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STUDY BY THE STAFF OF THE U.S.

General Accounting Office

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An Unclassified Version Of A Classified Report Entitled "The Navy's Strategic Communications Systems--Need For Management Attention And Decisionmaking"

Peacetime communications systems provide reliable day-to-day communications to the strategic submarine force. However, the Navy's most survivable wartime communications link to nuclear-powered strategic submarines--the TACAMO aircraft--has certain problems which need attention. Also, the Navy should reconsider whether another peacetime communications system--the extremely low frequency system--is needed.

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PSAD-79-48A
MAY 2, 1979

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-168707

To the President of the Senate and the
Speaker of the House of Representatives

This report is an unclassified version of a SECRET report (PSAD-79-48, March 19, 1979) to the Congress that describes the various communications systems used by our strategic submarine force and questions the need for the extremely low frequency system. Also, the report addresses the need for support of the TACAMO communications system.

We made this study because of widespread congressional interest in strategic communications systems, especially the TACAMO and proposed extremely low frequency systems. These issues are receiving increased recognition, and the Navy plans to spend millions of dollars to improve the TACAMO system and conduct research and development on the extremely low frequency system.

Copies of this report are being sent to the Secretary of Defense and the Secretary of the Navy.

Elmer B. Staats
Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

THE NAVY'S STRATEGIC COMMUNICATIONS SYSTEMS--NEED FOR MANAGEMENT ATTENTION AND DECISIONMAKING

D I G E S T

Peacetime communications systems provide reliable day-to-day communications to the strategic submarine force. However, the Navy's most survivable wartime communications link to nuclear-powered strategic submarines--the TACAMO aircraft--has certain problems which need attention. Also, the Navy should reconsider whether another peacetime communications system--the extremely low frequency system--is needed.

PEACETIME SYSTEMS RELIABLE

To meet the objectives of the strategic submarine force, the Navy must maintain positive command and control of the strategic submarine force. (See pp. 2 and 3.)

During peacetime, the Navy uses a combination of communications systems, ranging from very low frequency to ultrahigh frequency, to communicate with strategic submarines. The Navy's evaluation program shows that the Navy communicates with its strategic submarines nearly 100 percent of the time via a network of fixed, land-based transmission sites throughout the world. (See pp. 6 and 7.)

WARTIME SYSTEM NEEDS SUPPORT

The Navy maintains two squadrons of TACAMO aircraft (an airborne, very low frequency communications system) for communications with strategic submarines during an emergency. This system, because of its airborne status in the Atlantic, is considered the Navy's only survivable link to the strategic submarine force.

Although the TACAMO communications system is considered the only reliable means of communicating to submarines in wartime, the Navy has allowed the TACAMO fleet to decline in number and deteriorate in physical condition.

Furthermore, because no other communications systems are considered able to outperform TACAMO in delivering emergency action messages, the Navy must now take actions to upgrade TACAMO. ~~Such~~ actions include:

--A $22 million Service Life Extension Program for aging TACAMO aircraft.

--The procurement, for about $380 million, of new TACAMO aircraft and airframes to replace those whose service life will end in the early- to mid-1980s. (See pp. 8 to 11 and 26.)

We believe the Navy's planned actions constitute feasible near-term solutions to achieving the objective of delivering emergency action messages to the strategic force.

Though no system in existence or being developed would be an acceptable replacement for the TACAMO system, other communications systems may be available to assist TACAMO in delivering emergency messages.

The Department of Defense (DOD) and the Navy are studying a system which may work in a nuclear environment.

Peacetime systems are also available. Separately, they are not considered survivable during a nuclear war but, because of their quantity, some could survive. This should increase the probability that an emergency action message will be delivered to the strategic submarine force. (See p. 12.)

QUESTIONABLE NEED FOR ANOTHER PEACETIME SYSTEM

Although the Navy has day-to-day, reliable peacetime communications to the strategic submarine force, it considers current communications receiving methods limited and, thus, endangering force survivability. Available DOD data does not support that position. (See p. 13.)

The Navy believes that visually detectable appendages to the submarine, such as a towed buoy or buoyant cable antenna, are undesirable because they could help an enemy locate the submarine. (See p. 15.) The Navy has sponsored research on various alternative communications systems that penetrate ocean water to greater depths, allowing the submarine to remain deep and eliminate the need for antennas on or near the surface. The Navy has had the most success in researching systems that can penetrate ocean waters with an extremely low frequency communications system. At least five variations of the system (referred to variably as Sanguine, Seafarer, etc.), each generally having less capability than the preceding version have been considered, and over $115 million has been spent on extremely low frequency research and testing. (See pp. 39 to 44.)

The need for an extremely low frequency communications system is questionable. The system has been troubled by inadequate program management--the Navy has changed system requirements radically and frequently. Of greater significance, though, is that the modified system, in GAO's opinion, cannot be justified because

--of the extensive duplication and reliability of existing systems (see pp. 16 to 18);

--there is a high likelihood that submarine antennas and other receiving systems will not be detected and, therefore, will not endanger the strategic submarines (see pp. 18 and 19);

--strategic submarines are extremely survivable now and will continue to be survivable for the foreseeable future (see pp. 19 to 21);

--of the limited applicability of the extremely low frequency system to attack submarine missions and operations (see pp. 21 to 23); and

--there is a lack of compatibility between the extremely low frequency system design specifications and strategic and attack submarine operational requirements. (See p. 23.)

Further, the proposed modified extremely low frequency system is no more survivable than existing day-to-day communications systems. Finally, although GAO does not believe the proposed extremely low frequency system is needed, there is doubt that the system will work as planned even if it is needed. (See pp. 23 to 27 and 52 to 56.)

AGENCY COMMENTS AND EVALUATION

DOD, in commenting on our proposed report, concurred with our general comments on Navy strategic communications requirements. Defense recognized and agreed with the management and decision problems GAO identified with the TACAMO system and affirmed that planned and ongoing Navy actions are in consonance with the GAO findings. DOD did not concur with the portion of the proposed report which addressed the extremely low frequency communications system. In essence, DOD maintained that the extremely low frequency system was needed to free strategic submarines from having an antenna at or near the ocean surface and that the technical feasibility of the extremely low frequency system was validated and the system would work as planned. GAO does not agree with DOD on either of these issues.

Information obtained during GAO's review indicates that:

--Strategic submarines are extremely survivable now and will continue to be survivable for the foreseeable future and will be even more so with the deployment of the Trident submarine.

--Submarine antennas and buoys do not endanger strategic submarines now or in the foreseeable future.

--The ability of the extremely low frequency system to perform in a realistic strategic submarine operational environment is questionable and the lack of definitive operational requirements makes it nearly impossible to address the extremely low frequency system's operational utility from a technical standpoint with any reasonable degree of confidence. (See ch. 4 and 5.)

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

GAO recommends that the Secretary of Defense terminate any plans to construct an extremely low frequency system transmitter and to install extremely low frequency system receivers on strategic submarines, since the extremely low frequency communications system is not needed; enhances communications capability only marginally at best; and, at a price of $283 million, cannot be justified. However, GAO recognizes that at some future time (probably not sooner than 10 to 12 years from now) circumstances or conditions related to strategic submarine survivability could change and that a clear need for an improved communications capability could be demonstrated. Accordingly, GAO believes, however, that some level of research on the extremely low frequency system should continue in view of the potential this technology offers. in the event a need should be demonstrated in the future for an improved communications capability

RECOMMENDATION TO THE CONGRESS

The President's fiscal year 1980 budget package, submitted to the Congress in January 1979, only included about $13 million for continuing research and development of the extremely low frequency system. GAO does not believe the Congress should consider funding any full-scale system development or construction until the Navy specifies definitive communications goals and requirements, demonstrates a clear need for such a system and shows that the proposed system contributes to strategic submarine survivability and flexibility beyond what already exists, and conducts a detailed analysis of the extremely low frequency system's capability compared to strategic submarine's operational environments and documents the results of the analysis.

Contents

ABBREVIATIONS

DOD	Department of Defense
ELF	extremely low frequency
GAO	General Accounting Office
HF	high frequency

LF	low frequency
MEECN	Minimum Essential Emergency Communications Network
NCA	National Command Authority
SLEP	Service Life Extension Program
SSBN	nuclear-powered strategic submarine
SSN	nuclear-powered attack submarine
UHF	ultrahigh frequency
VLF	very low frequency
WWMCCS	World Wide Military Command and Control System

CHAPTER 1

INTRODUCTION

TRIAD, our U.S. strategic force, is composed of submarines, bombers, and fixed silos that can launch nuclear weapons. The Department of Defense (DOD) believes the nuclear-powered strategic submarine (SSBN) force is the most survivable element of TRIAD because it is nearly impossible to detect and, therefore, attack. For obvious reasons, the Navy is spending hundreds of millions of dollars to provide the best possible communications to and from this essential force. The best possible control of the fleet, increased survivability, and defense against the projected Soviet threat are the main reasons for this funding commitment.

This report

--discusses DOD efforts to improve the command, control, and communications of its SSBN force;

--analyzes the Navy's current capability to communicate with its strategic force in peacetime and wartime;

--describes the Navy's planned improvements of current communications systems; and

--addresses Navy efforts to use the extremely low frequency (ELF) range of the radio spectrum for SSBN and attack submarine (SSN) communications. In that context, the report analyzes the Navy's need for another peacetime system.

STRATEGIC SUBMARINES IN BRIEF

The U.S. naval undersea forces are composed of SSBNs and SSNs. Both SSBNs and SSNs have the primary mission of deterring any U.S. opponent from using nuclear weapons. SSBNs have an equally vital mission of providing flexible, credible, postattack nuclear capability. Attack submarines also have the mission to protect U.S. control of sea lanes and to achieve immediate battlefield advantage over the opponent in time of crisis.

The SSBN force has 41 submarines, 10 carrying the POLARIS missile and 31 carrying the POSEIDON missile. As of the end of fiscal year 1978, 7 POLARIS submarines were deployed in the Pacific Ocean, Deleted POSEIDON submarines in the Atlantic Ocean, Deleted in the Mediterranean Sea. Also, eight submarines were either in overhaul, undergoing maintenance, or in postoverhaul status. Many of the submarines are coming to the end of their planned 20-year lives. To forestall an untimely retirement of the force, the Navy has a continuing program to replace aging submarines with quieter and faster TRIDENT submarines. The TRIDENT submarines will carry 24 missiles, 8 more than the POLARIS/POSEIDON submarines. Also, the Navy has considered keeping the POLARIS/POSEIDON fleet for 22 to 25 years instead of 20 years and has considered backfitting TRIDENT I missiles on several POSEIDON submarines.

The SSBN force and strategic communications systems receive substantial funding. Excluding expenditures related to developing the TRIDENT submarine and other research and development related to enhancing existing or developing new systems, expenditures for fiscal years 1977 and 1978 were:

	Fiscal year 1977	Fiscal year 1978
	(millions)	
SSBN support and upkeep	$653.7	$643.8
Strategic command, control, and communications	92.6	110.3

The extent of command, control, and communications with the strategic submarine force varies according to the force's role in the pre-, trans-, and postnuclear attack environment. The Navy must retain positive, flexible command and control via communications with the strategic force in each phase.

During peacetime, some SSBNs are being overhauled, some are in transit to a patrol area, and about a third are on alert status in a patrol area. SSBNs not being overhauled or prepared for duty must maintain highly covert patrols. If a submarine is on alert status, the Navy requires that it receive continuous, full-time communications from shore commands so it can respond to an attack. At the same time, these submarines must remain undetected. To avoid jeopardizing its covertness, alert submarines rarely transmit messages. The Navy requires a submarine on modified alert status to receive communications periodically. Modified alert means that the submarine Deleted

Communications received during this phase take the form of fleet broadcasts, antisubmarine warfare information, weather reports, news, and family grams.

However, during escalating tensions the strategic submarine force's role changes. The National Command Authority (NCA) becomes heavily involved in command and control. In the preattack phase, NCA directs the strategic and conventional forces to prepare to deter nuclear attack and to help control the escalating conflict.

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This in turn has created a need for further analysis of command, control, and communications with SSBNs.

SCOPE OF REVIEW

We gathered information from interviews and documents prepared and provided by representatives of various DOD agencies and selected contractors. These representatives were responsible for planning, evaluating, developing, and approving strategic submarines' communications systems. Also, these representatives were responsible for evaluating the threat to our strategic command, control, and communications systems and to the strategic submarine force itself.

In doing the review, we visited the following organizations within DOD:

--Office of the Joint Chiefs-of-Staff.

--Office of the Director, Telecommunications and Command and Control Systems.

--Office of the Director, Defense Research and Engineering.

--Office of the Assistant Secretary of Defense (Program Analysis and Evaluation).

--Deputy Assistant Secretary of Defense (Audit).

--Defense Advanced Research Projects Agency.

--Defense Communications Agency.

--Defense Intelligence Agency.

Also, we visited the following organizations within the Department of the Navy:

--Office of the Assistant Secretary of the Navy (Research and Development).

--Naval Electronics Systems Command.

--Naval Telecommunications Command.

--Office of the Deputy Chief of Naval Operations (Plans, Policy, and Operations).

--Office of Command and Control and Communications Programs.

--Naval Ship Engineering Center.

--Naval Sea Systems Command.

--Office of Naval Intelligence.

--Naval Underwater Systems Center, New London, Connecticut.

--Fleet Air Reconnaissance Squadron Four, Patuxent River, Maryland.

--U.S. Naval Radio Transmitting Facility, Annapolis, Maryland.

CHAPTER 2

PRESENT SYSTEMS PROVIDE EFFECTIVE AND RELIABLE PEACETIME COMMUNICATIONS TO THE STRATEGIC SUBMARINE FORCE

Current communications systems provide reliable day-to-day peacetime communications to the strategic submarine force. Navy evaluations of these systems indicate that the probability of successful communications to alert SSBNs is nearly 100 percent.

These systems are designed to contribute to the long-term survivability of the strategic submarine force by lessening the probability of our submarines being detected. They utilize a large portion of the radio frequency spectrum, from very low frequency (VLF) to ultrahigh frequency (UHF). Each communications system has unique capabilities and inherent limitations. Some, for example, can transmit information very quickly and others can broadcast over large areas, permitting simultaneous reception by our strategic submarines. Still others can penetrate a disturbed environment, such as that caused by jamming or high-altitude nuclear explosions. The Navy uses existing communications systems to complement one another in peacetime and provide backup when needed in a crisis.

DOD and the Navy continually research and review communications systems to improve overall communications capability and enhance submarine survivability.

COMMUNICATIONS SYSTEMS PROVIDING DAILY COMMUNICATIONS TO THE SSBN FORCE

During peacetime, the Navy can communicate to SSBNs on a daily basis nearly all of the time, via a network of fixed, land-based transmission sites throughout the world. VLF and low frequency (LF) are the primary frequencies used for communications to SSBNs. (See app. I and II.) Submarines can communicate two way with shore stations (see app. III); the fleet; aircraft; and, to an increasing extent, with satellites through high frequency (HF) and UHF systems. Submarines receive communications primarily through either a mast antenna, bouyant cable/floating wire antenna, or a towed buoy.

PRESENT SSBN COMMUNICATIONS SYSTEMS RELIABLE

Scientific evaluations have shown that present day-to-day communications systems are reliable.

The Navy has been continuously evaluating the SSBN communications systems since 1972. A December 1977 report indicated that the probability of communications to alert SSBNs via VLF and LF communications systems was

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A March 1978 report indicates, for VLF only, more than probability of communications. The probability of communications for alert SSBNs in the Pacific Ocean via VLF/LF/HF systems was **Deleted** **Deleted** These test and evaluation results indicate that current communications systems do the job well.

ALTERNATIVES TO EXISTING COMMUNICATIONS SYSTEMS

DOD and the Navy continue to research and review communications systems and technologies to improve submarine command, control, and communications. DOD and the Navy hope to develop alternative peacetime and emergency communications systems which will improve overall communications capability and further enhance submarine survivability by making SSBNs even less detectable than they are now.

During the 1960s and 1970s, DOD and the Navy reviewed a wide variety of technologies. They looked at technical feasibility, operational utility, and how each concept would influence the overall survivability of the submarine forces. Alternative command, control, and communications methods were divided into three basic classes--electromagnetic methods employing frequencies below VLF, blue-green optical, and methods employing acoustic reception. Various system configurations exist within each of these basic classes. (See app. IV.)

Of the various command, control, and communications methods reviewed, the Navy is actively considering ELF, a method which employs frequencies below VLF, as another peacetime communications system. ELF, as described by the Navy, would permit constant communications to our submarines while they are operating deep within the ocean.

CHAPTER 3

EFFECTIVENESS OF EMERGENCY COMMUNICATIONS SYSTEM

REDUCED BY INSUFFICIENT AND INADEQUATE ASSETS

The TACAMO aircraft is the Navy's most survivable communications link to the strategic submarine force during an emergency. However, because of the lack of adequate Navy attention, the TACAMO fleet has declined in number and deteriorated in physical condition.

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Because no other communications system can be expected to outperform TACAMO in delivering emergency action messages, the Navy must take action to upgrade the TACAMO system. The Navy and DOD have other communications systems which, based on different scenarios, may be available to aid TACAMO in delivering emergency messages.

TACAMO--MOST SURVIVABLE EMERGENCY SYSTEM NEEDS SUPPORT

The TACAMO fleet, consisting of EC-130 aircraft, is the only component of the Navy's strategic command, control, and communications system that can survive and function effectively; that is, guarantee command and control in a wartime environment **Deleted** The TACAMO mission is to provide a survivable communications system; one that relays an emergency action message via airborne VLF to SSBN submarines on alert. (See app. V.)

The Joint Chiefs of Staff require a minimum force of **Deleted** The TACAMO fleet now numbers only 12, with 1 additional aircraft due for delivery in fiscal year 1979.

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How did this happen? It was due largely to inadequate budgeting and planning by the Navy. At one time, a continental United States-based, extremely low frequency system called Sanguine (see p. 39) was planned to replace TACAMO as the survivable communications link to SSBNs. However, growth in Soviet missile capability and political opposition to the ELF program led to a change in the ELF developmental concept. DOD decided ELF should be a peacetime, less survivable system, rather than a very hard survivable system. Meanwhile, TACAMO continued to be the Navy's only survivable means of delivering an emergency action message to the SSBN force. Despite this fact, TACAMO received little Navy attention. For example, the Navy's Director, Command and Control and Communications Programs, during April 1978 testimony before the Committee on Appropriations, House Appropriations Defense Subcommittee, stated:

> "We got into trouble in this (TACAMO) system by permitting it to gracefully degrade, numbers wise, during the years when the Department of Defense was viewing the very hard Sanguine (ELF) system as the keystone of surviving communications to our deterrent forces. During those years, we drew down TACAMO assets in one command to keep a 24-hour airborne capability in another, and with the change in concepts--shifting from the very hard Sanguine to the soft and less survivable Seafarer system--our planning and budgeting has hardly kept pace with the ravages of time and accidents."

As a result of such inattention, the TACAMO force has declined in numbers and in physical condition

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Consequently, the Navy must now take immediate action to maintain its only survivable communications link to the SSBN force. The Navy's planned actions constitute a feasible near-term solution to maintaining the TACAMO system.

Navy officials said

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However, deploying the TRIDENT submarine will increase the size and importance of the Pacific SSBN deterrent, thus expanding the area TACAMO must cover. This will occur because the operating areas of the SSBN force will expand as the TRIDENT replaces the

POLARIS submarines in the Pacific Ocean and as the POSEIDON submarines are backfitted with the TRIDENT I missile. The TRIDENT I missile's range of 4,000 miles (as opposed to the POLARIS/POSEIDON range of 2,500 miles) will enable the TRIDENT to utilize 10 to 20 times the total current patrol areas. Also, because a TRIDENT submarine deployed in the Pacific Ocean will be capable of delivering its missiles at increased numbers of targets, a continuous TACAMO airborne alert will be required in the Pacific Ocean area.

The Navy plans to meet this need by increasing the TACAMO force level from The Navy estimates it will need to procure Deleted new aircraft with complete communications systems during fiscal years 1980-81. Also, the Navy plans to procure Deleted Deleted new airframes to be outfitted with existing communications suites during fiscal years 1981-85. The airframes would replace older TACAMO aircraft being retired. The Navy estimates that the new TACAMO aircraft and airframes will cost about $380 million.

NEED TO EXTEND SERVICE LIFE OF EXISTING TACAMO AIRCRAFT

The Navy, with present and authorized aircraft, will not be able to continue full-time airborne TACAMO operations in the Atlantic Ocean area between now and the time newly procured aircraft are deployed unless major fatigue components are replaced.

An October 1977 Navy staff study pointed out the deteriorating condition of the TACAMO aircraft. It estimated, based on present TACAMO operations, that the flight-hours, end-of-service life of nine aircraft would end during fiscal years 1978-80. The study stated the fatigue life index (a calculation of damage based on typical operations and actual airframe inspections) had been exceeded on four aircraft as of October 1977 and would be exceeded on three additional aircraft during fiscal year 1978.

Accordingly, the Navy has decided to support TACAMO through a Service Life Extension Program (SLEP), developed to extend the life of the older TACAMO aircraft. Major fatigue components of the aircraft (wing panels, fuselage panels, landing gear, etc.) are to be extensively examined and, if needed, replaced. The Navy estimates SLEP will provide TACAMO aircraft with 5,000 to 10,000 additional hours of life, depending on the condition of the airframe. However, several Navy officials said the estimated additional hours of life may be overstated. These officials indicated that until the wing fatigue on the first aircraft in SLEP is examined thoroughly, accurately estimating additional hours of life will be impossible. One TACAMO aircraft has undergone emergency major wing repair and several more are scheduled for this repair before SLEP. SLEP is scheduled to begin in June 1979 and is estimated to cost over $22 million.

THE TACAMO COMMUNICATIONS SYSTEM NEEDS CONTINUED EVALUATION

Historically, the TACAMO communications system has not been regularly evaluated to determine the probability that it will successfully communicate when required. The Chief of Naval Operations, as early as October 1968, stated that the operational effectiveness of TACAMO had not been established and that the TACAMO system had not had the same continuing evaluation given other SSBN systems. However, not until June 1976 was the first TACAMO continuing evaluation program (evaluating the communications relay from TACAMO to the SSBN only) done by the Johns Hopkins University Applied Physics Laboratory under contract with the Navy. This delay resulted from the need to first analyze operational requirements and determine whether system equipment could function. An official at the Applied Physics Laboratory said the evaluation was further delayed to install certain communications equipment on all aircraft.

The most recent program report made available, covering the period through December 1977, indicated **Deleted** **Deleted** that TACAMO would transmit emergency action messages. **Deleted** --results were based on limited testing and tests were conducted in a peacetime environment only. The limited testing is attributed to several factors.

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Through a contract with the Applied Physics Laboratory, the Navy will begin to initially evaluate the probability of successful communications from transmitters to TACAMO in the near future.

ADDITIONAL MEANS OF DELIVERING EMERGENCY ACTION MESSAGES

According to the Navy, no system in existence or being developed can be considered an acceptable replacement for the TACAMO system. However, the Navy and DOD have other communications systems which, based on the existing scenario, may be available to aid TACAMO in delivering emergency messages. Individual communications systems serving SSBNs on a daily basis are not considered survivable during wartime. Generally, they are ground-based, fixed in place, and employ a mixture of wireline and radio frequency transmissions. However, because these systems back each other up, together they should provide some degree of survivability in a wartime environment and, therefore, increase the probability that an emergency action message will be delivered to the SSBN force.

Other emergency or possible future capabilities could have potential as additional means of delivering emergency action messages. For example, the Defense Communications Agency is studying the possibility that an system **Deleted** may function in a nuclear environment. Navy and DOD officials agreed that the **Deleted** **Deleted** system has much potential for communicating in a nuclear environment. The Navy's fiscal year 1980 budget provides $500,000 for research and development on the system.

CHAPTER 4

NEED FOR MODIFIED PEACETIME

ELF SYSTEM QUESTIONABLE

Although the Navy has proposed and justified the need for an extremely low frequency, ground-based, peacetime communications system, we believe the need for it is questionable because

--of the extensive duplication and reliability of existing systems;

--there is a high likelihood that submarine antennas and other systems will not be detected and, therefore, will not endanger the strategic submarines;

--strategic submarines are extremely survivable now and will continue to be survivable for the foreseeable future;

--of the limited applicability of ELF to attack submarines; and

--there is a lack of compatibility between ELF design specifications Deleted Deleted and strategic and attack submarine operational requirements.

Though we do not believe the proposed ELF system is needed, there is insufficient evidence demonstrating that the system will work as planned even if it were needed.

Since ELF research began in 1958, the Navy has considered several variations for an ELF, ground-based communications system (see app. IV) and has spent $115 million on research and development. The Navy is advocating a small-scale peacetime ELF system. The Navy estimates it will cost about $283 million to develop this system. However, funds have not been authorized to construct it.

The following presents the Navy's justification for the proposed system and our assessment of it.

INDEFINITE REQUIREMENTS AND INADEQUATE MANAGEMENT

Over the years, the ELF program has suffered from inadequate program management, in that the Navy has not approved and documented short- and long-term goals and requirements which can be readily translated into engineering terms. Without such goals and requirements, it is extremely difficult to assess

--the system's objectives and whether benefits outweigh costs;

--whether the system is needed, considering the present and future threat; and

--whether the Navy is achieving its objectives effectively and efficiently.

Although many memorandums and much correspondence are available on the ELF program, no formally approved documents have established ELF requirements for the currently proposed system. The program, as of January 1979, had no approved development concept paper describing the modified ELF system. The only approved development concept paper, dated February 1, 1975, discussed the much different Sanguine system, which was to be survivable and have a much larger transmitting antenna and higher data transmission rate than the currently proposed system. Although a Navy official said several documents, such as Chief of Naval Operations' memoranda and letters supplant formal documents for this program, we believe an up-to-date development concept paper is needed to establish requirements for the modified ELF system. DOD, in commenting formally to this report in January 1979, advised us that a draft development concept paper had been completed and was undergoing staff review.

We believe the Navy's support of several very different ELF systems over the years has resulted from the management inadequacies cited and lowered program credibility. The ELF systems the Navy has supported have ranged from a wartime system with a specified data transmission rate, to a lower data rate peacetime system, to an even lower data rate peacetime system. Such variations in system configuration have prompted serious questions of the Navy's need for the currently proposed modified ELF system and the system's capability. The Navy says that its changing support is based on operational needs which changed due to new analysis. However, we believe that such radical changes in operational needs result from inadequate management; the failure to establish formal goals and requirements; and the failure to agree upon a specific concept describing where, when, how, how often, etc., the system will be used.

NAVY'S JUSTIFICATION FOR THE MODIFIED ELF SYSTEM

The Navy based its need for an ELF, ground-based communications system 1/ primarily on the fact that an SSBN cannot receive messages when the antenna is more than Deleted Deleted feet below the ocean surface. The justification maintains that using a buoy in near-surface areas makes them vulnerable to detection, thereby endangering the survivability of the SSBN force. An ELF system can penetrate ocean water to depths greater than existing systems, eliminating the need for a receiving antenna at or near the ocean surface. The ELF system has a design requirement of being able to communicate with submarines operating at Deleted Deleted Speed can be traded off for depth and vice versa. For example, hypothetically, at Deleted

A secondary justification was based on SSNs being able to carry out their missions using ELF without having to make periodic trips to the surface for communications. They would be able to receive essential messages while submerged. The Navy believes this capability can improve the effectiveness of the attack submarine force.

NEED FOR ELF DOUBTFUL

The need for an ELF communications system is highly doubtful because existing systems are capable and reliable, present outboard reception systems (towed buoy and buoyant cable/floating wire antennas) are not systematically detectable, SSBNs are and should continue to be survivable without this system, and ELF has limited application to SSNs.

1/The Navy justification for an ELF communications system is contained in the Navy's presentation at the Defense System Acquisition Review Council on Jan. 12, 1978, and in the Council's recommendations made as a result of the program review. (See app. VII.)

Current peacetime communications effective and reliable

Navy documentation, statements made by Navy officials, and our discussions with DOD and Navy officials indicate that current communications systems are reliable during peacetime. (See ch. 2.) The Director, Navy Command and Control and Communications Programs, testified before the House Committee on Appropriations in March 1977 that VLF and LF provide long-term, day-to-day, peacetime SSBN communications. He affirmed that no gross changes were needed in submarine communications and that current systems provided reliable communications (close to Deleted percent). Results of the Navy's continuing evaluation program of existing strategic communications systems support this position.

Existing systems enable SSBNs to accomplish missions at desired speeds and depths

We believe current communications reception systems, such as the towed buoy antenna, enable SSBNs on alert status to carry out their missions at required depths and speeds. However, the Navy has taken the position that SSBNs cannot seek deeper ocean depths to further reduce the chance of detection.

SSBN's have four major mission elements which are to be carried out simultaneously. These are to remain (1) submerged, (2) undetected, (3) in continuous communications, and (4) in range of targets and prepared to launch missiles. To achieve these missions, SSBNs ideally want to travel at slow speeds that reduce submarine-generated noise and

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Existing outboard reception systems (the mast antenna, towed buoy antenna, and buoyant cable/floating wire antenna) enable SSBNs to receive VLF, LF, and HF transmissions at deeper depths by traveling slower. SSBNs can remain deepest while communicating through the towed buoy, which rests about Deleted below the ocean surface. Also, the towed buoy is omnidirectional, that is, it allows the submarine to operate in any position without affecting reception and, hence, does not inhibit the SSBN's movement. Using the current towed buoy, SSBNs can communicate via VLF/LF at depths Deleted if traveling very slowly. They usually travel at Deleted depth.

Likewise, the submarine, while using the buoyant cable antenna, can reduce speed to increase depth, Deleted Reception of VLF/LF with the buoyant cable antenna allows the submarine to go at Deleted depths Deleted speeds Deleted depth and speed levels which alert SSBNs normally use in conducting their mission. Unlike the towed buoy, the buoyant cable antenna and proposed ELF antenna are bidirectional, thus limiting operational flexibility since communications cannot be received throughout a full 360 degrees. Future hardware changes in the buoyant cable antenna may provide SSBNs more depth, speed, and operational flexibility.

Improvements of existing systems

Improved buoys will enable SSBNs to carry out their missions at greater speeds, further decreasing the need for ELF. For example, a new towed buoy system being developed for the TRIDENT and an improved buoy being developed for the POSEIDON are both designed to operate at Deleted Deleted keel depth, the same as the ELF specifications. As with ELF, speed can be traded off for depth and vice versa.

Historically, the towed buoy system has had engineering and operational problems. In the early 1970s, the Navy instituted a buoy improvement program, which improved the system's stability and reduced the noise output, two of the buoy's major problems. These improvements

Deleted

--added fairings to the tow cable, reducing radiated noise.

The Navy is further improving the buoy and redesigning it for the TRIDENT and the POSEIDON/POLARIS submarines. To improve overall buoy reliability, the Navy plans to install a Deleted system on TRIDENT. According to

Navy officials, the redesigned buoys are expected to eliminate most past problems.

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The justification for ELF stated that,

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But, the Navy stated that detections were of considerable concern because,

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The Navy argued that towed buoys and buoyant cables make the submarine vulnerable to detection. We agree that these systems, these physical objects, can in theory be detected.

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The Navy's Strategic Systems Project Office manages the SSBN Security Program, which technologically assesses the potential Soviet capability to reduce the deterrent effectiveness of the SSBN force and develops technology that may be required to keep the force covert. Budgets for this program are about $38 million, $42 million, and $45 million for fiscal years 1978, 1979, and 1980, respectively. Most of these funds are for projects relating to threats to the SSBN Deleted In explaining the priority given to this area, a program official acknowledged that the research Deleted Deleted was to provide a hedge against surprises, not a reaction to a perceived threat. The Navy plans call for only a slight funding increase in this area. The emphasis the Strategic Systems Project Office has given this threat area parallels the opinions of those in the intelligence community-- Deleted

SSBN force survivable now and for the foreseeable future

In justifying an ELF system, the Navy stated that the survivability of the strategic submarine force will be greater with an ELF system. This is a general statement on a very subjective issue. A question that must be answered, but which the Navy apparently did not ask, is: How much will ELF lower the incidence of detection by the enemy; that is, what will be the measurable improvement in SSBN survivability? We turned to the intelligence community for our answer.

According to intelligence officials, SSBNs are virtually invulnerable because Deleted Further, the Chairman, SSBN Security Working Group told the House Armed Services Committee, in April 1977, that:

> "I want to emphasize that the U.S. SSBN force is secure today and we know of no breakthrough that jeopardizes the security of the SSBNs force in the near future. * * * the bottom line is that at the present time, we do not believe that the SSBN force is threatened, and we do not believe that the SSBN force will be threatened in the foreseeable future * * *."

> "As you know, the TRIDENT system is designed to further enhance the most survivable component of our Nation's strategic forces. * * * The TRIDENT system has been designed to counter known and postulated ASW threats in order to

maintain the relative invulnerability our sea-based deterrent force has always enjoyed. * * * Since TRIDENT will incorporate the latest technology, is designed to counter known and postulated threats, and will operate in large areas of the world's oceans, it cannot be effectively targeted. TRIDENT is, therefore, essentially invulnerable to nuclear attack. * * *."

Officials of the Defense Intelligence Agency, Office of Naval Intelligence, and the Navy's Strategic Systems Project Office categorized the Soviet's problem as their lack of a broad ocean search capability.

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Though SSBN survivability is outstanding, Navy efforts to maintain the state of virtual invulnerability and extend survivability into the 21st century include:

--Developing methods of reducing SSBN detection, including conducting a noise reduction program for lowering SSBN-generated noise in existing SSBNs and implementing TRIDENT noise reduction goals. SSBN-generated noise of the existing fleet has been and is being reduced.

--Providing the longer ranged TRIDENT I missile to the TRIDENT submarine and backfitting it on to POSEIDON submarines to increase their operating area, thus decreasing the probability of detection and enhancing survivability.

--Improving sonars to increase the probability our SSBNs will detect the enemy before being detected.

--Improving SSBN operating procedures to lower the possibility of being detected.

Though the Navy has stated that the need for an ELF communications system is real and urgent, the Assistant Secretary of Defense's (Communications, Command, Control and Intelligence) ELF Ad Hoc Review Group, in its December 1977 report, stated that the Soviet's open ocean antisubmarine warfare capability is not regarded as a serious threat to SSBN survivability. The report also stated that near surface antennas "* * * <u>may someday</u> jeopardize the covertness and survivability of our submarine forces * * *." (Emphasis added.) Further, the Ad Hoc Review Group, in its interim report in June 1977, stated that

> "* * * It is the consensus of the Group that a delay of some 2 years in implementing an operational ELF system * * * should not increase the vulnerability of the submarine force given the ASW threat projection presented by Defense Intelligence Agency/Office of Naval Intelligence."

<u>SSN application doubtful</u>

Another argument discrediting the Navy's justification of ELF, is the uncertain need for ELF on SSNs. While recognizing that the proposed ELF system could benefit some SSN missions, there is no evidence that SSN operations will be seriously hampered without it.

The Navy officially addressed the use of ELF for attack submarines in its February 1975 Development Concept Paper for the Sanguine program. Since then, the Navy has emphasized the benefits of ELF to SSNs. During its January 1978 justification to the Defense System Acquisition Review Council, the Navy indicated that with an ELF system, the SSN could carry out its missions in the most desirable posture and with minimum interruptions for communications.

According to the Navy, SSNs,

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According to the Navy, SSNs in a barrier or holding position in open ocean areas are adversely affected by current systems. To be effective,

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However, the Navy is making improvements to the SSN which will enable it to carry out its missions more effectively. Several of the more important improvements include developing an SSN towed buoy and increasing the sonar capability through the BBQ-5 sonar. This towed buoy is expected to enhance SSN communications capabilities by allowing the submarine to receive communications at depths and speeds

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The BBQ-5 sonar will enable SSNs to detect enemy submarines at longer ranges than with existing sonars.

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These improvements will lessen the effect of interrupting the mission for communications.

According to the Navy's antisubmarine master plan, no single system is designed to meet all SSN communications requirements, and this includes ELF. Therefore, the SSN will continue to rely on existing systems for detailed broadcasts, requiring the SSN to periodically interrupt operations for communications.

Still another problem the Navy must face, according to several Navy officials, is the limited space available for backfitting an ELF system in the already overcrowded SSN radio room. It appears that not enough consideration has been given to this problem.

How much benefit can be derived from SSNs using ELF will remain unclear until the Navy develops a specific concept describing SSN usage of ELF and until the impact of other developments (buoys, sonars, etc.) on SSN operations is determined.

ELF design requirements incompatible with SSBN/SSN operations

SSBN operational requirements, most of the time, are less than ELF design requirements Deleted Alert SSBNs normally travel at slow speeds Deleted According to a Navy official, alert SSBNs stay in the depth range percent of the time.

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For certain missions, SSN operational requirements can be more than ELF design requirements. SSNs, in conducting some missions, must be able to travel at high speeds and deep depths simultaneously, and the speed/depth trade offs available with ELF may not satisfy all mission needs. Athough the Navy is developing and testing Deleted Deleted floating wire antennas, the design of the antennas and the design parameters of the ELF system appear to be inconsistent. This issue was addressed by the Office of the Assistant Secretary of Defense (Program Analysis and Evaluation) in a January 10, 1978, Operational Test and Evaluation memorandum.

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TECHNICAL CONCERNS ABOUT ELF COMMUNICATIONS

The Navy maintained in the January 1978 Defense Systems Acquisition Review Council on ELF that

> "After 20 years of RDT&E [research, development, test and evaluation], and the expenditure of some $115M [million], we have demonstrated that ELF is technically sound, operationally useful and safe and compatible with the environment." "* * * there is little technical risk in now proceeding to development of production prototype equipment."

We believe the Navy position on ELF is insufficiently based in fact for the following reasons:

--System reliability and maintainability have not been proven.

--Only limited testing has been done, and this has been on a random basis, and data gathered could not be used for proper statistical analysis.

--Firm operational requirements and system performance criteria for ELF (which could be used to evaluate ELF) have not been established.

--Testing results did not specify the depth and attitude 1/ of the ELF antenna during testing.

While some ELF test results correspond to ELF design requirements, we believe the testing and analysis should be more comprehensive before the Navy proceeds with this program.

Office of Assistant Secretary of Defense supports our analysis

We are not alone in questioning the analysis of the ELF system. As part of the Defense System Acquisition Review Council process, the Office of the Assistant Secretary of Defense (Program Analysis and Evaluation), in January 1978, expressed concern about technical aspects of the proposed ELF system, as follows:

--Seafarer (ELF) had not been subjected to operational testing per se. Tests had been conducted on a non-interfering basis and in a somewhat random fashion. Reliability and maintainability had not been proven.

--The Navy had no approved development concept paper or test and evaluation masterplan. Also, the Navy had no consolidated report placing test results in proper statistical perspective. (DOD, in responding formally to this report in January 1979, advised us that a draft development concept paper had been completed and was undergoing staff review.)

1/For example, the angle, slant, and direction of the antenna.

--The design of the buoyant cable/floating wire antenna appeared inconsistent with the design parameters of the Seafarer system and fleet operational requirements.

--Development of a high-speed antenna was technologically of high risk, while the antenna being developed was of moderate risk.

--Inadequate examination had been made of the trade offs in distance, speed, and depth needed to extend ELF's geographic coverage.

The December 1977 report of the Assistant Secretary of Defense's (Communications, Command, Control and Intelligence) Ad Hoc Review Group indicated its concern for the operational utility of the modified ELF system (which it supported), when it stated that:

> "* * * actual utility of small systems is yet to be determined; therefore, none of the options can be confidently supported as a final system design at this time due to their uncertain operational utility. It might, therefore, be necessary to pursue the development and acquisition of a more capable ELF system at some future time if at all feasible."

CHAPTER 5

CONCLUSIONS, AGENCY COMMENTS AND EVALUATION, AND RECOMMENDATIONS

CONCLUSIONS

The Navy provides effective and reliable peacetime communications to strategic submarines each day through a combination of land-based, very low frequency, low frequency, and high frequency transmitter stations.

The TACAMO aircraft is the Navy's most survivable communications link to the SSBN force during a crisis. However, the Navy has allowed the TACAMO fleet to decline in number and deteriorate in physical condition.

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To meet the mission of delivering emergency action messages, the Navy must now act on its planned actions to upgrade TACAMO. Such actions include a $22 million SLEP for aging TACAMO aircraft and the procurement, for about $380 million, of new TACAMO aircraft and airframes to replace those whose service life will end in the early- to mid-1980s. We believe the Navy's planned actions constitute feasible near-term solutions to achieving the objective of delivering emergency action messages to the strategic force.

The Navy has also been deficient in assessing the capability of the TACAMO system. Historically, the system has not been regularly evaluated to determine whether it will communicate successfully when required. No continuing evaluations have been made for communications to TACAMO; however, the Navy plans to begin such evaluations in the near future.

The Navy has said it needs another peacetime communications system: the ELF. However, the need for an ELF communications system is questionable. The program has been troubled by inadequate management--the Navy has changed system requirements radically and frequently. Of greater importance, though, is that the modified ELF system, we believe, cannot be justified because

--of the extensive duplication and reliability of existing systems;

--there is a high likelihood that submarine antennas and other systems will not be detected and, therefore, will not endanger the strategic submarines;

--strategic submarines are extremely survivable now and will continue to be survivable for the foreseeable future;

--of the limited applicability of ELF to attack submarine missions and operations; and

--there is a lack of compatibility between ELF design specifications Deleted Deleted and strategic and attack submarine operational requirements.

Further, the proposed modified ELF system is no more survivable than existing day-to-day communications systems. Finally, although we do not believe the proposed ELF system is needed, there is doubt that the system will work as planned even if it is needed.

AGENCY COMMENTS AND EVALUATION

DOD's comments included a cover letter highlighting the major areas of agreement and disagreement between us and DOD (see app. IX) and detailed paragraph by paragraph comments on our proposed report that have been incorporated into or resulted in changes to our report as required.

DOD, in commenting on our proposed report, concurred with our general comments on the Navy's strategic communications requirements. Defense recognized and agreed with the management and decision problems we identified with the TACAMO system and affirmed that planned and ongoing Navy actions are in consonance with our findings. DOD did not concur with the portion of the proposed report which addressed the ELF program. Specific areas of disagreement or difference of opinion with respect to the TACAMO and ELF systems are discussed below.

TACAMO system

DOD stated in its detailed paragraph by paragraph comments on this report that the original service life of the TACAMO aircraft was 15,000 hours and had been extended to 25,000 with SLEP. Further, DOD stated that with this currently projected service life, the first aircraft in today's inventory will reach the end of its service life Deleted Deleted We do not concur with these statements.

Information obtained during our review differs from these DOD comments. Several Navy officials associated directly with SLEP advised us that it is unlikely the full additional 10,000 hours will be achieved with SLEP. Also, an internal December 1977 Navy staff study cast doubt about achieving the additional 10,000 hours, noting that SLEP may provide as little as 5,000 additional hours, thereby leaving a question whether it will take Deleted for the first aircraft to reach the end of its service life.

DOD stated that the TACAMO communications system has been tested since it was deployed in 1963. While some form of testing may have existed, no systematic qualitative testing was carried out. The Chief of Naval Operations, as early as October 1968, stated that TACAMO's operational effectiveness had not been established and the TACAMO system had not been given the same continuing evaluation given other SSBN communications systems. Also, the Navy's TACAMO project manager for strategic command, control, and communications advised us that there was no systematic means of determining how successful TACAMO was in relaying messages to SSBNs until the Johns Hopkins University Applied Physics Laboratory continuing evaluation program was effected in 1976.

ELF communications system

DOD took issue with our position that the extensive duplication and reliability of existing systems makes ELF unjustified, in that none of the existing operational communications systems frees the submarine from having an antenna at or near the ocean surface nor provides the submarine freedom to use optimum speed and depth in combination to gain concealment or mobility. Further, DOD maintained that we minimized the threat of buoy/antenna detection. The DOD comments further stated the capability of a potential enemy to detect our SSBNs is limited, but maintained there is no assurance that the limitation will not diminish with time.

We agree with DOD, and make this clear in our report, that the essential difference between existing communications systems and the proposed ELF system is that existing communications systems require having a buoy or antenna near or on the ocean surface, whereas the ELF receiving antenna would be further from the ocean surface. The issue then becomes one of the Soviet ability to detect antennas and buoys and the implications of this on SSBN survivability.

During our review we sought, but were unable to obtain from the Navy, specific documented evidence discussing

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Accordingly, we took the best and most appropriate actions we could to obtain information to clarify this area. We conducted interviews with appropriate Defense Intelligence Agency and Office of Naval Intelligence officials with respect to the threat now and in the future to antennas, buoys, and SSBNs. We discussed the Soviet capability and assets, including the subjects of sonar capability, acoustics, ocean search capability, etc., as well as the impact future U.S. longer range missiles will have on SSBN operations. We also held discussions with officials knowledgeable of SSBN operations in the Office of the Chief of Naval Operations and the Strategic Systems Project Office. Further, we read the testimony of Navy officials made in recent years before cognizant congressional committees concerning SSBN survivability. Also, we analyzed recent year budgets of the Navy's Strategic Systems Project Office, which showed the Deleted

Also, we reviewed the Navy's many efforts to maintain the SSBN state of virtual invulnerability. As discussed in detail in this report, the overwhelming conclusion we reached from our extensive fact gathering and analysis process is that (1) our SSBN force is extremely survivable now and will continue to be survivable for the foreseeable future and that (2) submarine antennas and buoys do not endanger SSBNs now or in the foreseeable future.

The other issue, discussed vaguely in the DOD comments, is the need for more and the degree of increased operational flexibility required in SSBN operations. Though we have seen reference periodically to the desirability of increased operational flexibility, there is no specific requirement for more operational flexibility than our SSBNs have today. There is a very solid current capability in this area, as indicated by the information discussed above. There are at least two questions that should be asked and responded to in this area:

1. What is the required operational flexibility that SSBNs do not have today but which is needed?

2. Does the proposed ELF system exceed, match, or fall short of the requirement?

DOD maintained that ELF has applicability to SSNs and stated in its detailed comments that it is when the SSN is in Deleted that effective, reliable communications from the operational authority to the submarine are most critical in time of crisis. We agree with the latter point, and stated in our report that though SSNs may Deleted In our view, this makes the requirement for ELF questionable. Also, the availability of ELF for wartime SSN usage is highly scenario dependent because of the survivability aspects of the ELF system. ELF is not considered survivable with respect to SSBNs, thereby the requirement for TACAMO. Therefore, how can it be considered survivable for SSNs? Further, an important point with respect to SSN applications is that we were not able to obtain a specific requirement document for ELF for the SSN force though we requested this information. Lastly, in view of the questionable need for and the limited ELF applications to SSNs, we do not believe that system costs can be justified for SSNs.

DOD indicates the ELF system specifications, Deleted Deleted are not incompatible with SSBN and SSN operations. DOD supports its contention by stating that ELF messages have been received as deep as feet and at speeds up to Deleted Deleted Navy test documents indicate that these results were not obtained simultaneously. Our position is not fully appreciated by the DOD comments. Alert SSBNs normally travel at Deleted and are highly survivable and able to effectively conduct their missions. SSN operational requirements, for many missions, exceed the ELF design requirements and planned capabilities.

DOD maintains that our position that "there is considerable doubt that the ELF system will work as planned" is without technical substance and is in opposition to actual test results. Further, in the detailed comments, DOD attributed to us a lack of understanding of the DOD acquisition process, in that we concluded that system reliability and maintainability had not been proven and that only limited and random testing had been done and could not be used for proper statistical analysis. DOD indicated that these matters would be addressed in the way we desired at a later stage in the acquisition cycle.

There appears to be an inconsistency in DOD's comments to this section of our draft report. On the one hand, DOD maintains that the ability of ELF to satisfy the need for reliable communications has been demonstrated on numerous occasions, even utilizing relatively crude experimental equipment. On the other hand, DOD attributes to us a lack of understanding of the DOD acquisition process and states reliability, maintainability, performance against specification, etc., will occur at a later stage of the acquisition process. Our position is basically that (1) ELF cannot be depended upon, at this time, to perform in a realistic SSBN operational environment where continuous communications is a requirement and (2) the maximum ELF capability from a technical standpoint is known and, at this time, is largely a function of the size of the transmitting antenna. With this knowledge, we believe issues not normally addressed until later in the acquisition process could have been addressed before now on this program. More importantly though, we believe the lack of definitive operational requirements for SSBN usage (optimum depth and speed, operating above/below thermal layers, etc.) and lack of testing in operational environments makes it nearly impossible to address ELF's operational utility from a technical standpoint with any reasonable degree of confidence.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that the Secretary of Defense terminate any plans to construct an ELF transmitter and to install ELF receivers on SSBNs, since the extremely low frequency communications system is not needed; enhances communications capability only marginally at best; and, at a price of $283 million, cannot be justified. However, we recognize that at some future time (probably not sooner than 10 to 12 years from now) circumstances or conditions related to SSBN survivability could change and that a clear need for an improved communications capability could be demonstrated. Accordingly, we believe that some low level of research on ELF should continue in view of the potential this technology offers.

RECOMMENDATION TO THE CONGRESS

The President's fiscal year 1980 budget package, submitted to the Congress in January 1979, only included $13 million for continuing research and development of the ELF system. We do not believe the Congress should consider funding any full-scale development or construction until the Navy specifies definitive communications goals and requirements, demonstrates a clear need for such a system and shows that the proposed system contributes to SSBN survivability and flexibility beyond what already exists, and conducts a detailed analysis of ELF capability compared to SSBN operational environments and documents the results of the analysis.

COMMUNICATIONS SYSTEMS PROVIDING DAILY

COMMUNICATIONS TO THE SSBN FORCE

The Navy employs various communications systems using different radio frequencies to communicate to its strategic submarine force. Daily communications are provided by VLF, LF, HF, UHF, and Clarinet Pilgrim systems.

VLF AND LF COMMUNICATIONS SYSTEMS

The fixed VLF system is the system most often used to communicate with submarines and is, therefore, the primary means of exercising command and control. This system has a primary role in NCA's World Wide Military Command and Control System (WWMCCS). WWMCCS is the special communications link direct to the operating forces. It includes not only strategic communications systems, but also other overall command and control systems associated with general purpose forces. The fixed VLF and LF systems are assigned a support role in the Joint Chiefs of Staff's Minimum Essential Emergency Communications Network (MEECN). The MEECN supporting systems include those not specifically designed to survive in a transattack environment but which, because of their duplication or potential reconstruction, are expected to provide some communications capability then.

Fixed VLF and LF stations are located in the Atlantic Ocean, Pacific Ocean, and the Mediterranean Sea areas. Fixed VLF stations are located at Annapolis, Maryland; Cutler, Maine; Harold E. Holt, Australia; Jim Creek, Washington; Luoluolei, Hawaii; and Yosomi, Japan. Two of these stations--Cutler and Harold E. Holt--together provide VLF signals to virtually all ocean areas. In peacetime, the remaining VLF stations normally provide backup to the two main communications transmitters.

The VLF stations are equipped with 67-word per minute, multichannel, encrypted transmitters, referred to as VERDIN, which rapidly transmit messages to patrolling SSBNs.

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VLF radio transmissions can penetrate seawater to depths of about 30 feet. This allows SSBNs to remain deep and keep their radio reception devices, primarily the towed buoy and buoyant cable antenna, below the surface of the water, thus promoting covertness.

Additionally, 21 LF stations serve as secondary transmission stations. Operational procedures require that SSBNs obtain LF broadcasts if they are not receiving VLF transmissions. Likewise, if both VLF and LF signals are lost, SSBNs must copy HF broadcasts. This communications overlap is required to guarantee continuity of broadcast when individual stations are out of service.

Although fixed VLF and LF stations provide reliable communications in peacetime, they are not designed to survive direct, physical attacks. Such attacks, particularly those using nuclear weapons, could destroy these facilities

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The Navy's airborne VLF system, TACAMO, provides a survivable communications link to SSBNs. (See p. 8.)

The Navy's fixed VLF and LF stations were designed, constructed, and modified at various times over the past several decades. Each station has a unique construction, and they are in different stages of becoming obsolete. The Navy plans to improve and modernize the current VLF and LF transmitting facilities in the areas of performance, reliability, and efficiency. Transmitter efficiency is important, since the annual cost for energy for the six VLF transmitters alone exceeds $3.6 million.

UHF AND HF COMMUNICATIONS SYSTEMS

UHF and HF communications systems currently provide U.S. submarines with a two-way communication capability with shore stations, the fleet, aircraft, and satellites. The Navy operates 24 land-based HF radio communications stations which contribute to the command and control of SSBNs and other strategic forces with nuclear arms. HF stations are a backup for the VLF and LF components. In practice, two or more HF stations simultaneously transmit the same information broadcast over VLF and LF transmitters. Many fixed HF transmitters are located near VLF and LF transmitters

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SATELLITE COMMUNICATIONS

The Submarine Satellite Information Exchange System allows strategic submarines to transmit and receive messages through UHF at a high data rate of 2,400 bits per second.

The system's broadcasts complement those of VLF and LF, and its transmissions are comparable to those of HF facilities. The broadcast mode enables the transmission (by the shore terminal on a scheduled basis) of selected portions of the submarine broadcast. At all other times, the system operates in a query/response mode, allowing submarines to transmit messages to and receive messages from the shore terminal. The system is leasing satellites (called "gapfiller" satellites) on an interim basis until enough Fleet Satellite Communications synchronous orbit satellites are available. The first Fleet Satellite Communications satellite was launched in February 1978.

SSBNs must deploy an antenna above the surface of the water to receive broadcasts or transmit via the satellite system. Because of the nature of SSBN operations--to remain submerged and covert--the system is not relied on as a primary communications system. It serves only as a backup system. Satellite communications are more widely utilized by tactical submarines.

CLARINET PILGRIM

Clarinet Pilgrim is a communications system

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The Pilgrim system provides a parallel link to improve the overall reliability of broadcast transmissions **Deleted**

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The Clarinet Pilgrim system in a peacetime environment serves as another means for relaying day-to-day communications

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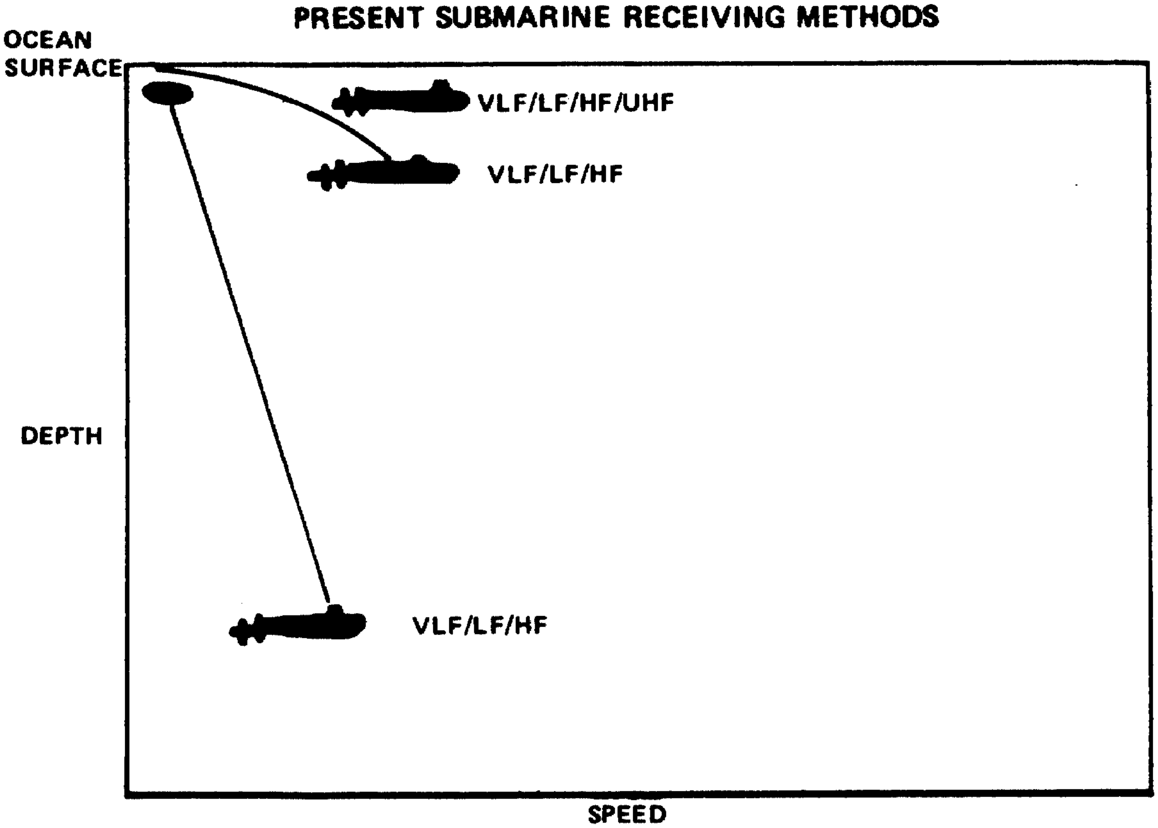
SSBN COMMUNICATIONS RECEPTION METHODS

Submarines receive communications through three principal methods: (1) they can raise a mast antenna above the surface of the water, (2) the submarines can remain submerged and stream a buoyant cable antenna astern Deleted Deleted of the antenna must be on the surface for effective communications reception), and (3) the towed buoy, which is tethered to the submarine by a steel cable and automatically controlled to a preset depth, usually Deleted Deleted below the ocean's surface. The amount of buoyant cable antenna and towed buoy cable deployed varies with the depth and speed of the submarine. The chart below depicts the present receiving methods and their reception capabilities.

PRESENT SUBMARINE RECEIVING METHODS



According to Navy officials, SSBNs on alert rarely use mast antennas for normal communications, since the mast is usually above the ocean's surface and the submarine itself has to be near the surface. This is undesirable, since the SSBN mission calls for it to be submerged and undetected.

The buoyant cable antenna and the towed buoy systems are primarily used for receiving communications. Each allows the submarine to operate deep while receiving VLF/LF/HF broadcasts, thus enhancing the covertness of the SSBN force. For example, the towed buoy is designed to allow the SSBN to communicate at a **Deleted** speed and **Deleted** keel depth. Likewise, an SSBN using the buoyant cable antenna, **Deleted** **Deleted** long, can go deeper by traveling slower.

Navy officials said that deciding to use the buoyant cable antenna or towed buoy depends upon the operational environment and is left largely to the discretion of the SSBN commanding officer. According to Navy officials, SSBN commanding officers have been reluctant to use the towed buoy because of its reliability problems. Therefore, the buoyant cable antenna has been more widely used.

The Navy has corrected many of the engineering and operational problems that have historically plagued the towed buoy. Also, additional improvements are being made. (See pp. 17 and 18.)

The Navy has designated the towed buoy as the primary receiving system because it can receive communications below the surface of the water and in any direction, which provides greater operational flexibility.

SSBN SHIP-TO-SHORE COMMUNICATIONS SYSTEMS

Alert strategic submarines, because of their mission to remain covert, rarely transmit via radio to shore, because to do so means using an antenna above the ocean surface.

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Strategic submarines use satellite systems, the Circuit Mayflower and Clarinet Merlin, to communicate to shore stations. Clarinet Omen, if approved, will provide a submarine-to-shore satellite communications system in the mid-1980s.

Circuit Mayflower is a Deleted system used for submarine-to-shore communications.

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The Circuit Mayflower system provides

Clarinet Merlin is an operational submarine-to-shore emergency communications system used to report the loss or "in extremis" situation of a strategic submarine. The Clarinet Merlin system is comprised of two major subsystems--the AN/BST-1 buoy and the AN/FRR-93 receiver system. The buoy, upon release, broadcasts a continuous signal, Deleted at 12 to 15 words per minute in the HF band. The approximate position of the submarine can then be determined through the HF direction finding net.

Clarinet Omen is an extremely high frequency submarine-to-shore satellite communications system planned for the mid-1980s and beyond. If approved, this system will provide secure, Deleted report-back capability to SSBN submarines.

ALTERNATIVES TO EXISTING

COMMUNICATIONS SYSTEMS

DOD and the Navy have reviewed various alternatives to existing SSBN communications systems. These systems fall into three categories--low frequency electromagnetic, blue-green optical, and methods employing acoustic reception.

LOW FREQUENCY ELECTROMAGNETIC

An extremely low frequency communications system operates in the portion of the radio spectrum below 100 hertz. Energy transmitted in this spectrum can travel nearly worldwide through the air bounded by the Earth's surface and the ionosphere and can penetrate water.

ELF ground-based systems

At least five different ELF ground-based systems were researched during the 1960s and 1970s--Sanguine, Shelf, Pisces, Seafarer, and a modified version of Seafarer.

Sanguine

The Navy originally proposed the Sanguine system to provide ELF communications to strategic submarines, including delivering emergency action messages. ELF was designed in the early 1960s to survive a nuclear attack, because of its many buried, cement-encased transmitters and a very extensive antenna array spread over an area in excess of 20,000 square miles. In 1968 it was estimated that the Soviets would have had to target about a third of their strategic nuclear weapons on Sanguine to destroy it. At that time, it was believed the Soviets would have been reluctant to use so many of their nuclear assets to destroy Sanguine and the system was thought to be survivable.

However, as Soviet missile technology continued to improve, increasing the number and accuracy of missiles and the use of multiple independently targeted reentry vehicles, estimates of the number of Soviet missiles required to destroy the Sanguine system were reduced. Therefore, the Navy concluded that the system would likely not be survivable and development of Sanguine was discontinued.

Shelf

The Shelf (super hard extremely low frequency) system was investigated as an alternative to Sanguine, because a survivable ELF system that could deliver emergency action messages to SSBNs was still desired. The antenna cables for this system would have been placed in tunnels and powered by transmitters installed in cavities. The entire complex would have been constructed at about a 3,000- to 6,000-foot depth. This concept posed high-technical risks and costs and was not pursued beyond the research phase.

Pisces

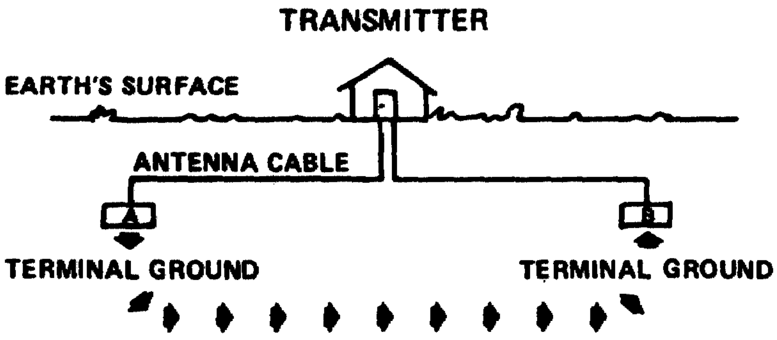
A high-voltage, direct-current line crosses Oregon, Nevada, and California. The Defense Communications Agency once thought an ELF signal could be superimposed on the line, but technical feasibility was not demonstrated. The Navy estimated that considerable time and money would be required to prove its technical feasibility. In 1976 an ad hoc committee of the Defense Communications Agency Scientific Advisory Group recommended concentrating on Seafarer and limiting further Pisces work to analytical studies after concluding, among other things, that Seafarer was preferable with respect to submarine operating area coverage, growth potential, and physical security.

Seafarer and modified Seafarer

Until 1975, the Navy was still considering three alternative ELF systems--Sanguine, Shelf, and Seafarer. However, in February 1975, the WWMCCS Council directed the Navy to shift its planning from a survivable to nonsurvivable peacetime system. Seafarer is a soft, nonsurvivable system with transmitting antennas buried several feet below ground level.

For best performance, Seafarer requires an antenna several thousand miles long. It is not easy to have a single strand that long, so Seafarer gets the equivalent with a crisscross array. This array, buried 3 to 6 feet, is fed by transmitters in buildings on the surface.

Seafarer transmitters send electrical current through the antenna. The current flows out the terminal ground at one end of each antenna (point A), travels through the Earth, and into the terminal ground at the other end of the antenna (point B). This path of electrical current forms a loop which actually becomes a part of the Seafarer antenna.



The size of the loop formed between the terminal grounds is the key to the efficiency of the system. The larger the loop, the lesser the electrical power needed to go into the antenna to send out the necessary signal. The conductivity of the deep underlying rock determines the size of the loop, with best results in areas with low conductivity; that is, rock that does not conduct electricity well. In these areas, electrical current flows deep into the ground--a 1,000 feet or more--before it returns through the other terminal ground.

Airborne ELF systems

Airborne ELF transmission systems, such as balloons and conventional aircraft, have been considered to take advantage of the greater efficiency of vertical antennas they can carry.

Balloon-supported systems

One system would employ an array of balloon-supported antennas about 2 miles above the Earth's surface. The Navy found many practical problems in implementing such a concept, including dubious technical feasibility, noncontinuous operations due to weather, and a potential air hazard.

Conventional airborne systems

This system requires aircraft to tow long antennas. Since the transmitter power which can be carried by an airplane as large as a Boeing 747 is limited to a few hundred kilowatts, the airplane-to-submarine range is limited to less than 3,000 miles and, thus, would require many airplanes. Problems with this system include high-technical risk, power limitations, and airspace hazard.

ELF satellite systems

Satellite-borne ELF transmitters orbiting either in the ionosphere or magnetosphere are a potential means of submarine communications. Multiple satellites would be required. The Navy maintains that an extensive experimental program lasting more than 5 years and consisting of actual satellite-borne experiments would be required to evaluate the technological risks, particularly those associated with achieving adequate radiation efficiency and widespread geographic coverage.

Superconducting transmitters

Superconductors can carry very strong currents with little power loss. Since the fields radiated by a magnetic dipole 1/ are proportioned to the product of the current and the area, superconducting antennas could be much smaller than conventional ones. Such a trade off between current and size is attractive. However, huge electric currents produce intense electromagnetic fields. Thus, for long-range systems, the use of ELF by rotating magnets shows little promise. Structural considerations, as well as limitations of superconducting materials, limit the size of a rotating magnet.

Lithospheric waveguide

Some geologists think a low conductivity layer of rock exists in the lithosphere, which is the relatively rigid outer portion of the Earth. This layer is estimated to be centered about 5 to 15 kilometers below the Earth's surface.

1/A pair of equal and opposite magnetic poles of opposite sign separated by a small distance.

If such a layer exists, it might provide a waveguide for ELF or ultralow frequency (ULF) radio signals. The signals perhaps could be launched into the guide and retrieved from it by huge antenna arrays in wells many miles deep. Conceptually, these signals could be relayed to submarines by means of acoustical transmitters placed on the ocean floor above receiving wells.

The existence of a usable crustal waveguide has not been established, and its use must be regarded as speculative. Considerable research over several years will be needed to adequately determine waveguide existence and properties and to better understand the risks associated with this concept.

ULF systems

ULF refers to frequencies between 0.1 and 10.0 hertz, which is the next band below ELF. ULF penetrates seawater even better than ELF. However, for equal communications coverage, the field-generating element of a ULF transmitter would occupy several times the area of an ELF transmitting antenna and consume several times as much power. Thus, the public could be very concerned about the environmental impact of such a system.

BLUE-GREEN OPTICAL

A satellite-to-submarine optical link is possible. The blue-green optical system would use a blue-green laser to take advantage of the well-known transmission window in seawater that exists at optical wavelengths around 0.5 micrometers. The satellite directs a pulsed laser beam onto a spot on the ocean surface where the beam enters the water and begins to scatter. The beam from the satellite scans the ocean surface and illuminates each area long enough to transmit messages.

Although promising for certain applications, the laser concept cannot simultaneously satisfy the communications coverage, submarine depth, and message delivery time requirements. However, the Navy, as of January 1979, was investigating the blue-green laser concept to determine if it can be adapted to meet submarine communications needs.

ACOUSTIC RECEPTION

A number of schemes have been postulated to provide acoustical transmitters. One would place projectors on the seafloor along continental shelves and connect them to shore with underwater cables. Technology is available to do this, and tests have been made over long distances. However, one principal problem is that communications coverage is uncertain and transmitting a reliable message is difficult. Acoustic signals require 20 minutes to travel 1,000 nautical miles and, thus, all projectors near the continental United States would require a very long time to transmit messages to submarines far away. Also, relatively simple enemy measures during peacetime could locate the systems, thus, reducing their effectiveness during war.

TACAMO COMMUNICATIONS SYSTEM OPERATIONS

The TACAMO fleet consists of two squadrons. The Atlantic squadron, based at Patuxent River, Maryland, is assigned seven operational aircraft, one devoted exclusively to research and development, and one reserve aircraft. The Pacific squadron, based at Guam, consists of two operational and one reserve aircraft. During normal peacetime operations, TACAMO aircraft transit to and are deployed from North Atlantic Treaty Organization and U.S. air bases. The normal TACAMO airborne mission is about 11 hours. TACAMO aircraft operating in the Atlantic Ocean will use Deleted during a typical 2-week deployment. About different Atlantic Ocean airbases were utilized during June 1978.

TACAMO AS COMMUNICATIONS RECEIVER

TACAMO, to remain covert when airborne, operates over wide and varied areas and makes few electronic transmissions. Because TACAMO only relays communications Deleted it has been designed to receive communications from multiple sources. These include existing VLF, LF, and HF ground communications systems. Also, TACAMO is served by dedicated, land-based LF and HF transmitters. Deleted LF and Deleted Deleted HF stations are active in the Atlantic and HF stations are active in the Pacific. TACAMO also can receive emergency action messages via UHF satellite circuits. Ground stations and satellite systems,

Deleted

The principal survivable systems that can relay an emergency action message to TACAMO are the

Deleted

Also, the Emergency Rocket Communications System can deliver an emergency action message to TACAMO.

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The VERDIN and 616A programs were developed by the Navy and Air Force, respectively, to correct deficiencies in the VLF and LF radio transmission and reception capabilities.

A February 1978 MEECN status report cited the installation of the Deleted Deleted as the single most important MEECN improvement. It will assure communications to Atlantic SSBNs and improved communications to Pacific SSBNs. The report recommended that the

Deleted

A Navy program official said that both programs were on schedule for simultaneous completion Deleted

TACAMO AS COMMUNICATIONS TRANSMITTER

The TACAMO system operates with both Navy and Air Force communications systems and can transmit in frequency bands from VLF to UHF. However, TACAMO aircraft use primarily the VLF frequency spectrum for transmitting messages. VLF allows the submarines to remain submerged well below the ocean surface and still receive their communications. TACAMO aircraft are equipped with 200-kilowatt, VERDIN-modulated, VLF transmitters.

Deleted

The TACAMO VLF signal range and ability to penetrate seawater depends upon how vertical the long trailing wire antenna is.

Deleted

Message transmission time depends on the location of the TACAMO aircraft when it receives the message

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RECENT EVENTS RELATED TO THE PROPOSED ELF SYSTEM

After directing its focus away from survivable systems in 1975, the Navy proposed and received funds to research Project Seafarer in fiscal year 1976. It was to be a system with the following characteristics:

Size of transmitting antenna	2,400 miles
Message length	
Message delivery time	
Messages transmitted daily	Deleted
Average number of messages per submarine daily	

The Assistant Secretary of Defense (Communications, Command, Control and Intelligence) was directed to review ELF system alternatives in March 1977 and report back to the Secretary of Defense. The ad hoc review group established for this purpose recommended in June 1977 that the full-scale Seafarer system be developed and acquired. It judged the modified ELF system, and other smaller system designs, to be of marginal operational utility which could not be supported then as the final, operational ELF system. The modified ELF system was to have the following characteristics:

Size of transmitting antenna	130 miles
Message length	
Message delivery time	
Messages transmitted daily	Deleted
Average number of messages per submarine daily	

However, the ad hoc review group, in its final report in December 1977, advocated funding the modified ELF system. The group said two factors influenced its recommendation: (1) a full-scale system might not be needed or justified in view of the political controversy about its use, environmental concerns, and high cost and (2) the modified version would provide a basis for future system growth if ELF requirements later increased.

The Navy, for a Defense Systems Acquisition Review Council presentation on January 12, 1978, recommended that a modified ELF system be researched and developed at a cost of $283 million. After reviewing Project Seafarer in January 1978, the Council recommended that the Secretary of Defense approve a modified ELF system that would use the combined capabilities of an existing ELF test facility in Wisconsin and a proposed ELF facility in Michigan.

The Secretary of Defense, on March 18, 1978, directed that work on the full-scale Seafarer be stopped and that the Navy develop a program plan for an austere ELF system like that recommended by the Council. It is to have an ELF transmitter facility at K.I. Sawyer Air Force Base, Michigan, operating with a 130-mile antenna array and use the existing ELF test facility in Wisconsin operating with a 28-mile antenna array. The two antenna arrays are to be linked together electronically, probably by leased telephone lines.

THE NAVY'S JUSTIFICATION FOR

THE ELF COMMUNICATIONS SYSTEM

The Navy justified the ELF system in the Defense Systems Acquisition Review Council presentation and in the Council's memorandum to the Secretary of Defense.

The Navy said present communications systems have one major deficiency in their ability to communicate with the submarine force. Their messages cannot penetrate the ocean more than a few feet. Therefore, to communicate, a submerged submarine must have a receiving antenna on or very close to the surface of the water. The Navy said this increases the detectability of missile submarines and limits the efficiency of attack submarines. An ELF communications system can penetrate seawater to depths where submarines routinely operate and where ELF messages can be received by a submarine equipped with a suitable antenna and communications receiver. Also, ELF is largely immune from jamming and the effects of atmospheric disturbances, including high-altitude nuclear bursts.

The Navy's justification for the ELF communications system focused on what it described as the limitations of existing antenna systems (mast antenna, buoyant cable antenna, and towed buoy antenna). The mast antenna presents a radar target which can be detected under the worst case conditions out to ranges of about ______ Deleted ______ increases acoustic vulnerability, and might be visually detected. For these reasons, strategic submarines do not normally use mast antennas for communications when on patrol.

The buoyant cable/floating wire antenna is much more difficult to detect. However, it can be observed under some circumstances, particularly when the sea is calm, with detection possible for several miles. The submarine is usually relatively shallow when using this antenna and the submarine generates more noise when shallow than when deep. Also, the buoyant cable antenna restricts the speed and depth of a submarine during communications. Nevertheless, the buoyant cable must be used rather frequently by submarines on patrol.

The towed buoy antenna is most likely to be detected by acoustic means since it can generate large transient noises when reeling in or out or when cycling to maintain depth. Because of its size and the shallow depth at which it must operate, it also can be detected by other means under certain circumstances. The towed buoy is normally used by missile submarines on patrol. Navy officials said reliability problems with the towed buoy was another reason for favoring ELF.

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However, their ability to detect the antennas will probably increase. The antennas might be detected by chance, and even this causes considerable concern.

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To keep from being visually detected,

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The physical limitations of present antennas do not allow SSBNs to use their depth and speed capabilities to best carry out missions. In particular, they cannot seek the ocean depths to greatly reduce the possibility of detection. The Navy feels an ELF communications system will, in many ways, reduce the submarine's vulnerability to detection.

In summary, the Navy contends that ELF communications will increase the survivability of the strategic submarine force and, as an important added benefit, increase the effectiveness of attack submarines in carrying out their assignments in peacetime or in a conventional or limited nuclear war.

The Navy cited an added benefit of ELF as improving the effectiveness of the attack submarine force.

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In surfacing, the submarine may have to penetrate a density layer, caused by uneven heating of the near-surface water, that alters or blocks sound. Thus, SSNs may not know that warships or large merchant ships are very near.

Attack submarines can be stationed in a barrier or on a holding station in an open ocean area. To be most effective,

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at specified intervals. With an ELF system, SSNs can carry out missions at depth, receiving essential messages while submerged.

An ELF communications system would have SSBNs copy ELF continuously to receive essential operational messages. About once a week, or when directed by ELF, SSBNs would copy VLF or other higher frequency systems to receive long operational and administrative messages. Likewise, selected SSNs on high-priority missions would copy ELF continuously and would need to copy another broadcast only when directed.

TECHNICAL CONCERNS ABOUT

THE PROPOSED ELF COMMUNICATIONS SYSTEM

There are a number of technical areas related to the proposed ELF system that have not been resolved adequately or addressed sufficiently by the Navy.

NEED FOR DEMONSTRATED SYSTEM RELIABILITY AND MAINTAINABILITY

Whether ELF will be able to satisfy the need for reliable and secure peacetime and wartime communications is, at this time, an open question. DOD and the Navy believe that the reliability of strategic communications systems is important. However, because of inadequate management, the Navy has not thoroughly examined the diminished reliability and capability which may result from a smaller modified ELF system.

The Navy has been gathering ELF propagation and atmospheric noise data through its propagation validation system. A Navy program official stated that this data demonstrates feasibility, not reliability and maintainability. However, reliability and maintainability should be given critical attention, even in early evaluation.

One developmental area could greatly affect system reliability--the research and development of ELF reception antennas. So far, nothing new has been developed. The Navy has been able only to adapt an existing buoyant cable antenna to ELF. This antenna is bidirectional and reduces the SSBN's operational flexibility. This can cause SSBNs to miss messages. Existing towed buoy and mast antennas are omnidirectional antennas capable of receiving communications signals in any direction and do not limit the SSBN's operational flexibility like bidirectional antennas. The Navy hopes that either a technical breakthrough will enable them to develop a more capable antenna or that the TRIDENT submarine will prove quiet enough to use the modified, lower capability, ELF system.

Additionally, we observed that in several tests the Navy attributed poor results to such factors as the ship's direction not being optimum, equipment malfunction, and antenna damage. Actual ELF performance in the real world depends on the aforementioned factors and other factors such as atmospheric noise, distance from the transmitter, length of antenna used, and interference from the ship's own noise. We believe these factors should be thoroughly investigated as they relate to the SSBN's ability to communicate reliably and not interfere with the submarine's flexibility, requirements, procedures, and readiness.

NEED FOR MORE COMPREHENSIVE TESTING AND CONSOLIDATED TEST EVALUATION

Despite the fact that ELF research has been going on for 20 years, actual testing at sea has been very limited and only analyzed by bits at a time. The Navy, beginning in July 1976, installed ELF receivers temporarily in 10 SSNs to gather ELF data and to support 8 fleet exercises. The Navy has also permanently installed receivers on five SSBNs to gather ELF signal strength and atmospheric noise data and to conduct limited operational testing. Test data gathered and evaluations of this data could not be used for proper statistical analysis because the amount and type of data available were insufficient. As a result, important questions about ELF capability could not be assessed.

We could not find any single authoritative document placing test results in proper statistical perspective. Only fragmented analysis described SSBN and SSN fleet testing. Examples of these analyses were as follows:

--The July 1977 Quarterly Report on the ELF propagation validation system performance data profile.

--Naval Underwater Systems Center technical memorandums and informal "quick look" studies.

--Fleet exercise analyses of communications support.

The Johns Hopkins University Applied Physics Laboratory prepares ELF propagation validation system data for the Navy. This data profile organizes the SSBN test data under a set format to help interpret it. According to a Navy official, as of August 1978, the laboratory had issued only one report on the ELF reception system because of limited funding. Because the report involved only 6 days of ELF testing, in 1976 and early 1977, a Navy official considered the report inconclusive.

Both Naval Underwater Systems Center officials and fleet commanders prepared limited analyses of ELF in fleet exercises. The Center prepared a brief summary, dated January 4, 1978, of ELF propagation validation test results in six fleet exercises for the 1978 Defense System Acquisition Review Council presentation. It concluded that ELF performance in several fleet exercises was successful. In contrast, fleet commanders rarely even mentioned ELF performance in reporting on fleet exercises. Fleet commanders usually prepare detailed analyses of fleet exercises and communications performance which they distribute throughout the Navy. Only one of the four fleet exercise reports reviewed, "Coordination in Direct Support Exercise Report Analysis of Selected Direct Support Communications in Exercise Ocean Safari 77," dated April 14, 1978, even mentioned ELF performance.

Naval Underwater Systems Center research and development officials have drafted technical memorandums and several informal quick look studies of ELF testing for internal Navy distribution. Most of the data (contained in the informal studies) was accumulated from the 10 temporarily equipped SSNs. These studies also describe data collected from antenna stress tests. The Navy has issued a detailed draft technical memorandum of results from tests at sea of an SSBN, the U.S.S. Bolivar, in modified alert status.

Center officials gave various reasons for the limited testing information gathered to date. The principal problems cited were:

--The relatively high number of equipment failures in the experimental receiver set.

--Breaking of antennas caused by SSN tow speeds.

--Limited operations testing and equipment maintenance training for fleet personnel.

NEED FOR OPERATIONAL REQUIREMENTS AND SYSTEM PERFORMANCE CRITERIA

Fleet commanders and Naval Underwater Systems Center evaluations of ELF were inconsistent. We believe the inconsistencies result, in part, from the lack of established operational requirements and system performance criteria. Without these, the statistical significance of test data cannot be assessed.

Although the Navy has justified the ELF system principally for SSBN use, much of the test data gathered has been on SSNs. This raises a question: Can data collected by SSNs be validly applied to SSBNs, since the SSBNs operate in different environments and perform different missions? A Center report stated that, while SSN testing has provided valuable data,

> "* * * the ELF system is intended to provide communications to the SSBN fleet and, since SSNs and SSBNs have different missions, tests performed on SSNs in fleet exercises could not be expected to address the SSBN performing its mission."

Although the Navy has not established specific operational requirements for an ELF SSN system, the Navy believes it could be adapted for SSN use. The fleet, however, described the major drawback of using ELF on SSNs as receiving antenna limitations. The speed and depth requirements of the buoyant cable were considered a continuing serious problem in scenarios calling for high speed. They requested that the development of a high-speed ELF antenna be considered high priority.

Center officials said no system performance criteria exists for evaluating propagation validation results. This results in test data evaluations not arriving at consistent conclusions and makes it very difficult to objectively analyze statistical significance. We found contrasting evaluations from the Center and fleet commanders. For example, a research and development official described an SSN's performance in the Ocean Safari fleet exercise as follows: "While the data is being analyzed it is clear that the U.S.S. Lipscomb enjoyed considerable success." He briefly mentioned that two submarines suffered hardware problems.

However, fleet commanders described the ELF contribution in the Ocean Safari fleet exercise in more complete terms. The report stated:

--Speed and depth requirements

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--Only one submarine (U.S.S. Lipscomb) out of three used the system consistently throughout the exercise.

--The two other submarines (U.S.S. Bluefish and U.S.S. Russell) had antenna and processor problems and personnel training limitations.

--System reliability for U.S.S. Lipscomb was low (26.7 percent).

DEPTH AND ATTITUDE OF ELF ANTENNA NOT SPECIFIED IN TEST RESULTS

The Navy, in justifying ELF, said present communications systems have one major deficiency in their ability to communicate with the submarine force--their messages cannot penetrate the ocean more than a few feet. Therefore, to communicate, a submerged submarine must have a receiving antenna on or very close to the surface of the water. The Navy said this increases the detectability of strategic submarines. The Navy stated that ELF communications systems can penetrate seawater to depths where submarines routinely operate and where ELF messages can be received by a submarine equipped with a suitable antenna and communications receiver.

Though we do not believe receiving antennas and buoys endanger the survivability of SSBNs, the Navy has made such an issue of this matter that we expected the depth and attitude of the ELF antenna to be addressed prominently during testing and testing analysis. However, there does not appear to be a specific design requirement for the location of the ELF antenna while receiving communications nor for the antenna location during testing to be discussed in test results. In fact, documented test results did not discuss the position of the ELF antenna during testing until July 1978, when a Naval Underwater Systems Center letter addressed preliminary results of testing conducted aboard the U.S.S. Bolivar. These results mentioned only the depth of the midpoint of the antenna when the submarine operated at various depths and speeds and did not discuss the location of the end of the antenna, as was the case when the Navy discussed deficiencies with existing receiving devices.

THE UNDER SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

4 JAN 1979

Mr. J. H. Stolarow
Director, Procurement and Systems
Acquisition Division
US General Accounting Office
Washington, D. C. 20548

Dear Mr. Stolarow:

(U) This is in reply to your letter to the Secretary of Defense regarding your draft report, dated 20 November 1978, on "The Navy's Strategic Communications Systems -- Need for Management Attention and Decision-making," OSD Case #5042, GAO Code 951421.

(U) We are deeply concerned by the apparent difference between our and the General Accounting Office's understanding of the Navy Strategic Communications Systems and their relationship to the fulfillment of national objectives and requirements for the command and control of our strategic submarine forces. The keystone to our national policy is deterrence, i.e., to deploy our strategic forces in such a manner as to convince a potential adversary that our nuclear capability is real and that we will exercise it if necessary. The strategic submarine forces are a major factor in this deterrence posture.

(U) Both the continuously airborne TACAMO program and the planned Extremely Low Frequency (ELF) program are considered important to the Navy Strategic Communications Systems. These programs are a part of the overall Department of Defense communications capability required to effectively command and control our strategic submarine forces and, therefore, are paramount to the credibility of the US deterrent posture. Further, the fact that these programs impact heavily on the US ability to discourage aggression and to control crisis escalation, makes them a matter of extreme importance.

(U) We have completed the review of the draft report. The enclosed detailed comments, in a side by side format, are forwarded as requested. We concur in the general comments on Navy strategic communications requirements. Further, the portion of the draft report related to earlier management and decision problems with the TACAMO system are recognized and the current program which was initiated prior to your review is in consonance with your findings.

Classified by USDR&E
Declassify on 31 Dec 1984
Review on

(U) We do not concur with the portion of the draft report which addresses the ELF program. It contains a significant number of errors and misunderstandings in both fact as well as interpretation. This is disappointing in view of the considerable time spent in preparation of the draft report (approximately 10 months) and the large number of DOD manhours devoted in an attempt to provide your representatives with appropriate information.

(U) The capability of ELF communications to penetrate sea water to deep depths is unique; therefore, to categorize it as duplicative of existing systems is inaccurate. Twenty years of research on ELF have already documented the technical feasibility and environmental compatibility of an ELF system. Although the specific design of the system has changed, its basic operational application to improve strategic submarine force command and control has not changed.

(U) Examples of the most pertinent errors follow. The draft report:

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o (U) Questions the survivability of the system. It is a fact that an ELF system is no more survivable than the other existing communications systems and is not designed to be survivable against a direct nuclear attack. However, it is more survivable to effects of nuclear blackout. Its buried antenna and inland CONUS location represents a very hard system in a conventional war. Further, it is highly resistant to enemy jamming in comparison to other communications systems.

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o

(U) The misunderstandings and errors in these key areas, have led the GAO to invalid assertions and the conclusion to terminate the ELF program. We do not concur. I request you use the enclosed, detailed comments during the finalization of your report and offer you the support of the responsible DOD staffs to assist you in the preparation of a factual and comprehensive report.

William J Perry

Enclosure

GAO note: The enclosure has been incorporated into or resulted in changes to our report as required.

(951421)

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