Advanced Communications Project

Technology Assessment of U.S.C.G. Long-Range Communications Alternatives

Prepared for
The United States Coast Guard
Research & Development Center
1082 Shennecossett Rd.
Groton, CT 06340-6096

By
Ogden Government Services / SEMCOR Inc. Team

March 1995

TABLE OF CONTENTS

Section		Page
SECTION I	**INTRODUCTION AND SUMMARY**	1
1.0	**INTRODUCTION**	1
1.1	**SCOPE**	1
1.1.1	Overview	1
1.2	**SUMMARY**	1
1.2.1	Message Server Benefits	3
1.2.2	Cost Comparison of Messaging	4
1.2.3	INMARSAT-A With Message Server Enhancement	4
1.3	**CONCLUSIONS**	5
1.3.1	What HF Radio Capability for USCG to Retain	5
1.3.1.1	*Primary/Back-up HF Systems for USCG Communications*	7
1.3.1.2	*Interoperability with DoD*	7
1.3.1.3	*Interoperability with Commercial Maritime/Distress Systems*	7
1.3.2	Best Technical Alternative	7
1.3.2.1	*Ship-Shore*	7
1.3.2.2	*Air-Ground*	8
1.3.3	Best Cost-Effective Alternative	8
SECTION II	**TECHNOLOGY ASSESSMENT OF LONG-RANGE COMMUNICATIONS ALTERNATIVES**	11
2.0	**INTRODUCTION**	11
2.1	**U.S. NAVY POLICY AND PLANS**	11
2.1.1	HF Policy and Plans	11
2.1.2	SATCOM Architecture	13
2.1.2.1	*UHF SATCOM*	13
2.1.2.2	*SHF SATCOM*	13
2.1.2.3	*EHF SATCOM*	13
2.1.2.4	*Commercial SATCOM*	13
2.2	**REQUIREMENTS, INTEROPERABILITY, AND SHORE ACCESS CONSIDERATIONS**	14
2.2.1	USCG Long-Range Communications Requirements	14

TABLE OF CONTENTS (Contined)

Section		Page
2.2.1.1	*Global Worldwide Communications Requirements*	14
2.2.1.2	*Maritime Distress and Safety*	15
2.2.1.3	*Coast Guard Internal Communications/Interface with CGDN*	15
2.2.1.1	*Voice Requirements*	16
2.2.1.1	*Data Requirements*	16
2.2.2	Interoperability	17
2.2.3	Shore Network Access Alternatives	17
2.3	HF TECHNOLOGY ASSESSMENT	19
2.3.1	Coast Guard Capabilities	19
2.3.1.1	*Ships/Cutters*	19
2.3.1.2	*Aircraft*	20
2.3.1.3	*Shore*	20
2.3.2	Technology	20
2.3.2.1	*Narrowband HF*	21
2.3.2.1.1	HF Transmitters	21
2.3.2.1.2	HFRG Narrowband	22
2.3.2.1.3	HF Transceivers	22
2.3.2.1.4	Receivers	23
2.3.2.1.5	RF Path Communications Decision Aids	23
2.3.2.1.6	Wideband HF	24
2.3.2.1.7	Fast-Tuning Coupler/Multicouplers	25
2.3.2.1.8	Frequency Agile Wideband Systems	26
2.3.2.1.9	Antenna Applications and Antennas	27
2.3.2.1.10	Near Vertical Incidence Skywave (NVIS) Application	27
2.3.2.1.11	HF Loop Antennas	27
2.3.2.1.12	HF Adaptive Antenna Receiving System (HFAARS)	28
2.3.3	High Data Rate Technology	28
2.3.3.1	*Serial-Tone Modems (STMs)*	28
2.3.3.2	*Multitone Modems*	29
2.3.3.2.1	16-Tone Differential Phase Shift-Keyed (DPSK) Modems	29
2.3.3.2.2	39-Tone Parallel Mode Modems	29
2.3.3.2.3	A Comparison of STMs and 39-Tone Parallel Mode Modems	29
2.3.3.3	*AN/USQ-122 High Speed Fleet Broadcast/High Frequency Data System (HSFB/HFDS)*	30
2.3.3.4	Imagery and Video Compression/Transmissions	31
2.3.3.4.1	Image Compression	31
2.3.3.4.2	Voice, Video, Facsimile, and Data (VVFD)	32

TABLE OF CONTENTS (Contined)

Section		Page
2.3.4	Link Establishment Technology	33
2.3.4.1	*Automatic Link Establishment (ALE)*	33
2.3.4.1.1	Automatic ALE	34
2.3.4.1.2	Automatic Receive, Manual Transmit ALE	34
2.3.4.2	*Sounding Technologies*	35
2.3.4.2.1	Chirp Sounding	35
2.3.4.2.2	ALE Sounding	35
2.3.5	Integrated Network Technology Applications	36
2.3.5.1	*BG E-Mail Technology*	36
2.3.5.2	*RF Integrated Networks*	36
2.3.5.2.1	Adaptive Code Combining	37
2.3.5.2.2	Multiple-Channel Routing	37
2.3.5.2.3	Applicability to the Coast Guard	37
2.3.6	Meteor Burst Communications (MBC)	37
2.3.7	Conclusions	38
2.3.7.1	*HF Data Exchange Technologies*	38
2.3.7.1.1	HF Transmission/Reception Equipment	39
2.3.7.1.2	HF Serial-Tone Modems	39
2.3.7.1.3	File Exchange Protocols	39
2.3.7.1.4	Automatic Link Establishment	40
2.3.7.1.5	HF Access to AUTODIN, DCS, and CGDN	40
2.3.7.2	*HF Voice Exchange Technologies*	40
2.3.7.2.1	Automation	40
2.3.7.2.2	Secure Voice	41
2.3.7.2.3	Automatic Operations	41
2.3.7.3	*Constraints*	41
2.3.7.4	*Options for Coast Guard Communications Stations*	41
2.3.7.4.1	HF Data	41
2.3.7.4.2	HF Voice	42
2.3.7.5	*Summary of Conclusions*	42
2.4	SATELLITE TECHNOLOGY ASSESSMENT	44
2.4.1	Coast Guard Current and Planned Satellite Communications Capabilities	44
2.4.2	USCG Owned and Operated Communications Satellite System	44
2.4.3	Military Satellite Communications (MILSATCOM) Systems	45
2.4.3.1	*EHF MILSATCOM*	45

TABLE OF CONTENTS (Contined)

Section		Page
2.4.3.2	*UHF MILSATCOM*	47
2.4.3.3	*SHF MILSATCOM*	50
2.4.4	Commercial Satellite Systems	53
2.4.4.1	*International Maritime Satellite (INMARSAT) System*	53
2.4.4.2	*American Mobile Satellite Communications (AMSC)*	59
2.4.4.3	*Wideband Mobile Services*	60
2.4.4.4	*Direct Broadcast Satellite (DBS) Systems*	61
2.4.4.5	*Portable Satellite Terminal (PoST)*	62
2.4.4.6	*Low Earth Orbit Satellites*	63
2.4.4.7	*Radio Determination Satellite Service (RDSS) SATCOM*	64
2.4.4.8	*Adaptive Multiplexer*	66
2.4.5	Coast Guard Leased SATCOM Alternatives	67
2.4.6	SATCOM Conclusions	68
2.5	ANALYSIS OF ALTERNATIVES	69
2.5.1	Transmission Systems	69
2.5.1.1	*High Frequency Radio Systems*	69
2.5.1.2	*Satellite Communications (SATCOM) Systems*	69
2.5.2	Analysis of Required Features and Services	70
2.5.2.1	*Features and Services*	72
2.5.2.2	*Discussion of Alternatives*	72
2.5.3	What HF Technology to Retain	75
2.5.4	What HF to Retain	75
2.5.5	Capability, Cost and Benefits of HF Radio Alternatives	76
2.5.5.1	*Current USCG HF Radio Operations*	76
2.5.5.2	*HF and Serial-Tone Modem (STM) Upgrade*	77
2.5.5.3	*HF STM with Automatic Link Establishment Upgrade*	78
2.5.6	INMARSAT Solutions	79
2.5.6.1	*Capability, Cost and Benefits of Standard INMARSAT-A*	79
2.5.6.2	*Capability, Cost and Benefits of INMARSAT-A with Server Upgrade*	80
2.5.6.3	*Capability, Cost, and Benefits of INMARSAT-B*	82
2.5.6.4	*Capability, Cost, and Benefits of INMARSAT-M*	86
2.5.6.4	*Capability, Cost, and Benefits of INMARSAT-C*	88
2.5.7	Capability, Cost, and Benefits of American Mobile Satellite Communications (AMSC)	89
2.5.8	Capabilities, Benefits, and Cost of PoST	90
2.5.9	Capabilities, Benefits, and Cost of UHF MILSATCOM	90
2.5.10	Capabilities, Benefits, and Cost of SHF MILSATCOM	91

TABLE OF CONTENTS (Contined)

Section		Page
2.6	COST-BENEFIT ANALYSIS	93
2.6.1	Assumptions	93
2.6.2	Current USCG HF Radio Operations	96
2.6.3	Serial-Tone Modem (STM) Upgrade	97
2.6.4	STM with Automatic Link Establishment (ALE) Upgrade	98
2.6.5	INMARSAT-A	99
2.6.5.1	*INMARSAT-A With Message Server Enhancement*	101
2.6.6	INMARSAT-B	105
2.6.7	INMARSAT-C	106
2.6.8	INMARSAT-M	107
2.6.9	American Mobile Satellite Communications (AMSC)	108
2.6.10	Portable Satellite Terminal (PoST)	110
2.6.11	UHF MILSATCOM and SHF MILSATCOM	111
2.7	CONCLUSIONS	113
2.7.1	Best Technical Option for USCG Long-Range Communication.	113
2.7.1.1	*Best Technical Option for SATCOM*	113
2.7.1.2	*Best Technical Options for HF*	113
2.7.2	Best Cost-Effective Options	113
2.7.2.1	*Best Cost-Effective Options for HF*	113
2.7.2.1.1	Costs and Benefits of HF Using Serial-Tone Modems	114
2.7.2.1.2	Costs and Benefits of Automatic Message Transfer over HF	114
2.7.2.2	*Best Cost-Effective Option for SATCOM*	115
2.7.3	Conclusions and Recommendations	115

LIST OF FIGURES

Figure ..... **Page**

Figure 2-1. Representative Integrated Broadband Communications System 24
Figure 2-2. Voice, Video, Facsimile, and Data (VVFD) 33
Figure 2-3. FLTSAT UHF Satellite Coverage 49
Figure 2-4. FLTSAT UHF Follow-On (UFO) Satellite Coverage 50
Figure 2-5. DSCS Earth Coverage 51
Figure 2-6. INMARSAT Satellite Coverage 57
Figure2-7. RDSS Satellite Coverage 66
Figure 2-8. LOGSCOMA Network 67

LIST OF TABLES

Table **Page**

Table 1-1. INMARSAT Installations and Recommended Installs 2
Table 1-2. Cost Comparison of Messaging 5
Table 1-3. Total Projected Life-Cycle Cost INMARSAT-A and Server Enhancement 6
Table 1-4. Cost-Benefit Findings 9
Table 2-1. Coast Guard Military Long-Range Communications Capabilities 19
Table 2-2. USCG-Owned Satellite Options 45
Table 2-3. AN/USC-38(V)2 Physical Characteristics 46
Table 2-4. AN/USC-38(V)2 LDR Communications Support 47
Table 2-5. Selected DSCS Gateway Terminals 52
Table 2-6. Physical Description of Navy SHF-X SATCOM Terminals 52
Table 2-7. Shipboard SHF Antenna and Terminal Cost (Uninstalled) 53
Table 2-8. Technical Specifications of INMARSAT Terminals 54
Table 2-9. INMARSAT Services and Cost Comparison 58
Table 2-9a. Cost Comparison INMARSAT-A vs. -B Voice Services 59
Table 2-10. AMSC Telephone and Data Communications Costs 61
Table 2-11. PoST Implementation Cost for Dual Hub/90 Ship Configuration 63
Table 2-12. Long-Haul Transmission Systems Considered for USCG Alternatives 69
Table 2-13. Transmission Systems Not Viable in 1995-99 for USCG Alternatives 70
Table 2-14. USCG Long-Haul Communications Technical Alternatives 71
Table 2-15. Cost Comparison of Messaging 73

LIST OF TABLES (Continued)

Table		Page
Table 2-16.	INMARSAT Installations and Recommended Installs	85
Table 2-17.	Cost per Service	94
Table 2-18.	Total Mobile Users	95
Table 2-19.	Cost, Type, Transmitters of Current HF Radio	96
Table 2-20.	Projected Life-Cycle Costs	97
Table 2-21.	Cost of STM Upgrade	97
Table 2-22.	Estimated Life-Cycle Cost	98
Table 2-23.	HF STM ALE Upgrade	99
Table 2-24.	Alternative Life-Cycle Projection	99
Table 2-25.	INMARSAT-A Traffic Rates of Increase	100
Table 2-26.	Projections for Future INMARSAT-A Costs	101
Table 2-27.	Life-Cycle Cost of Standard INMARSAT-A Capability	101
Table 2-28.	Upgraded Configuration Costs	102
Table 2-29.	Total Projected Life-Cycle Cost INMARSAT-A and Server Enhancement	104
Table 2-30.	CAMSLANT and CAMSPAC Costs	109
Table 2-31.	Costs for AMSC Alternative	110
Table 2-32.	PoST Investments Cost	111
Table 2-33.	AMSC Yearly Recurring Costs	111
Table 2-34.	CG HF Configuration Costs	117

APPENDICES

Appendix A	DoD HF Policy	A-1
Appendix B	Bibliography	B-1
Appendix C	List of Attachments	C-1
Appendix D	U.S. Government Multiple Services Contract (MSC)	D-4
Appendix E	Extracts from Navy UHF Satellite Communications System Description	E-1
Appendix F	Acronym Listing	F-1

SECTION I INTRODUCTION AND SUMMARY

1.0 INTRODUCTION

The purpose of this assessment is to examine long-range communication alternatives for U.S. Coast Guard (USCG) ship-shore and air-ground applications. A high-level cost-benefit analysis is included. The best technical and most cost-effective alternatives are identified. This assessment is provided in accordance with COMMSYS 2010 Statement of Work dated

12 May 1994, and satisfies data item number A003.

1.1 SCOPE

This report is primarily focused on high frequency (HF) radio and satellite communications (SATCOM) technologies available in the next five years to satisfy USCG long-range communications requirements. HF systems include narrowband, wideband, high data rate modem and Automatic Link Establishment (ALE) technologies. SATCOM systems include both commercial and military systems that provide worldwide coverage and other selected SATCOM options. In addition, meteor burst communications are examined.

1.1.1 Overview

Section I provides a summary of recommendations and outlines the cost and benefits of viable alternatives for USCG long-range communications. Section II contains the detailed technical analysis of HF radio and SATCOM alternatives, and includes a discussion of U.S. Navy plans, policy, and architectures.