50ohms the input voltage Vr of the
receiver is:

$$Vr = \sqrt{\mathrm{Pr} \times Z} = \sqrt{8.93 \times 50} = 21.13 Vrms$$

According to the above calculations, since the frequencies are close, the effective length of the receiving antenna is the same as that of the transmitting antenna

3-4-2　Effects on other transmitters:

The output of the transmitter which undergoes induction is 1000W.　If an induction wave of 8.93 W is received for 1000W. the VSWR value in terms of the output of the transmitter which undergoes induction is:

$$
\begin{aligned}
VSWR &= \frac{\sqrt{Pt} + \sqrt{Pr}}{\sqrt{Pt} - \sqrt{Pr}} \\
&= \frac{\sqrt{1000} + \sqrt{8.93}}{\sqrt{1000} - \sqrt{8.93}} \\
&= 1.21
\end{aligned}
$$

Improvement of VHF Coverage at Dumai and Samarinda Stations

This report is prepared for improvement of VHF coverage (Area A1 in GMDSS) at Dumai and Samarinda coastal radio stations.

1. Background

At Dumai, Rupat island sizing around forty-five (45) kilometers in diameter is lying in front of the coast station. Current VHF coverage at Dumai is limited within the corridor between Sumatra main island and Rupat island, and does not cover any part of Malacca strait.

While Samarinda coast station is located approximately fifty (50) kilometers upper reaches of Muarapengah-Muarajawa-Mahakam reivers from the coastline. Samarinda's VHF communication is possible only for ships sailing on the Mahakam and Muarajawa rivers, that is, the coastal waters out of the Samarinda delta are not covered by the VHF system at present.

Such situations make not only inconvenience communication between the coast stations and ships sailing at off-shore, but also do not comply with the requirement (the standard coverage is to be 25 nautical miles, or 46 kilometers area from coastline) of IMO.

2. Solution

To solve the coverage problem, two options are considered. The first option is to install huge tower at the site, and the second, to prepare a repeating station at an appropriate place near the coast.

The first option gives very simple solution, but it is not realistic because the tower height will become more than 200m. Then the second option of the repeating will be only the solution of this coverage problem.

3. Design of Repeating Link

The repeating link between coast station and new VHF station will be established by a digital microwave system. DGSC as a private link owner can use 7.5GHz frequency band for this purpose due to the frequency allotment plan for small capacity's private link in the radio regulations.

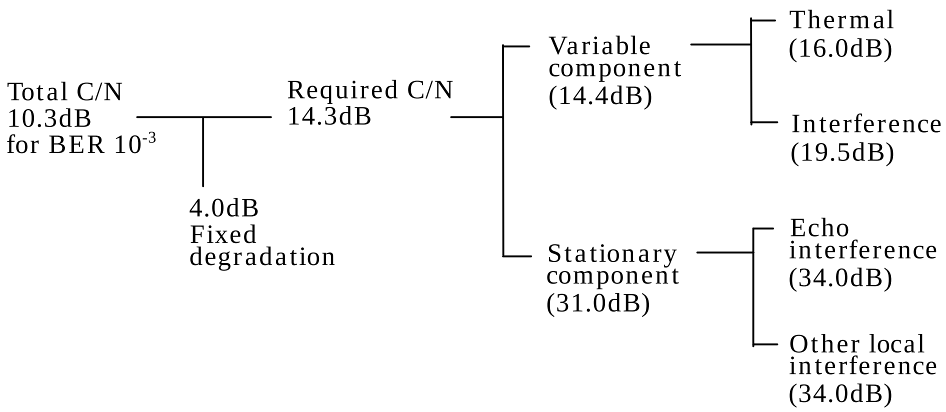
3.1. Design Conditions

Design conditions and criteria applicable to this DGSC repeating link are as follows:

a. Full first fresnel zone should be kept through the radio path under the standard atmosphere K=4/3, and 30% of fresnel zone should be kept even the K becomes 2/3.

b. Severely error second rate (SESR) for bit error rate (BER) of $1x10^{-3}$ should not exceed the value 280/2500 x 0.00054 (= 6×10^{-5}) in any month. 【Rec. ITU-R F.594 and its related reports】

c. Signal's carrier to noise ratio (C/N) for each degradation component in a link should be better than the distributed value given below.



3.2. System Design and its Conclusion

3.2.1. Dumai Microwave Link

(1) Candidate location for VHF station

To extend the coverage up to Dumai's entrance area in Malacca straits, there are two candidate locations, i.e., the existing lighthouse site located in northern part of Rupat island and the pilot station site in eastern part of the island. But the lighthouse site is too far from Dumai coast station to establish a microwave link, then the pilot station site is to be selected.

Figure 1.1. shows locations of Dumai coast station and the planned VHF station in Rupat island, and the microwave path line. The path distance will be 49.5km.

(2) Design results

If below mentioned equipment/facilities are furnished, a sufficient system in quality and in reliability, can be realized.

	Dumai	Rupat (Pilot station)
System capacity	4 Mb/s (2 Mb/s x 2)	
Transmitter output power	30 dBm	
Ground Level (GL)	2 m	2 m
Anntena height from GL	100 m / 90 m	100 m / 90 m
Antenna diameter	1.2 mφ(4ftφ)	1.2 mφ(4ftφ)

Space diversity system is required.

3.2.2. Samarinda Microwave Link

(1) Candidate location for VHF station

Samarinda is a hilly area. New VHF station should be placed at a point where the access to the site is easy (i.e., nearby existing public road), line-of-sight of the microwave can be kept, and the east (Makassar strait) side should be opened for VHF service.

From these aspects, a hill having ground elevation 68m above sea level and located around 7km south from Sangasangadalam town (herein after called “Hill 68”) is selected as the most recommended point.

Figure 1.2. shows locations of Samarinda coast station and the planned VHF station site at Hill 68, and the microwave path line. This path distance will be 23.8km.

(2) Design results

Following equipment/facilities will make a sufficient system in quality and reliability.

	Samarinda	Hill 68
System capacity	4 Mb/s (2 Mb/s x 2)	
Transmitter output power	30 dBm	
Ground Level (GL)	2 m	65 m
Anntena height from GL	85 m	70 m
Antenna diameter	0.6 mφ(2ftφ)	0.6 mφ(2ftφ)

3.3. Calculation of Path Performance

Path profiles for Dumai and Samarinda links are **shown in Figure 2.1.** and **2.2.** And using parameters or the obtained figures/results at each calculation step are summarized in **Table 1.1.** for Dumai link and **Table 1.2.** for Samarinda link respectively.

(1) First fresnel zone

First fresnel zone radius (r1) is calculated by following formula:

$$r1 = \sqrt{\lambda \cdot \frac{d1 \cdot d2}{d}}$$

where λ: Wave-length 7.5 GHz = 0.04 m

d: Path distance

d1 (or d2): Distance from Tx (or Rx) side

Example: Dumai's intermediate point

d = 49.5 km, d1, d2 = 24.75 km, then r1 = 22.3 m

Samarinda's ridge point

d = 23.8 km, d1 = 13.0 km, d2 = 10.8 km, then r1 = 15.4 m

(2) Receiver input level

Receiver input level (Pr) is as follows:

$$Pr = Pt + Gat + Gar - Lo - Ladd - Lft - Lfr - Lct - Lcr \text{ (dBm)}$$

where Pt: Transmitter output power (dBm)

Gat (or Gar): Tx (or Rx) side antenna gain (dB)

Lo: Free space loss (dB)

$$Lo = 10 \log \left[\frac{4 \cdot \pi \cdot d}{\lambda} \right]$$

Ladd: Additional loss on the path, if any (dB)

Lft (or Lfr): Tx (or Rx) side feeder loss (dB)

Lct (or Lcr): Tx (or Rx) side duplexer loss (dB)

without S/D Lft = 4.0 dB, Lfr = 6.0 dB

with S/D Lft = 4.0 dB, Lfr = 2.5 dB

(3) Thermal noise of receiver

Thermal noise of receiver (Prni) is obtained by the following:

$$Prni = 10 \log B + NF - 144 \text{ (dBm)}$$

where B: Equivalent bandwidth of receiver (kHz)
NF: Receiver noise figure (dB)

(4) Occurrence probability of Rayleigh fading

Occurrence probability of Rayleigh fading (PR) is estimated by the following formula:

$$PR = Q \cdot (f / 4)^{1.2} \cdot d^{3.5}$$

where Q: Propagation path coefficient

Mountain area:	2.1×10^{-9}		
Plain field:	5.1×10^{-9}	if	h 100 m
	$2.35 \times 10^{-8} \times (1 / hav)^{(1/3)}$	if	h < 100 m
Sea or river:	$3.7 \times 10^{-7} / \sqrt{hav}$	if	h 100 m
	$3.7 \times 10^{-6} / hav$	if	h < 100 m

"hav" is average path height : (Hat + Har) / 2 - hm

Where effective attenuation for reflected wave from the earth surface is less than 20dB, "Equivalent Rayleigh" probability (PRe) should be applied instead of PR for interruption calculation. Relation between PR and PRe is given in **Figurer 3.**

(5) Space diversity (S/D) improvement factor

S/D improvement factor (A) depends on correlation coefficient of two antennas spacing (ρ), and is obtained from the chart shown in **Figure 4.**

The correlation coefficient of antennas spacing (ρ) is given by the following formula:

$$\rho = \exp [-0.0021 \cdot \varDelta h \cdot f \cdot \sqrt{0.4 \cdot d + s^2 \cdot 10^4 \cdot \gamma^2 / (1+\gamma^2)^2}\,]$$

where ⊿h: Antenna spacing (m)
f: Frequency (GHz)
d: Propagation path distance (km)
s: Path difference between direct and reflected waves (m)
γ: Effective attenuation coefficient of reflected wave

$$\gamma = 10^{(-D/Ur)/20} \quad \text{D/Ur in dB}$$

Example: Dumai link

Δh = 10 m, f = 7.5 GHz, d = 49.5 km, s = 0.42 m,

D/Ur = 10 dB, γ = 0.316, then ρ becomes 0.132.

(5) Fading and circuit reliability

Circuit reliability, that is, interruption time (Pi) under the fading is calculated by the following formula:

$$Pi = k \cdot PR \cdot 10^{-Fm/10} / A$$

where k: a constant for yearly increment, “2” in usual

PR: Occurrence probability of Rayleigh fading, but if effective attenuation for reflected wave (D/Ur) is less than 20dB, probability of equivalent Rayleigh fading (PRe) should be applied.

Fm: Fading margin

$$Fm = Pr - Prni - C/Ntho$$

C/Ntho: Required C/Nthermal for keeping the BER 1^{-3}.

16.0 dB is allotted (See Figure 1.)

A: S/D improvement factor, but to be applied to S/D link only.

(6) Judgment

Allowable interruption time (Pis) is specified in Clause 3.1. as 6×10^{-5}.

Now, the estimated interruption time (Pi) should be smaller than the allowable interruption time (Psi).

$$Pi < Pis$$

In other words, even the fading occurs, that time’s C/N (C/Nth’) should still be better than the required C/N (C/Ntho), i.e., following equation should be kept.

$$C/Nth' - C/Ntho \quad 0$$

where C/Nth’ = Pr - Prni - Fms (dB)

Fms: Required fading margin to keep the allowable interruption time.

$$Fms = 10 \log \left[\frac{k \cdot PR}{Pis \cdot A} \right] \text{ (dB)}$$

4. Design of VHF Coverage

4.1. Equipment Parameters and Calculation Results

Following equipment parameters are assumed for this calculation:

Name of VHF station:	Dumai [Rupat (Pilot st.)]	Samarinda [Hill 68]	
Transmitter output	25 w (Ship's output)		
Antenna gain at VHF st.	4.1 dB		
Antenna gain at Ship	2.1 dB		
Feeder loss at VHF st.	4.0 dB		
Feeder loss at Ship	2.0 dB		
Antenna height at station (h_1)	97 m	130 m	(from S.L.)
	95 m	65 m	(from G.L.)
Antenna height at ship (h_2)	4 m	4 m	

From the calculation in later, following distances are expectable as the VHF coverage area. These coverages drawn on maps are shown in **Figure 5.1.** and **5.2.**

Name of VHF station:	Dumai [Rupat (Pilot st.)]	Samarinda [Hill 68]
Coverage, if ship's h_2 = 4 m,	52 km	62 km
or h_2 = 10 m,	66 km	75 km

4.2. Calculation of the VHF Coverage

(1) Receiver's threshold level and S/N at the Pth

Threshold level (Pth) is obtained by the following formula:

$$Pth = 10 \log 8 + 10 \log Bw + 10 \log NF - 144 \text{ (dBm)}$$
$$= -110.0 \text{ dBm}$$

where Bw: Bandwidth 16 kHz

NF: Receiver noise figure 13 dB

And signal to noise ratio at the Pth level (S/Nth) is given by the following formula:

$$S/Nth = I + Cf = 10 \log \left[\frac{fdo^2 \cdot Bw}{fv^2 \cdot fs} \right] \quad 10 \log Cf \text{ (dB)}$$

where			
	I:	Improvement factor	
	Cf:	Crest factor	8
	fdo:	Frequency deviation (rms/CH)	5 kHz
	Bw:	Bandwidth	16 kHz
	fv:	Base band frequency	3 kHz
	fs:	Bandwidth of voice	3 kHz

Accordingly the S/Nth = 21.0 dB

(2) Required receiving level

S/N 30dB is required for this VHF system, then the minimum level required by the receiver (Preq) should be;

$$Preq = Pth + (30 - 21)$$
$$= -110.0 + 9 = -101.0 \text{ dBm}$$

(3) Receiving level

Receiving signal level (Pr) is calculated by the following formula:

$$Pr = Pt + Ga - Lf - \Gamma o - Ap \text{ (dBm)}$$

where			
	Pt:	Transmitter output power	44.0 dBm (25 w)
	Ga:	Antenna gain (Tx + Rx)	6.2 dB
	Lf:	Feeder loss (Tx + Rx)	6.0 dB
	Γo:	Free space loss (dB)	

$$\Gamma o = 10 \log \left[\frac{4 \cdot \pi \cdot d}{\lambda} \right]$$

Ap: Additional loss caused by the spherical earth (dB)

Ap is obtained by the monograph given in **Figure 6.** with the parameters χ_0, χ_1, χ_2 and B.

where $B = 670 \, [f / (K \cdot a)^2]^{1/3} = 1.95 \quad [f(MHz) / K^2]^{1/3}$

$\chi_0 = B \cdot D$ D: Distance (or coverage area)

$\chi_1 = B \, (2 \cdot K \cdot a \cdot h_1)^{1/2} = B \cdot 3.57 \cdot (K)^{1/2} \cdot (h_1)^{1/2}$

$\chi_2 = B \, (2 \cdot K \cdot a \cdot h_2)^{1/2} = B \cdot 3.57 \cdot (K)^{1/2} \cdot (h_2)^{1/2}$

K (Coefficient of effective earth radius in normal condition) = 1.333

Following tables show the calculation results of some cases varying the parameters:

h1 (m) = 97　　h2 (m) = 4

D (km)　d1 (km) = 40.6　　d2 (km) = 8.2

D (km)	B	(χ0)	(χ1)	(χ2)	G(χ0)	F(χ1)	F(χ2)	**Ap**	**Γo**	**Ap+Γo**	**Pr**
40	8.5529	342	347	71	-5	-14	-42	**30.5**	108.0	**138.5**	**-94.7**
50	8.5529	428	347	71	-2	-14	-42	**33.5**	109.9	**143.4**	**-99.6**
60	8.5529	513	347	71	3	-14	-42	**38.5**	111.5	**150.0**	**-106.2**
70	8.5529	599	347	71	6	-14	-42	**41.5**	112.9	**154.4**	**-110.6**

h1 (m) = 130　　h2 (m) = 4

D (km)　d1 (km) = 47.0　　d2 (km) = 8.2

D (km)	B	(χ0)	(χ1)	(χ2)	G(χ0)	F(χ1)	F(χ2)	**Ap**	**Γo**	**Ap+Γo**	**Pr**
40	8.5529	342	402	71	-5	-9	-42	**25.5**	108.0	**133.5**	**-89.7**
50	8.5529	428	402	71	-2	-9	-42	**28.5**	109.9	**138.4**	**-94.6**
60	8.5529	513	402	71	3	-9	-42	**33.5**	111.5	**145.0**	**-101.2**
70	8.5529	599	402	71	6	-9	-42	**36.5**	112.9	**149.4**	**-105.6**

h1 (m) = 97　　h2 (m) = 10

D (km)　d1 (km) = 40.6　　d2 (km) = 13.0

D (km)	B	(χ0)	(χ1)	(χ2)	G(χ0)	F(χ1)	F(χ2)	**Ap**	**Γo**	**Ap+Γo**	**Pr**
40	8.5529	342	347	111	-5	-14	-35	**23.5**	108.0	**131.5**	**-87.7**
50	8.5529	428	347	111	-2	-14	-35	**26.5**	109.9	**136.4**	**-92.6**
60	8.5529	513	347	111	3	-14	-35	**31.5**	111.5	**143.0**	**-99.2**
70	8.5529	599	347	111	6	-14	-35	**34.5**	112.9	**147.4**	**-103.6**

Figure 7. shows the relation between distance versus receiving signal level under the varying the antenna heights at VHF station (h_1) and ship side (h_2), as the results of calculation.

Table 1.1. Path Performance Calculation Table for Dumai Link

Frequency band: 7.5 GHz (ITU-R Rec. 385-6)
Transmission capacity: 2 Mb/s x 2

Path Name					**Dumai Rx - Rupat (Pilot Station)**		
					without SD	**with SD**	
Frequency			F	(MHz)	7500	7500	
Path distance			d	(km)	49.5	49.5	
Antenna height above sea level	Tx side		Hat	(m)	102	102	
Antenna height above sea level	Rx side		Har	(m)	102	102	
Free space loss			Lo	(dB)	143.8	143.8	
Transmitter output power			Pt	(dBm)	30.0	30.0	
Additional loss on the path			Ladd	(dB)	0.0	0.0	
Antenna gain	Tx side		Gat	(dBi)	43.0	37.0	31.5dBi by 2ft, 37.0dBi by 4ft
Antenna gain	Rx side		Gar	(dBi)	43.0	37.0	40.5dBi by 6ft, 43.0dBi by 8ft
Feeder loss	Tx side	115m	Lft	(dB)	6.9	6.9	0.06dB/m
Feeder loss	Rx side	105m	Lfr	(dB)	6.3	6.3	
Duplexer loss	Tx side		Lct	(dB)	4.0	4.0	
Duplexer loss	Rx side		Lcr	(dB)	6.0	2.5	
Equivalent bandwidth of receiver			Bw	(kHz)	2200	2200	
Noise figure of receiver			NF	(dB)	4.0	4.0	
Receiver input level			Pr	(dBm)	-51.0	-59.5	Max：-43.9dBm
Thermal noise of receiver			Prni	(dBm)	-106.6	-106.6	
Required C/Nth for 10^{-3}			C/Ntho	(dB)	16.0	16.0	
Fading margin			Fm	(dB)	39.5	31.0	
Type of path			N		3	3	1.mountain 2.plain 3.sea/river
Average ground level (0 m at sea)			hm	(m)	20	20	
Average path height			hav	(m)	82	82	
Propagation path coefficient			Q		4.51E-08	4.51E-08	
Occurrence probability of Rayleigh fading			PR		8.19E-02	8.19E-02	
Effective attenuation for reflected wave			D/Ur	(dB)	10	10	
Occurrence probability of equivalent Rayleigh			PRe		0.38	0.38	
Correlation coefficient of antenna spacing			ρ			0.132	
SD improvement factor			A			50	
Required fading margin			Fms	(dB)	41.0	24.0	
C/N under fading			C/Nth'	(dB)	14.5	23.0	
Estimated Interruption time rate			**Pi**		**0.0000844**	**0.0000120**	
Allowable interruption time rate			**Pis**		**0.0000600**		
Margin (C/Nth' - C/Ntho)				(dB)	-1.48	7.01	
Judgment					**Bad**	**Passed**	

Table 1.2. Path Performance Calculation Table for Samarinda Link

Frequency band: 7.5 GHz (ITU-R Rec. 385-6)
Transmission capacity: 2 Mb/s x 2

Path Name	Samarinda - Hill 68

				without SD	with SD	
Frequency		F	(MHz)	7500		
Path distance		d	(km)	23.8		
Antenna height above sea level	Tx side	Hat	(m)	87		
Antenna height above sea level	Rx side	Har	(m)	135		GL at Hill 68 wil be 65m after cutting
Free space loss		Lo	(dB)	137.5		
Transmitter output power		Pt	(dBm)	30.0		
Additional loss on the path		Ladd	(dB)	0.0		
Antenna gain	Tx side	Gat	(dBi)	31.5		31.5dBi by 2ft, 37.0dBi by 4ft
Antenna gain	Rx side	Gar	(dBi)	31.5		40.5dBi by 6ft, 43.0dBi by 8ft
Feeder loss	Tx side 100m	Lft	(dB)	6.0		0.06dB/m
Feeder loss	Rx side 75m	Lfr	(dB)	4.5		
Duplexer loss	Tx side	Lct	(dB)	4.0		
Duplexer loss	Rx side	Lcr	(dB)	6.0		
Equivalent bandwidth of receiver		Bw	(kHz)	2200		
Noise figure of receiver		NF	(dB)	4.0		
Receiver input level		Pr	(dBm)	-65.0		Max：-43.9dBm
Thermal noise of receiver		Prni	(dBm)	-106.6		
Required C/Nth for 10^{-3}		C/Ntho	(dB)	16.0		
Fading margin		Fm	(dB)	25.6		
Type of path		N		1		1.mountain 2.plain 3.sea/river
Average ground level (0 m at sea)		hm	(m)	35		
Average path height		hav	(m)	76		
Propagation path coefficient		Q		2.10E-09		
Occurrence probability of Rayleigh fading		PR		2.94E-04		
Effective attenuation for reflected wave		D/Ur	(dB)	30		
Occurrence probability of equivalent Rayleigh		PRe				
Correlation coefficient of antenna spacing		ρ				
SD improvement factor		A				
Required fading margin		Fms	(dB)	9.9		
C/N under fading		C/Nth'	(dB)	31.7		
Estimated Interruption time rate		**Pi**		**0.0000016**		
Allowable interruption time rate		**Pis**		**0.0000600**		
Margin (C/Nth' - C/Ntho)			(dB)	15.70		
Judgment				**Passed**		

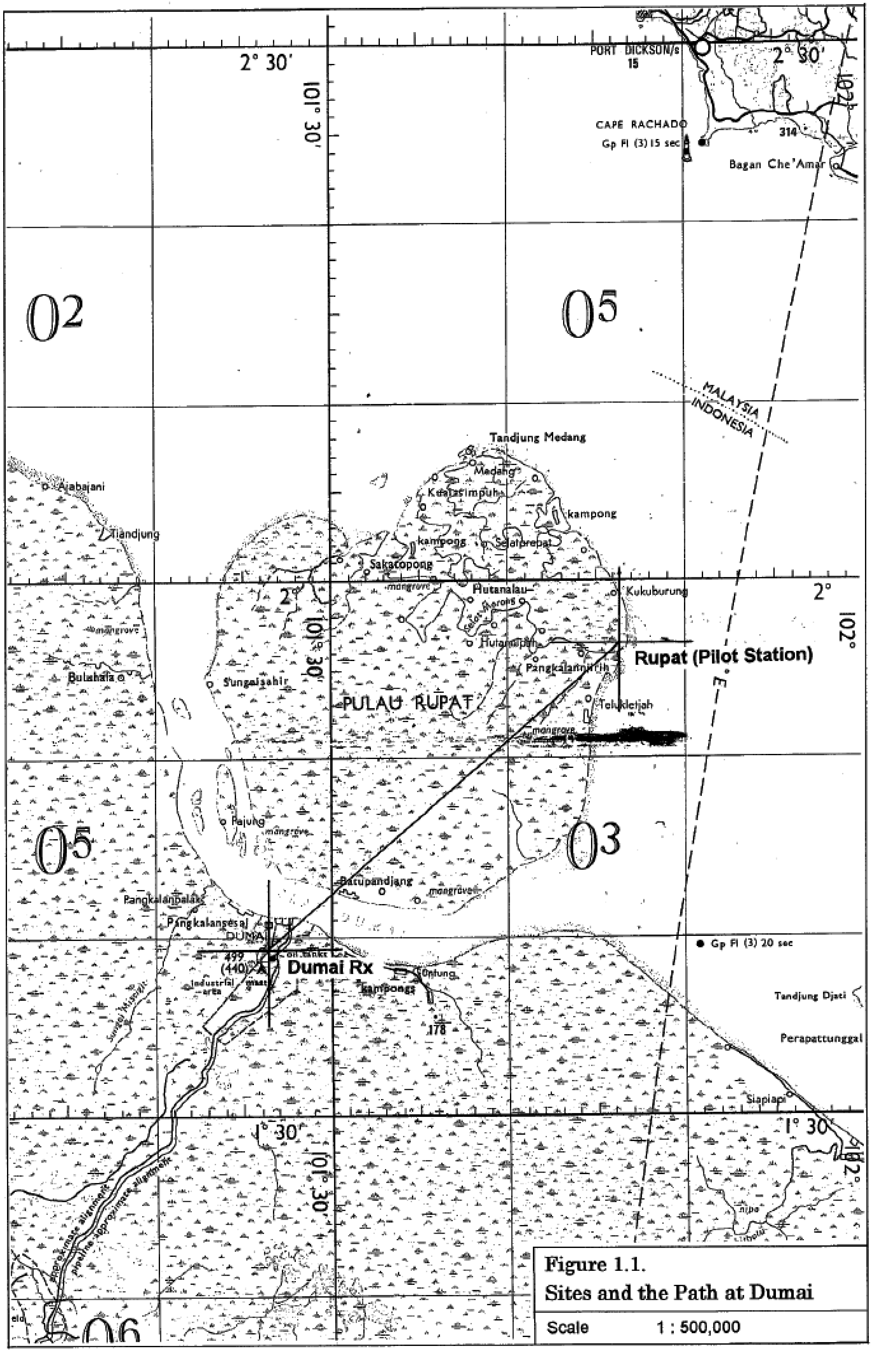


Figure 1.1.
Sites and the Path at Dumai

Scale 1 : 500,000

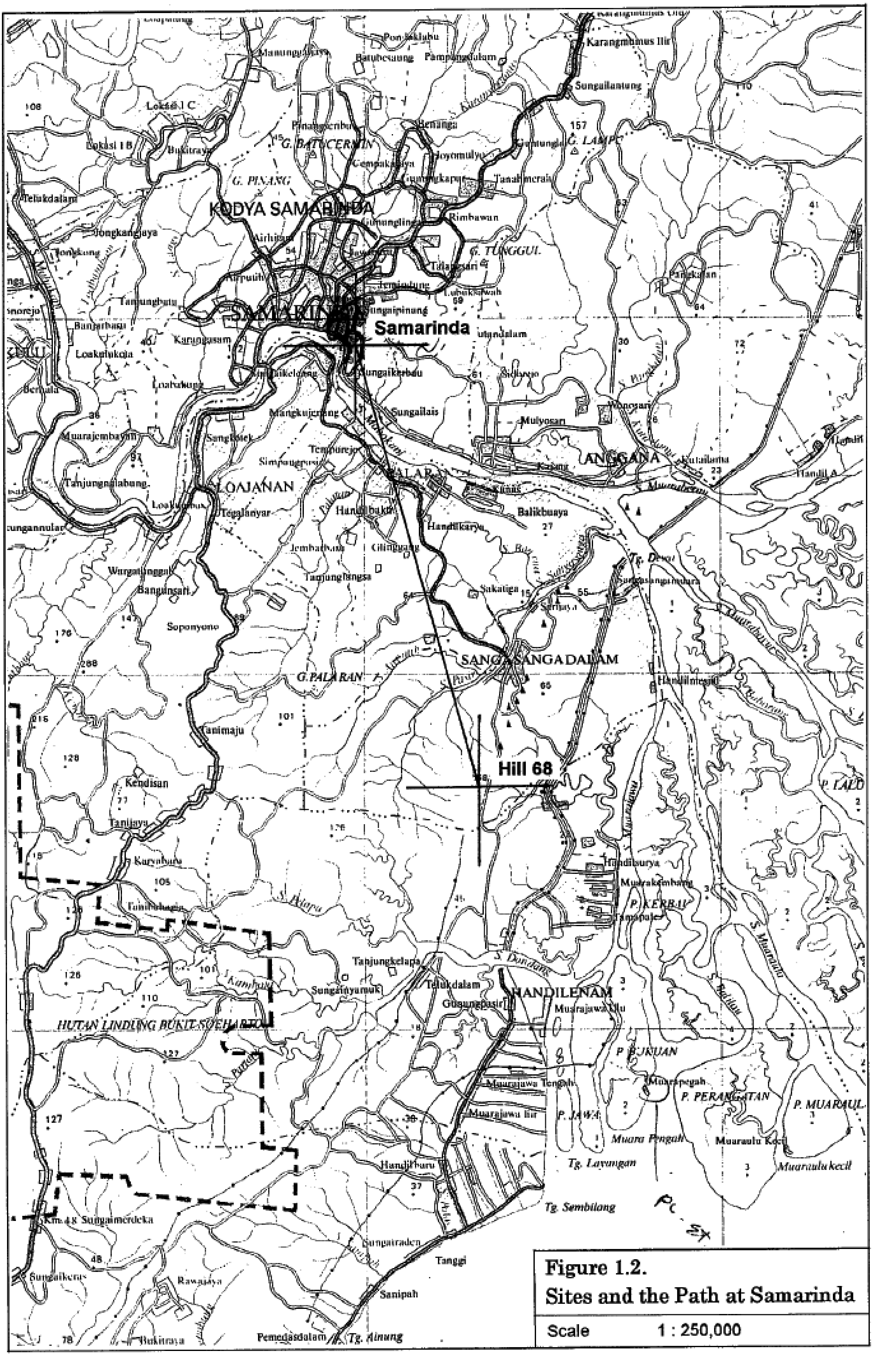


Figure 1.2.
Sites and the Path at Samarinda

Scale 1 : 250,000

Figure 2.1. Path Profile at Dumai

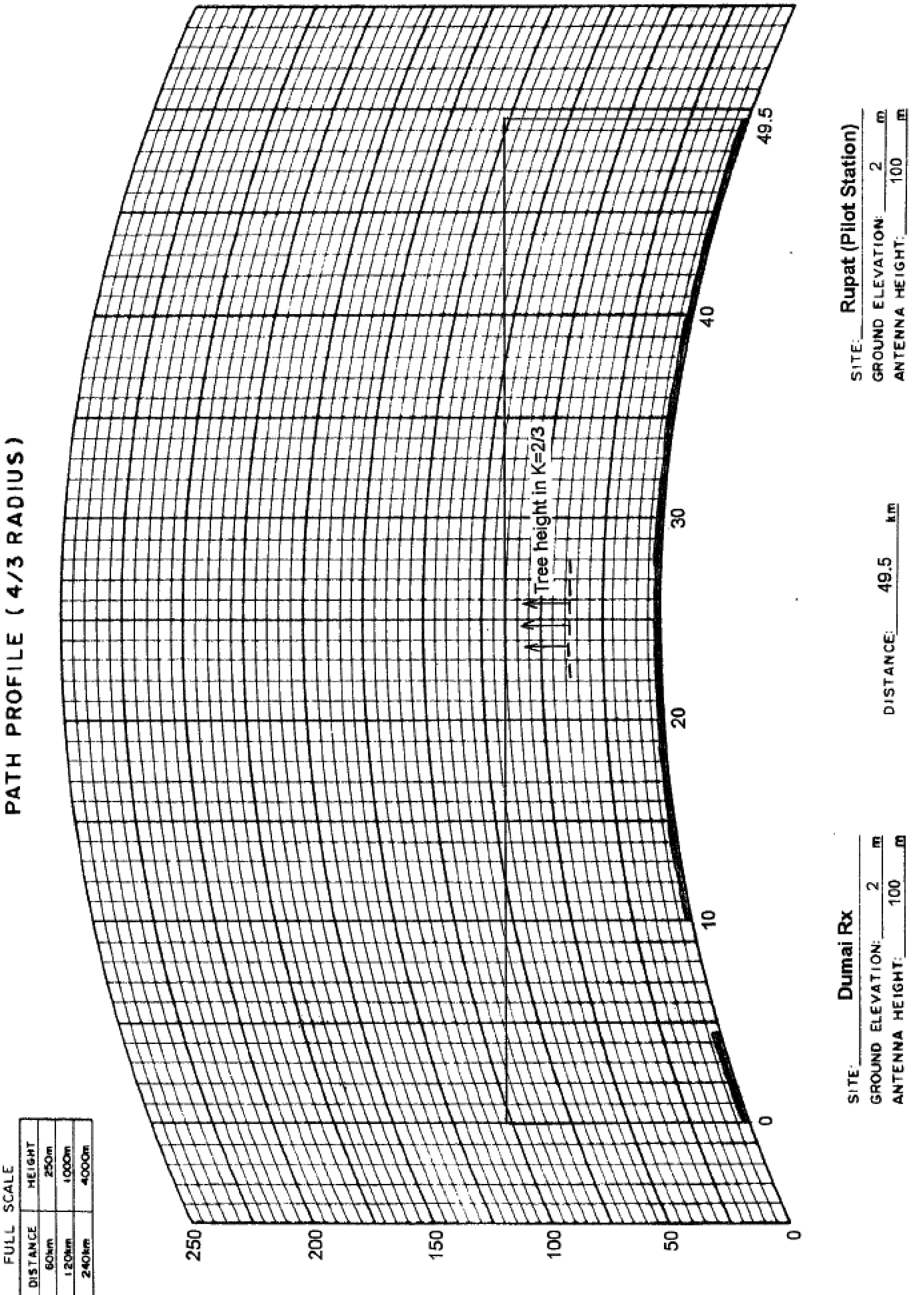


Figure 2.2. Path Profile at Samarinda

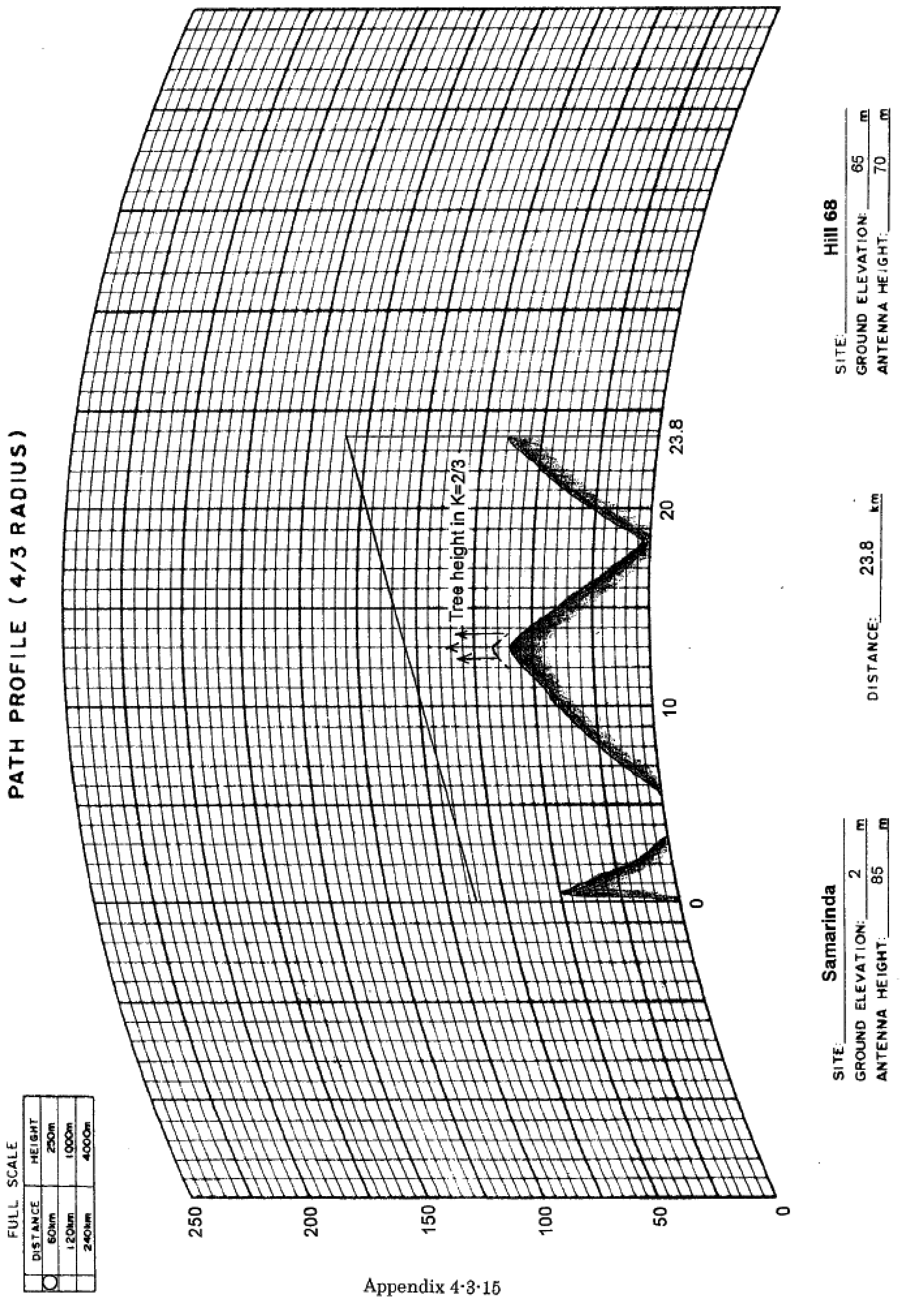


Figure 3. Occurrence Probability of Equivalent Rayleigh Fading Where Reflected Wave Exists

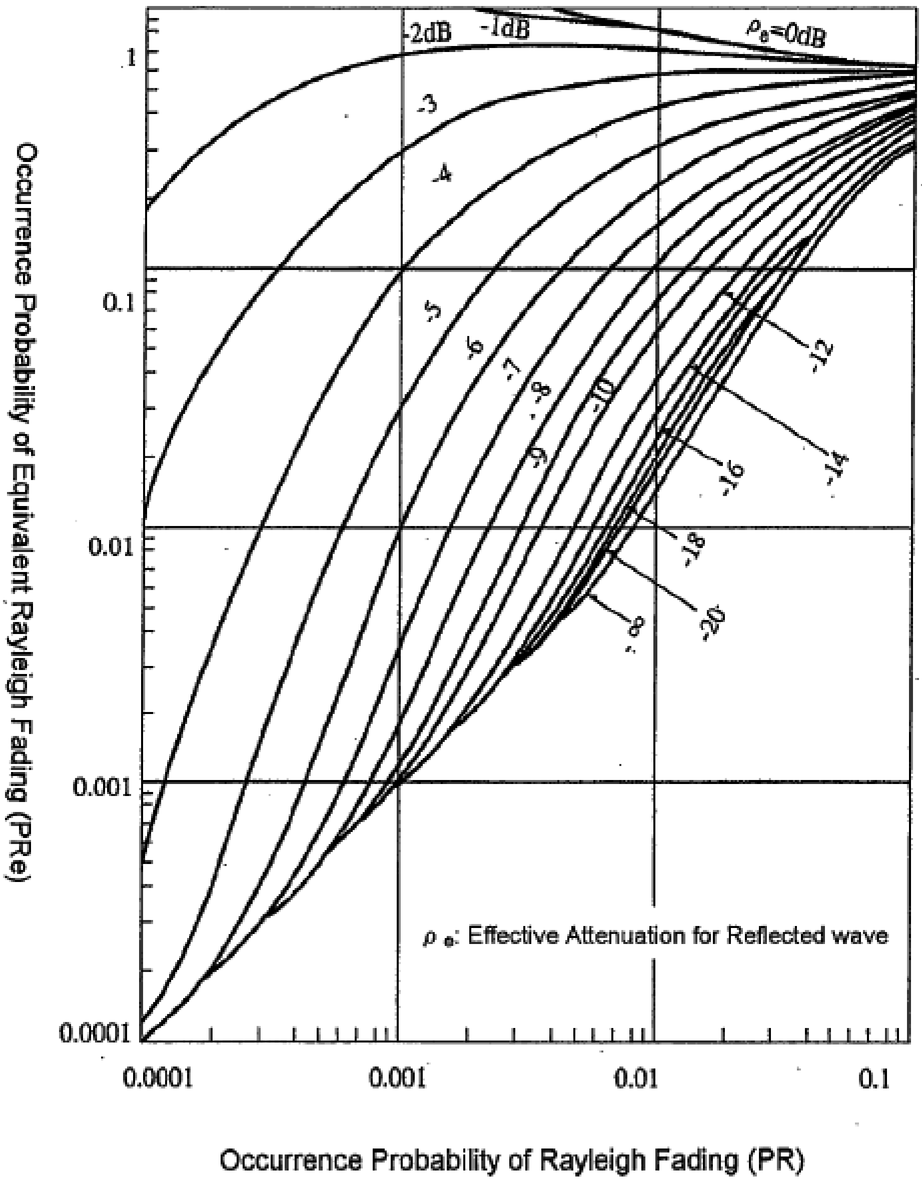
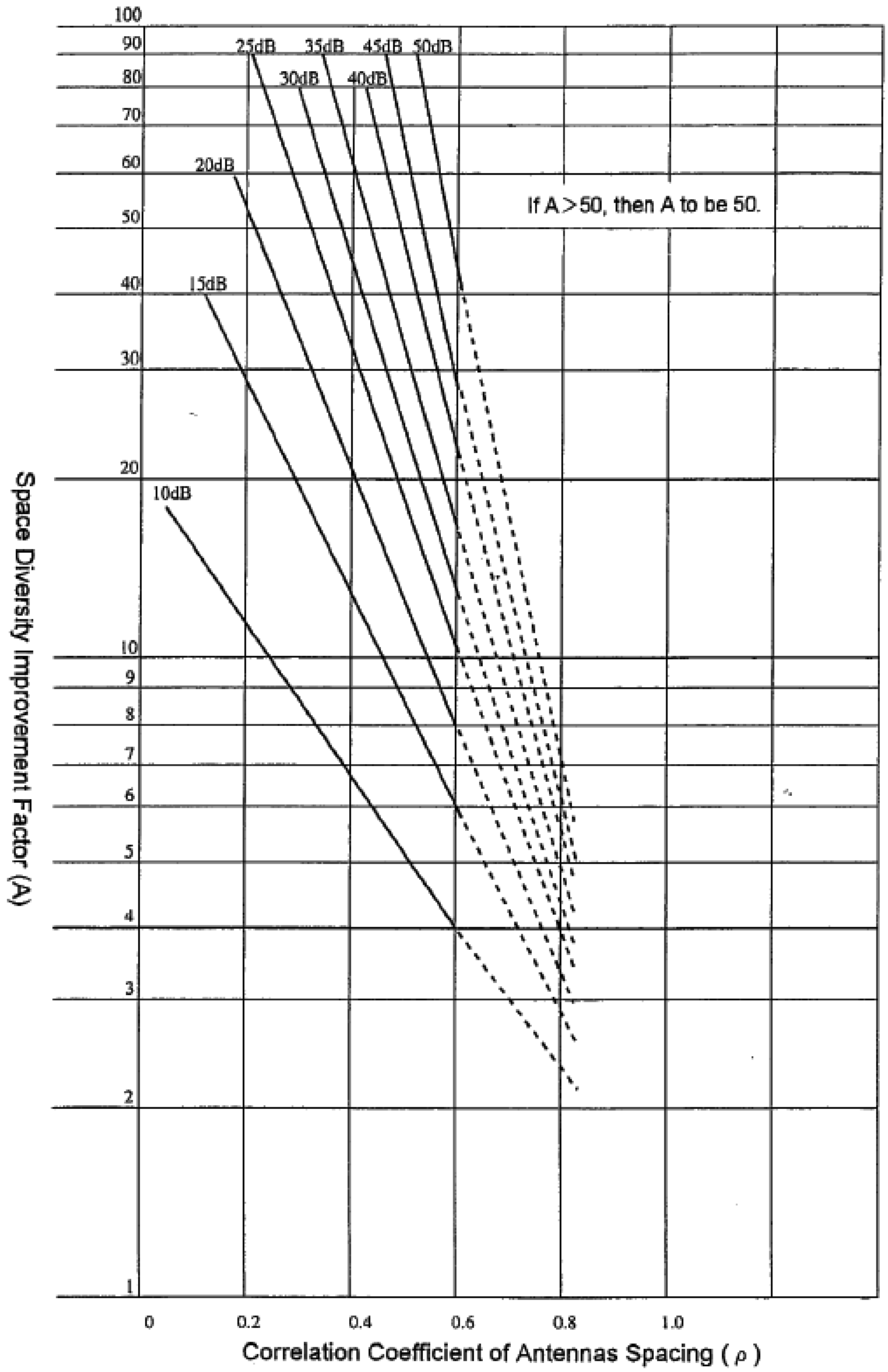


Figure 4. Space Diversity Improvement Factor



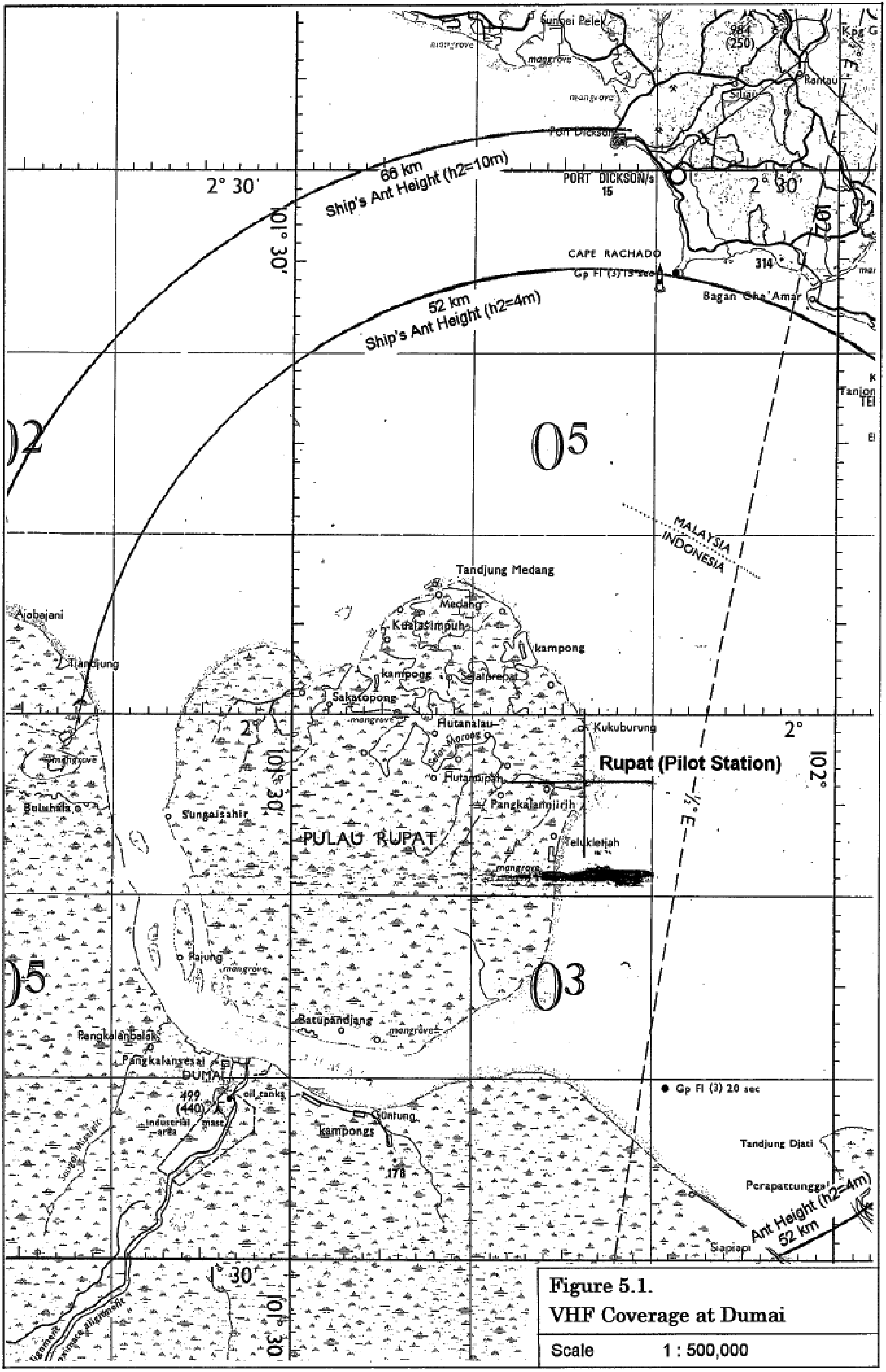


Figure 5.1.
VHF Coverage at Dumai

Scale 1 : 500,000

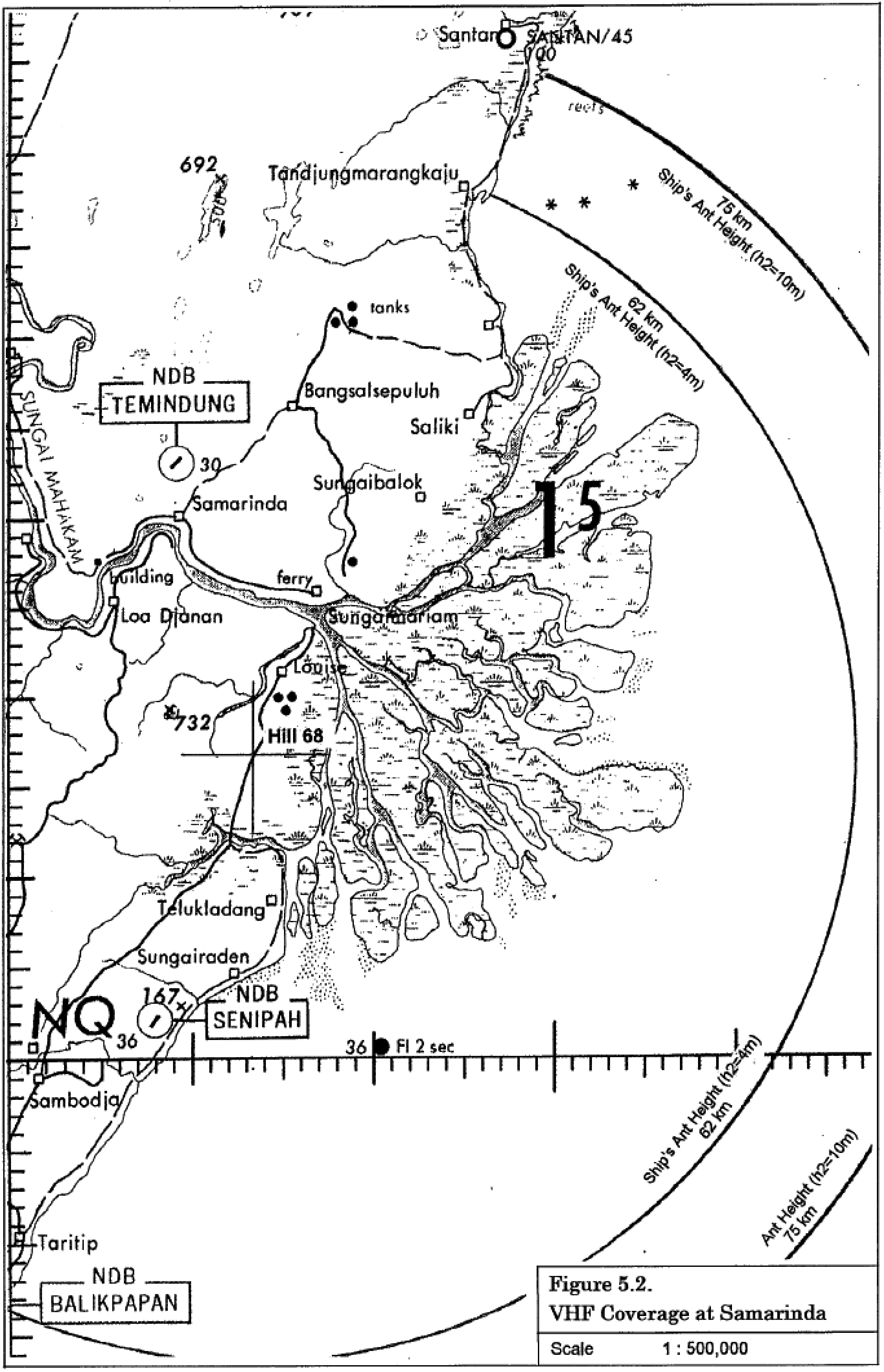


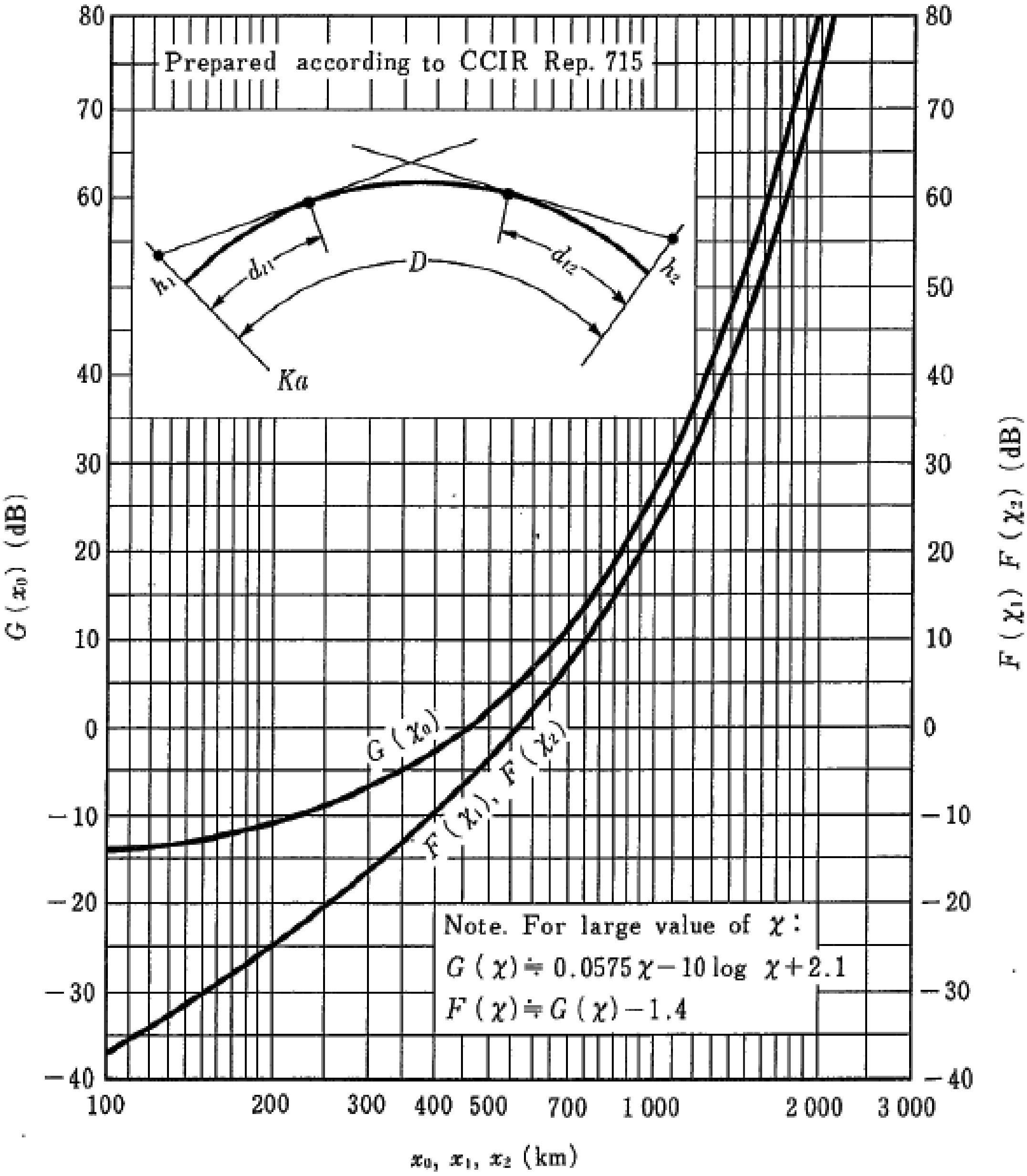
Figure 5.2.
VHF Coverage at Samarinda

Scale 1 : 500,000

Figure 6. Spherical-ground Diffraction Loss

$$A_P = G(\chi_0) - \{F(\chi_1) + F(\chi_2)\} - 20.5 \text{ (dB)}$$

Additional loss caused by the spherical earth



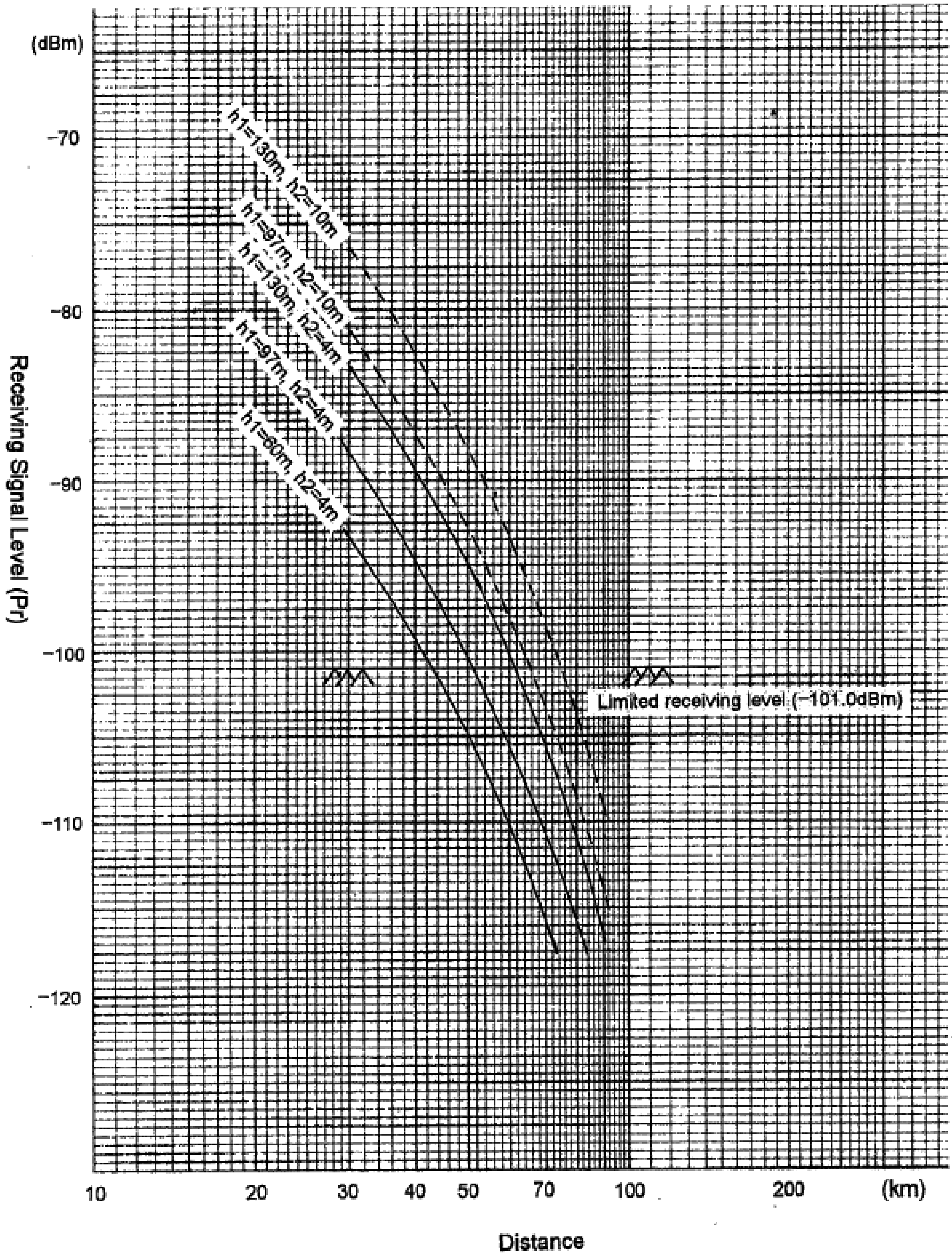
$\chi_0 = B \cdot D$ (km)

$\chi_1 = B \cdot d_{l1} = B \cdot \sqrt{2Kah_1} = B\ (3.57\sqrt{K}\sqrt{h_1(\mathrm{m})})$

$\chi_2 = B \cdot d_{l2} = B \cdot \sqrt{2Kah_2} = B\ (3.57\sqrt{K}\sqrt{h_2(\mathrm{m})})$

$B = 670\ \{f/(Ka)^2\}^{1/3} = 1.95\ (f\ (\mathrm{MHz})/K^2)^{1/3}$

Figure 7. Distance versus Receiving Signal Level



Appendix 4.4.

(Proposed Plan)
Comprehensive Maintenance Function

1. Purpose

The purpose is to establish practical and effective maintenance system with fully prepared facilities, equipment, simulators, measuring equipment, spare parts, etc and high-level technicians.

2. Supervisor of the Function

NAVIGASI of DGSC

3. Place to be installed

Tg. Priok, Jakarta

4. Major tasks

① Management of budget for Maintenance
② Management of spare parts, measuring equipment, repairing tools
③ Management of inventory for facilities and equipment of all the stations
④ Repairing and guidance of technology and repairing
⑤ Management of trouble, repair and training record
⑥ Preparing of Maintenance manual
⑦ Other services concerning maintenance

5. Equipment to be provided

① Various types of equipment (for 1st, 2nd, 3rd and 4th stations)
② Various types of measuring instruments
③ Various types of repair tools and testing equipment
④ Simulators for GMDSS etc
⑤ Spare parts and units
⑥ Inventory of facilities and equipment of all the station
⑦ Personal Computers (PC)
⑧ Log of repair
⑨ Maintenance manual

6. PC Network

Form PC network between Function and 1st / 2nd stations, and utilize for;

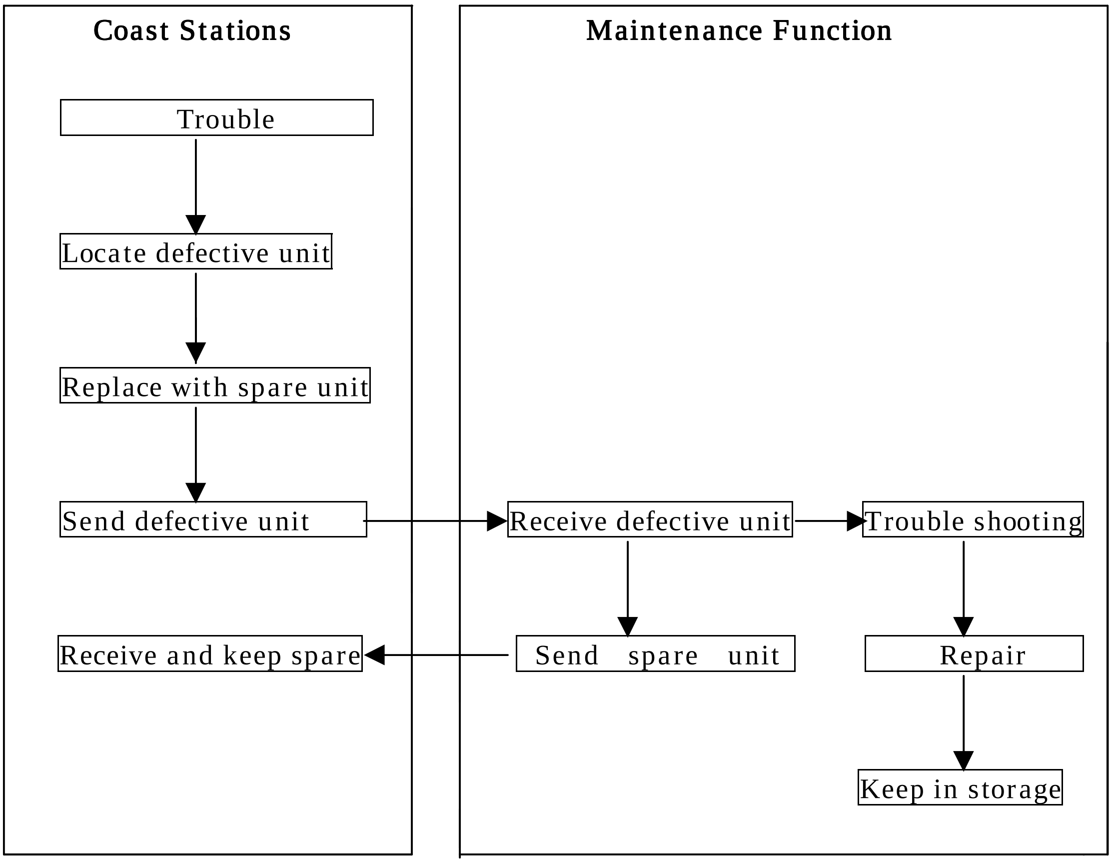
① Report from 1st / 2nd station on trouble and repair
② Instruction from Function to 1st / 2nd station on repair

③ Guidance and counseling of inspection and repair
④ Inventory of facilities and equipment
⑤ Storage management of spare parts
⑥ Repair record
⑦ Trouble statistics
⑧ Maintenance personals
- Certificates, training record, etc,
⑨ And any other maintenance matters.

7. Basic flow of maintenance

Basic flow for maintenance works by spare units is shown in the following **Figure.**

Basic Flow of Maintenance Works



REFERENCE 4.1.

SOLAS Convention, Chapter Ⅳ: Radiocommunications, Part B:

Undertaking by Contracting Governments

SOLAS Convention

Chapter Ⅳ : Radiocommunications

Part B : Undertaking by Contracting Governments

Regulation 5 : Provision of radiocommunication services

1 Each Contracting Government undertakes to make available, as it deems practical and necessary either individually or in co-operation with other Contracting Governments, appropriate shore-based facilities for space and terrestrial radiocommunication services having due regard to the recommendations of the Organization. These services are;

.1 a radiocommunication service utilizing geostationary satellites in the Maritime Mobile-Satellite Service;

.2 a radiocommunication service utilizing polar orbiting satellites in the mobile-satellite service;

.3 the maritime mobile service in the bands between 156 MHz and 174 MHz,

.4 the maritime mobile service in the bands between 4,000 kHz and 27,500 kHz; and

.5 the maritime mobile service in the bands between 415 kHz and 535 kHz and between 1,605 kHz and 4,000 kHz.

2 Each Contracting Government undertakes to provide the Organization with pertinent information concerning the shore-based facilities in the maritime mobile service, mobile satellite service and Maritime Mobile-Satellite Service, established for sea areas which it has designated off its coasts.

REFERENCE 4.2.

IMO Resolution A.801 (19): Provision of Radio Services for The Global Maritime Distress and Safety System

Resolution A.801(19)

adopted on 23 November 1995
(Agenda item 10)

PROVISION OF RADIO SERVICES FOR THE GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS)

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO that regulation IV/5 of the International Convention for the Safety of Life at Sea (SOLAS), 1974 as amended in 1988, requires each Contracting Government to undertake to make available, either individually or in co-operation with other Contracting Governments, as they may deem practical and necessary, appropriate shore-based facilities for terrestrial and space radio services having due regard to the recommendations of the Organization,

RECALLING FURTHER that the Inmarsat system provides for radiocommunication services, including those for distress and safety, utilizing geostationary satellites in the 1.5 and 1.6 GHz band,

NOTING that the COSPAS-SARSAT system provides for the reception of distress alerts on the frequency 406 MHz utilizing polar orbiting satellites,

NOTING ALSO that regulation IV/5 of the 1974 SOLAS Convention requires the following radio services to be provided:

- a radiocommunication service utilizing geostationary satellites in the maritime mobile satellite service,
- a radiocommunication service utilizing polar orbiting satellites in the mobile satellite service,
- the maritime mobile service in the bands between 156 MHz and 174 MHz,
- the maritime mobile service in the bands between 4,000 kHz and 27,500 kHz, and
- the maritime mobile service in the bands 415 kHz to 535 kHz and 1,605 kHz to 4,000 kHz,

NOTING FURTHER that the provision contained in paragraph 5.1.1 of the annex to the International Convention on Maritime Search and Rescue, 1979, requires that Parties shall ensure that such continuous radio watches as are deemed practicable and necessary are maintained on international distress frequencies,

TAKING INTO ACCOUNT the resolutions of the World Administrative Radio Conference for Mobile Services, 1987, in particular resolution 331(Mob-87) relating to the introduction of provisions for the global maritime distress and safety system (GMDSS) and the continuation of the existing distress and safety provisions, and resolution 322 (Rev.Mob-87) relating to coast stations and coast earth stations assuming watchkeeping responsibilities on certain frequencies in connection with the implementation of distress and safety communications for the GMDSS,

TAKING INTO ACCOUNT ALSO resolution 3, Recommendation on the Early Introduction of the global maritime distress and safety system (GMDSS) Elements, adopted by the 1988 GMDSS Conference, CONSIDERING that the GMDSS will use digital selective calling equipment operating in the MF, HF and VHF bands,

CONSIDERING ALSO that ships should not be required to install equipment intended primarily for ship/shore communication functions when operating in areas where no corresponding shore-based facilities are available,

CONSIDERING FURTHER that it is necessary to provide radio services for transmission and reception of distress and safety communications and that not all coast stations will be obliged to provide for such distress and safety communications,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-third session,

1. ADOPTS the Recommendation on Provision of Radio Services for the GMDSS, the Criteria for Use When Providing Shore-Based Digital Selective Calling (DSC) Facilities for Use in the GMDSS, the Criteria for Establishing GMDSS Sea Areas, the Criteria for Use When Providing a NAVTEX Service and the Criteria for Use When Providing Inmarsat Shore-Based Facilities for Use in the GMDSS set out respectively in annexes 1, 2, 3, 4 and 5 to the present resolution;

2. RECOMMENDS that Governments undertake, as a matter of urgency, a review of the need to provide shore-based facilities to support the GMDSS and to make available, either individually or in co-operation with other Governments, adequate shore-based facilities for terrestrial and space radio services deemed practicable and necessary;

3. URGES Governments to provide, either individually or in co-operation with other Governments, the radio services deemed practicable and necessary for the proper operation of the GMDSS;

4. INVITES Governments and organizations concerned to inform the Secretary-General of radio facilities to be provided in support of the GMDSS in response to this resolution;

5. REQUESTS the Maritime Safety Committee to keep this resolution under review and to adopt amendments thereto, as necessary;

6. REVOKES resolution A.704(17).

Annex 1

RECOMMENDATION ON PROVISION OF RADIO SERVICES FOR THE GMDSS

1 Governments should establish such coast stations, individually or in co-operation with other Governments, as are needed to designate a sea area or areas A1 or A2, or both, off their coasts. Each sea area should be established in accordance with the criteria for establishing GMDSS areas recommended in annex 3.

2 Areas not defined by Governments as sea areas A1 or A2 will, as appropriate, be designated as sea areas A3 or A4 in accordance with regulations IV/2.14 and IV/2.15 of the 1974 SOLAS Convention, as amended in 1988.

3 Each Government should submit to the Organization information on the sea area or sea areas A1, A2 and A3, NAVTEX and/or International SafetyNET service areas it has established for the GMDSS and on any changes which may affect the sea area or areas it has so defined.

4 Governments, taking into account annex 2, should, as appropriate, make provision for radiocommunications in each sea area A1 or A2 they have defined and, in addition, Governments are invited to provide for radiocommunications in sea areas A3 or A4, as appropriate, for the purposes of:

.1 reception of ship-to-shore distress alerting; in particular, facilities for receiving distress alerts on the frequency 406 MHz are urgently needed in the southern hemisphere;

.2 transmission of shore-to-ship distress alerting;

.3 transmission and reception of search and rescue co-ordinating communications;

.4 transmission and reception of navigational and meteorological warnings and urgent information; and

.5 transmission and reception of general radiocommunications.

Annex 2

CRITERIA FOR USE WHEN PROVIDING SHORE-BASED DIGITAL SELECTIVE CALLING (DSC) FACILITIES FOR USE IN THE GMDSS

1 Governments desiring to provide an HF coast station facility for use in the GMDSS should notify the Organization of their intention so that the Organization can maintain and circulate a complete list of stations providing HF DSC distress watch. Governments should ensure that such shore-based HF DSC facilities are provided in accordance with the criteria contained in appendix 1.

2 Governments, individually or in co-operation with other Governments within a specific SAR region, desiring to provide MF coast station DSC facilities serving, either wholly or in part, a particular sea area A2, should notify the Organization as to the extent of continuous coverage and the extent of coverage from shore. This information should be determined by Governments in accordance with the criteria for establishing GMDSS sea areas contained in annex 3. Governments should ensure that shore-based MF coast station DSC facilities providing part of this sea area A2 coverage, are provided in accordance with appendix 2.

3 Governments, individually or in co-operation with other Governments within a specific SAR region, desiring to provide VHF coast station DSC facilities serving, either wholly or in part, a particular sea area A1, should notify the Organization as to the extent of continuous coverage and the extent of coverage from shore. This information should be determined by Governments in accordance with the criteria contained in annex 3. Governments should ensure that shore-based VHF coast station DSC facilities providing part of this sea area A1 coverage, are provided in accordance with appendix 3.

4 The Organization should maintain a master plan of all sea areas covered by MF and VHF coast station DSC facilities and should periodically circulate an updated copy of the description of such sea areas to Governments.

Appendix 1

1 Basic principles for establishing HF DSC coast stations for sea areas A3 and A4

The selection of HF DSC coast stations for sea areas A3 and A4 should be based on the following principles:

.1 each ocean area requiring HF guard should have a minimum of two stations to provide the required HF cover;

.2 where practicable, stations should be selected on opposite sides of an ocean area; and

.3 in ocean areas of high traffic density, e.g. the North Atlantic, more than two stations should be provided.

2 Criteria for the selection of HF DSC stations

Stations participating in HF DSC watchkeeping in the GMDSS should:

.1 be affiliated to an RCC and have reliable communications by telephone and telex;

.2 have long-range HF communication capability in all HF bands;

.3 monitor all HF DSC distress frequencies in order to avoid the multiplication of communications links between RCCs which would be required if several stations divided the watchkeeping on different frequencies;

.4 provide as complete a coverage of their ocean area as possible;

.5 be in continuous operation; and

.6 be able to relay communications under a common procedure.

3 Availability of participating HF stations

The minimum number of coast stations indicated in 1.1 for any given ocean area may need to be adjusted in future in order to:

.1 provide full back-up in the event of operational failure; and

.2 confirm full HF coverage as a result of future tests.

Appendix 2

1 Basic principles for establishing sea area A2

The selection of MF DSC coast stations for sea area A2 should be based on the following principles:

.1 each sea area designated as A2 requires a continuous MF guard on the distress frequencies and a sufficient number of coast stations to provide MF coverage in the coastal area of the Government concerned; and

.2 in certain areas, several Governments may collectively provide complete coverage (e.g. the North Sea).

2 Criteria for provision of MF DSC stations

Stations participating in MF DSC watchkeeping in the GMDSS should:

.1 be affiliated to an RCC and have reliable communications by telephone and telex;

.2 have medium-range MF capability;

.3 provide as complete a coverage of their immediate sea area as possible; and

.4 be in continuous operation.

Appendix 3

1 Basic principles for establishing sea area A1

The selection of VHF DSC coast stations for sea area A1 should be based on the following principles:

- **.1** each sea area designated as A1 requires a continuous VHF guard and should have the minimum number of stations necessary to provide VHF coverage in the coastal area of the Government concerned; and
- **.2** in certain areas, several Governments may collectively provide complete coverage along their coasts (e.g. the North Sea).

2 Criteria for the provision of VHF DSC stations

Stations participating in VHF DSC watchkeeping in the GMDSS should:

- **.1** be affiliated to an RCC and have reliable communications by telephone and telex;
- **.2** have short-range VHF capability;
- **.3** provide as complete a coverage of their immediate sea area as possible; and
- **.4** be in continuous operation.

Annex 3

CRITERIA FOR ESTABLISHING GMDSS SEA AREAS

1 INTRODUCTION

It is intended that Governments should use the following criteria as guidance when determining the four mutually exclusive sea areas off their coasts, which are defined in regulations IV/2.12, IV/2.13, IV/2.14 and IV/2.15 of the 1974 SOLAS Convention, as amended in 1988.

2 SEA AREA A1

2.1 General

The communication range of stations operating in the maritime mobile VHF band is likely to be limited by propagation factors rather than lack of radiated power.

2.2 Guidance criteria

Sea area A1 is that sea area which is within a circle of radius *A* nautical miles over which the radio propagation path lies substantially over water. The radius *A* is equal to the transmission distance between a ship's VHF antenna at a height of 4 m above sea level and the antenna of the VHF coast station which lies at the centre of the circle.

2.3 Determination of radius *A*

2.3.1 The following formula should be used to calculate the range *A* in nautical miles:

$$A = 2.5(\sqrt{H} \text{ (in metres)} + \sqrt{h} \text{ (in metres)})$$

H is the height of the coast station VHF receiving antenna and *h* is the height of the ship's transmitting antenna which is assumed to be 4 m.

2.3.2 The following table gives the range in nautical miles (nm) for typical values of *H*:

h \ *H*	50 m	100 m
4 m	23 nm	30 nm

2.3.3 The formula given above applies to line-of-sight cases but is not considered adequate for cases where both antennae are at a low level. The VHF range in sea area A1 should be verified by field strength measurements.

3 SEA AREA A2

3.1 General

3.1.1 Consideration of the reception of radio signals in the 2 MHz band indicates that the range is likely to be limited by propagation conditions and atmospheric noise, which are affected by variations in geographical position and time of day, as well as radiated power.

3.1.2 The theoretical distance to be expected from ground-wave propagation can be determined by reference to the "Ground-wave propagation curves: Sea Water" in Recommendation ITU-R PN.368-7, adjusted as necessary to take account of the actual radiated field strength from the transmitting antenna and the minimum field strength necessary for the proper operation of a receiver conforming with resolution A.804(19).

3.1.3 The determination of the minimum signal level required for satisfactory radio reception in the absence of other unwanted signals necessitates taking account of the noise with which the wanted signal must compete. ITU-R Report 322 gives the world distribution of values of noise level and of other noise parameters and shows the method of using these in the evaluation of the probable performance of a radio circuit.

3.2 Guidance criteria

Sea area A2 is that sea area which is within a circle of radius *B* nautical miles over which the propagation path lies substantially over water and which is not part of any sea area A1, the centre of the circle being the position of the coast station receiving antenna.

3.3 Determination of radius *B*

The radius *B* may be determined for each coast station by reference to Recommendation ITU-R PN.368-7 and ITU-R Report 322 for the performance of a single sideband (J3E) system under the following conditions:

Frequency	- 2,182 kHz
Bandwidth	- 3 kHz
Propagation	- ground wave
Time of day	- *
Season	- *
Ship's transmitter power (PEP)	- 60 W†
Ship's antenna efficiency	- 25%
S/N (RF)	- 9 dB (voice)
Mean transmitter power	- 8 dB below peak power
Fading margin	- 3 dB

The range of sea area A2 should be verified by field strength measurements.

* Administrations should determine time periods and seasons appropriate to their geographic area based on prevailing noise level.

† See footnote to regulation IV/16(c)(i) of the 1981 amendments to the 1974 SOLAS Convention.

4 AREA A3 – Guidance criteria

Sea area A3 is that sea area of the world not being part of any sea area A1 or A2 within which the elevation angle of an Inmarsat satellite is 5° or more.

5 AREA A4 – Guidance criteria

Sea area A4 is that sea area of the world not being part of any seas area A1, A2 or A3.

Annex 4

CRITERIA FOR USE WHEN PROVIDING A NAVTEX SERVICE

1 There are two basic areas which must be defined when establishing a NAVTEX service. They are:

Coverage area: An area defined by an arc of a circle having a radius from the transmitter calculated according to the method and criteria given in this annex.

Service area: A unique and precisely defined sea area, wholly contained within the coverage area, for which MSI is provided from a particular NAVTEX transmitter. It is normally defined by a line which takes full account of local propagation conditions and the character and volume of information and maritime traffic patterns in the region.

2 Governments desiring to provide a NAVTEX service should use the following criteria for calculating the coverage area of the NAVTEX transmitter they intend to install, in order to:

- determine the most appropriate location for NAVTEX stations having regard to existing or planned stations;
- avoid interference with existing or planned NAVTEX stations; and
- establish a service area for promulgation to seafarers.

3 The ground-wave coverage may be determined for each coast station by reference to Recommendation ITU-R PN.368-7 and ITU-R Report 322 for the performance of a system under the following conditions:

Frequency	- 518 kHz
Bandwidth	- 500 Hz
Propagation	- ground wave
Time of day	- *
Season	- *
Transmitter power	- †
Antenna efficiency	- †
RF S/N in 500 Hz band width	- 8 dB‡
Percentage of time	- 90

4 Full coverage of the NAVTEX service area should be verified by field strength measurements.

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* Administration should determine time periods in accordance with the NAVTEX time transmission table (NAVTEX Manual, figure 3) and seasons appropriate to their geographic area based on prevailing noise level.

† The range of a NAVTEX transmitter depends on the transmitter power and local propagation conditions. The actual range achieved should be adjusted to the minimum required for adequate reception in the NAVTEX area served, taking into account the needs of ships approaching from other areas. Experience has indicated that the required range of 250 to 400 nautical miles can generally be attained by transmitter power in the range between 100 and 1,000 W during daylight with a 60% reduction at night.

‡ Bit error rate 1×10^2.

Annex 5

CRITERIA FOR USE WHEN PROVIDING INMARSAT SHORE-BASED FACILITIES FOR USE IN THE GMDSS

1 Governments desiring to provide an Inmarsat coast earth station facility for use in the GMDSS should notify the Organization of their intention so that the Organization can maintain and circulate a complete list of stations providing distress watch. Governments should ensure that such shore-based facilities are provided in accordance with the criteria contained in the appendix.

2 Governments, individually or in co-operation with other Governments within a specific SAR region, desiring to provide Inmarsat coast earth station facilities serving, either wholly or in part, particular sea areas, should notify the Organization as to the extent of continuous coverage and the extent of coverage from shore. This information should be determined by Governments in accordance with the criteria for establishing GMDSS sea areas contained in annex 3 to the present resolution.

3 The Organization should maintain in the GMDSS Master Plan details of all sea areas covered by Inmarsat coast earth station facilities and should periodically circulate an updated copy of the description of these sea areas to Governments.

4 Governments having coast earth stations participating in the GMDSS should ensure that those stations conform with these criteria specified in 2 of the appendix to this annex and ensure that only those stations are listed in the GMDSS Master Plan.

Appendix

1 Basic principles for establishing Inmarsat coast earth stations for GMDSS services

1.1 The selection of Inmarsat coast earth stations for GMDSS services should be based on the following principle:

each ocean area requiring guard should have a minimum of two coast earth stations to provide the required cover for each system.

1.2 The minimum number of coast earth stations indicated in 1.1 for any given ocean area may need to be adjusted in future in order to provide full back-up in the event of operational failure.

2 Criteria for Inmarsat coast earth stations

2.1 Inmarsat coast earth stations participating in the GMDSS should:

.1 meet the Inmarsat technical requirements confirmed by Inmarsat type acceptance and commissioning tests;

.2 operate in compliance with the Inmarsat system operating procedures (SOP) for distress alerting and distress communications;

.3 have a registered associated RCC and have reliable communications by telephone, telex, or other means;

.4 be in continuous operation; and

.5 support the following GMDSS communications functions:

.5.1 ship-to-RCC distress alerting preferably by a dedicated link;

.5.2 RCC-to-ship(s) distress alert relay preferably by a dedicated link;

.5.3 RCC-to-RCC co-ordinating communications by using SES terminals;

.5.4 transmit maritime safety information (Inmarsat-C only); and

.5.5 receiving maritime safety information.

2.2 Stations with store-and-forward systems should:

.1 make an initial attempt to deliver a ship-to-shore or shore-to-ship message within 60 s for any distress alert or traffic, and 10 min for all other safety messages, from the time the receiving station receives the message;

.2 generate the notification of non-delivery immediately once the message is considered non-deliverable; and

.3 activate an aural/visual alarm to alert a designated responsible person if the distress traffic cannot be forwarded within the criteria of paragraph 2.2.1.

2.3 Stations with circuit switching systems should immediately attempt to deliver a ship-to-shore or shore-to-ship distress alert or traffic.

2.4 Stations should:

.1 be capable of recognizing distress alerts in the ship-to-shore direction;

.2 be capable of recognizing the following categories of priorities in both the ship-to-shore and shore-to-ship direction:

maritime distress,

all other maritime (urgency, safety and routine);

and

.3 ensure the avoidance of degradation of, or obstructions to, urgency and safety maritime communications by employing four levels of priority in the shore-to-ship and ship-to-shore directions, by differentiating non-maritime from maritime communications or by other means established by Inmarsat.

REFERENCE 4.3.

IMO GMDSS Handbook

G·M·D·S·S Handbook

Handbook on the Global Maritime Distress and Safety System

1st Edition, 1992

This Handbook is not to be considered as a replacement or substitute for the ITU Manual for use by the maritime mobile and maritime mobile-satellite service or any other publication required to be carried on board a ship by the Radio Regulations or any other international convention.

IMO
London, 1992

Published in 1992
by the INTERNATIONAL MARITIME ORGANIZATION
4 Albert Embankment, London SE1 7SR

Printed by the International Maritime Organization, London

2 4 6 8 10 9 7 5 3 1

ISBN 92-801-1287-2

IMO PUBLICATION
Sales number: IMO-970E

NOTE: ITU materials included in this publication have been reproduced, with the prior authorization of the publishers, from the following ITU publications: *Recommendations of the CCIR, 1990,* volume VIII (XVII Plenary Assembly, Düsseldorf); *Radio Regulations* (Edition of 1990); and *Final Acts of WARC-92.* These publications can be ordered directly from the General Secretariat (Sales Service), International Telecommunication Union, Place des Nations, 1211 Genève 20, Switzerland.

Photos in this publication were kindly made available by the International Maritime Satellite Organization, COSPAS-SARSAT, the International Radio-Maritime Committee, and the Japan Maritime Safety Agency.

Foreword

Since its establishment in 1959, the International Maritime Organization and its Member Governments, in close co-operation with the International Telecommunication Union (ITU) and the International Radio Consultative Committee (CCIR); other international organizations, notably the World Meteorological Organization (WMO), the International Hydrographic Organization (IHO) and the International Maritime Satellite Organization (INMARSAT); and the COSPAS–SARSAT partners, have striven to improve maritime distress and safety radiocommunications.

The culmination of this work will be the entry into force and implementation of the global maritime distress and safety system (GMDSS) between 1992 and 1999.

The intent of this Handbook is to provide in a single comprehensive publication an explanation of the principles upon which the GMDSS is based, the radiocommunication requirements and recommendations for its implementation, the operational performance standards and technical specifications to be met by GMDSS equipment, and the procedures for and method of operation of the various radio services which form the GMDSS and the Master Plan for the GMDSS.

Regulations cited in the text are taken from the 1988 (GMDSS) amendments to the International Convention for the Safety of Life at Sea, 1974, as amended.

Contents

Abbreviations

In addition to standard SI units, the following abbreviations are used in this publication:

ADE	above-deck equipment
ALC	automatic level control
BDE	below-deck equipment
CCIR	International Radio Consultative Committee
CES	[INMARSAT] coast earth station
CMC	COSPAS mission control centre (Moscow)
COSPAS	Space System for Search of Distress Vessels
CSS	co-ordinator surface search
DMG	distress message generator
DSC	digital selective calling
EGC	[INMARSAT] enhanced group call
ELT	emergency locator transmitter
EPIRB	emergency position-indicating radio beacon
GMDSS	global maritime distress and safety system
HF	high frequency
ICAO	International Civil Aviation Organization
IF	intermediate frequency
IFRB	International Frequency Registration Board
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INMARSAT	International Maritime Satellite Organization
ITU	International Telecommunication Union
LCD	liquid crystal display
LUT	local user terminal
MCC	mission control centre
MF	medium frequency
MSI	maritime safety information
NBDP	narrow-band direct printing (telegraphy)
NCC	[INMARSAT] network control centre
NCS	[INMARSAT] network co-ordination station
OCC	operations control centre
OSC	on-scene conmmander
PLB	personal locator beacon
RCC	rescue co-ordination centre
RF	radio frequency
RR	[ITU] Radio Regulations
RSC	rescue sub-centre
SAR	search and rescue
SAR Convention	International Convention on Maritime Search and Rescue, 1979
SARSAT	Search and Rescue Satellite-Aided Tracking
SART	search and rescue radar transponder
SES	[INMARSAT] ship earth station
SOLAS	International Convention for the Safety of Life at Sea
VDU	visual display unit
VHF	very high frequency
WARC	World Administrative Radio Conference
WMO	World Meteorological Organization
WWNWS	World-Wide Navigational Warning Service

Part 1
Introduction

1.1 History

Since its establishment in 1959, the International Maritime Organization (IMO), in its efforts to enhance safety at sea by the adoption of the highest practicable standards, has sought to improve the radiocommunication provisions of the International Convention for the Safety of Life at Sea (SOLAS) and to exploit the advances made in radiocommunication technology.

The shipborne radiocommunication equipment prescribed by the 1960 and 1974 SOLAS Conventions consisted of radiotelegraph equipment for passenger ships of all sizes and cargo ships of 1,600 tons gross tonnage and upwards, as well as radiotelephone equipment for cargo ships of 300 to 1,600 tons gross tonnage. The ships so fitted, although they could receive a distress alert, could not communicate with each other, and it was not until 1984 that all ships were required to be able to communicate by means of VHF and MF radiotelephone. The range of transmission on MF was only 150 miles, so for ships beyond this distance from the nearest coast station, the old system is essentially a ship-to-ship distress system.

In 1972, with the assistance of the International Radio Consultative Committee (CCIR), IMO commenced a study of maritime satellite communications which resulted in the establishment, in 1979, of the INMARSAT organization, thus making available to shipping an international satellite communications system.

In 1973, through Assembly resolution A.283(VIII), IMO reviewed its policy on the development of the maritime distress system so as to incorporate satellite communications and foresaw the possibility of automatic alerting and transmission of maritime distress and safety information.

In 1979 the International Conference on Maritime Search and Rescue adopted the International Convention on Maritime Search and Rescue, 1979 (1979 SAR Convention), the ultimate objective of which is to establish a global plan for maritime search and rescue (SAR) on a framework of multilateral or bilateral agreements between neighbouring states on the provision of SAR services in coastal and adjacent ocean waters to achieve co-operation and mutual support in responding to distress incidents. The Conference also invited IMO to develop a global maritime distress and safety system, including telecommunication provisions, for the effective operation of the search and rescue plan prescribed in the 1979 SAR Convention.*

The IMO Assembly, at its eleventh session in 1979, considered the existing arrangements for maritime distress and safety communications and decided that a new global maritime distress and safety system should be established to improve distress and safety radiocommunications and procedures. In conjunction with a co-ordinated search and rescue infrastructure, it would incorporate recent technical developments and significantly improve the safety of life at sea.

With the assistance of the International Telecommunication Union (ITU), CCIR, other international organizations, notably the World Meteorological Organization (WMO), the International Hydrographic Organization (IHO), INMARSAT, and the COSPAS-SARSAT partners, IMO developed and proved the various equipment and techniques used in the global maritime distress and safety system (GMDSS). The ITU also established the appropriate regulatory framework for the implementation of the GMDSS.

The 1983 and 1987 World Administrative Radio Conferences for the Mobile Services (WARC-Mob-83 and 87) and WARC-92 adopted amendments to the ITU Radio Regulations which prescribe the frequencies, operational procedures and radio personnel for the GMDSS.

* See appendix 1.2.

In 1988, the Conference of Contracting Governments to the 1974 SOLAS Convention on the Global Maritime Distress and Safety System (GMDSS Conference) adopted amendments to the 1974 SOLAS Convention concerning radiocommunications for the GMDSS, together with several relevant resolutions. These amendments entered into force on 1 February 1992, and the GMDSS will be fully implemented on 1 February 1999.

1.2 The old system and the need for improvement

The old maritime distress and safety system, as defined in chapter IV of the 1974 SOLAS Convention in force prior to 1 February 1992, was based on the requirements that certain classes of ships, when at sea, keep continuous radio watch on the international distress frequencies assigned in accordance with the ITU Radio Regulations and carry radio equipment capable of transmitting over a minimum specified range. The master of any ship at sea should, on receiving a signal that a ship, aircraft or survival craft is in distress, proceed with all speed to the assistance of the persons in distress, informing them that he is doing so. Since the minimum specified range of communications provided by the required shipborne equipment is 100–150 nautical miles, assistance to a ship in distress could generally only be rendered by other shipping in the vicinity of an incident, which means that the old system is primarily intended for ship-to-ship operation. However, in accordance with the ITU Radio Regulations, coast stations generally maintain a continuous watch during their service hours on the distress frequencies.

The old system includes two major manually operated subsystems:

- The Morse telegraphy system on 500 kHz for all cargo ships of 1,600 tons gross tonnage and over and all passenger ships. Since Morse competence is essential to the operation of this system, a Morse-qualified radio officer is required on all ships having radiotelegraph installation.
- The radiotelephony system on 2182 kHz and 156.8 MHz for all cargo ships of 300 tons gross tonnage and over and all passenger ships, which provides common distress communications for all ships, subject to the 1974 SOLAS Convention.

It has proved difficult to make any significant progress in the communication arrangements for a ship in distress when it is beyond the range of MF coast radio stations, although various measures have been implemented to improve the situation.

The introduction of modern technology, including satellite and digital selective calling techniques, enables a distress alert to be transmitted and received automatically over long range with a significantly higher reliability.

Part 2
Basic concept of the GMDSS

2.1 General

2.1.1 The basic concept of the GMDSS (shown in figure 1) is that search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship in distress, will be rapidly alerted to a distress incident so that they can assist in a co-ordinated SAR operation with the minimum delay. The system also provides for urgency and safety communications and the promulgation of maritime safety information (MSI) - navigational and meteorological warnings and forecasts and other urgent safety information to ships. In other words, every ship is able, irrespective of the area in which it operates, to perform those communication functions which are essential for the safety of the ship itself and of other ships operating in the same area.

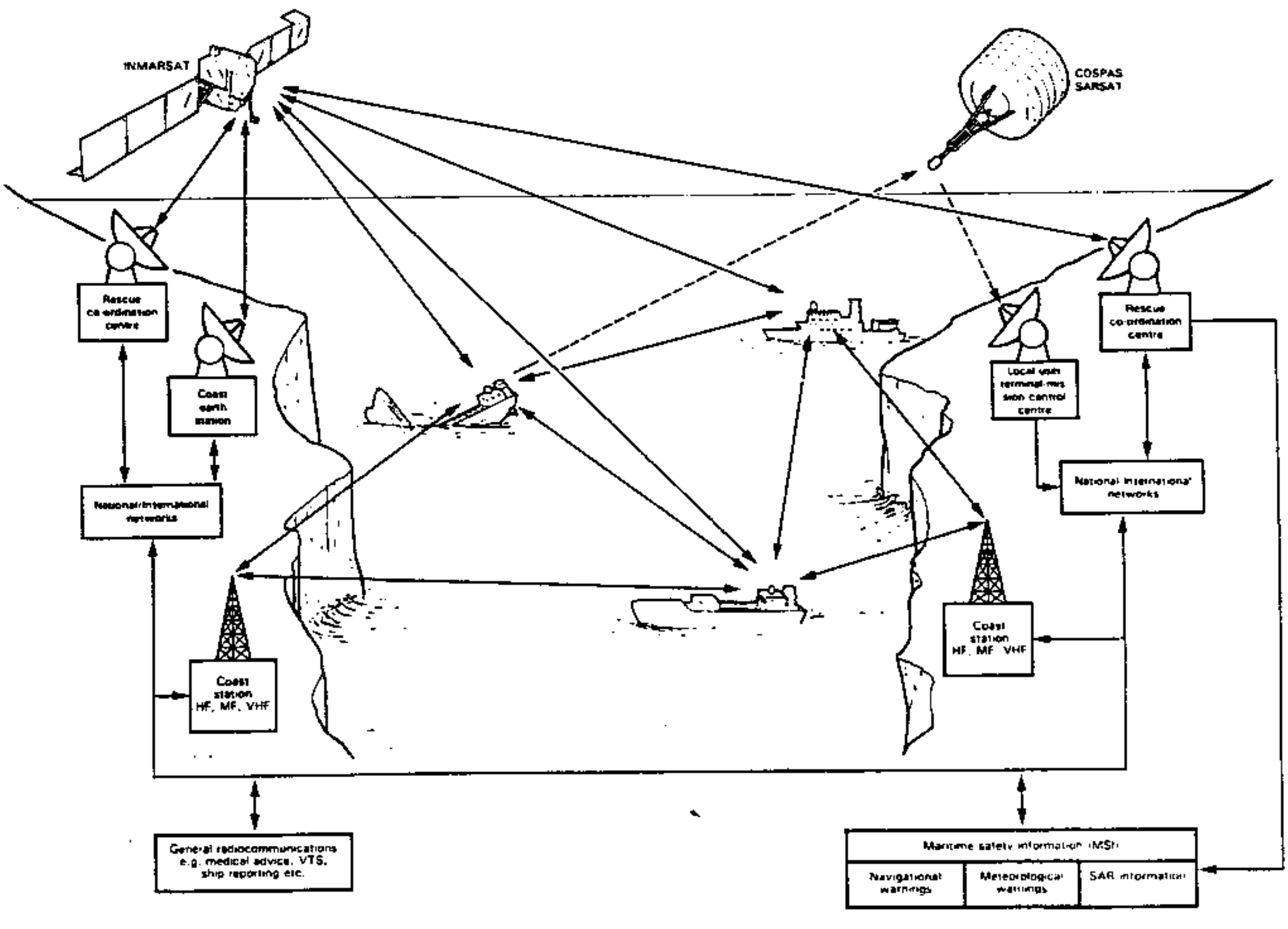

Figure 1 – *General concept of the GMDSS*

2.1.2 Recognizing that the different radio subsystems incorporated in the GMDSS system have individual limitations with respect to the geographical coverage and services provided, the equipment required to be carried by a ship is determined in principle by the ship's area of operation, which is designated as follows (regulation IV/2.1.12-2.1.15):

- Sea area A1 – an area within the radiotelephone coverage of at least one VHF coast station in which continuous digital selective calling (DSC) alerting is available, as may be defined by a Contracting Government;
- Sea area A2 – an area, excluding sea area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available, as may be defined by a Contracting Government;
- Sea area A3 – an area, excluding sea areas A1 and A2, within the coverage of an INMARSAT geostationary satellite in which continuous alerting is available; and
- Sea area A4 – an area outside sea areas A1, A2 and A3.

In all areas of operation the continuous availability of alerting is required. Criteria for establishing those GMDSS sea areas are given in annex 2-12 (resolution A.704(17)).

2.2 Communications functions in the GMDSS

The GMDSS comprises the following communications functions as required by regulation IV/4. These functions are individually performed by the radio subsystems set out in part 3.

Alerting (regulation IV/4.1.1–4.1.3)

2.2.1 Distress alerting is the rapid and successful reporting of a distress incident to a unit which can provide or co-ordinate assistance, as prescribed in RR N3112.* This would be a rescue co-ordination centre (RCC) or another ship in the vicinity. When an alert is received by an RCC, normally via a coast station or coast earth station, the RCC will relay the alert to SAR units and to ships in the vicinity of the distress incident. A distress alert should indicate the ship's identification and the position of the distress and, where practicable, its nature and other information which could be used for rescue operations (RR N3113*).

2.2.2 The communication arrangements under the GMDSS are designed to enable distress alerting to be performed in all three directions – ship-to-shore, ship-to-ship and shore-to-ship – in all sea areas (regulation IV/4.1.1–4.1.3). The alerting function is based on both satellite and terrestrial means and the initial distress alert is primarily transmitted in the ship-to-shore direction. When the distress alert is transmitted by DSC on VHF, MF or HF, ships within DSC range of the ship in distress will also be alerted (ship-to-ship alerting).

2.2.3 A distress alert is normally initiated manually and all distress alerts are acknowledged manually. When a ship sinks, a float-free satellite emergency position-indicating radio beacon (EPIRB) is automatically activated. Ships operating exclusively in sea area A1 may, in lieu of satellite EPIRBs, use VHF EPIRBs on channel 70.

2.2.4 The relaying of a distress alert from an RCC to ships in the vicinity of a distress incident is made by satellite communication or by terrestrial communication using appropriate frequencies. In either case, to avoid all ships in a large sea area being alerted, an "area call" is normally transmitted so that only those ships in the vicinity of the distress incident are alerted. On receipt of a relayed distress alert, ships in the area addressed are required to establish communication with the RCC concerned to enable the assistance to be co-ordinated. Parts 5 and 6 deal with the operational procedure and routeing of the distress alert.

SAR co-ordinating communications (regulation IV/4.1.4)

2.2.5 In general these are the communications necessary for the co-ordination of ships and aircraft participating in a search and rescue operation following a distress alert and include communications between RCCs** and any "on-scene commander (OSC)"** or "co-ordinator surface search (CSS)"** in the area of the distress incident.

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* See annex 9.3

** They are defined in the 1979 SAR Convention annex, chapter 1.

2.2.6 For SAR operations messages are transmitted in both directions, as distinct from "alerting", which is generally the transmission of a specific message in one direction only, and distress and safety traffic by radiotelephony and direct-printing telegraphy will normally be used for passing such messages.

2.2.7 The techniques which are available for SAR co-ordinating communications are radiotelephony or direct-printing telegraphy or both. These communications can be carried out by terrestrial or satellite means, dependent upon the equipment fitted on the ship and the sea area in which the incident occurs.

On-scene communications (regulation IV/4.1.5)

2.2.8 On-scene communications normally take place in the MF and VHF bands on frequencies designated for distress and safety traffic (given in annex 9.3), by radiotelephony or direct-printing telegraphy. These communications between the ship in distress and assisting units relate to the provision of assistance to the ship or the rescue of survivors. When aircraft are involved in on-scene communications they are normally able to use 3023, 4125 and 5680 kHz. In addition, SAR aircraft can be provided with equipment to communicate on 2182 kHz or 156.8 MHz or both, as well as on other maritime mobile frequencies.

Locating (regulation IV/4.1.6)

2.2.9 Locating is the finding of a ship/aircraft in distress or its survival craft or survivors, as defined by regulation IV/2.1.8. In the GMDSS this function is performed by means of 9 GHz SAR radar transponders (SARTs) by the ship in distress or its survivors, whose position is indicated when the SART is interrogated by the searching unit's 9 GHz radar. Use of the frequency 121.5 MHz in most satellite EPIRBs is provided for homing by aeronautical SAR units.

Promulgation of MSI (regulation IV/4.1.7)

2.2.10 Ships need to be provided with up-to-date navigational warnings and meteorological warnings and forecasts and other urgent safety information (MSI). MSI is made available by narrow-band direct-printing telegraphy broadcasts, using forward error correction on the frequency 518 kHz (international NAVTEX service – regulation 2.1.7) and, for ships which navigate beyond the NAVTEX coverage, by broadcasts via the INMARSAT enhanced group call (EGC) system (known as the international SafetyNET system). A high seas MSI broadcast system by HF direct-printing telegraphy is under development.* Details for MSI systems are given in section 3.7.

General radiocommunications (regulation IV/4.1.8)

2.2.11 General radiocommunications in the GMDSS are those communications between ship stations and shore-based communication networks which concern the management and operation of the ship and may have an impact on its safety (regulation IV/2.1.5). These communications can be conducted on any appropriate channel, including those used for public correspondence. Examples are orders for pilot and tug services, chart replacement, repairs, etc.

Bridge-to-bridge communications (regulation IV/4.1.9)

2.2.12 Bridge-to-bridge communications are inter-ship safety communications conducted from the position from which the ship is normally navigated (regulation IV/2.1.1), normally performed by VHF radiotelephony.

* See regulation IV/7.1.5 and annex 2-14, paragraph 3.5. See also annexes 3-5-3, 3-5-4 and 3-5-6.

Part 3
Communications systems in the GMDSS

3.1 General

Satellite communications

Satellite communications are particularly important elements of the GMDSS.

3.1.1 The INMARSAT system, which employs geostationary satellites and operates in the 1.5 and 1.6 GHz band (L-band) provides ships fitted with ship earth stations with a means of distress alerting and a capability for two-way communications using direct-printing telegraphy and radiotelephone. L-band satellite EPIRBs are also used for distress alerting. The INMARSAT SafetyNET system is used as a main means to provide MSI to areas not covered by the NAVTEX system.

3.1.2 A polar-orbiting satellite system, operating in the 406 MHz band using satellite EPIRBs (COSPAS-SARSAT system), provides one of the main means of distress alerting and determining the identity and position of the ship in distress or its survivors in the GMDSS.

Terrestrial communications

3.1.3 With terrestrial communications, DSC forms the basis of distress alerting and safety communications. Distress and safety communications following a DSC call can be performed by radiotelephony or direct-printing telegraphy or both.

Long-range service

3.1.4 Use of HF provides a long-range service in both the ship-to-shore and shore-to-ship directions. In areas covered by INMARSAT it can be used as an alternative to satellite communications and outside these areas it provides the only long-range communication capability. Frequencies have been designated in the 4, 6, 8, 12 and 16 MHz bands for this service.

Medium-range service

3.1.5 MF radiocommunications provide the medium-range service. In the ship-to-shore, ship-to-ship and shore-to-ship directions 2187.5 kHz will be used for distress alerts and safety calls using DSC, and 2182 kHz will be used for distress and safety traffic by radiotelephony, including SAR co-ordinating and on-scene communications. 2174.5 kHz will be used for distress and safety traffic by direct-printing telegraphy.

Short-range service

3.1.6 VHF provides short-range service on the frequencies:

- 156.525 MHz (channel 70) for distress alerts and safety calls using DSC, and
- 156.8 MHz (channel 16) for distress and safety traffic by radiotelephony, including SAR co-ordinating and on-scene communications.

There is no short-range direct-printing telegraphy service on VHF.

Frequencies used in the GMDSS

3.1.7 Frequencies used in the GMDSS communications systems allocated by ITU WARC-Mob-87 are given in annex 9.3 (RR Art. N38).

3.2 INMARSAT system

Introduction

3.2.1 INMARSAT grew out of an idea that originated within IMO in 1966. Following extensive study by IMO experts an international conference was convened which, after three sessions on 3 September 1976, unanimously adopted the Convention and Operating Agreement on the International Maritime Satellite Organization (INMARSAT). According to its Convention, INMARSAT is "to make provision for the space segment necessary for improving maritime communications, thereby assisting in improving distress and safety of life at sea communications".

3.2.2 The INMARSAT system has three major components: the space segment provided by INMARSAT, the coast earth stations (CESs) provided by INMARSAT signatories and ship earth stations (SESs).

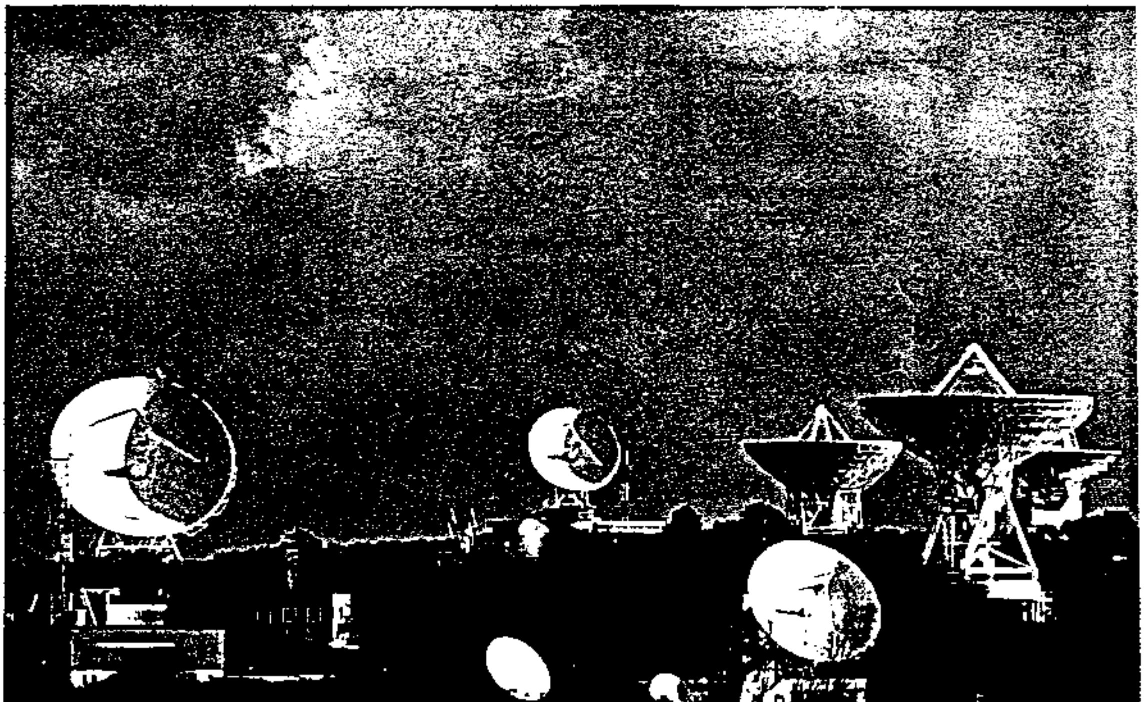
3.2.3 The nerve centre of the system is the operations control centre (OCC), located at INMARSAT's headquarters in the United Kingdom. The OCC is responsible for controlling the INMARSAT system operation as a whole. Operating 24 hours a day, it co-ordinates a wide range of activities. The OCC also arranges the commissioning of SESs upon application by the shipowner.

Space segment

3.2.4 Four satellites in geostationary orbit 36,000 km above the equator cover four ocean regions, namely AOR-E (Atlantic Ocean Region-East), AOR-W (Atlantic Ocean Region-West), IOR (Indian Ocean Region) and POR (Pacific Ocean Region), and provide near-global coverage. The current status of the INMARSAT system and coverage is given in annex 4 of the GMDSS Master Plan (see annex 5 of this publication).

Coast earth stations

3.2.5 The CESs provide the link between the satellites and terrestrial telecommunications networks. Currently, all CESs are owned and operated by telecommunications carriers. A typical CES consists of a parabolic antenna about 11 m to 14 m in diameter, which is used for transmission of signals to the satellite at 6 GHz and for reception from the satellite at 4 GHz (figure 2). The same antenna or another dedicated antenna is used for



(The photo includes antennae other than INMARSAT)

Figure 2 – *Example of an INMARSAT coast earth station*

L-band transmission (at 1.6 GHz) and reception (at 1.5 GHz) of network control signals. The type of communication service provided varies depending on the CES. A CES designated for each ocean area for each communication service (i.e. telephone, direct-printing telegraph, etc.) serves as a network co-ordination station (NCS) which assigns communication channels, on demand, to SESs and other CESs and monitors signals transmitted by these stations.

Ship earth stations

3.2.6 The requirements for the SESs in the GMDSS can be met by INMARSAT SESs capable of two-way communications, such as INMARSAT-A, INMARSAT-B and INMARSAT-C SESs. Performance standards for SES equipment are given in annex 3-4.

INMARSAT-A SES

3.2.7 An INMARSAT-A SES consists of two parts, above-deck equipment (ADE) and below-deck equipment (BDE) (figure 3). The ADE includes a parabolic antenna, about 0.85 m to 1.2 m in diameter, mounted on a platform and stabilized so that the antenna remains pointed at the satellite regardless of ship motion. It also includes a solid state L-band power amplifier, an L-band low-noise amplifier, a diplexer and a low-loss protective radome. The BDE consists of an antenna control unit; communications electronics used for transmission, reception, access control and signalling; and telephone and telex equipment.

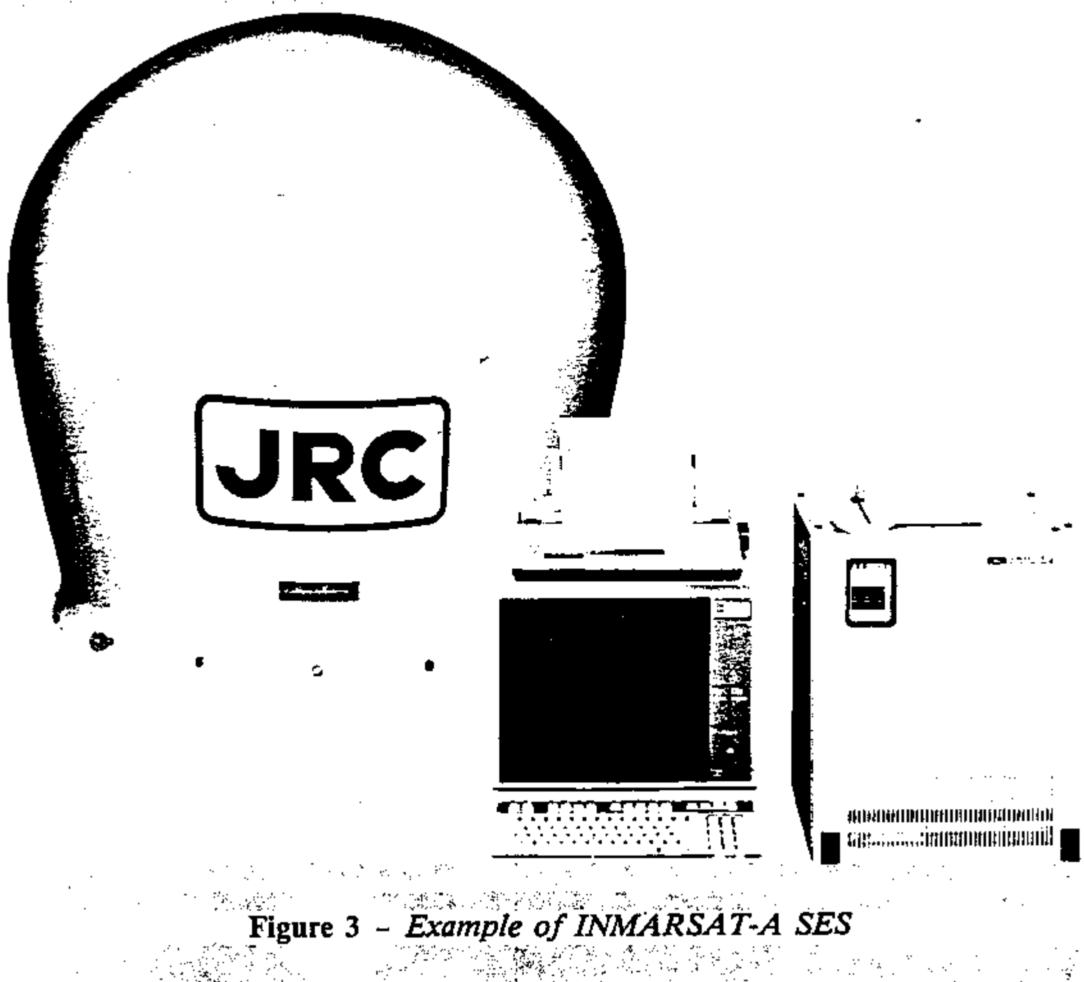


Figure 3 – *Example of INMARSAT-A SES*

3.2.8 The new generation of INMARSAT-A equipment currently being produced by manufacturers is smaller and easier to use than earlier models. ADE is now available weighing less than 50 kg, making it suitable for installation on most types and sizes of vessels and yachts. Many of the current systems are modular in design and allow the addition of optional equipment such as facsimile, data and slow-scan television, etc. Some BDE has a microcomputer with a visual display unit (VDU), alphanumeric keyboard, hard-copy printer and modem. The computer can be used to prepare telex messages with the ease of modern word-processing equipment. Messages can be composed, edited and transmitted directly from the screen or stored for later transmission. In some models, the computer memorizes the satellite's co-ordinates and CES tariffs and automatically routes the call in the most economical way.

3.2.9 With additional facilities, users have modified their terminals to allow automated vessel reporting. Those involved in vessel management on shore can dial the ship at any time of the day or night and automatically receive information as to its position, heading, etc., as well as data on its cargo and operation - all without disturbing or distracting the crew. A distress message generator is normally built into a terminal (mostly a software modification) for storage of basic essential vessel information and automatic transmission in a distress situation.

INMARSAT-B SES

3.2.10 The INMARSAT-B SES is a digital complement of INMARSAT-A SES developed to replace INMARSAT-A SES equipment in the future. It provides the same communications services as an INMARSAT-A SES.

INMARSAT-C SES

3.2.11 INMARSAT-C SESs are small, lightweight terminals designed for two-way message communication (figure 4). INMARSAT-C SESs cannot be used for radiotelephone communications; they operate at 600 bit/s and provide access to the international telex/teletex networks, electronic mail services and computer databases. This low-powered terminal with its omnidirectional antenna and light weight is a practical solution for installation on the smallest of vessels, thereby bringing the benefits of satellite communications within the reach of all mariners. It will enlarge the user community by providing equal access to existing and emerging satellite services to all seafarers.

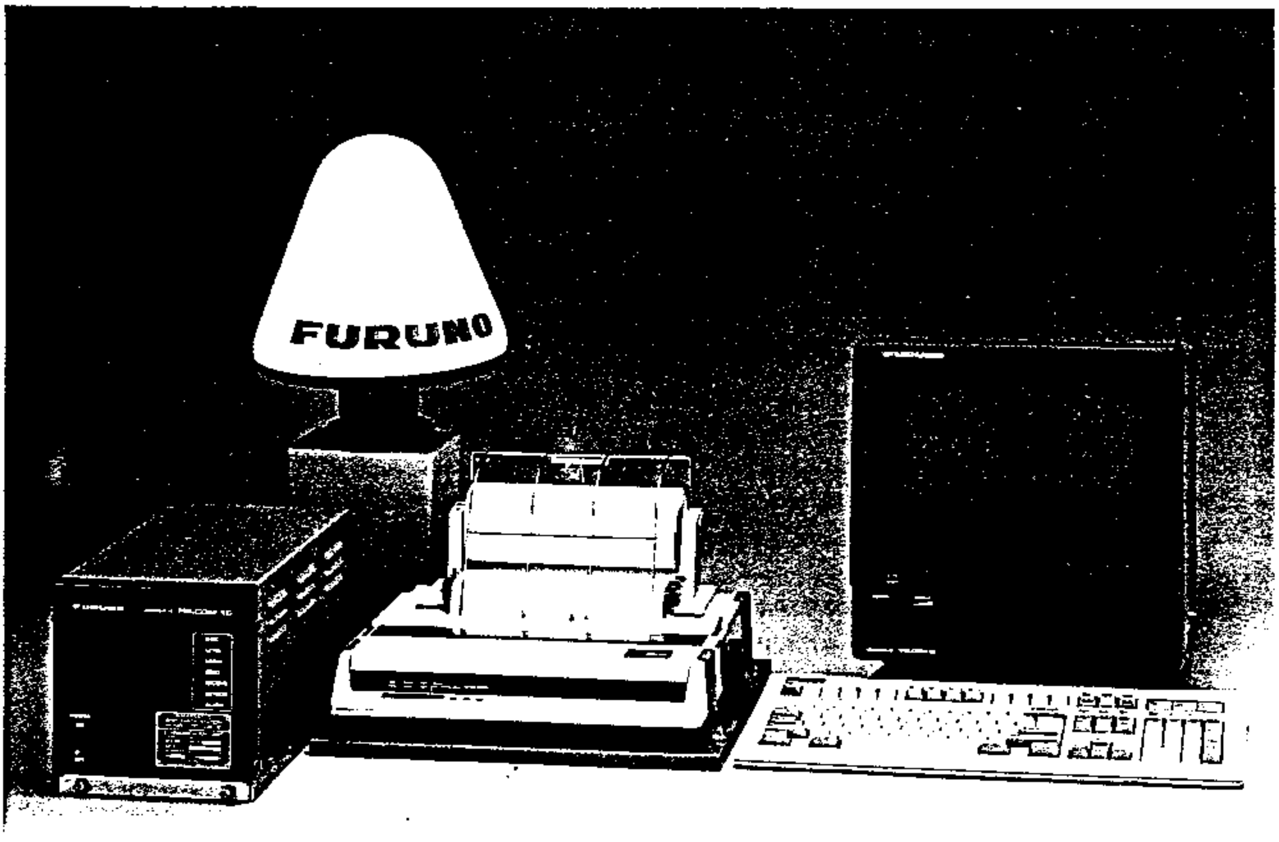


Figure 4 - *Example of INMARSAT-C SES*

3.2.12 Additionally, an INMARSAT-C SES can serve as a back-up for an INMARSAT-A SES on large ships and also fulfill a potentially vital role as a fixed or portable transmitter/receiver for use on board ship or in survival craft. The omnidirectional antenna characteristics are particularly valuable for a vessel in distress as the SES continues to operate even when the vessel is listing severely. As with the INMARSAT-A SES, a distress message generator can be included in the terminal software for storage of basic essential vessel information and automatic transmission in a distress situation.

Enhanced group call receiver

3.2.13 The INMARSAT EGC receiver is a dedicated piece of equipment for the reception of information by INMARSAT EGC service. It has been designed to enable automatic continuous watch on international SafetyNET MSI broadcasts and commercial INMARSAT FleetNET messages, such as subscription to news services, etc. An EGC capability can be added to INMARSAT-A, INMARSAT-B and INMARSAT-C SESs or it can be a stand-alone receiver with its own antenna. Annex 3-5-2 gives the performance standards for EGC receivers.

3.2.14 An EGC receiver is required in the GMDSS for all ships which proceed beyond coverage of the international NAVTEX service (regulation IV/7.1.5).

INMARSAT services

Ship-to-shore distress alerting

3.2.15 The INMARSAT system provides priority access to satellite communications channels in emergency situations. Each SES is capable of initiating a "request" message with distress priority (INMARSAT priority-3 call). Any "request" message with a distress priority indication is automatically recognized at the CES and a satellite channel is instantly assigned. If all satellite channels happen to be busy, one of them will be pre-empted and allocated to the SES which initiated the distress priority call. The processing of such calls is completely automatic and does not involve any human intervention. The CES personnel, however, are notified of the reception and passing through of a distress priority message by audio-visual alarms.

3.2.16 To ensure the correct treatment of distress priority requests, the NCS in each ocean region automatically monitors the processing of such calls by all other CESs in that region. In the event that any anomalies in processing are detected, the NCS will take appropriate action to establish the end-to-end connection. In addition, the monitoring NCS also checks the CES identity contained in the distress priority message and automatically accepts the call if an identity of a non-operational CES has been detected (which may happen due to operator error aboard the vessel in distress).

3.2.17 The distress priority applies not only with respect to satellite channels but also to the automatic routeing of the call to the appropriate RCC. Each CES in the system is required to provide reliable communication interconnection with an RCC; these national RCCs are known as associated RCCs. The means of CES–RCC interconnection may vary from country to country and include the use of dedicated lines or public switched networks. Thus, any distress priority request message received at the CES is automatically processed and passed to the associated RCC. Some CESs, due to national considerations, pass distress priority messages to special operators, who are responsible for the subsequent routeing of the call to the appropriate RCC, or provide an option which allows the shipboard operator to contact any RCC when a satellite channel has been assigned on the distress priority basis.

3.2.18 The initiation of a distress priority message in most SESs is made simple for ship crew members by provision of a "distress button" or code in the SES. On activation of this button, the equipment instantaneously transmits a distress priority message. This single operation, a push of the "distress button", provides automatic, direct and assured connection to a competent rescue authority, thereby avoiding the need for the SES operator to select or key the telex or telephone number of the RCC and eliminating possible human error. The establishment of this end-to-end connection, being completely automatic and on a priority basis, takes only a few seconds.

3.2.19 INMARSAT has issued technical guidelines to manufacturers for a distress message generator (DMG), which consists of SES software to transmit automatically, after the connection has been established, the distress message in a standardized format that provides information on the vessel's identification, its position and the particular emergency.

3.2.20 The procedure described above is the primary means of ship-to-shore distress alerting in the INMARSAT system. It should be noted, however, that INMARSAT SES-equipped ships can also contact any RCC of their choice by following the calling procedure for routine calls. In this case, the complete international telephone/telex number has to be selected.

3.2.21 A major benefit of the INMARSAT distress priority system is that it eliminates the need for dedicated frequencies to be allocated for distress and safety communications. Distress messages made through the INMARSAT distress priority system are sent through the general communication channels on an absolute priority basis to ensure an immediate connection.

Shore-to-ship distress alerting

3.2.22 Shore-to-ship alerting to groups of ships with INMARSAT-A, INMARSAT-B or INMARSAT-C SESs but without INMARSAT SafetyNET capability can be performed in the following modes:

.1 "All ships call" – Calls to all ships in the ocean region concerned. It should be noted, however, that due to the large coverage zones of geostationary satellites such alerting is not very efficient, although it may be justified under exceptional circumstances;

.2 "Geographical area calls" – Calls to ships navigating in a defined geographical area. Each satellite coverage region is subdivided into smaller areas, and the boundaries of these areas are based on NAVAREAs each having a unique two-digit area code.* SESs will automatically recognize and accept geographical area calls only if the correct code has been input by the SES operator; the system requires the periodic manual input of appropriate area codes; or

.3 "Group calls to selected ships" – This service is provided by a number of CESs in the operator-assisted mode and allows alerting of a predetermined group of vessels. This service could be very useful for alerting, for example, SAR units.

3.2.23 As long as they are not engaged in traffic, SESs accept all incoming messages without any differentiation of priority.

Shore-to-ship distress alerting through the INMARSAT SafetyNET system

3.2.24 The EGC receiver can be an integral part of an SES or a completely separate unit and it ensures a very high probability of receiving shore-to-ship distress alert messages. When a distress priority message is received, an audible alarm will sound and it can only be reset manually.

3.2.25 Accessing the INMARSAT SafetyNET service by RCCs requires arrangements similar to those needed for shore-to-ship distress alerting to a standard SES. Those RCCs unable to obtain a reliable terrestrial connection to a coast earth station can install an INMARSAT SES at the RCC. The RCC would then transmit the distress alert via the SES to a CES, where it would be relayed by means of a broadcast over the INMARSAT SafetyNET system. See section 3.7 and annex 4-3** for further details of the INMARSAT SafetyNET system.

Search and rescue co-ordinating communications

3.2.26 For the co-ordination and control of SAR operations, RCCs require communications with the ship in distress as well as with units participating in the operation. The methods and modes of communication

*See annex 4-1 (WWNWS).

** Draft International SafetyNET Manual.

(terrestrial, satellite, telephone, telex) used will be governed by the capabilities available on board the ship in distress as well as those on board assisting units. Where those ships are equipped with an SES, the advantages of the INMARSAT system for rapid, reliable communications including receipt of MSI can be exploited.

3.2.27 A reliable interlinking of RCCs is important for the GMDSS, in which a distress message may be received by an RCC thousands of miles away from where the assistance is needed and it may not be the RCC best suited to provide the necessary assistance. In this case prompt relay of the distress message to the appropriate RCC is essential and any communications means, whether landlines, terrestrial radio networks or satellite links, must be used.

3.2.28 To increase the speed and reliability of inter-RCC communications, some RCCs have installed SESs providing them with the capability of communicating via the INMARSAT system.* These facilities are useful for long-distance interconnection of SAR organizations, especially when dedicated lines or public switched networks are unavailable or unreliable.

On-scene SAR communications

3.2.29 On-scene communications are those between the ship in distress and assisting vessels, and between SAR vessels and the OSC or the CSS, and are normally short-range communications made on the VHF or MF distress and safety frequencies in the GMDSS. However, INMARSAT SES-fitted ships could, if necessary, use satellite communications as a supplement to their VHF and MF facilities.

Promulgation of MSI (via INMARSAT SafetyNET services)

3.2.30 In the INMARSAT system, promulgation of MSI is performed by means of the INMARSAT SafetyNET system. Although an INMARSAT-A, INMARSAT-B or INMARSAT-C SES can receive the SafetyNET broadcasts, if uninterrupted receipt of important MSI is required when the SES is engaged for other communications, then it is essential to have a dedicated EGC reception capability for such broadcasts. Alternatively, an EGC receiver can be installed as a separate unit. Details of the INMARSAT SafetyNET service are given in annex 4-3.

General radiocommunications

3.2.31 The INMARSAT system provides ships at sea with the same types and quality of modern communications as are available ashore. The capability for direct-dial, automatic connection without delay using high-quality multi-mode communications is provided by SES. Teleprinters, VDUs and telephone sets, as well as facsimile machines and data equipment, can serve as peripheral equipment to SESs.

3.2.32 The quality and availability of general radiocommunications offered by the INMARSAT system permit a ship's master to rapidly consult and seek assistance on any matter, whether of a safety or commercial nature. High-quality general communications are therefore a valuable asset to safety at sea as well as to the efficient operation of the ship.

3.2.33 The following are examples of INMARSAT services:

- Telephony
- Direct-printing telegraphy
- Data communications
- Facsimile
- Slow-scan television
- Automatic data collection from ships (see section 3.2.9)

* See RR N2938 (annex 9.2).

L-band satellite EPIRBs

3.2.34 L-band satellite EPIRBs operating through the INMARSAT system can be used as a means of alerting by ships operating in sea areas A1, A2 and A3 as an alternative to 406 MHz satellite EPIRBs, mentioned in section 3.3.

3.2.35 The basic concept of the INMARSAT L-band satellite EPIRB system is shown in figure 5. The distress signal transmitted from the float-free satellite EPIRB on the dedicated channel in the 1.6 GHz frequency (L-band) is relayed by an INMARSAT satellite to CESs equipped with the appropriate receiver and processor equipment.

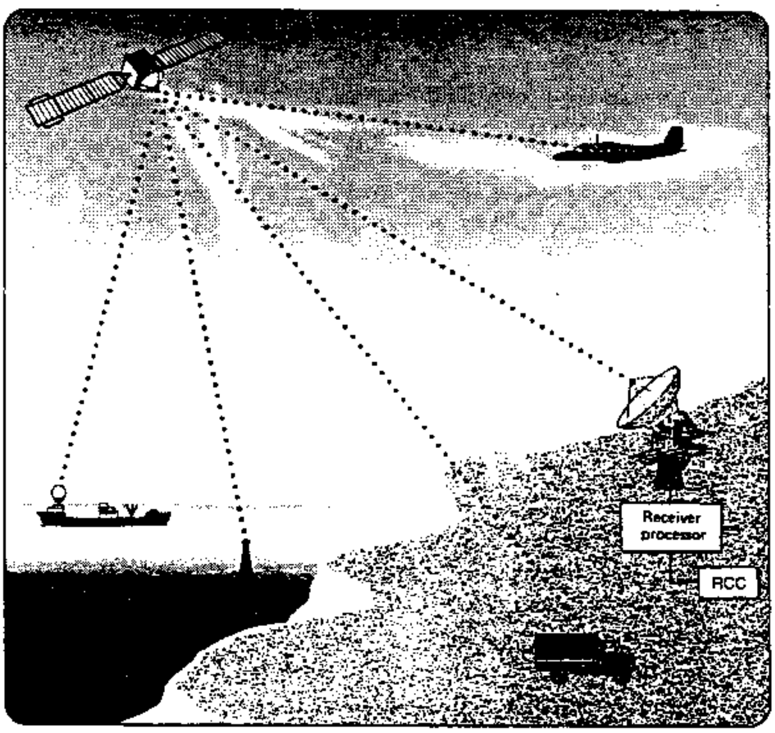


Figure 5 – *Basic concept of the L-band satellite EPIRB system*

3.2.36 The L-band satellite EPIRB provides for rapid distress alerting (in the order of 10 minutes with 1 W output power radiated by an EPIRB), coverage up to ± 70° latitude, 20 simultaneous alerts within a 10-minute time frame and the possibility of manual or automatic entry and update of position information to the satellite EPIRB. The satellite EPIRB can be activated either manually or automatically, by floating free from the sinking ship.

3.2.37 After activation, the satellite EPIRB transmits the distress message containing the ship station identity, position information and additional information which could be used to facilitate rescue. The transmission is repeated on a pre-selected duty cycle. Additionally, unless an integrated electronic position-fixing device is included which provides position updates, a built-in 9 GHz SART is activated for locating purposes. Annexes 3-3-3* and 3-3-4* give detailed technical characteristics of L-band satellite EPIRBs.

3.2.38 After being relayed by the satellite, the distress signal is down-converted at the CES to the specified intermediate frequency to be transferred to the computer-aided multi-channel receiver for satellite EPIRB identification and message decoding.

3.2.39 After the signal channels are identified, they are assigned to processor channels where the incoming signal plus noise is superimposed in the memory. Having accomplished the necessary number of superpositions,

* Resolution A.661(16) and CCIR Rec.632.

which results in 2 ~ 3 dB improvement of signal-to-noise ratio for every frame, the memory is read out and the usual procedures, such as bit and frame synchronization, evaluation of the error-correcting code and the message print-out, are performed.

3.2.40 The distress message is then forwarded to an associated RCC for appropriate action.

3.3 COSPAS-SARSAT system

Introduction

3.3.1 The COSPAS-SARSAT* system is a satellite-aided SAR system designed to locate distress beacons transmitting on the frequencies 121.5 MHz or 406 MHz.** It is intended to serve all organizations in the world with responsibility for SAR operations whether a distress occurs at sea, in the air or on land.

3.3.2 COSPAS-SARSAT is a joint international satellite-aided SAR system, established by organizations in Canada, France, the United States and the former USSR.***

3.3.3 The COSPAS-SARSAT system has demonstrated that the detection and location of distress signals can be facilitated by global monitoring based on low-altitude satellites in near-polar orbits. It has been used successfully in a large number of SAR operations world-wide.

3.3.4 Unless, as an alternative, a ship is provided with an L-band satellite EPIRB, the carriage of a float-free satellite EPIRB operating on the frequency 406 MHz in the COSPAS-SARSAT system is mandatory on all SOLAS ships (regulation IV/7.1.6.1).

General concept of the system

3.3.5 The basic COSPAS-SARSAT system concept is given in figure 6. There are at present three types of satellite beacons, namely emergency locator transmitters (ELTs) (airborne), EPIRBs (maritime) and personal locator beacons (PLBs) (land). These beacons transmit signals that are detected by COSPAS-SARSAT polar-orbiting satellites equipped with suitable receivers/processors. The signals are then relayed to a ground receiving station, called a local user terminal (LUT), which processes the signals to determine the beacon location. An alert is then relayed, together with location data and other information, via a mission control centre (MCC), either to a national RCC, to another MCC or to the appropriate SAR authority to initiate SAR activities.

3.3.6 Doppler shift (using the relative motion between the satellite and the beacon) is used to locate the beacons. The carrier frequency transmitted by the beacon is reasonably stable during the period of mutual beacon-satellite visibility. The frequencies currently in use are 121.5 MHz (international aeronautical emergency frequency) and 406.025 MHz. The 406 MHz beacons are more sophisticated than the 121.5 MHz beacons because of the inclusion of identification codes in the messages, but complexity is kept to a minimum. To optimize Doppler location, a low-altitude near-polar orbit is used.**** The low altitude results in a low uplink power requirement, a pronounced Doppler shift, and short intervals between successive passes. The near-polar orbit results in complete world coverage over a period of time.

3.3.7 The Doppler location concept provides two positions for each beacon: the true position and its mirror image relative to the satellite ground track. This ambiguity is resolved by calculations that take into account the earth's rotation. If the beacon frequency stability is good enough, as with 406 MHz beacons which are designed for this purpose, the true solution is determined over a single pass. In the case of 121.5 MHz beacons, the ambiguity is resolved by the results of the second pass if the first attempt is unsuccessful. The improved performance of 406 MHz satellite EPIRBs is the reason these devices were selected for the GMDSS. The status of the COSPAS-SARSAT system is given in annex 6.

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* COSPAS: Space System for Search of Distress Vessels; SARSAT: Search and Rescue Satellite-Aided Tracking.

** Certain beacons also transmit on 243 MHz, but this signal is relayed only by SARSAT satellites and not all local user terminals are equipped with 243 MHz receivers. This system, therefore, is not described in this publication, but it operates in the same manner as a 121.5 MHz system.

*** Since 26 December 1991 the membership in IMO of the USSR and its participation in treaty instruments adopted under the auspices of IMO is continued by the Russian Federation.

**** The altitude of the COSPAS satellites' orbit is approximately 1,000 km while that of SARSAT satellites is about 850 km.

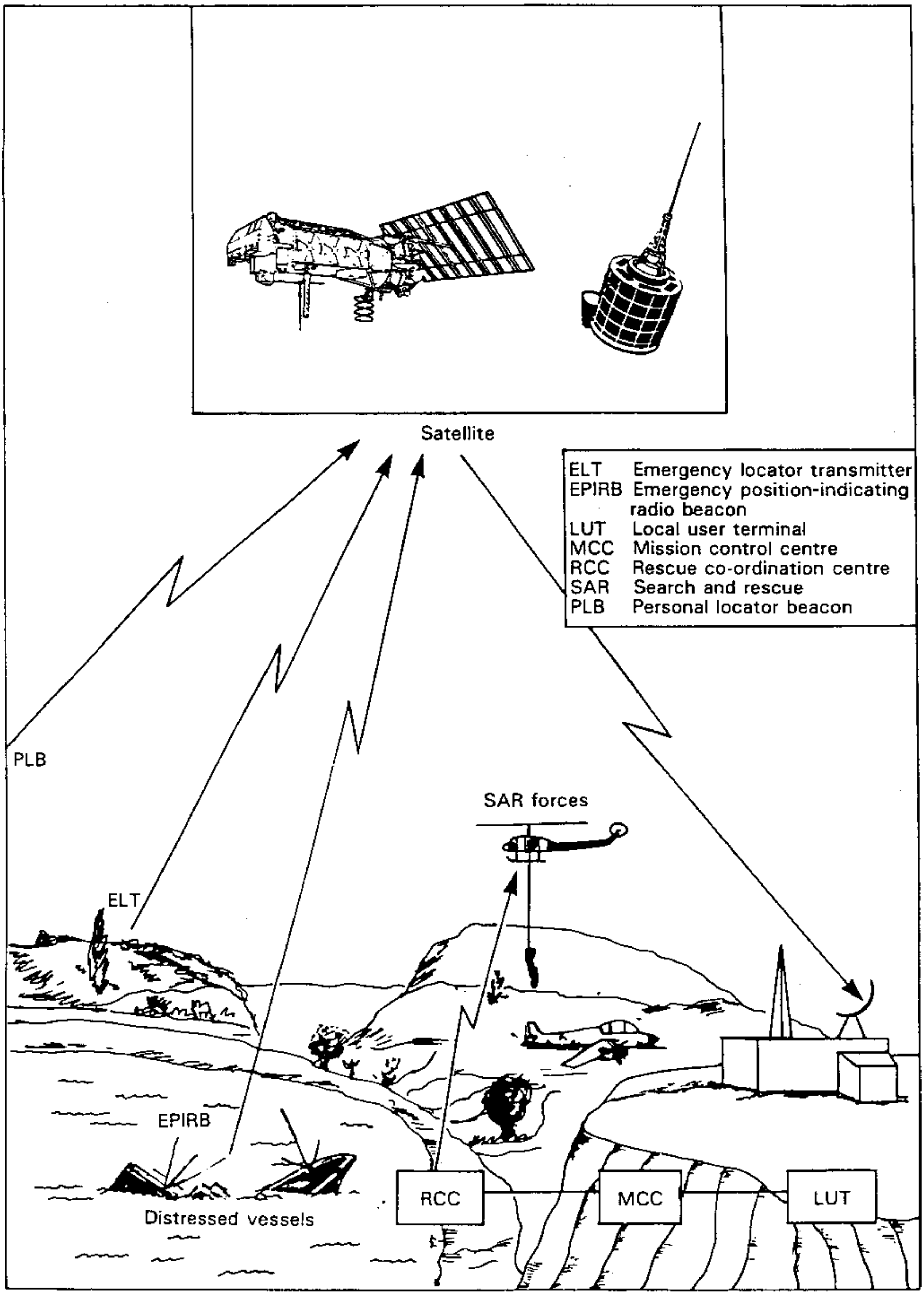

Figure 6 – *Basic concept of COSPAS–SARSAT system*

Coverage modes

3.3.8 The COSPAS–SARSAT system implements two coverage modes for the detection and location of beacons, namely the real-time mode and the global coverage mode. Both the 121.5 and 406 MHz systems operate in the real-time mode, while only the 406 MHz system operates in the global coverage mode.

121.5 MHz real-time mode

3.3.9 In this mode, an LUT and EPIRBs must be in the same view of the satellite for the 121.5 MHz EPIRB signal to be relayed by a repeater on board the satellite directly to the ground, where it is received and processed. For this reason, world-wide real-time mode coverage is unlikely to be achieved.

406 MHz real-time mode

3.3.10 Once the satellite receives the 406 MHz satellite EPIRB signals, the Doppler shift is measured and the beacon digital data, which include ship's identification, etc., are recovered from the beacon signal. This information is time-tagged, formatted as digital data, and transferred to the downlink repeater for real-time transmission to any LUT in the satellite's view. The data are simultaneously stored in the on-board memory of the satellite for later transmission in the global coverage mode.

406 MHz global coverage mode

3.3.11 The 406 MHz system provides global coverage by storing data on board for later dumping and reception by LUTs. Each satellite EPIRB can therefore be located by all operating LUTs.

121.5 MHz satellite EPIRBs

3.3.12 EPIRBs operating on 121.5 MHz are already in widespread use. They are used on board light aircraft and ships and must meet national specifications based on International Civil Aviation Organization (ICAO) standards. The 121.5 MHz beacon signals also provide for homing by SAR units and overflight monitoring by aircraft.

406 MHz satellite EPIRBs

3.3.13 The development of 406 MHz satellite EPIRBs (figure 7) has been undertaken to overcome certain shortcomings of the 121.5 MHz system. The new EPIRBs were specifically designed for satellite detection and Doppler location and include the following features:

- improved location accuracy and ambiguity resolution;
- increased system capacity, i.e. a greater number of beacons transmitting simultaneously in the field of view of a satellite can be processed;
- global coverage;
- unique identification of each beacon; and
- inclusion of distress information.

Annexes 3-3-1 and 3-3-5* give technical details of the 406 MHz satellite EPIRBs.

3.3.14 The 406 MHz satellite EPIRBs transmit a 5 W radio frequency (RF) burst of approximately 0.5 second duration every 50 seconds. Improved frequency stability ensures improved location accuracy, while the high peak power increases the probability of detection. The low duty cycle provides good multiple-access capability, with a system capacity of 90 activated beacons simultaneously in view of the satellite, and low mean power consumption.

* Resolution A.695(17) and CCIR Rec. 633.

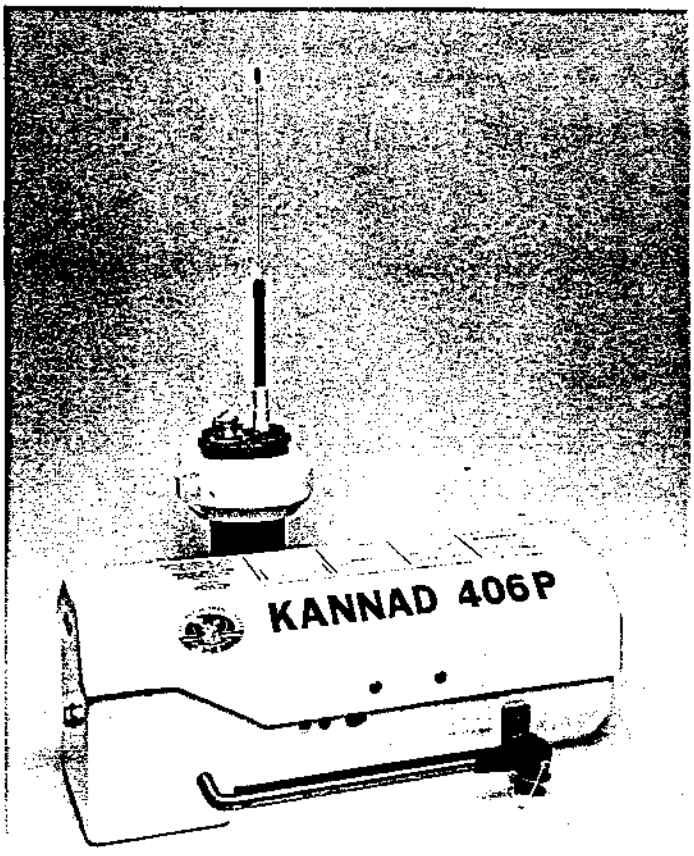

Figure 7 – *Example of 406 MHz COSPAS-SARSAT satellite EPIRB*

3.3.15 An important feature of the new satellite EPIRBs is the inclusion of a digitally encoded message, which may provide such information as the country of origin of the unit in distress, identification of the vessel or aircraft, nature of distress and, in addition, for satellite EPIRBs coded in accordance with the maritime location protocol,* the ship's position as determined by its navigation equipment.

3.3.16 Most satellite EPIRBs are, as recommended, dual-frequency 121.5/406 MHz beacons, though the inclusion of the frequency 121.5 MHz is not mandatory. This enables suitably equipped SAR units to home in on the 121.5 transmission and permits overflight monitoring by aircraft. This type of homing facility, if provided, is indicated to the rescue authorities by the message. As SARTs have limited range of operation (5 nautical miles), consideration is being given to requiring all maritime satellite EPIRBs to operate on the frequencies 121.5 MHz and 406 MHz.

3.3.17 Depending on the type of beacon (maritime, airborne or land), beacons can be activated either manually or automatically.

Space segment

3.3.18 The SAR instrumentation on board the COSPAS and SARSAT satellites operates in the following modes:

- real-time mode: 121.5 MHz repeater;
- real-time mode: 406.025 MHz data processing and downlink; and
- global coverage mode: 406.025 MHz stored data transmission.

* See annex 3-3-5 (CCIR Rec. 633).

3.3.19 The equipment on board the satellite consists of the following basic sub-assemblies:

- 121.5 MHz receiver;
- 406.025 MHz receiver/processor and memory unit; and
- 1544.5 MHz downlink transmitter.

121.5 MHz receiver

3.3.20 This unit has a bandwidth of 25 kHz. Automatic level control (ALC) is provided to maintain a constant output level.

406.025 MHz receiver/processor

3.3.21 The functions of the receiver/processor are as follows:

- demodulating the digital messages received from beacons;
- measuring the received frequency; and
- time-tagging the measurement.

All these data included in the output signal frame are modulated for downlinking to LUTs. The signal frame is transmitted at 2,400 bits/second in the real-time mode and also stored in memory for later transmission by the global coverage mode. In the global coverage mode, the on-board memory is dumped in the same format and at the same bit rate as real-time data. LUTs thus directly receive the stored beacon messages acquired during an entire orbital revolution. If a new beacon signal is received during the stored memory dump, the dump is interrupted so that the signal can be processed and the resultant message interleaved with the stored data. Appropriate flag bits indicate whether the data are real-time or stored and the time at which full playback of the stored data was accomplished.

1544.5 MHz downlink transmitter

3.3.22 The 1544.5 MHz downlink transmitter accepts input from the 406 MHz receiver/processor and receiver(s) operating on the other COSPAS-SARSAT band(s) (121.5 MHz and 243 MHz*), adjusts the relative power level in accordance with ground command, phase modulates a low-frequency carrier with the composite signal, multiplies the frequency to produce 1544.5 MHz, amplifies the power level and drives the satellite downlink antenna.

Local user terminals and mission control centres

3.3.23 The configuration and capabilities of each LUT vary to meet the specific requirements of countries, but the COSPAS and SARSAT satellite downlink signal formats ensure interoperability between the various satellites and all LUTs meeting COSPAS-SARSAT specifications.**

3.3.24 There are two types of LUTs, those which process 121.5 MHz and 406 MHz signals and those which process 406 MHz signals only.

3.3.25 Figure 8 is a block diagram of a typical COSPAS-SARSAT LUT. The antenna and receiving system pick up the signal, which is down-converted to an intermediate frequency (IF) and linearly demodulated to produce the composite baseband spectrum, which is filtered and separated into the various bands of interest. As the signal is received, the processing of each band is accomplished according to the specific capabilities of the LUT. The option for LUT configuration incorporating analogue tape recorders provides a back-up mode in the event of processor failure.

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* See footnote to section 3.3.1.

** Refer to the following COSPAS-SARSAT basic documents:

.1 Specification for COSPAS-SARSAT 406 MHz Distress Beacons (C/S T.001);
.2 Local User Terminal (LUT) Performance Specification (C/S T.002);
.3 COSPAS-SARSAT Data Distribution Plan (C/S A.001);
.4 COSPAS-SARSAT MCC Standard Interface Description (C/S A.002).

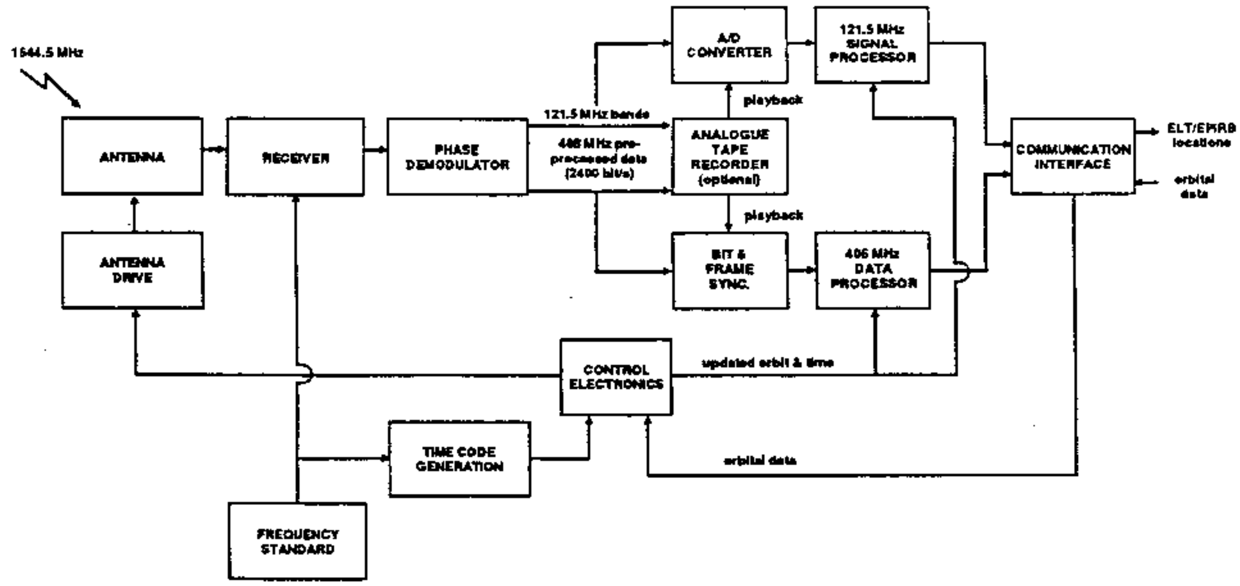

Figure 8 - *Example of COSPAS-SARSAT LUT functional block diagram*

3.3.26 For the 121.5 MHz signal, each transmission is detected and the Doppler shift is calculated. A beacon location is then determined using these data. All 406 MHz data received from the satellite memory on each pass can be processed within a few minutes of pass completion. Figures 9 and 10 show a typical LUT and an example of an MCC/RCC.

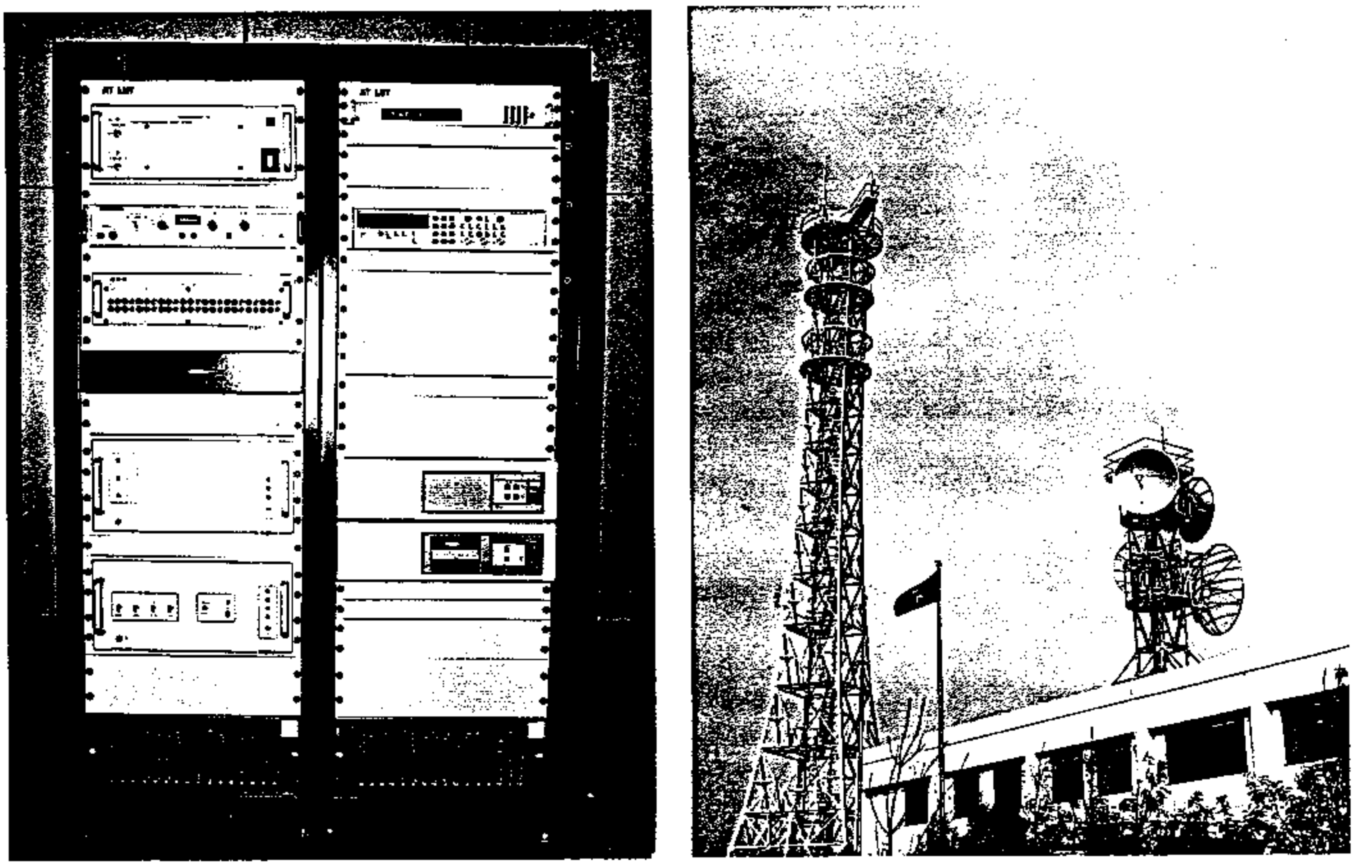

Figure 9 - *Example of a local user terminal*

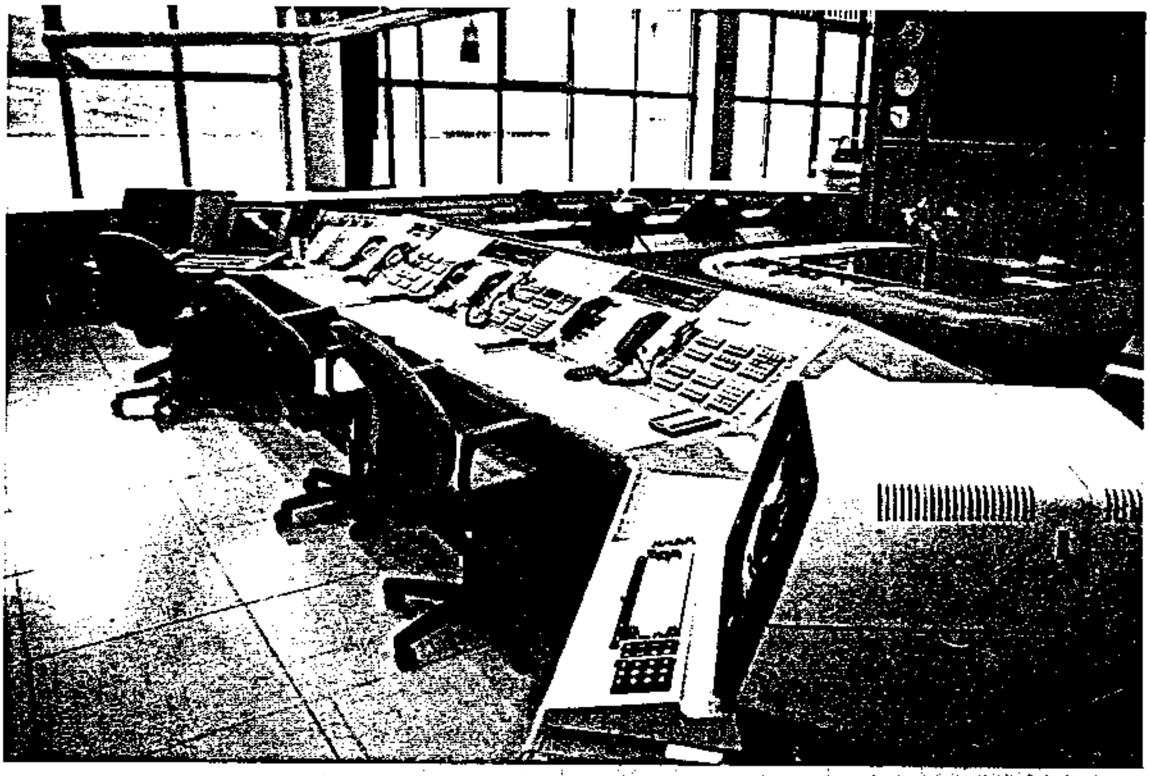

Figure 10 - *Example of a mission control centre/rescue co-ordination centre*

3.3.27 MCCs have been set up in each country operating at least one LUT. Their main functions are to collect, store and sort the data from LUTs and other MCCs, and to provide such data to SAR networks (see figure 11). Most of the data handled consist of the following:

.1 *Alert data* is the generic term for COSPAS-SARSAT 121.5 and 406 MHz data derived from EPIRB information. Alert data comprise the beacon location and (for 406 MHz satellite EPIRBs) other information such as beacon identification data and other coded information.

.2 *System information* is primarily used to maintain efficient operation of the COSPAS-SARSAT system and to provide users with as accurate and timely alert data as possible. It consists of tabulated data (ephemeris and time calibration) used to determine beacon locations, the current status of all subsystems, and co-ordination messages required to operate the COSPAS-SARSAT system.

3.3.28 The COSPAS mission control centre (CMC) in Moscow is responsible for co-ordinating all COSPAS activities and provides the link via the SARSAT MCCs for all interaction with the SARSAT system. The CMC computes and sends COSPAS satellite ephemeris data to other MCCs and LUTs, and receives, processes and transmits SARSAT ephemeris and time calibration data received from the SARSAT MCC to the COSPAS MCCs and LUTs.

3.3.29 A designated MCC in the United States (USMCC) acts as a focal point for the co-ordination of SARSAT satellite operations. It calculates 406 MHz satellite EPIRB locations using stored data received from LUTs, distributes ephemeris data, processes time calibration data (required for use of SARSAT 406 MHz data), and forwards the appropriate results to other MCCs. The USMCC acts as the main system operational contact point between the SARSAT system and the CMC.

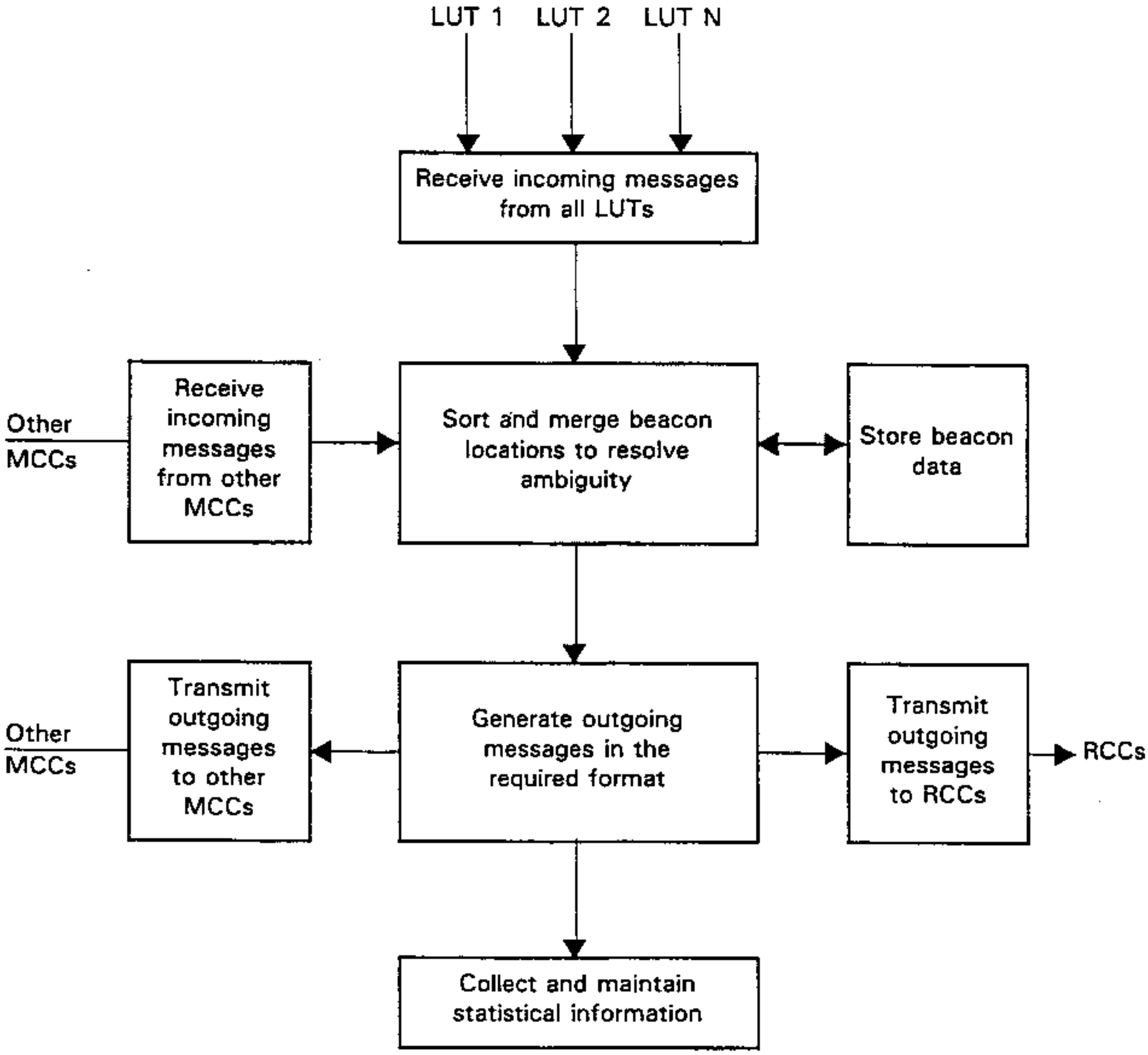

Figure 11 - *Functions of MCCs*

System performance and operations

Performance parameters

3.3.30 The following parameters are particularly important for the user:

- EPIRB detection probability;
- EPIRB location probability;
- EPIRB location error;
- ambiguity resolution;
- capacity;
- coverage; and
- notification time.

.1 *EPIRB detection probability* for the 406 MHz satellite EPIRB is defined as the probability of detection by LUT of at least one message with a correct code-protected section from the first tracked satellite.

.2 *EPIRB location probability* for the 406 MHz satellite EPIRB is defined as the probability of detecting and decoding at least four individual message bursts during a single satellite pass so that a Doppler curve-set estimate can be generated by the LUT. At 121.5 MHz, EPIRB location probability is defined as the probability of location during a satellite pass above 10° elevation with respect to the beacon. EPIRB location probability relates to the two solutions ("true" and "mirror") and not to a single unambiguous result.

.3 *EPIRB location error* is defined as the difference between the location calculated by the system using measured Doppler frequencies and the actual location.

.4 *Ambiguity resolution probability* is defined as the ability of the system to select the "true" rather than the "mirror" location.

.5 *Capacity* is defined as the number of EPIRBs in common view of the spacecraft which the system can process simultaneously.

.6 *Notification time* is the period from activation of an EPIRB (i.e. first transmission) to reception of a valid alert message by the appropriate RCC.

Performance of the COSPAS–SARSAT system

.3.31 The system performance characteristics are given in table 1.

Note: Performance at 121.5 MHz is highly sensitive to EPIRB spectral characteristics. The values given below were confirmed by statistical analysis of over 5,000 beacons during the development and experiment phase.

Table 1

Characteristic	121.5 MHz	406 MHz
Detection probability	(not applicable)	0.98
Location probability	0.9	0.9
Location accuracy	17.2 km	90% within 5 km
Ambiguity resolution	0.73	0.96
Capacity	10	90

.1 Coverage: The 121.5 MHz system operates in real-time only, while the 406 MHz system operates in both real-time and global modes. The overall coverage provided by the COSPAS–SARSAT system in real-time mode is determined by the number and positions of LUTs, each covering an area with a radius of approximately 2,500 km.

The real-time coverage of LUTs is shown in the COSPAS–SARSAT system status in annex 6. In the global coverage mode using 406 MHz satellite EPIRBs, complete world coverage is achieved.

.2 Notification time depends on the following parameters:

- satellite constellation;
- LUT configuration;
- beacon location relative to an LUT;
- beacon latitude; and
- ground communication network.

Operational procedures

3.3.32 This section provides a description of alert data and system information and a general description of data flow.

Alert data

3.3.33 *Alert data* users are defined as those responsible for SAR operations; *system information* users are primarily organizations with technical responsibility for the COSPAS–SARSAT system (MCCs, LUT operators, managers of ground segment facilities).

3.3.34 Alert data are of two types: coded beacon-generated messages and LUT/MCC-generated alert messages. Signals transmitted by activated EPIRBs provide the initial input which triggers the generation of alert messages. Once the incoming coded EPIRB message has been received and processed by the LUTs, the alert data are forwarded to the national MCC for distribution.

3.3.35 Each MCC distributes alert data according to its own requirements and procedures to any country within its service area which has agreed to accept such data. These data are given to SAR authorities so that immediate SAR action can be taken. Additionally, any MCC receiving alert data relating to an EPIRB within another MCC's service area or elsewhere in the world relays that information to the appropriate MCC or SAR authority.

System information

3.3.36 The term *system information* covers five types of system messages - ephemeris messages, time calibration messages, telemetry data, satellite command and co-ordination messages:

- Ephemeris or orbit vector information is used to acquire and track the satellite and to compute EPIRB positions.
- Spacecraft time calibration is vital for the accurate determination of EPIRB locations.
- Telemetry data provides for information on the status of the on-board SAR instruments.
- Satellite command messages are transmitted on uplink during the post-launch checkout procedure to correct faults or out-of-limit conditions.
- Co-ordination messages are used to communicate general information required for COSPAS-SARSAT system operation.

Communications network

3.3.37 Each MCC transfers alert data and system information to ground system elements within its service area according to communications network requirements and procedures.

Message formats

3.3.38 Messages between MCCs are sent in a specific format permitting automatic processing and retransmission, while messages between MCCs and their LUTs are formatted in accordance with national requirements. Standard message formats are used to transmit alert data to RCCs outside the COSPAS–SARSAT system.

3.4 Digital selective calling system

Introduction

3.4.1 Digital selective calling (DSC) is an integral part of the GMDSS and is used for transmitting distress alerts from ships and for transmitting the associated acknowledgements from coast stations. It is also used by ships and coast stations for relaying distress alerts and for other urgency and safety calls. Trials of DSC systems were co-ordinated by the CCIR Interim Working Party 8/10 during 1982 – 1986 and included tests of the HF, MF and VHF DSC systems. The distribution of VHF, MF and HF DSC coast stations is given in the GMDSS Master Plan in annex 5.

Basic description of DSC

Technical characteristics

3.4.2 The system is a synchronous system using a ten-unit error-detecting code. The information in the call is presented as a sequence of seven-unit binary combinations.

3.4.3 The classes of emission, frequency shifts and modulation rates are as follows:

- F1B or J2B 170 Hz and 100 baud for use on HF and MF channels. When frequency-shift keying is effected by applying audio signals to the input of single-sideband transmitters (J2B), the centre of the audio-frequency spectrum offered to the transmitter is 1700 Hz.
- Frequency modulation with a pre-emphasis of 6 dB/octave with frequency-shift of the modulating sub-carrier for use on VHF channels:
  - the frequency-shift is between 1300 Hz and 2100 Hz, the sub-carrier being at 1700 Hz;
  - the frequency tolerance of the 1300 Hz and 2100 Hz tones is ± 10 Hz;
  - the modulation rate is 1,200 baud; and
  - the modulation index is 2.0 ± 10%.

3.4.4 More detailed technical characteristics of DSC including signal format are given in annexes 3-2-1, -2, -3 and -4.*

Operational procedures

3.4.5 CCIR Rec. 541** gives operational procedures of the DSC system. The content of a DSC call includes the numerical address of the station (or stations) to which the call is transmitted, the self-identification of the transmitting station and a message which contains several fields of information indicating the purpose of the call.

* Resolutions A.609(15), A.610(15) and A.613(15), and CCIR Rec. 493.

** Annex 3-2-5. See also RR Art. N39 (annex 9.4).

3.4.6 Various types of DSC calls are available, being broadly either distress and safety-related calls or "commercial" calls (to indicate that a commercial communication, e.g. a telephony or telegraphy call, etc., is required). In the case of VHF, automatic connection to the public network can also be established through suitably equipped coast stations.

3.4.7 The receipt of a DSC call by a receiving station is accompanied by a suitable display or printout of the address, the self-identification of the transmitting station and the content of the DSC message, together with an audible or visual alarm or both for certain categories of calls (e.g. for distress and safety related calls).

3.4.8 The transmission speed of a DSC call is 100 baud on MF and HF and 1,200 baud on VHF. Error-correction coding is included involving the transmission of each character twice, together with an overall message-check character. The duration of a single DSC call varies between 6.2 and 7.2 seconds on MF and HF or 0.45 and 0.63 seconds on VHF depending on the type of DSC call transmitted.

3.4.9 For distress and safety operation simplex frequencies are used, there being one frequency in the MF band, five in the HF bands and one in the VHF band (these frequencies are given in annex 9.3). For commercial operation at MF and HF paired frequencies are used, but at VHF the simplex channel 70 is used for both distress and safety and commercial calling.

3.4.10 In order to increase the probability of a DSC distress call or a DSC distress relay being received it is repeated several times to form a *distress call attempt*. On MF and HF two types of distress call attempts may be used, either a *single frequency call attempt** (five consecutive DSC distress calls on one frequency) or a *multi-frequency call attempt** (up to six consecutive DSC distress calls dispersed over any of the six DSC distress frequencies – one on MF and five on HF). On VHF only a single-frequency call attempt is used since there is only one VHF DSC frequency (channel 70). VHF and MF/HF distress calls may be transmitted simultaneously.

3.4.11 The various distress and safety-related calls by DSC are itemized below, together with a description of the content of the message for each type of call. In addition to the message content, each DSC call also contains other information, which is not displayed to the receiving station but which is used to ensure the technical integrity of the DSC system. Signal format in the various DSC calls is specified in CCIR Rec.493.**

Distress call (alert)

3.4.12 DSC distress calls are transmitted by a ship in distress and will be received by all suitably equipped ships and coast stations within propagation range of the radio frequency used.

3.4.13 A DSC distress call contains various items of information including the self-identification of the ship in distress, which will be displayed to the receiving station. This information will either be automatically included in the transmitted DSC distress call or will be inserted by the operator prior to transmission. When time does not permit the insertion of any information, "default" information will be included automatically.

Distress acknowledgement

3.4.14 Distress acknowledgements by DSC are normally transmitted manually by coast stations in response to a DSC distress call on the same frequency as the distress call was received (RR N3129, N3130***). However, a distress alert may be acknowledged by ship stations when they believe that no coast station is likely to be able to acknowledge it (RR N3132, N3133 and N3124***). In this case, the acknowledgement is made by radiotelephony on the associated radiotelephone distress and safety traffic frequency.****

* See CCIR Rec.541, paragraphs 3.1.3.1 and 3.1.3.2 (annex 3-2-5).
** Annex 3-2-4.
*** See annex 9.4.
**** CCIR Rec.541, paragraph 3.3.5 (see annex 3-2-5).

)istress relay

.4.15 DSC distress relays are transmitted in the following two situations:

.1 By a coast station to alert ships in the area of a distress incident. Such a relay transmission would be addressed, as appropriate, to all ships, to a selected group of ships or to a specific ship (RR N3117*).

.2 By a ship station to an appropriate coast station if it received a DSC distress call on an HF frequency and it was not acknowledged by a coast station within 3 minutes (RR N3134*).

.4.16 The distress relay is transmitted as either a single-frequency or a multi-frequency call attempt.

.4.17 If a ship receives a DSC distress relay addressed to ships in a particular geographical area,** then he display or print-out and alarm will not be activated if geographical co-ordinates inserted manually or y navigational interface into the receiving ship station's DSC equipment processor lie outside the addressed eographical area.

)SC distress call repetitions and acknowledgement transmissions

.4.18 If no distress acknowledgement is received in response to a DSC distress call transmission, then the hip in distress may repeat the DSC distress call attempt (on different DSC distress frequencies if desired) ifter a delay of between 3.5 and 4.5 minutes from the beginning of the initial call.*** This delay allows ime for any acknowledgement to be received.

.4.19 A coast station receiving a DSC distress call on MF or HF should transmit a DSC distress icknowledgement after a minimum delay of 1 minute after receipt of the distress call, normally within a naximum delay of 2.75 minutes. On VHF a DSC distress acknowledgement should be transmitted as soon is practicable.****

Reception of DSC calls

3.4.20 All DSC distress-related calls transmitted on MF and HF contain, at the beginning of each single call, a 200-bit 100-baud (i.e. 2 seconds) dot pattern to allow the use of scanning receivers on board ships. When used, a scanning receiver should be set to scan only the desired DSC distress frequencies, i.e. selected from the one MF frequency and the five HF frequencies.

3.4.21 It is important to ensure that, where a scanning receiver is used, all selected frequencies are scanned within 2 seconds, and the dwell time on each frequency should be adequate to allow detection of the dot pattern. The scan should only stop on detection of a 100-baud dot pattern. It is advisable that coast stations are able to receive more than one DSC distress-related call simultaneously on different frequencies, and scanning receivers should therefore not be used at coast stations.

DSC shipborne equipment

3.4.22 Figure 12 shows an example of a DSC control unit which, together with suitable VHF or MF/HF radio equipment, provides a complete shipborne radio system for automatic or manual operation within the DSC system for use in the maritime mobile services.

* See annex 9.4
** CCIR Rec.493, paragraph 5.3 (see annex 3-2-4).
*** CCIR Rec.541, paragraph 3.1.3 (see annex 3-2-5).
**** CCIR Rec.541, paragraph 3.3.1 (see annex 3-2-5).

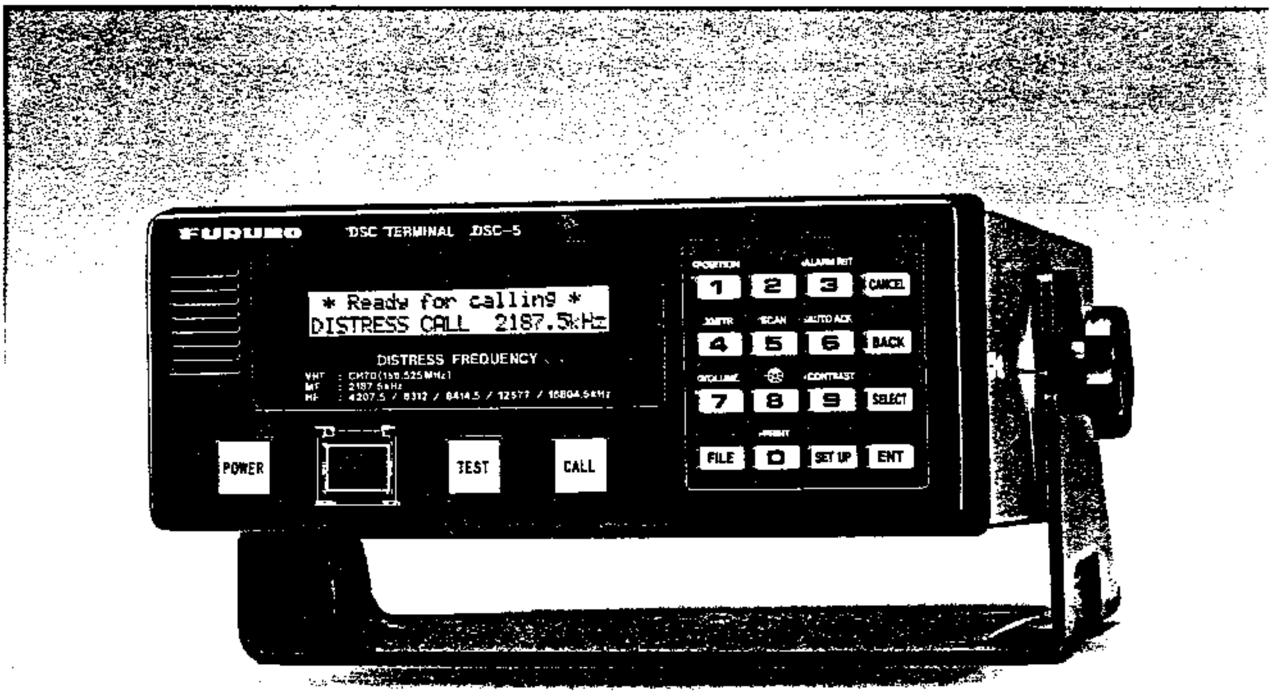

Figure 12 - *Example of a DSC control unit*

3.4.23 The unit consists of a modem and a signal coder/decoder for producing DSC signals; it also contains a central processor unit for creating the different call formats, etc.

3.4.24 In addition, the unit includes an interface sub-unit, enabling automatic channel control of the connected VHF radio equipment, hard-copy printing of messages, and data collection from, for example, the navigational equipment on board the ship.

3.4.25 The unit also contains an audio alarm giving an acoustic alarm when a DSC message is received.

3.4.26 The information contained in the received DSC message is decoded and displayed on the front panel LCD display. This information may be stored in an internal memory.

3.4.27 When receiving DSC messages other than a distress, urgency and safety call, the control unit provides for an automatic transmission acknowledging the call received.

3.4.28 Transmission of a distress call by VHF DSC from the ship in distress can be initiated by simply pushing the distress button on the front panel of the control unit. The control unit also provides a function for including additional information concerning the distress situation in the distress message. Once initiated, the distress call is automatically repeated at intervals of about 4 minutes* until acknowledged by another station or interrupted manually.

3.4.29 By using the keypad on the front panel of the control unit, the operator can compose different types of DSC message. In the case of VHF, the operator may, for individual DSC messages to a coast station, include in the message the telephone number of the land subscriber, thus providing for the use of semi-automatic VHF systems expected to be implemented at coast stations in the future.

* See CCIR Rec.541, paragraphs 3.1.3.1 and 3.1.3.2 (see annex 3-2-5).

3.4.30 The control unit includes an internal register enabling the operator to store, for example, identity numbers of the coast stations with which the ship often operates. Also, telephone numbers of land subscribers may be stored in the register. These facilities make it possible for the operator to use abbreviated forms when composing DSC messages to coast stations.

3.5 Search and rescue radar transponders

Introduction

3.5.1 Search and rescue radar transponders (SARTs) are the main means in the GMDSS for locating ships in distress or their survival craft, and their carriage on board ships is mandatory (regulations III/6.22 and IV/7.1.3). The SART operates in the 9 GHz frequency band and generates a series of response signals on being interrogated by any ordinary 9 GHz shipborne radar or suitable airborne radar. No modification is needed to a ship's radar equipment for detecting SART signals. SARTs can be either portable, for use on board ship or carrying into any survival craft, installed on the ship and in each survival craft, or so as to operate after floating free from the sinking ship (figure 13). They may also be incorporated into a float-free satellite EPIRB. Technical details of SARTs are given in annexes 3-6-1 and 3-6-6.*

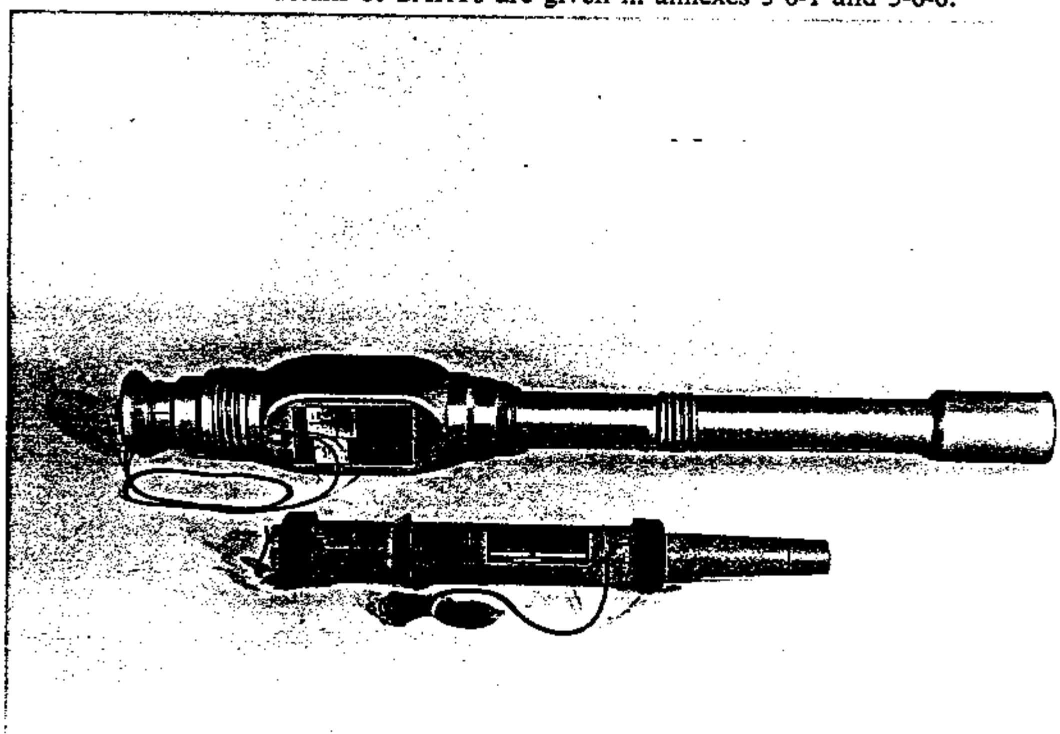

Figure 13 - *Search and rescue radar transponder*

Operational and technical characteristics

3.5.2 The SART can be activated manually or automatically when placed into the water so that it will thereafter respond when interrogated.

* Resolution A.697(17) and CCIR Rec.628.

3.5.3 When activated in a distress situation the SART responds to radar interrogation by transmitting a swept frequency signal which generates a line of blip code (figure 14) on a radar screen outward from the SART's position along its line of bearing.* This unique radar signal is easily recognized on the radar screen and the rescue vessel (an aircraft, if equipped with suitable radar) can detect the survivors even in poor visibility or at night.

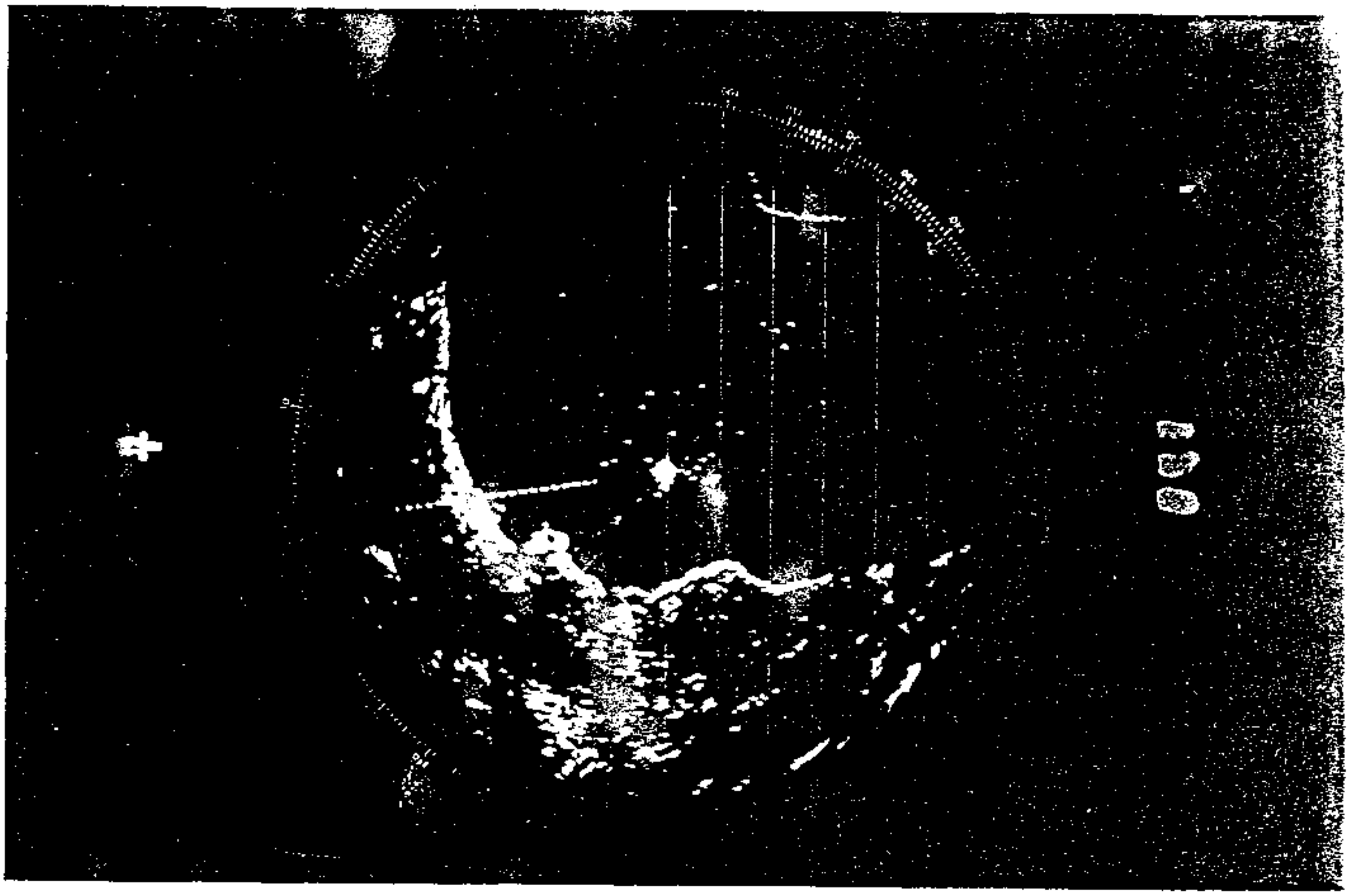

Figure 14 – *SART blip code on a radar screen*

3.5.4 The SART provides a visual or audible indication of its correct operation and will also inform survivors when it is interrogated by a radar.

3.5.5 The SART will have sufficient battery capacity to operate in the stand-by condition for 96 hours and will be able to operate under ambient temperatures of −20°C to +55°C.

3.5.6 The vertical polar diagram of the antenna and hydrodynamic characteristics of the device will permit the SART to respond to radars under heavy swell conditions. SART transmission is substantially omni-directional in the horizontal plane.

* See resolution A.530(13) (see ... 6-5).

3.6 Equipment performance standards

In order to ensure proper operation, radio equipment carried in the GMDSS is required to be type-approved by Administrations in accordance with the performance standards developed by IMO (regulation IV/14). These standards, in addition to requiring the radio equipment to comply with the relevant CCIR recommendations, define various operational requirements to be met.

3.7 Maritime safety information system

Introduction

3.7.1 The World-Wide Navigational Warning Service (WWNWS) was established by IMO and IHO for the purpose of co-ordinating the transmission of navigational warnings to ships in co-ordinated geographical areas (NAVAREAs*). In the GMDSS, the WWNWS was included in the systems developed for the promulgation of maritime safety information (MSI).

3.7.2 Radio systems to be used internationally for the promulgation of MSI in the GMDSS and for which requirements have been included in SOLAS chapter IV** are:

- the International NAVTEX system;
- the INMARSAT SafetyNET system; and
- HF narrow-band direct-printing (NBDP) which may be used to augment these systems (under development***)

3.7.3 The HF Morse telegraphy system which is currently used for broadcasts of NAVAREA warnings will be superseded by the above automated systems during the implementation periods of the GMDSS.

3.7.4 Annex 4 gives more details of the co-ordination of various MSI systems.

The international NAVTEX system

3.7.5 This system is an international direct-printing service for promulgation of MSI in the English language, pertaining to coastal waters up to about 400 miles offshore. Unlike NAVAREA warnings, which are tailored for international sea commerce on or near main shipping lanes, NAVTEX carries information relevant to all sizes and types of vessels within a region established for this service. It also carries routine meteorological forecasts and warnings and other urgent safety information to ships. A selective message-rejection feature of the receiver allows the mariner to receive only that safety information pertinent to his requirements.

3.7.6 Procedures to be followed by Administrations and the International Frequency Registration Board (IFRB) for co-ordination of the planned used of the frequency 518 kHz in the international NAVTEX system are contained in RR Article 14A.

3.7.7 The existing NAVAREAs are used as regions for planning and co-ordination of the international NAVTEX service. To assist such planning and advise IMO on the progress and on solutions to problems of system expansion, IMO has established the NAVTEX co-ordinating panel, which reports to the IMO Sub-Committee on Radiocommunications. Operational and planned international NAVTEX service is given in the GMDSS Master Plan in annex 5.

3.7.8 NAVTEX is a single-frequency broadcast system; the frequency 518 kHz is used for this purpose.**** Mutual interference will be avoided by limiting the transmitter power to that necessary for coverage of the assigned area and by co-ordinating the broadcast schedules. MSI on the international NAVTEX service is

* See annex 4-1 (WWNWS).
** See annex 2-14 (resolution A.706(17)). See also annexes 3-5-3, -4 and -6.
*** See annex 3-5-4 (resolution A.700(17)).
**** See RR Art. 14A, N2969 and N2970 (annexes 9-1 and 9-3).

broadcast in English. A dedicated receiver/processor (figure 15) is used for the reception of NAVTEX broadcasts. Details of the system are contained in the NAVTEX Manual, given in annex 4-2. For the technical characteristics of NAVTEX receivers, see annexes 3-5-1 (resolution A.525(13)) and 3-5-5 (CCIR Rec. 540).

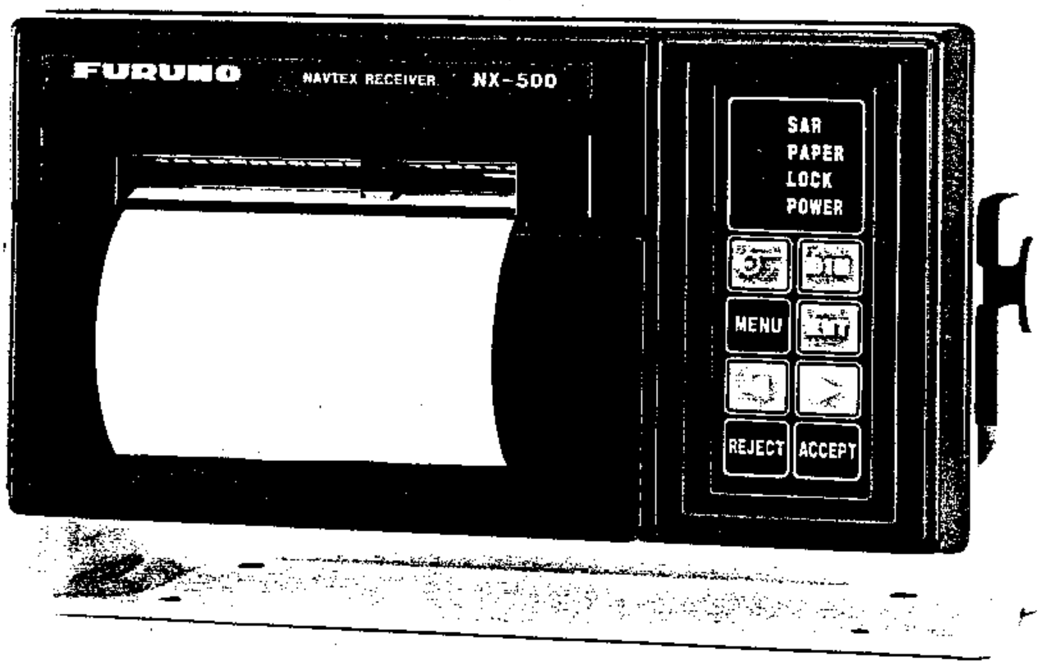

Figure 15 - *Example of NAVTEX receiver*

Enhanced group call system

3.7.9 The enhanced group call (EGC) (SafetyNET*) system, which was developed by INMARSAT, enables the provision of a unique global automated service capable of addressing messages to pre-determined groups of ships or all vessels in both fixed and variable geographical areas.

3.7.10 The system is able to meet requirements of broadcasting global, regional or local navigational warnings, meteorological warnings and forecasts and shore-to-ship distress alerts to any region within INMARSAT satellite coverage. In addition to covering the mid-ocean areas, the SafetyNET system can also provide an automated service in coastal waters where it may not be feasible to establish the NAVTEX service or where shipping density is too low to warrant its implementation.

3.7.11 A particularly useful feature is the ability to direct a call to a given geographical area. The area may be fixed, as in the case of a NAVAREA or weather forecast area, or it may be uniquely defined. This is useful for messages, such as a local storm warning or a shore-to-ship distress alert, for which it is inappropriate to alert all ships in the satellite coverage area.

3.7.12 SafetyNET messages originate from registered information providers anywhere in the world and are broadcast to the appropriate ocean region via a CES. Messages are transmitted by the CES according to their priority, e.g. distress, urgency, safety and routine.

* *Note:* SafetyNET and FleetNET are registered trademarks of INMARSAT.

3.7.13 Aboard ship, SafetyNET messages will be received either via a dedicated receiver (figure 16) or via an optional receiver integrated in INMARSAT SES equipment. Upon reception of messages of distress or urgency category, aural and visual alarms are activated and they can only be reset manually. Performance standards for the EGC receiver are given in annex 3-5-2.

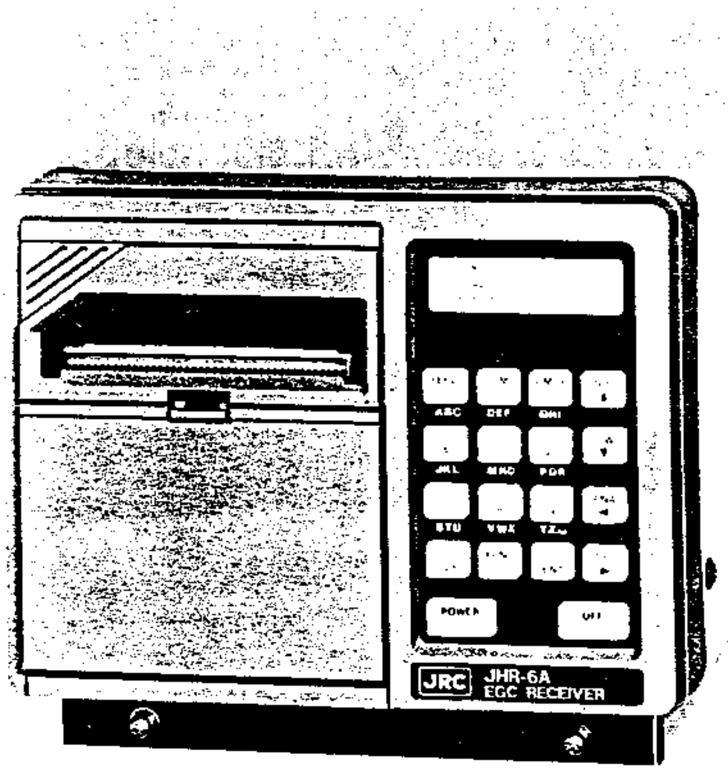

Figure 16 - *INMARSAT EGC SafetyNET receiver*

3.7.14 IMO has established an international SafetyNET co-ordinating panel for the purpose of co-ordinating the development and the use of the international SafetyNET system for promulgating MSI. More details of the system are contained in the Draft International SafetyNET Manual, given in annex 4-3.

Part 4
GMDSS equipment carriage requirements

4.1 All the ships to which the 1974 SOLAS Convention, as amended in 1988, applies, are required to carry the GMDSS radio equipment, depending on the sea areas in which they operate, prescribed in the Convention (given in annex 1).

4.2 One of the basic principles on which the GMDSS carriage requirements is based is (as prescribed in regulation IV/4) a functional requirement to ensure the capability of transmitting ship-to-shore distress alerts by at least two separate and independent means. The capability of performing other communications functions is also required. Regulations IV/7 – IV/11 regulate the specific carriage requirements for ships according to the sea area(s) in which they operate.

4.3 Carriage requirements for GMDSS radio equipment can be summarized as follows:

- sea area A1 ships will carry VHF equipment and either a satellite EPIRB or a VHF EPIRB;
- sea area A2 ships will carry VHF and MF equipment and a satellite EPIRB;
- sea area A3 ships will carry VHF, MF, a satellite EPIRB and either HF or satellite communication equipment;
- sea area A4 ships will carry VHF, MF and HF equipment and a satellite EPIRB; and
- all ships will carry equipment for receiving MSI broadcasts.

4.4 The 1974 SOLAS Convention, as amended in 1988, sets out the time frame for installing the GMDSS radio equipment (regulation IV/1), taking into account system amortization, operational continuity, personnel training, etc. To this end, the following transitional approach for the implementation of the GMDSS is given:

- all ships constructed after 1 February 1992 to be fitted with a radar transponder and two-way VHF radiotelephone apparatus for survival craft;
- all ships to be fitted with a NAVTEX receiver and a satellite EPIRB by 1 August 1993;
- all ships constructed before 1 February 1992 to be fitted with a radar transponder and two-way VHF radiotelephone apparatus for survival craft by 1 February 1995;
- all ships constructed after 1 February 1995 to comply with all the appropriate requirements for the GMDSS;
- all ships to be fitted with at least one radar capable of operating in the 9 GHz band by 1 February 1995; and
- all ships to comply with the appropriate requirements for the GMDSS by 1 February 1999.

4.5 Ships which are not required to comply with the 1974 SOLAS Convention are recommended to comply with the guidelines for the participation of non-Convention ships in the GMDSS (MSC/Circ.469), given in annex 7-7.

4.6 Amendments to the following instruments are under consideration by IMO for their compatibility with the GMDSS:

- Torremolinos International Convention for the Safety of Fishing Vessels, 1977;
- Code for the Construction and Equipment of Mobile Offshore Drilling Units;
- Code of Safety for Dynamically Supported Craft;
- FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels; and
- FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels.

Part 5
Operational procedures for the GMDSS

.1 Operational procedures for distress, safety and urgency communications in the GMDSS are prescribed n the Radio Regulations, Articles N39 and N40, given in annexes 9-3 and 9-4, respectively.

.2 The following documents, reproduced in annex 3, give detailed operational procedures for GMDSS adio equipment:

- Operational procedures for the use of digital selective calling equipment in the maritime mobile service (CCIR Rec. 541, annex 3-2-5);
- Operational procedures for the use of direct-printing telegraph equipment in the maritime mobile service (CCIR Rec. 492, annex 3-2-9); and
- Operational and technical characteristics for an automated direct-printing telegraph system for promulgation of navigational and meteorological warnings and urgent information to ships (CCIR Rec. 540, annex 3-5-5).

5.3 Actions to be taken by masters of ships in distress situations are summarized in annex 8-12 (GMDSS operating guidance for shipmasters - COM/Circ.108).

Part 6
Shore-based SAR communication network and operation

6.1 To exploit the full advantages of globally integrated satellite and terrestrial communications, the GMDSS necessitates the establishment of an efficient communication network between RCCs. This will consist of interconnecting links between RCCs in accordance with arrangements made by IMO in support of the 1979 SAR Convention. In addition, each RCC will need rapid and effective communication links with its associated coast stations, INMARSAT CESs and COSPAS-SARSAT MCCs.

6.2 The interconnecting links between RCCs will usually be implemented using the public switched networks or dedicated circuits. Some RCCs, particularly those not having sufficient access to the public switched networks, may use an INMARSAT SES to assist in the rapid exchange of distress and safety information between RCCs (RR N2938*).

6.3 The communications network for the future system and associated SAR procedures will be flexible enough to satisfy many levels of international SAR co-ordination from the ideal of ocean areas where a SAR plan** is operational, through many variations in the designation of search and rescue regions (SRR) and provision of SAR facilities, to the worst cases where no responsibility has been assumed for, nor facilities provided in, a specific area.

6.4 SAR action in response to any distress situation will be achieved through co-operation among SAR administrations which are able to provide assistance.

6.5 The shore station nearest to the reported distress position should, whenever possible, acknowledge the alert. Other shore stations receiving the alert should acknowledge it if the nearest station does not appear to respond. The shore station which acknowledges the alert must establish and maintain communications with the ship in distress until relieved of this duty.

6.6 The *first RCC*, which is the RCC affiliated with the shore station which first acknowledged the alert, should assume responsibility for all subsequent co-ordination of SAR measures unless and until that responsibility is accepted by another RCC which is in a better position to assist.

6.7 If it is not at once clear which RCC has become the first RCC because more than one shore station has acknowledged the alert, the RCCs concerned should, as soon as possible, agree which is to become the first RCC so that the incident is responded to promptly. Follow-up action by the first RCC to co-ordinate SAR activities or to refer action to a more suitable RCC should also be carried out promptly.

6.8 A flow-chart for communications and procedures, illustrating the actions to be taken by the first RCC, is given in figure 17.

* See annex 9.2.

** Pursuant to the 1979 SAR Convention, IMO is developing a global SAR plan to co-ordinate search and rescue services in all maritime areas through bilateral or multilateral agreements among coastal states.

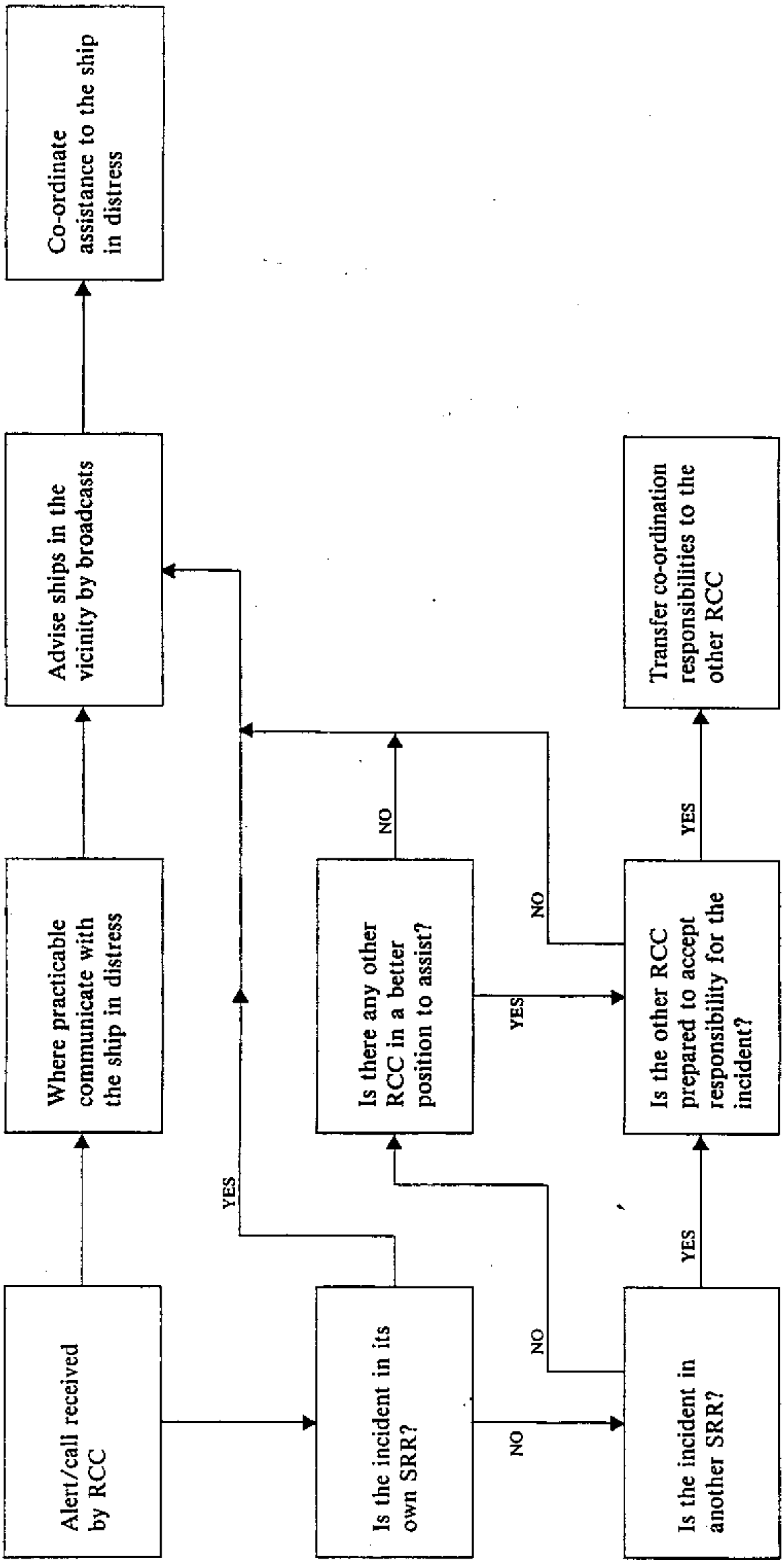

Figure 17 – *Actions by the "First RCC"*

Part 7
Master Plan for the GMDSS

In order to provide information on shore-based facilities for space and terrestrial communication services for the GMDSS, the information provided by Governments in accordance with regulation IV/5.2 of the 1988 SOLAS amendments, in response to MSC/Circ.468 or revisions thereof,* is being included by IMO in the Master Plan for the GMDSS (GMDSS/Circ.1 as it may be revised) given at annex 5.

The Master Plan includes:

.1 the list of VHF coast stations for sea area A1;

.2 the list of MF coast stations for sea area A2;

.3 the list of HF coast stations for sea areas A3 and A4;

.4 the list of INMARSAT CESs;

.5 the list of COSPAS-SARSAT MCCs;

.6 operational and planned NAVTEX services;

.7 distress message routeing in the INMARSAT/RCC ship-to-shore distress alerting networks;

.8 SESs commissioned for RCC operations;

.9 HF NBDP MSI broadcast schedule;

.10 the list of proposed and operational SafetyNET services;

.11 maritime SAR regions, RCCs and associated shore-based facilities; and

.12 information on shore-based facilities in the GMDSS.

* See annex 7-6.

Part 8
Maintenance of equipment in the GMDSS

8.1 In the GMDSS, ships are not necessarily required to carry radio personnel on board for the purpose of the maintenance of equipment. The following are three options which ships may choose as methods to ensure the availability of equipment:

- duplication of equipment;
- shore-based maintenance;
- at-sea electronic maintenance capability (on-board maintenance).

8.2 As prescribed in regulation IV/15.7 of the 1988 SOLAS amendments, for ships which navigate in GMDSS sea areas A1 or A2, availability shall be ensured by using at least one of the three methods; ships which navigate in sea areas A3 and A4 shall employ a combination of at least two of the above three options.

8.3 SOLAS regulation IV/15.7 requires Administrations to take into account the recommendations of IMO when they nationally approve the methods to be employed in order to ensure availability in sea areas A3 and A4.* The recommendations of IMO are given in annex 2-10 (resolution A.702(17)).

* Also see annex 8-9 (COM/Circ.105): "Clarifications of certain provisions of the 1988 SOLAS amendments for the GMDSS".

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