# CONSIDERATIONS RELATED TO WARFARE SYSTEM DESIGN AND OPERATION OF TACTICAL PLATFORMS IN A LOW-FREQUENCY ACTIVE SONAR ENVIRONMENT

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**Abstract** Low-Frequency Active Sonar System (LFASS) can provide significant improvements in the detection, localization and classification of very quiet submarine contacts. Achievement of the predicted performance improvements will require addressing and solving a number of issues related to the technical implementation of LFASS. These include the associated command, control, and communication ($C^3$) systems necessary to operate LFASS, impacts on operational requirements while using LFASS, and impacts to other systems operated concurrently with LFASS. This paper does not address the design and implementation of LFASS. Rather, the focus is on the required coordinated operations and the $C^3$ systems necessary to conduct those operations. The potential performance reduction impacts of LFASS operation on other concurrently operating systems and platforms are also addressed.

## 1. Introduction

Modern naval warfare requires greater operational coordination between the tactical platforms involved in an engagement. Naval surface and air forces have already addressed a number of interoperability issues, resulting in improved operational command, control, and communications. The inclusion of the submarine in the coordinated battle group adds a new dimension to the $C^3$ problem.

Effective operation of an LFASS places additional requirements and constraints on the $C^3$ systems, related tactical systems, and the coordinated operations of the tactical platforms in a battle group.

Battle group operations, when using LFASS, will require coordination with higher command authority, other battle groups, and other operating units which might be affected by the LFA transmissions.

Tactical operations will require control of multiple transmitter locations, signal characteristics and transmission times, and location of multiple receivers and their associated received signal-processing characteristics.

Systems providing centralized target information/data fusion, coupled with real-time robust communications links, will be required to satisfactorily operate the LFASS. Incorporation of real-time, expert, tactical decision aids may be necessary to realize the full benefit of the LFASS.

Some passive sonar systems may suffer performance degradation when operating concurrently with the high source levels of the LFASS transmitted signals. The impact of the LFASS on these systems must be evaluated, and modifications must be implemented if concurrent operations are required.

Platform vulnerability due to the higher level of communications and possible acoustic counterdetection from reflected LFASS signals must also be addressed.

## 2. Discussion

The major topics that are addressed in this paper are shown in figure 1.

### *2.1 Performance*

The performance enhancements provided by an LFASS include longer detection ranges, reliable classification, and rapid and accurate localization of very quiet submarine contacts, see figure 2.

The longer detection ranges are achieved by low-frequency, high-source-level transmissions and geographically separated, highly-sensitive, receiving arrays. The volume of ocean which can be searched by a battle group operating an LFASS can be very large, as shown in figure 3. In addition, a high probability of detection at very long ranges can be expected, as shown in figure 4. A high probability of detection for the environment shown can be achieved at extended ranges.

**LFASS OPERATIONS**

- SIGNIFICANT PERFORMANCE ENHANCEMENTS
  - LFASS Detection/Classification/Localization
- OPERATIONAL AND SUPPORTING SYSTEM REQUIREMENTS
  - Operations
  - Supporting Systems
- ASSOCIATED SYSTEM IMPACTS
  - Reduction in Other Acoustic Systems Performance
  - Vulnerability
  - Neutral Parties

Figure 1. Major Discussion Topics

- LONGER DETECTION RANGES
- RELIABLE CLASSIFICATION TECHNIQUES
  - Derived from Multiple Source/Receiver Target Aspects
- RAPID AND ACCURATE LOCALIZATION
  - Cross-fix from Multiple Source/Receiver Locations in Conjunction with the Inherent Active Ranging Capability

Figure 2. LFASS Performance Enhancements

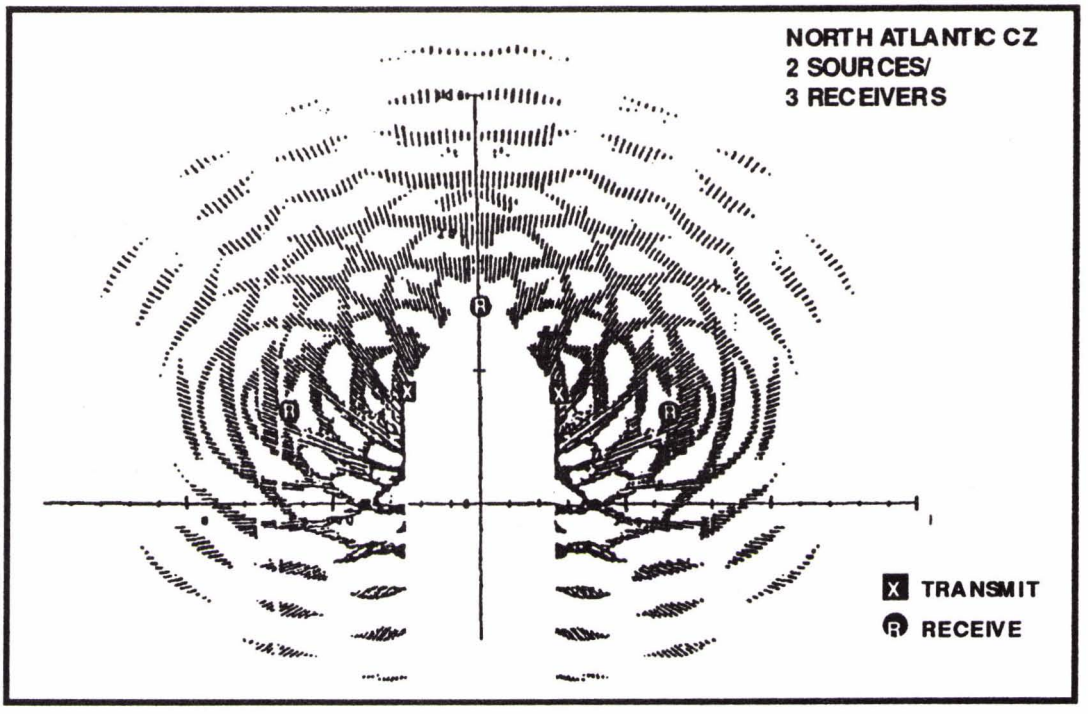


Figure 3. LFASS Transit Scenario, PDET

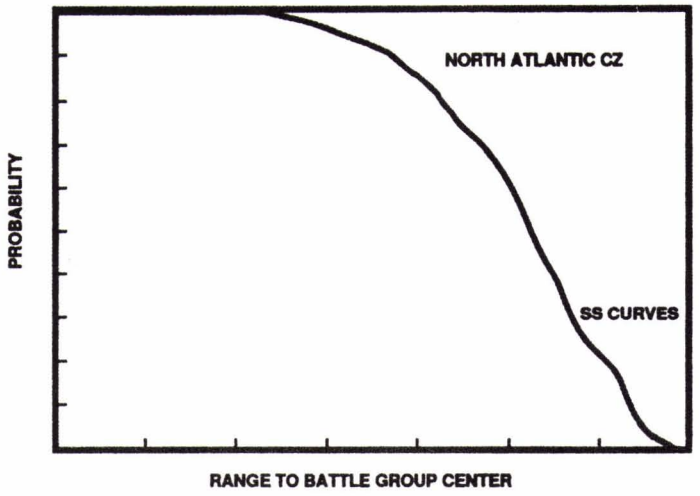


Figure 4. Cumulative Probability of Detection

Even more significantly, is the very high probability of detection that can be achieved out to medium ranges. Further increases in probability of detection and detection ranges are possible if a submarine operating at a greater distance from the center of the battle group is used as the receiving platform.

Once detection of a contact is gained, the next step in prosecution of the contact is battle group threat assessment. Reliable classification of very quiet submarine contacts has long been a difficult problem to solve, and currently classification typically occurs at much shorter ranges than in the past. The characteristics of an LFASS provide a potential solution by providing the capability to observe the contact from multiple aspects and thus differentiate contact type.

Once detection and classification have been achieved, it is necessary to localize the position of the contact with respect to the battle group. An LFASS provides the possibility for very rapid and precise localization. This is the result of the cross-fixing or triangulation techniques that may be applied due to the geographic separation of the participating platforms in conjunction with the inherent active ranging capability of the LFASS.

### *2.2 Operational and Supporting System Requirements*

The performance enhancements provided by an LFASS can only be realized if changes are made in the areas of how we operate our platforms in a battle group and how well we can modify associated systems to support LFASS operation.

*2.2.1 Operations* Figure 5 presents a possible battle group formation that could be used during an LFASS operation. There is a potential for a significant variety of participating platforms including surface ships, submarines, helicopters with dipping sonars, and

aircraft with sonobuoys. Overall operational command and control of the battle group lies in the hands of the Battle Group Commander, who is normally located on a vessel (commonly referred to as a Flag Ship) equipped with special $C^3$ suites. The operational effectiveness of the LFASS may be improved if LFASS specific tactical command and control is located on one of the source or receiver units. This would provide the capability to place emphasis on tactically controlling the receiver units which may be critical to optimizing LFASS operation. Further definition of operational command and control requirements for LFASS operations is presented in figure 6.

Operational command and control, as defined herein, includes all operations except those operations directly necessary for tactical employment of the LFASS. The focus is on defining overall command structure, procedures, and communication channels. This function provides the interface with higher-level authority to receive operational instructions/limitations, which in the presence of LFASS operations, may be expanded to include restricted area of operations, modified rules of engagement (ROE), special coalition team operations, neutral party concerns, vulnerability of associated units, etc. Target information resulting from LFASS employment may be distributed to other battle groups and operational commands. These additional requirements on operational command and control are not deemed sufficient to require modification to existing systems.

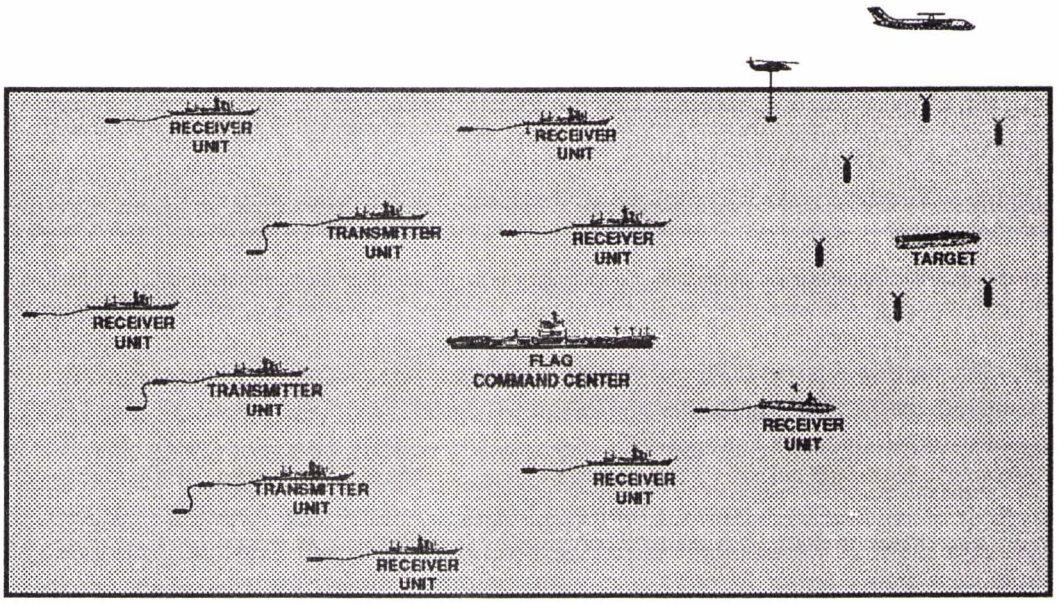


Figure 5. LFASS Battle Group Formation

- COMMAND STRUCTURE, PROCEDURES, COMMUNICATION CHANNELS
- RECEIVE OPERATIONAL INSTRUCTIONS/LIMITATIONS
  - Coalition Team Operations
  - Neutral Party Concerns
  - Vulnerability
  - Area of Operations
  - Etc.
- DISTRIBUTE REFINED TARGET INFORMATION
  - External to Battle Group

Figure 6. Operational Command and Control Requirements for LFASS Operations

Tactical command and control includes all operations within the battle group necessary to employ the LFASS. This includes the proper positioning of each platform deploying either an LFASS transmitter or receiver system, providing the necessary communications to control these platforms and systems, receiving and integrating all of the raw target data, and distributing refined target information to all the platforms in the battle group.

Further definition of tactical command and control requirements for LFASS operations is presented in figure 7.

- POSITIONING OF LFASS TRANSMITTER AND RECEIVER UNITS
- DISTRIBUTE PREPLANNED EPOCH TRANSMISSION TIMES AND SEQUENCES
- UNIT CONTROL (TRANSMITTERS/RECEIVERS)
- RAW CONTACT DATA FUSION
- INTRA-BATTLE GROUP REFINED TARGET DATA DISTRIBUTION

Figure 7. Tactical Command and Control Requirements for LFASS Operations

*2.2.2 Supporting Systems* The systems which will provide the necessary capability to accomplish the tactical command and control functions required to operate the LFASS are addressed in figures 8 through 11.

Figure 8 presents the Central Combat Control Systems requirements for LFASS operations. One of the functions of the Central Combat Control System is to provide an operation planning capability which supports optimizing the performance of the LFASS.

A real-time performance prediction capability based on multiple, geographically separated, in situ environmental measurements can be implemented to provide high-quality inputs for determining source/receiver locations and LFASS operating parameter

selections. The Central Combat Control System then provides the source and receiver systems with the operating commands and controls to initiate the coordinated LFASS operation. All received contact data is sent to the Central Combat Control System where it is integrated and the target classification and targeting information is determined. Finally, the target information is distributed to all platforms in the battle group.

- OPERATIONS PLANNING SYSTEM
  - Environmental Measurement
  - Performance Prediction
  - Operational Recommendations
  - System Setup Recommendation
- COMMAND GENERATION, DATA COLLECTION AND DATA FUSION SYSTEM
- CLASSIFICATION AND TARGETING INFORMATION DISTRIBUTION SYSTEM

Figure 8. Central Combat Control System Requirements for LFASS Operations

The Central Combat Control System must be in almost continuous communication with each source/receiver platform in the battle group in order to operate the LFASS. Figure 9 illustrates the communications network that must be available. Because of the potential for long distances between participating platforms, both line-of-sight and relayed-satellite-linked communications may be required. All platforms must also be able to communicate via a system that is compatible with the communication systems located on the central command and control ship (i.e., Flag Ship). The Operational/Tactical Communications System requirements for LFASS operations are shown in figure 10.

The communications systems must provide the capability for real-time transmitting and receiving of command control information, near real-time transmitting and receiving of contact data, and target classification and localization information. Multiple communications links may be employed for implementing these various communications requirements and, in fact, may be necessary due to the different types of communications systems carried by the different platforms. While the necessary communications systems exist to support the command and control, contact data, and targeting information requirements, the addition of LFASS related communications must be factored into the overall battle group communications requirements.

Successful operation of the LFASS requires that the position of each source and receiver be accurately known by all participating units. This may require that navigational corrections be relayed to each participant to compensate for each participating unit's navigational system inaccuracies. This allows all units to report relative to a common reference point. These corrections could be determined and relayed by using the LFASS with an acoustic link, see figure 11. This process is similar to that used for over-the-horizon targeting using an electromagnetic link to execute Gridlock Procedure.

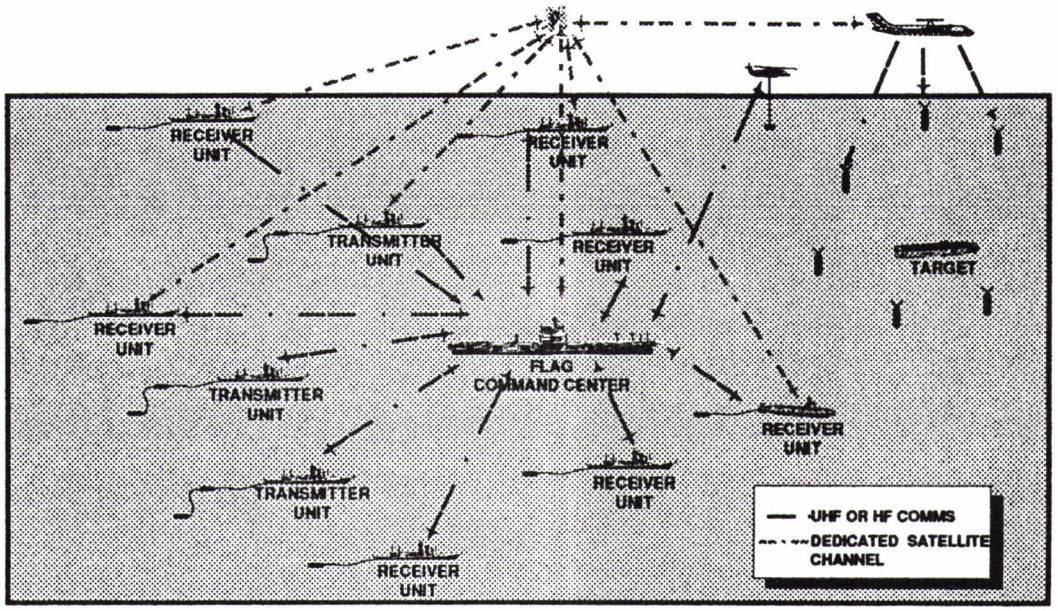


Figure 9. LFASS Battle Group Operational/Tactical Communications Network

- REAL-TIME COMMUNICATIONS SYSTEM
  - Command and Control Information
- NEAR REAL-TIME COMMUNICATIONS SYSTEM
  - Contact Data
  - Target Classification and Localization Information
- COMPATIBILITY OF SYSTEMS ACROSS PLATFORMS
  - Surface
  - Submarine
  - Aircraft

Figure 10. Tactical Communications System Requirements for LFASS Operations

- ACOUSTIC LINK EMPLOYMENT
  - Converts to True Range by Using Acoustic Inputs of:
    - Source bearing
    - Blast arrival time
    - Doppler
    - Preplanned epoch transmission times and sequences

Figure 11. Tactical Acoustic System Requirements for LFASS Operations

*2.3 Associated Systems Impacts*

The operation of the LFASS can potentially impact the performance of other passive acoustic systems that are operating concurrently with the LFASS, see figure 12. This performance reduction can occur in two ways; by degrading processing and display, and by total blanking of the receiving system. Some modification of these systems may be possible in order to reduce the level of performance degradation caused by the LFASS operation. A second, and potentially more significant negative impact of LFASS operation, is the potential for increasing the vulnerability of the participating platforms to acoustic and electromagnetic counterdetection. The potential exists, from an acoustic vulnerability point of view, for a threat platform to intercept the reflected LFASS transmitted signals from a participating or associated friendly submarine. The requirement for increased two-way electromagnetic communications provides more opportunity for interception by enemy forces.

These potential negative impacts may also apply to third-party forces operating in the geographic area impacted by the LFASS operations. Figure 13 provides a pictorial view of a possible situation. Figure 14 indicates some of the impacts that might be experienced by third-party assets. The same two types of impacts, vulnerability of platforms and performance degradation of passive systems, can occur.

The deployment of an LFASS can provide a significant capability for the detection, classification, and localization, see figure 15, of very quiet submarine targets. In order for the LFASS to be effectively utilized, the operations and communications requirements of the battle group must be modified to support a higher level of coordination. The issues of associated passive sonar degradation, increased vulnerability of participating and third-party units, and political implication must be considered and/or addressed before LFASS operations can be successfully conducted.

- PASSIVE ACOUSTIC SYSTEM BLANKING
- CURRENT SYSTEMS PROCESSING AND DISPLAY DEGRADATION
- ACOUSTIC VULNERABILITY
  - Creates an Environment that Could Be Exploited by the Enemy
- REQUIRES EXTENSIVE TWO-WAY EM COMMUNICATIONS FOR COMMAND AND CONTROL, CONTACT DATA AND TARGETING INFORMATION
  - Electromagnetic Covertness Compromised

Figure 12. Associated System Impacts

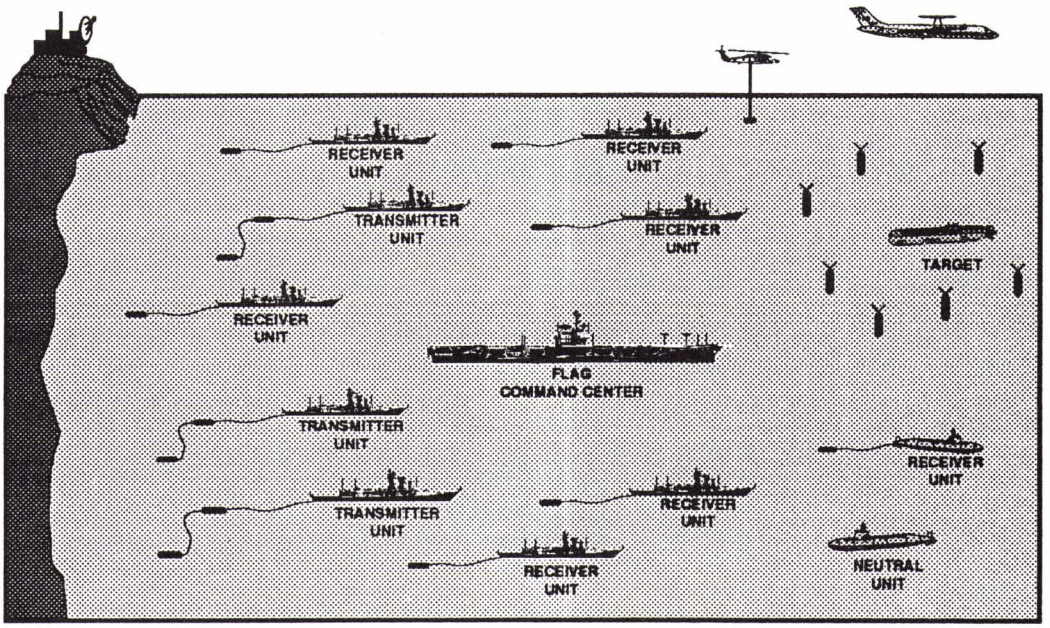


Figure 13. Neutral Party In-Situ Impacts

- VULNERABILITY OF SUBMARINES
- PERFORMANCE DEGRADATION OF PASSIVE ACOUSTIC SYSTEMS
  - Platform
  - Deployed

Figure 14. Neutral Party Implications

- POTENTIAL FOR SIGNIFICANT PERFORMANCE IMPROVEMENT
  - Revolutionary vice Evolutionary
- REQUIRES CONSORT OPERATION TO MAXIMIZE EFFECTIVENESS
  - Effective and Efficient Communication Is a "MUST"
- REQUIRES INTENSE PLANNING AND COORDINATION TO RESOLVE BOTH TECHNICAL AND OPERATIONAL CONCERNS
  - Impact Current Systems
  - Vulnerability (Battle Group and Submarine)
- REQUIRES THAT THE POLITICAL IMPLICATION BE ADDRESSED
  - Neutral Party Concerns

Figure 15. Summary