SEAFARER: EXTREMELY LOW FREQUENCY NAVAL COMMUNICATIONS SYSTEM

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ISSUE DEFINITION

Ballistic missile submarines (SSBNs) and nuclear attack submarines (SSNs) cannot perform all of their missions effectively under current communications limitations. Existing communications systems require these submarines to approach the surface and deploy a submerged antenna in order to receive messages from land-based stations. This reduces their operational efficiency and increases their detectability. Modern nuclear-powered submarines are capable of operating at much greater depths and for much longer periods than in the past. Despite these capabilities, they are required to approach the surface at least every 12 hours to receive messages and instructions.

SEAFARER (Surface ELF transmitting system For Addressing Remotely deployed Receivers), an extremely low frequency communications system designed for worldwide communications with submerged submarines, has been proposed as a supplement to current systems. SEAFARER can penetrate seawater to great depths, allowing communications with ballistic missile submarines while they remain at optimal operating depths and speeds. Critics of SEAFARER claim that the system is too vulnerable to nuclear attack, has too low a data transmission rate, and is too limited in capacity, and that its installation might present radiation hazards to onsite residents. For these and other reasons, system development of SEAFARER has been slow and no actual construction of the system has begun.

BACKGROUND AND POLICY ANALYSIS

Land-based communications systems for sending messages to and from submarines date back many years, indeed, to before World War II. Until well after this time, it was necessary for the submarine to "come shallow" to send or receive messages, which considerably increased its likelihood of being detected.

U.S. submarines today receive communications from a series of radio transmission systems that radiate signals at frequencies varying from very low frequency (VLF) to ultra high frequency (UHF). Reception of transmissions anywhere in this range requires the submarine to place an antenna within 30 feet of the surface for VLF and on or above the surface for higher frequencies. An ELF system, as noted, would largely obviate this threat of detection.

According to a Navy Department Environmental Impact Statement (December 1977):

> "There is a national security need for a responsive, reliable, flexible and survivable command and control capability to serve the National Command Authority across the spectrum of military operations.
>
> "Our national security is based upon the credibility of U.S. strategic nuclear forces as stabilizing interests in maintaining world peace. The U.S. Navy's missile submarine force is recognized as the most survivable element of all strategic forces. Programs which improve the operational effectiveness and survivability of these submarines are important for national security.

"Current submarine operational capabilities permit operations at depths of many hundreds of feet, but current communications systems are not effective beyond antenna depths of 25 to 30 feet below the ocean surface due to sea water attenuation. This constraint forces submarines out of their most effective (deep) operational envelope into the more susceptible near surface, making them vulnerable to detection and endangering their survivability."

SYSTEM DEVELOPMENT

The first ELF system proposed for worldwide communications was SANGUINE. As finally configured in Navy planning, the SANGUINE antenna grid would have covered an area of 3,000 square miles, used 100 transmitters, and have had a power input of 15-30 megawatts.

Serious questions were raised about SANGUINE's survivability in a nuclear environment, especially if the system were targeted during a first strike on the American retaliatory forces. Likewise, possible harmful biological effects of radiation to residents of the site were anticipated by some critics. Former Defense Secretary Laird directed the Navy to look for a site in Texas and an alternative to the proposed site in Wisconsin. This change was rejected shortly thereafter because of strong opposition in Texas, combined with the relatively unfavorable geological configuration of the area.

In 1975, the Navy proposed the development of SEAFARER, a more modest program than SANGUINE and one not hardened against nuclear attack. After formal environmental impact analysis of sites in Nevada, New Mexico, and Michigan, SEAFARER was proposed to be located on the Michigan Upper Peninsula.

A number of issues have been raised regarding SEAFARER. The major ones are:

Vulnerability. Opponents of the system's development argue that the transmitter and the command and control system could be targeted very easily by the Soviet Union during a first strike on the U.S. land-based strategic forces. They question whether the National Command Authorities would be able to send a message directing ballistic missile submarine commanders to launch their missiles after the U.S. sustained a nuclear strike. Supporters of the system's development agree that the SEAFARER communications system can be destroyed by a nuclear strike; however, they contend that primary reliance on dedicated, survivable, airborne systems (e.g., Tacamo) compensate for this drawback. However, they point out that SEAFARER would afford greater survivability to American submarines (both ballistic missile and attack) during a crisis or limited war short of nuclear strikes on land based strategic assets. This would preclude the necessity of remaining close to the surface at all times to deploy an underwater antenna -- a requirement that may simplify detection by the enemy. Furthermore, the requirement to approach the surface to receive message traffic reduces the effectiveness of the SSNs in the performance of other assigned tasks.

Effectiveness. ELF systems can only transmit at very low rates. While the precise rate of transmission in the SEAFARER system is classified, it is known that to transmit, "Good Morning, Commander," would take several minutes. For this reason SEAFARER opponents believe that a complex instruction from the command and control center would take far too long

during a crisis or rapidly changing situation. The Navy argues that the slow transmission rate would not unduly undermine the system performance. Messages are sent in three character codes (e.g., ABC, 123) which are self-contained messages or can refer the unit commander to other instructions stored in the submarine. (There are 46,656 possible combinations of three character codes in the 26-letter alphabet combined with 10 digits.) Moreover, using a binary coding system would considerably expand the total communication vocabulary.

Environmental Impact. The impact of an ELF system on the environment was a major area of dispute between opponents and supporters of the system. Opponents argue that very little is known about the long-term effects of ELF communications on the surrounding environment, especially on essentially virgin land. In addition, the opponents have argued that ambient electricity from improperly shielded ELF transmission could trigger telephones to ring. Finally, they argue that the establishment of a SEAFARER antenna system will attract enemy nuclear warheads in the event of nuclear war. The Navy does not deny the last point, but it is confident that other objectives can be satisfied. The December 1977 environmental impact statement concludes that...

> "the biological and ecological research program has revealed no deleterious electromagnetic effects attributable to ELF electromagnetic fields at intensities planned for a SEAFARER system."

Research programs supporting the SEAFARER system include network analysis, coverage prediction, modulation coding and compression, submarine antenna systems, integrated radio rooms, and a special operational evaluation program.

SEAFARER would not satisfy all submarine communications requirements, but would be an effective complementary system to other systems such as Tacamo, an airborne VLF relay system, and a network of VLF, LF, HF, and satellite shore broadcast stations.

GENERAL CHARACTERISTICS AND PROPOSED LOCATIONS

As originally conceived, SEAFARER would have occupied an area of 4,700 square miles in the Michigan Upper Peninsula. The system would have consisted of 2,400 miles of buried antennas, five transmitter stations, and a transmitter control center. ELF communications are most effective when the antenna is embedded in an area underlain by rock of low conductivity. The Laurentian Shield, the pre-Cambrian granite bedrock underlying the Upper Peninsula, is of uniquely low conductivity.

Test Facilities. In order to evaluate the SEAFARER system prior to construction of an operational system, the Navy has proposed construction of a test facility at K.I. Sawyer Air Force Base, near Marquette, Michigan, on the Upper Peninsula.

The test facility proposed for the Michigan SEAFARER consists of a control center and a transmitter station on K.I. Sawyer Air Force Base, with an antenna of one 54-mile east-west cable and two (33- and 49-mile) north-south underground cables. All but about 10 miles of these would be located along existing rights-of-way. The transmitter station would not be manned except for security personnel. It would be operated electronically from the

Transmitter Control Center. Operating signals would be sent to the station by cables buried with the antennas. The Transmitter Control Center is the principal work place and operations center for SEAFARER.

The Michigan test facility would be utilized to confirm the operational and environmental predictions developed in the environmental impact study and form the basis for a decision to proceed with a larger size system and production of receiving equipment for all SSNs and SSBNs. This analysis would be documented in a follow-up formal supplement to the environmental impact statement of December 1977.

Alternative ELF System (Michigan-Wisconsin Combination)

In response to extensive public concern over the large-size SEAFARER system and to congressional encouragement to find less expensive alternatives to the Michigan SEAFARER, the Navy is considering an alternative system. To this end, the Navy has examined the technical feasibility, environmental impact, and operational utility of a system that combines the output of the K.I. Sawyer Air Force Base test facility with the output of the existing ELF test facility at Clam Lake, Wisconsin.

This Wisconsin Test Facility, in existence since 1969, consists of a control center, a transmitter station, and two 14-mile cables above ground.

These two independent systems, about 165 miles apart, would be linked by leased telephone lines or a microwave relay station, to assure proper phasing of the signals. The Navy considers the linking to be a technical matter and not a serious problem. The Navy believes the operational capability of the combined test facilities' signals would be of sufficient magnitude to provide an operationally useful ELF communications capability. While the estimated overall performance of the alternative system is less than the Michigan SEAFARER's, it would still cover areas that the Navy considers vital. The data transmission rate of the alternative would also be lower than Michigan SEAFARER, but the Navy considers it adequate. The Navy plan does not call for any expansion of the Wisconsin Test Facility (Clam Lake).

COST

The Navy estimates the costs of the alternative program to be $250-300 million, compared to about $590 million for the Michigan SEAFARER system. About $110 million of the alternative program estimate would be for the further research and development required (wherever an ELF system is located), about $56 million for receivers, and the remainder for building the system.

To date, total ELF funding for the past 18 years has been about $130 million. These funds include moneys expended on such predecessor programs as SANGUINE (SEAFARER's immediate predecessor).

PRESENT STATUS OF THE PROGRAM

The FY78 Defense Authorization Act (P.L. 95-79) authorizes $20.141 million "to be available only for research and development of an extremely low frequency (ELF) system...."

In legislative action on the FY78 Defense Appropriation Act (P.L. 95-111), the House voted no funds for SEAFARER. The Senate voted the amount authorized. The Committee of Conference agreed on a compromise $15 million. To some degree this compromise was fostered by a letter from President Carter to Representative Cederberg (July 29, 1977) in which the President promised that none of the...

> "SEAFARER funding now under consideration in FY78 will be used for work on a site in Michigan. These funds will, if approved, be used for equipment development which is independent of ultimate site location, and for continued operation of the Wisconsin Test Facility and related research efforts. Finally, I want you to know that if we do decide to request funds for deployment of any sort SEAFARER systems in Michigan, I will be reviewing this issue personally."

With this assurance, the Committee of Conference recommended an appropriation of $15 million, which sum was eventually enacted. In January 1978, the Defense Systems Acquisition Review Council (DSARC) recommended proceeding with development of the small (Michigan-Wisconsin combination) SEAFARER, and forwarded the recommendation to the President. In February 1978, the President decided to (1) terminate SEAFARER as a specific program but retain an ELF communications option, (2) support the small system, and (3) make no final site decision at this time. The Navy has asked for $40.5 million for ELF communications programs in FY79. All but $6.4 million is non-site related. The $6.4 includes half the amount needed for site preparation for commencement of construction in FY80. Absent a Presidential decision to proceed with site development of any ELF communications system, it is difficult to see how these funds ($6.4 million) could be effectively used.

In April 1978, the House Armed Services Committee recommended $10 million for SEAFARER. The committee specificially included language in the FY79 military procurement bill limiting the expenditure of funds to improvement of the SEAFARER Test Bed Facility at Clam Lake. The House has not yet taken action on the bill.

Accordingly, the program now stands as follows:

(1) All FY78 appropriations are for research and development.
(2) All FY79 funding recommended by the House Armed Services Committee is for research and development.
(3) The Presidential decision to terminate SEAFARER but retain an option to develop an ELF communications capability has left the scope of the system largely unresolved.

ALTERNATIVE MEANS OF SUBMARINE COMMUNICATIONS

It has been suggested that a blue-green spaceborn laser could be used to resolve the ELF communications problem. Such a laser would be incorporated in a satellite placed in orbit. When activated, the laser would penetrate the ocean to sufficient depths and the specific communication would be sent down and therefore, if constructed, would obviate the necessity for a

SEAFARER-type system.

There are, however, certain drawbacks to this laser system. Changes in the salinity and density of the water can change the laser's penetrability. Since the frequency of the communications system cannot be changed once it has been placed in orbit, there would be a number of conditions under which the system could not be used.

Furthermore, the laser's beam might be subject to "thermal blooming." Thermal blooming occurs when the laser beam heats the molecules in the air, thus changing the density of the air. Under these conditions, it could not transmit communications.

SEAFARER FUNDING
(Millions of Dollars)

ADMINISTRATION REQUEST	HOUSE ACTION	SENATE ACTION	FINAL AMOUNT APPROVED
FY76 Authorization			
$18.0	$18.0	$17.7	$17.7
	FY76 Appropriation		
$18.0	$17.7	$17.7	$17.7
	FY76 Transition Period Authorization		
$ 4.4	$ 4.4	$ 3.63	$ 3.63
	FY76 Transition Period Appropriation		
$ 4.4	$ 3.63	$ 3.63	$ 3.63
	FY77 Authorization		
$29.8	$29.8	$22.5	$27.1
	FY77 Appropriation		
$29.8	$14.8	$27.1	$14.8
	FY78 Authorization		
$23.741	$ 0	$20.141	$20.141
	FY78 Appropriation		
$23.741	$ 0	$20.141	$15

LEGISLATION

FY76 AND TRANSITION PERIOD:

Authorization
H.Rept. 94-199 (May 10, 1975)
S.Rept. 94-146 (May 19, 1975)
H.Rept. 94-488 (Sept. 18, 1975)--Conference Report
S.Rept. 94-334 (July 25, 1975)--Conference Report
P.L. 94-106; 89 Stat. 531 (Oct. 7, 1975)

Appropriation
H.Rept. 94-517 (Sept. 25, 1975)
S.Rept. 94-446 (Nov. 6, 1975)
H.Rept. 94-710 (Dec. 10, 1975)--Conference Report
P.L. 94-212; 90 Stat. 153 (Feb. 9, 1976)

FY77:

Authorization
H.Rept. 94-967 (Mar. 26, 1976)
S.Rept. 94-878 (May 14, 1976)
S.Rept. 94-1004 (June 28, 1976)--Conference Report
P.L. 94-361; 90 Stat. 923 (July 14, 1976)

Appropriation
H.Rept. 94-1231 (June 8, 1976)
S.Rept. 94-1046 (July 22, 1976)
H.Rept. 94-1475 (Sept. 3, 1976)--Conference Report
P.L. 94-419; 90 Stat. 1279 (Sept. 22, 1976)

FY78:

Authorization
H.Rept. 95-194 (Apr. 7, 1977)
S.Rept. 95-129 (May 10, 1977)
H.Rept. 95-446 (June 20, 1977)--Conference Report
P.L. 95-79; 91 Stat. 323 (July 30, 1977)

Appropriation
H.Rept. 95-451 (June 21, 1977)
S.Rept. 95-325 (July 1, 1977)
H.Rept. 95-565 (Aug. 4, 1977)--Conference Report
P.L. 95-111; 91 Stat. 886 (Sept. 21, 1977)

HEARINGS

U.S. Congress. Senate. Committee on Armed Services. Fiscal year 1978 military procurement authorization. Hearings, 95th Congress, 1st session. Part 10. [Washington, U.S. Govt. Print. Off.] 1977. p. 6677-6756.

REPORTS AND CONGRESSIONAL DOCUMENTS

U.S. Congress. House. Conference Committee, 1977. Department of Defense appropriations for fiscal year 1978; conference report to accompany H.R. 7933. Aug. 4, 1977. [Washington, U.S. Govt. Print. Off.] 1977. (95th Congress, 1st session. House.

Report no. 95-565)

CHRONOLOGY OF EVENTS

04/27/78 — The House Armed Services Committee recommended an authorization of $10 million for SEAFARER. Specific language is included which limits expenditures to the improvement of the SEAFARER Test Bed facility at Clam Lake.

02/00/78 — President Carter decided to terminate SEAFARER while retaining the option and recognizing the need for a small ELF communications system. He made no final site selection.

01/12/78 — The Defense Systems Acquisition Review Council (DSARC) recommended approval of the small site (Michigan-Wisconsin combination) and forwarded the recommendation to the President.

12/00/77 — Final Environmental Impact Statement on Project SEAFARER was filed by Navy Department.

08/04/77 — Based on President Carter's assurance that no FY78 SEAFARER money will be used for site preparation in Michigan, Committee of Conference on the FY78 Defense Appropriations Bill recommended $15 million for SEAFARER RDT&E. (This amount was approved.)

06/29/77 — In a letter to Representative Cederberg, President Carter promised to utilize all FY78 SEAFARER funding at the Clam Lake, Wisconsin, test facility and specifically promised to spend none of the money for any SEAFARER construction in Michigan.

06/20/77 — Committee of Conference of the FY78 Military Procurement Bill restored SEAFARER funding. However the committee recommended that all funds be used strictly for RDT&E effort. (Recommendation sustained in legislation.)

04/07/77 — House Armed Services Committee recommended deletion or all SEAFARER funds for FY78. Recommended improvement Clam Lake facility, feasibility of space-borne laser as an alternative submarine communications system, and additional support for the Air Force Advanced Space Communications System. Basis of committee recommendation: Soviet ASW threat is not sufficiently great to justify funding of ELF system at this time.

03/18/77 — Governor Milliken of Michigan exercised a veto over the establishment of a SEAFARER antenna in the Michigan Upper Peninsula. Navy Department claimed that the Michigan Governor had no right of veto over an item of national security.

02/17/77 — Navy Draft Environmental Impact Statement on Project SEAFARER was filed. Examined impact in three areas:

Nevada, New Mexico, and the Michigan Upper Peninsula.

12/00/76 — National Academy of Sciences' National Research Council declared SEAFARER program safe. Council report states that the communications grid would radiate .07 volts/meter which is "smaller than those known to produce classic biologic effects such as electric shock and nerve stimulation."

09/03/76 — Committee of Conference on the FY77 Defense Appropriations Bill agreed to a recommendation that SEAFARER be funded at the same basic level as FY76. Specifically, all full-scale development funds are excluded.

06/28/76 — Committee of Conference agreed to restoration of engineering development funds contingent upon (1) environmental impact statement indicating no unacceptable environmental or biological hazards, (2) selection of a candidate site, and (3) firm schedule to begin construction.

05/14/76 — Senate Armed Services Committee recommended approval of Administration request for RDT&E funding for FY77; recommended deferral of full-scale engineering development until FY78.

02/10/76 — Deputy Secretary of Defense Clements, in a letter to Michigan Governor Milliken, stated that "I would not recommend a Michigan site to Congress if you object...."

05/19/75 — Senate Armed Services Committee recommended approval of Administration request for SEAFARER RDT&E funds; recommended deletion of full scale development funds during FY76 and transition period. (Committee recommendations sustained in legislation.)

05/00/75 — Proposed ELF system name changed from SANGUINE to SEAFARER. SEAFARER is less capable than the original SANGUINE because it is not to be hardened against nuclear attack. However, a SEAFARER system would be substantially cheaper than a SANGUINE system.

00/00/68 — ELF test facility constructed at Clam Lake, Wisconsin.

00/00/66 — Exploratory ELF contract was awarded.

ADDITIONAL REFERENCE SOURCES

Boffey, Philip M. Project SEAFARER: critics attack National Academy's review group. Science, June 18, 1976. p. 1213-1215.

Carter, Luther J. SEAFARER: project still homeless as Milliken says no to Navy. Science, Sept. 2, 1977. p. 964-968.

Magney, John. Project SEAFARER: Michigan's war against the Navy. Progressive, July 1977. p. 22-24.

A Navy project goes aground in Michigan. Business week, Apr. 11, 1977. p. 28.

U.S. General Accounting Office. Letter report of Oct. 7, 1977, concerning Project SEAFARER. Washington, October 1977. 5 p.

U.S. Navy. SEAFARER ELF Communications Systems Final Environmental Impact Statement for Site Selection and Test Operation. Washington, December 1977. 6 v.