# Mobile User Objective System (MUOS)

Executive Summary

- The Navy's Commander, Operational Test and Evaluation Force (COTF) conducted the Mobile User Objective System (MUOS) Multi-Service Operational Test and Evaluation 2 (MOT&E 2) from October 19 through November 20, 2015. DOT&E approved the Test and Evaluation Master Plan (TEMP) on November 29, 2010, and the MOT&E 2 test plan on October 13, 2015.
- MUOS is not operationally effective in providing reliable worldwide Wideband Code Division Multiple Access (WCDMA) communications to tactical users. MUOS was able to provide WCDMA communications on a limited scale during MOT&E 2, but MUOS cannot achieve this performance worldwide given the significant problems with planning and provisioning, situational awareness, network management, and capacity.
- MUOS is not operationally suitable. The ground system lacks the stability and maturity to enter into and sustain global operations. MUOS does not provide communications that deployed users can rely on when the system is in widespread use or at full capacity. MUOS performed poorly in almost every area of operational suitability.
- The system is not survivable against cyber-attacks. The COTF Red Team and U.S. Strategic Command (USSTRATCOM) conducted independent cyber assessments and obtained similar results. They discovered over 1,000 cybersecurity vulnerabilities in the MUOS ground system.
- MUOS is not ready to support military operations. Until the problems are fixed and verified in the FOT&E, the system use should be limited to small non-combat missions, testing, training, and exercises in the United States and protectorates in order to develop, exercise, and mature operational concepts and processes with a particular focus on addressing known issues and MOT&E-2 findings.
- The Navy launched the MUOS-5 on-orbit spare satellite on June 24, 2016. On June 29, the Navy discovered an anomaly during orbit-raising. The satellite is safe and remains in a stable interim orbit while the Navy evaluates options.
- On July 18, 2016, the Commander, USSTRATCOM accepted for Early Combatant Command Use the MUOS capability, consistent with the DOT&E recommendation.

System

- MUOS is a satellite-based communications network designed to provide worldwide, narrowband, beyond line of-sight, point-to-point, and netted communication services to multi Service organizations of fixed and mobile terminal users. The Navy designed MUOS to provide 10 times the throughput capacity of the current narrowband satellite communications.

Space Segment | Ground Transport Segment
Network Management Segment | Satellite Control Segment
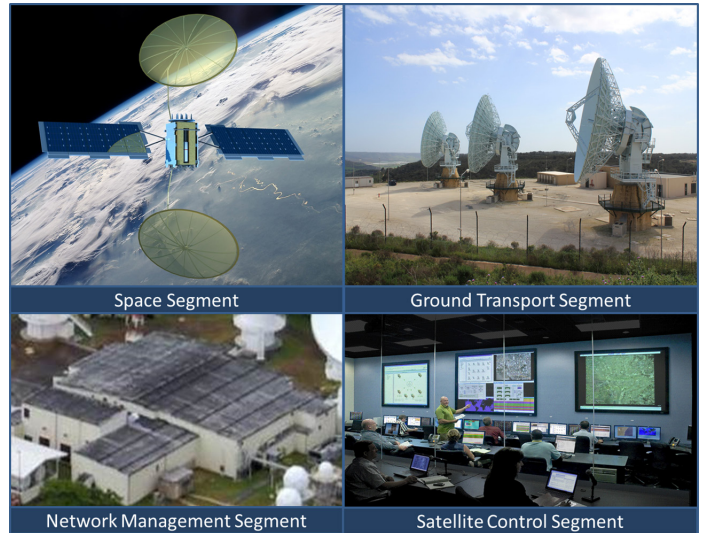
The Navy intends for MUOS to provide increased levels of system availability over the current constellation of Ultra High Frequency (UHF) Follow-On satellites and to improve availability for small, disadvantaged terminals.

- MUOS consists of six segments:
  - The Space Segment consists of four operational satellites and one on-orbit spare. Each satellite hosts two payloads: a legacy communications payload that mimics the capabilities of a single UHF Follow-On satellite and a MUOS communications payload.
  - The Ground Transport Segment is designed to manage MUOS communication services and allocation of radio resources.
  - The Network Management Segment (NMS) is designed to manage MUOS ground resources and allow for government-controlled, precedence-based communication planning.
  - The Ground Infrastructure Segment is designed to provide transport of both communications and command and control traffic between MUOS facilities and other communication facilities.
  - The Satellite Control Segment consists of MUOS telemetry, tracking, and commanding facilities at the Naval Satellite Operations Center Headquarters and Detachment Delta.
  - The User Entry Segment provides a MUOS waveform hosted on MUOS-compatible terminals. The Army's Project Manager for Tactical Radios is responsible for developing and fielding MUOS-compatible terminals. The Air Force, Navy, and Marine Corps are upgrading legacy UHF radios to be MUOS-compatible.

Mission

Combatant Commanders and U.S. military forces deployed worldwide will use the MUOS satellite communications system to accomplish globally assigned operational and joint force component missions, especially those involving highly mobile users. Such missions include major conventional war; regional conflicts; search and rescue; humanitarian or disaster relief (including severe weather events); homeland security; homeland defense; counterterrorism; non-combatant; evacuation operations; very important person travel; strategic airlift; global mobility; global strike; intelligence, surveillance, and reconnaissance; training; logistics support; and exercise support.

Major Contractors

- Lockheed Martin Space Systems – Sunnyvale, California
- General Dynamics C4 Systems – Scottsdale, Arizona

Activity

- The Navy conducted a government Developmental Test Technical Evaluation from June 1 – 30, 2015, in preparation for operational testing.
- COTF conducted MOT&E 2 from October 19 through November 20, 2015, in accordance with the approved TEMP and test plan. DOT&E approved the TEMP on November 29, 2010, and the MOT&E 2 test plan on October 13, 2015.
- COTF conducted a two-phase cybersecurity assessment of the MUOS system in conjunction with MOT&E 2. COTF conducted the phase one Cooperative Vulnerability and Penetration Assessment in November 2015 and a phase two Adversarial Assessment in April 2016.
- DOT&E submitted a report in June 2016, evaluating the system based on MOT&E-2.
- The program manager requested a deferral of the geolocation capability from MOT&E 2. Geolocation is the ability to locate a legacy UHF electromagnetic interferer on the ground.
- The Navy launched the MUOS-5 on-orbit spare satellite on June 24, 2016. On June 29, the Navy discovered an anomaly during orbit-raising. The satellite is safe and remains in a stable interim orbit while the Navy evaluates options.
- On July 18, 2016, the Commander, USSTRATCOM accepted for Early Combatant Command Use the MUOS capability, consistent with the DOT&E recommendation.
- The MUOS program manager and COTF have begun updating the previous TEMP to encompass the scope of the next operational test, planned for FY18 or FY19.

Assessment

- When MUOS works, it provides message accuracy and quality of service better than legacy UHF communications. However, MUOS cannot communicate on all types of group network services. COTF did not test fixed assigned networks because of known problems with them.
- MUOS does not meet the threshold capacity Key Performance Parameter criteria, based on the two satellite configurations in MOT&E-2. The 2 satellites under test operated at 72 percent of capacity during MOT&E-2. DOT&E determined that 92 of the possible 128 satellite beam carriers were active on the Pacific and Continental United States region satellites, for an availability of 71.9 percent. The Navy either locked or turned off 28.1 percent of the capacity to prevent problems with interference from ambient radio frequency signals. A locked satellite beam carrier means users cannot access it, effectively losing 5 megahertz of potential spectrum in that beam. A majority (56 percent) of 32 satellite beams across the two satellites were in a degraded mode.

- During MOT&E 2, resource planners were able to obtain information from the system in 61 percent (52 of 85) of attempts. USSTRATCOM cannot monitor MUOS and evaluate actual system performance against planned performance. MUOS does not provide USSTRATCOM with an accurate, real-time status of the system state. The system was unable to maintain call records for the 60 terminals that participated in MOT&E-2.

- The ability of MUOS to create, analyze, and implement communications plans has problems. The system occasionally freezes when analyzing what network resources are available and the network data are sometimes inaccurate. Without a valid and accurate plan, MUOS cannot create configurations for all of the radios and users cannot establish communications with one another.

- The MUOS fault management system is ineffective because it provides the network managers fault alarm events that are cryptic, inconsistently prioritized, and often excessive. The filtering effort was incomplete and arbitrary.

- During developmental and operational test periods, hardware failures at the MUOS Radio Access Facilities have led to the loss of as much as half of the communications resources on a single satellite. MUOS does not provide a proactive means to monitor WCDMA communication failures, resulting in potentially extended outages for deployed users. The MUOS network managers cannot assess and report on WCDMA satellite beam carrier availability. Key systems associated with WCDMA call services, such as the radio base stations in the Radio Access Facilities, do not provide fault information to the fault management system. The program manager is working on a solution to provide improved situational awareness.

- MUOS was able to conduct routine Over-the-Air Rekeys but cannot reliably conduct compromised terminal operations. The reliability problems could result in global communications outages for an entire military Service or all Special Operations units. An outage would persist until its root cause is resolved

and the MUOS ground system broadcasts an updated cryptographic key.

- The NMS was often not operationally available. The NMS was available 6.3 percent of the time during MOT&E-2 against a 95 percent threshold criterion. The NMS had long repair times, numerous high-priority problem reports, poor usability, poor documentation, and high reliance on depot maintainers. Additionally, NMS is undermanned and operators do not consider themselves adequately trained to perform their mission. Multiple failures in the NMS and the Ground Transport Segment during MOT&E-2 created long communications outages.
- During MOT&E-2, there were over 200 high-priority hardware and software problems remaining on the system.
- The geolocation capability is still in development and was deferred from MOT&E 2. The program manager is developing a geolocation capability which will need to be operationally tested in the planned FOT&E.
- MUOS is not operationally effective in providing reliable worldwide WCDMA communications to tactical users. MUOS was able to provide WCDMA communications on a limited scale during MOT&E 2, but MUOS cannot achieve this performance worldwide given the significant problems with planning and provisioning, situational awareness, network management, and capacity.
- MUOS is not operationally suitable. The ground system lacks the stability and maturity to enter into and sustain global operations. MUOS does not provide communications that deployed users can rely on when the system is in widespread use or at full capacity. MUOS performed poorly in almost every area of operational suitability.
- The system is not survivable from cyber-attacks. The COTF Red Team and USSTRATCOM conducted independent cybersecurity assessments and obtained similar results. They discovered over 1,000 cybersecurity vulnerabilities in the MUOS ground system. Approximately half of these vulnerabilities are Category-II and above. Category-II vulnerabilities have a high potential of giving system access to an intruder.
- MUOS is not ready to support military operations. Until the problems are fixed and verified in the FOT&E, the system's use should be limited to small non-combat missions, testing, training, and exercises in the United States and protectorates in order to develop, exercise, and mature operational concepts and processes with a particular focus on addressing known issues and MOT&E-2 findings.
- The Commander, USSTRATCOM decision for Early Combatant Command Use of the MUOS capability will benefit Service members and assist the MUOS program manager in resolving system problems while providing the operational manager, provisioners, and network managers with valuable experience through limited operations.
- The program manager, in coordination with USSTRATCOM, is evaluating courses of action to resolve the anomaly with the MUOS-5 on-orbit spare satellite. They continue to analyze the situation, consider alternate orbit adjustment options, and assess mission impacts.

Recommendations
- Status of Previous Recommendations. The Navy is in the process of updating the TEMP for the planned FOT&E.
- FY16 Recommendation.
  1. The Navy should provide resources to address the recommendations in the DOT&E MOT&E-2 report prior to the FOT&E. COTF should verify the corrections in the FOT&E.