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July 15, 2010

This is a final response to your Freedom of Information Act (FOIA) request to the Defense Technical Information Center dated August 12, 2008, referred to the Office of Naval Research (ONR) via the Department of Defense and the Chief of Naval Operations. ONR received it on June 17, 2010. You requested a report entitled, "AD-526067, Comments on Sub-LF SATCOM Technology Development Program, December 1972," totaling 22 pages.

The Defense Technical Information Center (DTIC) located the document and it has been reviewed by the Defense Advanced Research Projects Agency (DARPA), ONR, and the Joint Staff (JS). DARPA and ONR have no objection to the release of the document, and the position of the JS is as follows. The JS has determined that some of the information is exempt from release (portions of three pages and one whole page) under 5 U.S.C. section 552(b)(2), which pertains solely to the internal rules and practices of the agency, and would allow circumvention of an agency rule, policy, or statute, thereby impeding the agency in the conduct of its mission.

Additionally, the Central Intelligence Agency (CIA), has determined that some of the information in the document (one redaction) is exempt from release under 5 U.S.C. section 552(b)(3), which pertains to information exempted from release by statute -- in this instance, 50 U.S.C. section 403(g), Section 6, the withholding of functions and information regarding the CIA. The IDA for the Defense Intelligence Agency (DIA), has determined that some of the information in the document is exempt from release (one redaction) under 5 U.S.C. section 552(b)(3), which pertains to information exempted from release by statute -- in this instance, 10 U.S.C. section 424, which permits the withholding of information regarding organization and personnel for DIA, NRO, and NGA.

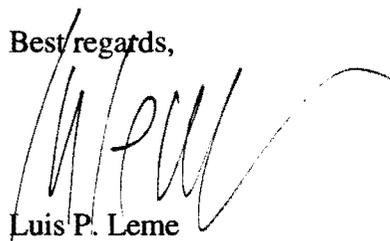
You have the right to appeal this response within 60 days of the date of this letter. Please address your appeal as follows:

Mr. James Hogan  
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Washington, DC 20301-1155

You must clearly and specifically articulate a basis for your appeal. Your appeal should be clearly marked "Freedom of Information Act Appeal" and reference case number 08-F-1844.

We have waived the fees for this request. If you have questions, please address them to Ms. Bonnie Gay at (703) 696-4309 or [bonnie.gay.ctr@navy.mil](mailto:bonnie.gay.ctr@navy.mil).

Best regards,



Luis P. Leme  
FOIA Officer

Enclosure

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AD 526067

NOTE N-820

COMMENTS ON SUB-LF SATCOM  
TECHNOLOGY DEVELOPMENT PROGRAM (U)

A.M. Peterson  
R. E. LeVier  
E. A. Frieman

December 1972

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ABSTRACT

(U) A brief review of the NRL Sub-LF SatCom Technology Development Program was conducted at the 1972 JASON Summer Study. The results of this review are reported. A number of specific technical questions are raised related to the operational characteristics and utility of a sub-LF satellite communications system. An appendix addresses the possible utility of such a system as an element of the WWCCS.

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\* The views expressed herein are those of the authors only. Publication of this Note does not indicate endorsement by IDA or the Department of Defense.

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(U) During the 1972 JASON Summer Study, at the request of ARPA a brief review was undertaken of the NRL Sub-LF SatCom Technology Development Program. A one-half-day briefing was presented by NRL and members of their program group. These included:

Dr. Allen - NRL  
Mr. Bearce - NRL  
Mr. Lucking - Navair  
Dr. McPherson - Aerospace  
Mr. Rorden - Develco  
Dr. Smith - Develco/Stanford University

In addition, several reports were made available for study:

1. The Feasibility of a Sub-LF Satellite-to-Submarine Communications Downlink  
Develco, Inc.  
Technical Report No. 1, Contract N00014-72-C-0113
2. ELF/VLF Transionospheric Propagation Satellite Experiment Study  
RCA/Govt. and Commercial Systems Astro Electronics Division/Princeton, New Jersey  
AED R-3857F, 13 July 1972
3. Concepts and Program for Satellite-to-Ground Communication at ELF/VLF  
D. A. McPherson and H. C. Koons  
Aerospace Corporation  
Report No. TOR-0059 (9220-02)-4, May 1, 1971.

(U) The Develco report and the briefing covered in considerable detail the technical problems of radiating a sub-LF (defined as below 30 kHz) signal from an antenna in the magnetosphere, its propagation in the magnetosphere, losses in penetration of the ionosphere, achievable signal-to-noise ratio at the ocean surface, and penetration of the ocean to modest depths. Although much more theoretical work (and experiments)

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would be required for a comprehensive understanding of these complex problems, the work to date appeared to be well done and of high quality. The RCA report on a satellite design to test sub-LF radiation and propagation characteristics is comprehensive and concludes that experiments are feasible though complex.

~~(S)~~ Although considerable information has been documented concerning the difficult physics and engineering problems associated with a "sub-LF satellite downlink," very little appears to have been undertaken concerning the possible operational utility of such a system. It appears that doubts as to system viability would exist even if the proposed downlink routinely achieved the best performance estimates for signal levels directly down a magnetic field line from the satellite. We believe that an attempt should be made to identify the minimal performance capabilities that would be required for such a system prior to embarking on the expensive applications research program outlined. Such a review would necessarily need to be made in comparison with existing or proposed systems, i.e., HF and VLF stations, TACAMO, SANGUINE, Fleet-Sat-Comm, and LES 8-9.

~~(S)~~ Thoughts and questions which arose during the Summer Study included the following:

1. How many "sub-LF satellites" would be required to obtain "operational" coverage? For ground area coverage of 1000 km below the ionosphere, Aerospace estimates 6 to 24 satellites! Perhaps this question can be resolved more favorably, but there exists doubt that coverage can be obtained at all near the equator and the poles.
2. What communication rates are believed possible? Though this probably has not been studied in any detail, signal-to-noise estimates appear to have been

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based on bandwidth less than 1 Hz (i.e., bit rates less than 1 bit/sec). Rates may, in fact, be comparable with those for SANGUINE.

3. Are these satellites with very large loops or dipoles particularly vulnerable to physical damage? This certainly appears to be the case for the low orbits discussed. Physical damage might be improved by maintaining satellites in orbit with antennas not deployed.
4. Theory, calculations, and geophysical observations suggest great variability will occur in the signal levels at ocean surface. It seems doubtful that sufficient signal level margin can be achieved to cover this variability. Whether performance will be sufficiently known to predict outages and periods of good communication is not certain.
5. Nuclear blackout attenuation appears to be a severe problem.
6. Although perhaps secondary to the questions raised above, there are a number of engineering questions such as: deployment and stability of very large antennas, prime power sources for satellites, and the required characteristics of the uplink stations required for communication to network of satellites.
7. In addition, LeLevier made a brief examination of the possible utility of a system of VLF satellites as an add-on to the present and planned WWMCCS. This examination, appended below, concludes that the VLF satellite system does not seem to offer a major increment in capability, primarily because of the apparently limited geographic coverage.

~~(G)~~ Despite doubts about the proposed system, it is believed that there are challenging and unsolved scientific and

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technological problems associated with the sub-LF research. The authors are also aware of the concern which has been expressed in DOD over the rather extensive Soviet R&D in trans-ionospheric/magnetospheric propagation (sometimes referred to as conjugate point studies). Almost certainly, not enough is known (at least in the USA) of the detailed phenomenology involved to be able to identify possible Soviet applications if they exist. A continuing research program (though perhaps modest in scope) aimed at better understanding this area of geophysics is probably justified in order to minimize the probability of surprise applications by the Soviets and to put us in a better position to exploit possibilities which might exist.

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APPENDIX

EVALUATION OF A SYSTEM OF VLF SATELLITES  
AS AN ELEMENT OF THE WORLDWIDE MILITARY  
COMMAND AND CONTROL SYSTEM (WWMCCS)

~~(C)~~ In order to place the possible utility of a system of VLF satellites in some perspective relative to the U.S. command, control and communications capability as represented by the present and planned worldwide system (WWMCCS), it would be useful to examine a spectrum of possible situation scenarios faced by the National Command Authorities (NCA) and inquire as to how the VLF satellites could augment or improve the total system operational capability.

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(U) These limitations may not necessarily be drawbacks in all of the candidate situation scenarios which we will now discuss.

1. Normal Peacetime Operations

~~(S)~~ We will restrict ourselves to communications with the fleet ballistic submarines (SSBN) which are currently conducted via VLF out of Cutler, Maine, for the Atlantic Fleet and Hawaii for the Pacific Fleet. At VLF frequencies (~ 15 kHz) this requires the SSBN to trail an external wire antenna which imposes some operational constraints on the submarine as dictated by skin-depth considerations (~ 2.4 meters at 15 kHz). It is not obvious that this will be significantly different for receiving transmissions from the satellite operating in the 1- to 5-kHz region with a skin depth varying from 9 meters to 4 meters.

2. Crisis Situations

~~(S)~~ During crisis situations, such as the Soviet invasion of Czechoslovakia, the taking of the Pueblo, the attack on the USS Liberty, etc., the strategic offensive forces are usually brought to a higher defense condition (DEFCON). This is a time-urgent procedure which may be accomplished through the Joint Chiefs of Staff Alerting Network (JCSAN) or the Emergency Message Automatic Transmission System (EMATS) or other means such as the Defense Satellite Communications System (DSCS). Messages to the SSBNs go by VLF from CINCPAC AND CINCLANT. A VLF satellite would be of dubious value in this situation due to the above-mentioned properties of limited area coverage;

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that is, coverage of two theaters of operations would be lacking.

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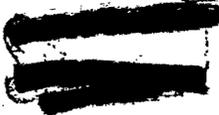
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