

The Next Generation

Mobile User Objective System (MUOS)

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ABSTRACT

The Navy's Ultra High Frequency (UHF) Follow-On (UFO) constellation provides narrowband tactical satellite communications to the DoD warfighter. The UFO constellation, initially launched in 1993, will begin to reach the end of its design life early in the next century. The Navy has developed an acquisition strategy to replace the UFO constellation and briefed it to the MILSATCOM Senior Warfighters Forum (SWarF) and the MILSATCOM Senior Steering Group. That strategy consists of three components: (1) procure a UHF Gapfiller satellite (UFO F11) for launch in 2003, (2) use commercial satellite assets as much as practical, and (3) procure the Mobile User Objective System (MUOS) with an initial operational capability in 2007. This paper presents the Navy's plans for continuing to provide communications to the mobile warfighter and provides the *construction*.details, as currently planned, for the MUOS acquisition.

NAVY OBJECTIVES FOR THE MOBILE WARFIGHTER

Mobile warfighters must be provided with three segments of C4I communications infrastructures. The first is **protected systems** using the EHF payload contained on the MILSTAR and UFO constellations. The second is **wideband systems** using the Defense Satellite Communications System (DSCS), Global Broadcast Service (GBS) on the last three UFO Satellites, and commercial wideband systems. The third segment is **narrowband systems**, provided by UHF Satellite Communications (SATCOM). For the next generation narrowband system, the MUOS planners will be legitimately predisposed to continue to use UHF for reasons to be discussed later in this paper (essentially foliage penetration characteristics and legacy terminal capabilities); however, several key issues must be addressed (Fig. 1). First, the International Telecommunications Union allocation of the UHF SATCOM spectrum may not be sufficient to provide the large network capacities required to satisfy mobile use requirements. Second, studies have found that significant background noise is present that may prevent closing the UHF link for small handheld terminals. Therefore, new innovative technical solutions may be necessary to provide adequate system capabilities.

For the next generation system, MUOS, the acquisition process will emphasize full and open competition beginning in FY00. Offerors will receive a broad requirements document. The process will consider all military unique and commercial proposals that meet the requirement, including Geostationary Earth Orbit (GEO), Medium Earth Orbit (MEO), and Low Earth Orbit (LEO) constellations.

The primary objective in the acquisition strategy is to remain flexible for as long as possible to take advantage of:

- Technical advances.
- The evolving process for commercial SATCOM acquisitions.
- Existing terminal infrastructures.
- Further acquisition reform initiatives that may affect the procurement strategy.

Fig. 1. Military UHF provides the mobile warfighter with worldwide communications that are assured, broadcast, netted and penetrate most weather, foliage and reinforced concrete

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MILITARY UHF TODAY

There is a great need for the UHF portion of the spectrum because it gives the warfighter the ability to penetrate heavy weather, foliage, and concrete reinforced buildings. UHF generally includes the frequencies from 300MHz to 3GHz. The portion of the UHF spectrum that does the job for the warfighter today is from 200MHz to 400MHz. UFO satellites, the first launched in 1993, are the mainstay UHF communications for the mobile warfighter. They operate in the general range of 290-320 MHz Uplink, and 240-270 MHz Downlink. These frequencies are well suited for low-cost, low power, portable radios that reliably penetrate severe environments and offer assured access and netted communication.

UHF SATCOM REQUIREMENT

The current UFO constellation will consist of eight satellites plus one in-orbit spare. Each satellite contains 38 UHF communication channels plus one additional channel for Fleet Broadcast. In order to keep the UHF availability from dropping below an acceptable level, a gapfiller satellite (UFO F11) will be procured and launched in the year 2003. In addition, as commercially operated constellations become operational, they will be considered as a means of reducing the dependence on current military systems by allowing for the off-loading of requirements that can be met by a commercial system. These actions will allow time to develop and acquire the MUOS, the next generation narrowband system.

LEGACY AND FUTURE TERMINALS INFRASTRUCTURE

UFO, and the older FLTSATs, are the primary providers of military UHF SATCOM. They are supplemented by L-Band INTELSAT and INMARSAT, which provide commercial services for military communications at sea. The demand for UHF communications has led to the proliferation of UHF terminals onboard practically every type of military platform: aircraft, submarines, warships, tanks, and trucks. It is estimated that there are over 7,500 terminals in use today, with a significant increase in terminals expected in the next few years. This significant investment in ground equipment must be taken into account when building the MUOS business case. The estimated length of service, life cycle cost, and performance utility must be considered when providing a new satellite constellation.

MUOS BACKGROUND

In August 1996, the Deputy Undersecretary of Defense for Space (DUSD Space) was tasked by the Joint Space Management Board (JSMB) to further define the DoD Space Architect's MILSATCOM recommended architecture and to develop an affordable transition roadmap. In November 1996, the Navy volunteered to lead the Joint Mobile User Study (MUS). It was co-chaired by the Chief of Naval Operations (CNO) N6B and the Program Executive Officer for Space, Communications and Sensors (PEO-SCS) to identify the requirements for the future narrowband mobile users. The goal of the study was to recommend an affordable narrowband transition plan based on the DoD Space Architecture plan that would be approved by the JROC and the JSMB.

The Navy, as UHF system manager, recommended a single additional UHF gapfiller (UFO F11) satellite in the 2003 timeframe, to be followed by a narrowband objective system in 2007. This option would allow DoD to continue to assess the current UFO constellation and commercial marketplace while mitigating risks with commercial Mobile Satellite Services (MSS), terminal modernization, and off-loading of requirements to EHF and wideband where it makes sense. The next generation system must allow for technological advances and preserve backward compatibility with legacy ground terminals.

The MUS examined the transition from the current UHF MILSATCOM constellation to a narrowband objective system conceived for the 2007 timeframe focusing on small terminal users, particularly those on-the-move. The MUS analyzed the current Integrated Communications Data Base (ICDB) and Emerging Requirements Data Base (ERDB). It considered potential frequency bands and allocations, new commercial resources, and system engineering issues to arrive at the findings and recommendations summarized here.

The Mobile User Study analyzed three main areas: (1) Requirements, (2) Systems Engineering, and (3) Costing and Acquisition Strategy. From more than one hundred mobile user narrowband requirements, eight primary requirements were identified, documented, and prioritized. Those requirements are (in order of priority):

- Assured Access.
- Netted Comms.Comms on the Move.
- Joint Interoperable.
- Worldwide Coverage.
- Point to Point Comms.
- Broadcast.
- Polar

An analysis of mobile user requirements determined that 25% of tactical communications (point-to-point) could potentially be off-loaded to commercial MSS. Of the remaining projected tactical needs, it was determined that 85% could be satisfied using a future narrowband objective system. While frequencies other than UHF were considered, it was determined that UHF was the only SATCOM spectrum that permitted sufficient triple-canopy foliage signal penetration to small hand-held terminals. These key findings were combined with the investment in UHF terminals, need for backward compatibility, and other technical considerations to generate a recommendation that UHF is the preferred narrowband, mobile user band for the transitional and objective system.

A summary of the MUS primary findings were:

- Military UHF frequency band is imperative for foliage penetration.
- The existing UHF ground infrastructure is a significant business and operational factor.
- Approximately 25% of emerging narrowband requirements can potentially be moved to commercial MSS.
- MUOS should use in-orbit processing for message routing and signal gain for highly disadvantaged terminals.

- Communications-on-the-move and assured access are most stressing of the prioritized warfighter requirements.
- MUOS needs at least a 20-dB increase in Effective Isotropic Radiated Power (EIRP) to provide service to mobile handheld terminals and at higher data rates than the current system.
- Tactical users are concentrated geographically in a few small areas throughout the world.

Additionally, several topics were recommended for further study, including:

- Lightweight spacecraft reflectors, feed structures, and phased array spacecraft antennas.
- MILSATCOM duty cycle definition.
- How to use more of the UHF spectrum, digital receiver utility and Demand Assigned Multiple Access (DAMA).
- Use of modeling and simulation.
- SATCOM control – integration with the DISN.
- Frequency allocation and management issues.

MOBILE USER OBJECTIVE SYSTEM (MUOS)

The solution for the mobile warfighter of the future is the next generation narrowband system referred to as the MUOS. MUOS is one part of the strategy mentioned above to replace the current UFO constellation. This strategy includes (1) procure an eleventh UFO satellite, (2) off-load to commercial systems as practical, and (3) develop the MUOS for launch in 2007. The MUOS acquisition is envisioned to employ full and open competition beginning in FY00 with multiple small research and development awards. Follow-up risk reduction contracts will begin in FY01 and a combined EMD/Production contract will be awarded in FY03. All contracts are expected to be awarded through full and open competition. Initial operational capability will occur in 2007.

It is expected that the request for proposals for FY00 Concept Exploration contracts will require the offerors to propose against a functional performance specification. The eight requirements from the MUS, identified above, will be included in the Performance Spec. Beyond the Performance Spec, no other technical restrictions will be placed on the offeror. An offeror will be allowed to propose any feasible system that meets the Performance Spec, whether that system is military unique or commercial or a combination of the two, and it may utilize GEO, MEO, or LEO satellites. The offerors will each propose their own design and identify those technical and economic factors that still need to be fully developed to bring the design to fruition. The Navy plan for these initial contracts is to allow new and developing technology to be folded into the MUOS design, even if some minor work is needed to prove out the technology, thereby gaining the latest and greatest capability available when the MUOS is deployed into service in 2007. Fig. 2 is a notional architecture for the advanced narrowband system. It shows the various conceivable segments of the MUOS, including spacecraft, ground-based satellite commanding, terminals, gateways/teleports/network control, and a commercial system

element. The Concept Exploration contractors will be expected to address the technical challenges associated with their designs for MUOS, including a vision for successfully integrating the spacecraft, ground infrastructure, terminals, and commercial segments, as well as the related contractual, economic, and spectrum allocation issues.

The Risk Reduction phase of the MUOS program is planned as multiple contracts that will go into more detail on proposed MUOS designs in response to a revised Performance Spec. These larger value contracts will allow the contractors to devise solutions to some of the technical issues and possibly build and test some of the higher risk components.

One contract for EMD and Production of the satellites and commanding segment will be awarded in FY03. This contract will also be awarded through full and open competition. The system could be a military unique system only or it may also include a commercial system. As mentioned earlier, the offeror will be free to propose any candidate system that meets the functional requirements of the Performance Spec. The offeror's proposal will have to address all technical challenges as well as contract issues (such as the possible buying of commercial services and their operation). Consideration of issues involving backward compatibility with the existing ground infrastructure must also be demonstrated (or it must be shown how the offeror's candidate system with an end-to-end capability is more cost effective for DOD than maintaining the existing equipment). The contract will also allow for incorporation of technology insertion and product improvements into subsequent satellites. Drawing on the success of the UFO program, the production contract will require the contractor to deliver the MUOS in-orbit, that is, the launch and in-orbit test will be successfully completed prior to the government taking possession. There may also be an extended warranty required.

The reader is cautioned to note that this strategy as presented is still being developed. As of this writing, a memo for the Undersecretary of Defense for Acquisition and Technology is in routing. This memo approves Milestone 0 (authorizing the Concept Exploration Phase) for MUOS, and schedules Milestone I Defense Acquisition Board in January 2001. A draft Request for Proposals for the FY00 Concept Exploration contracts will be released by early summer.

CONCLUSION

As has been discussed, the warfighter must and will have access to the military segment of the UHF spectrum, while probably utilizing an already present large terminal infrastructure and planned terminal procurements. Although there are many outstanding issues on how to provide the next generation of narrowband satellite communications, the current plan as outlined in this paper is a significant step forward in providing that necessary capability to the warfighter.

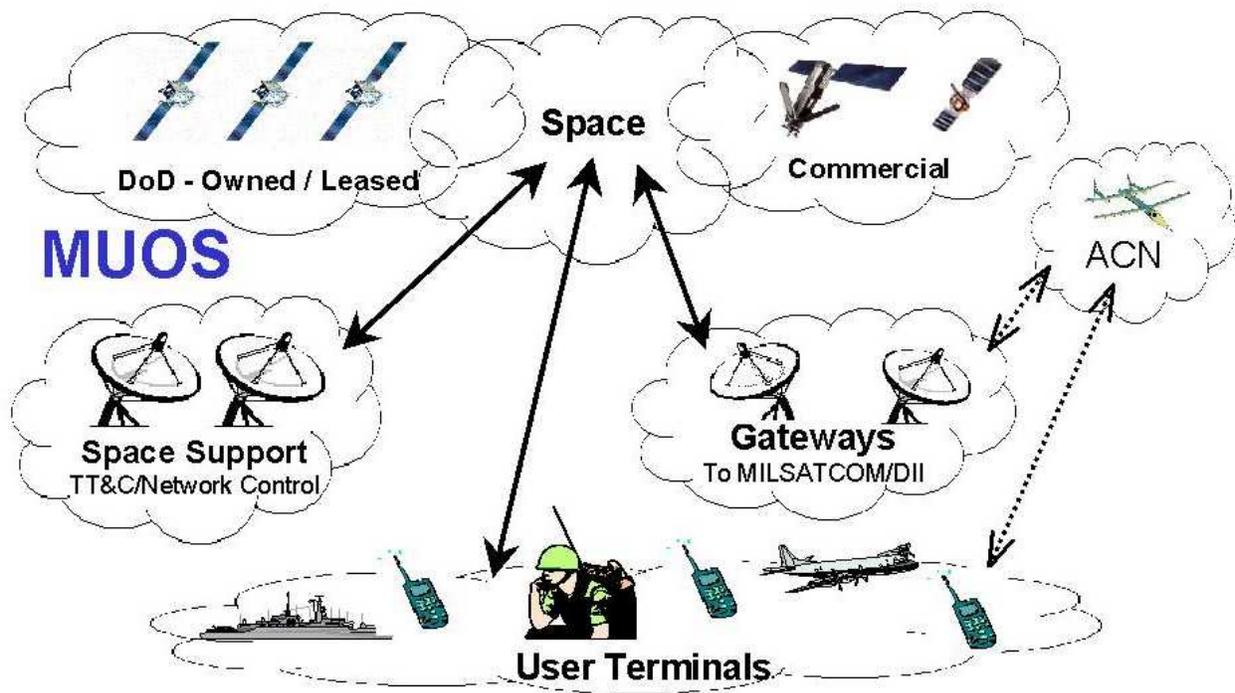


Fig. 2. Advanced Narrowband Notional Architecture where MUOS is currently defined as the Space and Space Support segments.