

# MOBILE TACTICAL COMMUNICATIONS, THE ROLE OF THE UHF FOLLOW-ON SATELLITE CONSTELLATION AND ITS SUCCESSOR, MOBILE USER OBJECTIVE SYSTEM

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## ABSTRACT

*The Ultra High Frequency (UHF) portion of the frequency spectrum is of great importance to the military for communications to the mobile warfighter. UHF has many advantages not available at other frequencies. UHF is used both for local line-of-site communications and also for worldwide military satellite communications (MILSATCOM). UHF Follow-On (UFO) is the satellite constellation used for narrowband MILSATCOM. UFO is used by all military services and many government agencies for a wide variety of purposes. The Navy uses UFO MILSATCOM for tactical operations involving all facets of Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR). The eleventh and last UFO will be launched in FY 2004. As UFO nears the end of its service life in 2008, it will gradually be replaced by a new satellite constellation called Mobile User Objective System (MUOS). MUOS is in the Component Advanced Development (CAD) phase of development with its first launch scheduled for 2008. MUOS will be interoperable with all legacy UHF terminals, provide handheld capability, and will have up to ten times the capacity of UFO. As the MUOS design is finalized, it may develop as a key component of "Network Centric Warfare," and operate within a larger broadband and Defense Information Systems Network (DISN) terrestrial network known as the Global Information Grid (GIG).*

## MILITARY COMMUNICATIONS ARCHITECTURE AND UHF'S ROLE

The communications portion of military C4ISR may be face-to-face by voice, landline (for voice or computers), line-of-site radio frequency, or satellites used as relays (MILSATCOM). Today the U.S. military consistently uses every portion of its allotted share of the frequency spectrum to communicate. Each portion of the radio frequency spectrum has unique advantages and disadvantages. In general, higher frequencies are more directional, carry more information, require more power,

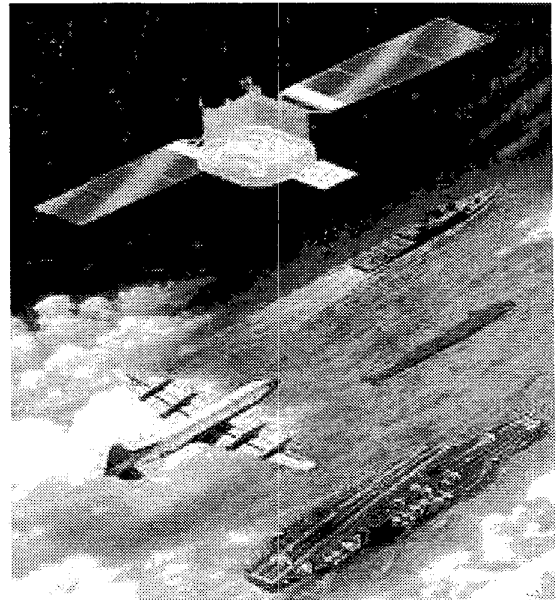


Figure 1. The Navy is a heavy user of UHF SATCOM

and the equipment is heavier, more complex and more expensive. MILSATCOM is used for long-distance, beyond line-of-site communications and may be divided into three areas: protected, wideband and narrowband.

**Protected** systems use the Extremely High Frequency (EHF) payloads contained on the Milstar and UFO constellations. Protected systems are used to avoid jamming, nuclear radiation propagation interference and maintain a stealthy, undetectable signal.

**Wideband** systems use Super High Frequency (SHF) payloads contained on the Defense Satellite Communications System (DSCS), Global Broadcast Service (GBS) on the last three UFO Satellites, or commercial wideband systems. Wideband systems are used for distributing large volumes of information, such as images or Video Teleconferences

**Narrowband** systems use UHF payloads like those contained on UFO satellites. Narrowband systems are used for mobile, tactical, urgent and routine voice and data.

On a typical deployment, an Army division, Marine Expeditionary Force (MEF), Air Force Aerospace Expeditionary Force, or Navy battlegroup ventures into harm's way equipped with a broad range of communications equipment, spanning the allotted spectrum. Each segment of the spectrum brings a unique capability to the warfighter. For example, when an Army Corps Commander needs to communicate without being detected, he uses the protected communications of the EHF spectrum. When an Air Force unit needs to receive a massive Air Tasking Order (ATO), it turns to the high throughput of the wideband Super High Frequency (SHF) spectrum. When an aircraft carrier needs to receive orders from the Combatant Command (formerly called CINC's), he uses the narrowband UHF spectrum. See Figure 1. In the future, these spectrum, bandwidth and function distinctions will blur as networks become more prevalent and "Network-Centric Warfare" becomes a reality.

### **MILITARY ADVANTAGES OF UHF**

The UHF portion of the frequency spectrum technically includes the frequencies from 300 to 3,000 Megahertz (MHz). The mobile warfighter uses the lower portion of the UHF region and dips down slightly into a small portion of the Very High Frequency (VHF) region of 30 to 300 MHz. The unique military advantages of UHF can be summarized into two categories: hardware and performance.

Hardware advantages include: small size, light weight, ruggedness, simplicity, and relatively low cost. UHF antennas are easy to set up and point to the appropriate satellite. Operator controls are simple, easy to use and understand. Terminals are small, light weight and rugged, suitable for ships, vehicles, aircraft, manpacks and even handheld use. Training costs and duration are minimal.

Performance advantages include: signal penetration, worldwide coverage, broadcast networks, and assured access. UHF penetrates heavy weather, jungle foliage and urban environments while higher frequencies cannot. With a UHF terminal, a warfighter may fight and communicate in all types of weather while using the foliage for concealment. Radios using other parts of the frequency spectrum, particularly the EHF spectrum, have problems with penetration and coverage, and must use small spot beams. UHF's large beam and relatively low power permit worldwide networks, broadcast to many thousands of terminals. UHF also provides assured access because the military "owns" a portion of the spectrum. This is the result of

international agreements confirmed by regulations of the International Telecommunications Union (ITU).

The UHF spectrum permits the soldier, sailor, airman, or Marine to easily communicate on a secure combat radio net from any place on earth under harsh environmental conditions. Some other satellite or terrestrial communications systems may satisfy a portion of battlefield communications requirements, but no other system, military or commercial, can match all the advantages that UHF systems deliver to the warfighter. UHF is ideal for providing the "last mile" of a long communications link to a soldier who desires to remain hidden from view.

Because of all these advantages, the military services are operationally committed to the UHF spectrum. They are keenly aware of the necessity of the UHF spectrum and the high demand for its capabilities. The military has invested heavily in UHF terminals and operator training. This investment in the UHF spectrum will steadily climb in the upcoming years as all services continue to field UHF terminals, particularly the Army's AN/PSC-5 Spitfire terminal.

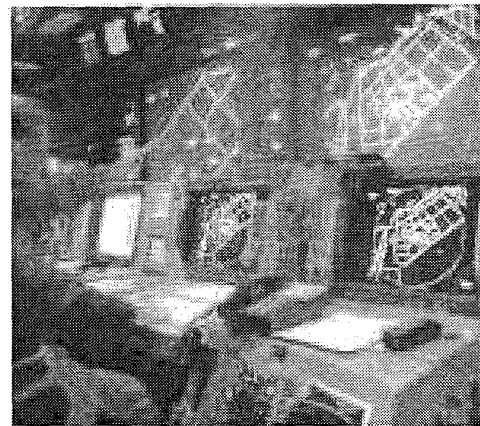


Figure 2. UFO provides a circuit called OTCIXCS to build a "common tactical picture."

### **MILITARY UHF TODAY**

The first attack wave of warfighters primarily use UHF. This is because of the advantages just discussed and there is no time to set up a communications infrastructure of large antennas, telephone wire or fiber optic cable. In the first days of an operation, mobile warfighters communicate using UHF terminals on small backpacks, vehicles or aircraft. Aircraft use UHF (and often VHF at a slightly lower frequency) to communicate with higher command, an air traffic controller, or artillery spotter. These are line-of-site, short range communications and do not involve

satellites. They are local communications, from a squad leader talking to his command post, or from a ship to her nearby aircraft carrier or Task Force Leader.

In order for the mobile warfighter to communicate a longer distance, farther than "line-of-sight," he must use a satellite. Older High Frequency and Very Low Frequency systems are not practical. When his message absolutely positively must get through, (that is, assured communications) he uses UHF. When an infantryman needs to communicate no matter the weather, his geographical location, or environment, he'll most likely push-to-talk on a UHF terminal.

After the territory is secured there is more time to set up the equipment required for telephones, large computer file transfers, video teleconferencing, etc. These services use the higher frequencies of SHF and EHF provided by wideband cable, DSCS, Milstar or commercial SATCOM (Intelsat, SES Americom etc.).

### UHF SATCOM

UHF SATCOM is provided by the UFO satellite constellation. After the first UFO launch in 1993, nine more were launched in the 1990's as a "Follow-On" to the Leased Satellite (LEASAT) and Fleet Satellite (FLTSAT) UHF satellites. See Figure 3. They are in geosynchronous orbit 22,000 miles above the earth and operate in the range of 290-320 MHz Uplink, and 240-270 MHz Downlink.

The kind of information passed over UFO varies from FLASH precedence message alerts for missile launches to ROUTINE messages about ship refueling or replenishment. In any given part of the world there are about 40 channels available. Some channels pass voice information, some pass data. The data channels interface with a computer or terminal for "email-like traffic," or provide data for a "common tactical picture." It may show the location of friends, enemies, and unknown fighting units. These locations are often superimposed on a map, depicting the user's own location in the center of the display. See Figure 2.

The real challenge is to make the UFO system more accessible to the users who need it. Today, the demand for UFO services exceeds the number of users who can access the network. Some estimates show that UFO is oversubscribed by 250 percent. Analysis conducted by the Naval Network Warfare Command as part of the Mobile User Study (MUS) shows that the demand for UHF is expected to increase. More efficient

ways to use the spectrum are badly needed. One such promise for greater spectrum efficiency is Demand Assigned Multiple Access (DAMA) techniques and equipment. The Department of Defense is committed to DAMA and is making steady progress towards its implementation.

Voice information over UFO may be from individuals engaging in battle or receiving routine orders from a commander. UFO circuits are tactical warfighting circuits supporting joint and allied forces. The circuits used by UFO are classified by functions such as: Secure Voice, Aircraft Carrier Strike, AAW (Anti-Air Warfare), CSEL (Combat Survivor), ASW (Anti-Submarine Warfare), ASUW (Anti-Surface Warfare), NTDS (Naval Tactical Data System) Links 11/16 and 22, worldwide message broadcast, cruise missile satellite data links, etc.

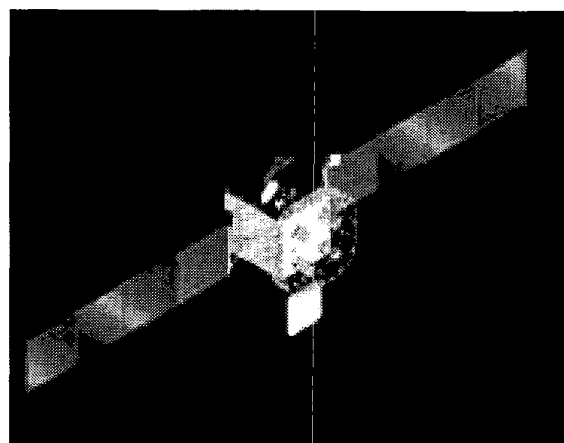


Figure 3. UHF Follow-On Satellite (UFO)

The UFO satellite system provides worldwide daily service to deployed forces in such hot spots as Korea, Southwest Asia, Bosnia and Afghanistan. U.S. military units, frequently deploy to areas where there is no ground communications infrastructure. Ground troops often find themselves in an area where there is little initial organic communications support and the host nation is unable or slow to help. Yet, these forces are always within reach of a UFO satellite. Every major battle fought by the U.S. in the last 20 years has been within the footprint of a UFO satellite. The UFO satellite constellation is ready to support the warfighter whenever and wherever he needs it.

The warfighter's interface to the UFO satellite is through the terminals. The terminals, three satellite control stations, and four Naval Computer and Telecommunications Area Master Station (NCTAMS) sites are the ground segment of the entire UHF SATCOM communications system. Some of the terminals used by UFO are AN/PSC-5 Spitfire, CSEL, URC-133 Federated, ARC-210, AN/USC-61

Digital Modular Radio (in limited production), and WSC-3. There are more than 50 different types of terminals, more than 10,000 terminals in service today, and about 20,000 more in the procurement pipeline. 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. UHF terminals in the manpack configuration are highly mobile. Manpack UHF satellite communications terminals, such as the AN/PSC-5 Spitfire, are widely distributed across all services to include such habitually deployed units as the U.S. Army's 82nd Infantry Division (Airborne) or Special Forces.

Today's UFO constellation will be complete with the launch of the eleventh satellite in FY 2004. The Navy will have invested well over two billion dollars in the present UHF satellite constellation once all UFO satellites are launched. While UFO will be operational for many more years, it will fall below its required 70% availability in 2008. UFO will transition to MUOS which will augment UFO, provide additional required UHF communications capability, and eventually replace it entirely. See Figure 4.



Fig. 4. Conceptual MUOS handheld terminal with ten times UFO capacity

### NAVY UHF SATCOM

While there are many users of UFO, this section describes how Navy uses it. A typical naval task force uses the following UHF networks: Battle Group Command Net, Link Coordination, Officer in Tactical Command Information Exchange Subsystem (OTCIXS), Tactical Data Information Exchange Subsystem (TADIXS), Tactical Intelligence (TACINTEL), Common User Digital Information Exchange Subsystem (CUDIXS), Fleet Satellite Broadcast Subsystem, Tactical Receive Equipment/TRE and Related Applications (TRE/TRAP), Submarine Satellite

Information Exchange Subsystem (SSIXS), Secure Voice Subsystem, and Satellite High Command (SATHICOM). A brief description of a few of these networks follows:

OTCIXS is designed as a communications link for battle group tactical operations. It exchanges over-the-horizon targeting (OTH-T) and C4ISR information inside the battlegroup and to higher authority. OTCIXS provides automatic cryptographic synchronization, storage, and forwarding of incoming and outgoing record traffic. It operates at either 2.4 Kilobits per Second (Kbps) or 4.8 Kbps in a half-duplex mode. OTCIXS is from one machine, or computer, to another. An OTCIXS message looks like a digital data stream. The result of the data stream is often a map-like display of friendly and enemy target locations with information about each target.

TADIXS provides over-the-horizon targeting (OTH-T) and C4ISR information from shore-based commands to fleet users in support of military operations. TADIXS provides integrated worldwide broadcast connectivity. Each TADIXS network makes use of a Net Control Station that transmits data to any one, several, or all subscribers. Most TADIXS message traffic is sent from shore facilities, and most mobile and afloat subscribers operate receive-only; however, carriers and some flagships have a TADIXS transmit capability.

TACINTEL supports the exchange of intelligence information at either 2.4 or 4.8 Kbps. Its purpose is to process time-sensitive, indications and warning, OTH-T information, and computerized message processing. The intelligence community uses TACINTEL to show, for example, missile launches and locations, or to display Sensitive Compartmented Information (SCI).

CUDIXS is the shore-based network used for transmitting general service (GENSER) message traffic between ships and shore installations. Naval Modular Automated Communications Subsystem (NAVMACS) is its sea-based counterpart. The subsystem interfaces with the automated processing features of the Naval Computer Processing and Routing System (NAVCOMPARS), allowing the exchange of high-volume, two-way message traffic. It operates at a data rate of 2.4, 4.8, or 9.6 Kbps.

The Fleet Satellite Broadcast Subsystem is the backbone of Naval communications providing shore-to-ship message connectivity with upper echelon commanders. The Fleet Broadcast provides various sub-channels for GENSER message traffic, special intelligence, and meteorological data. Underway, the ship receives operational messages, warning and execution orders, operational plans as well as

logistics and administrative messages. Each sub-channel operates at 75 bps with an aggregate 1.2 Kbps overall.

**SATHICOM.** Satellite High Command is secure voice communications to the highest levels of command.

### **MILITARY UHF TOMORROW – MUOS**

The Navy is preparing a transition from the present UFO satellite constellation to MUOS. The “Follow-On” to UFO, MUOS, will be a more modern and capable constellation with the first launch in 2008. See Figure 5. The Navy has included in its requirements and strategy that MUOS will be backward compatible with the thousands of UHF terminals in use today, and in the procurement pipeline to be delivered after 2008.

MUOS will satisfy military requirements by providing many more channels, digital waveform advantages, and up to ten times the capacity of UFO. MUOS will also be able to converse with a handheld terminal – a distinct improvement for the warfighter since today’s smallest UFO terminal is the size of a backpack.

Overall MUOS objectives are to (1) provide affordable narrowband MUOS communication capabilities to meet mobile warfighter needs for coverage, capacity, access and control, interoperability, services, communications-on-the-move, and availability, with an Initial Operational Capability (IOC) date of 2008; (2) sustain the Department of Defense (DoD) current narrowband performance and availability levels; and (3) provide a vehicle to address potential additional requirements in light of ongoing studies (e.g., Transformational Communications Study [TCS]) within DoD addressing MILSATCOM architectures.

MUOS has completed its initial acquisition phase, Concept Exploration. Results of the “CE” phase vary from using four to eight satellites, but all teams agreed that MUOS should have more power, larger antennas and new waveforms. They also all agreed that the UHF spectrum is vital to meet the requirements to be backward compatible to legacy systems. The significant investment in legacy equipment is being taken into account as the contractors build the MUOS business case. The estimated length of service, life cycle cost, and performance utility must all be considered when providing a new satellite constellation valued at more than \$6.1 billion over 20 years. As of October 2002, the Navy plans that two contractors will be developing MUOS in the CAD phase. CAD will last approximately fourteen months and then a single contractor, not yet

selected, will take MUOS into the System Design and Development (SDD) phase. As the procurement develops, and even after it is delivered, the warfighter will adapt the new MUOS to his needs because it will interface to the Defense Information Systems Network (DISN) and Global Information Grid.

MUOS terminals will be software programmable, interoperable with legacy terminals and compatible with the Joint Tactical Radio System (JTRS).

### **SUMMARY**

The mobile warfighter is a heavy user of UHF because he needs to operate worldwide, in all-weather, all-foilage, and urban conditions. UHF equipment is lightweight, small, rugged, and relatively low cost. These qualities are required for other government agencies as well. Because of these advantages, the warfighter must and will have access to UHF frequencies.

Today’s current UHF satellite constellation, UFO, will gradually degrade and be replaced by tomorrow’s MUOS. MUOS will satisfy all required capabilities and have the following attributes:

- 1) Operational in 2008,
- 2) Interoperable with all legacy UHF terminals,
- 3) Operate with JTRS compatible terminals,
- 4) Provide handheld capability and
- 5) Operate with up to ten times the capacity of today’s UFO.

Soldiers, sailors, airmen, and Marines will continue to enjoy all the advantages of UHF frequencies.

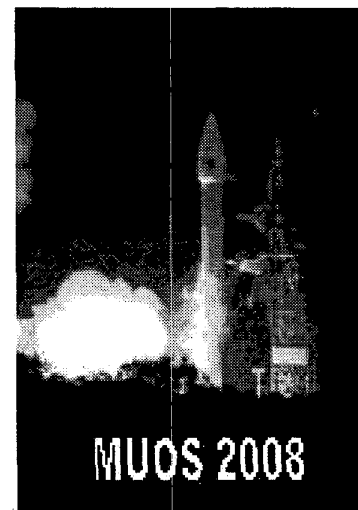


Figure 5. First MUOS launch is 2008