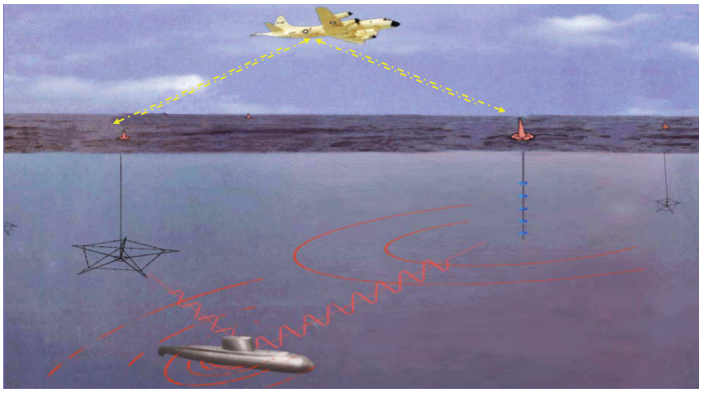
Multi-Static Active Coherent (MAC) System

Executive Summary
- The Navy completed the integration of the Multi-Static Active Coherent (MAC) Phase I system on P-8A Poseidon aircraft and conducted FOT&E in accordance with a DOT&E-approved test plan from March 2014 through February 2015.
- P-8A FOT&E results indicate that the MAC Phase 1 system provides P-8A aircraft with an early wide-area Anti-Submarine Warfare (ASW) search capability in some operational environments and in select scenarios, but it does not meet the MAC Phase I program's requirements in other environments or scenarios. The P-8A's MAC wide-area ASW search capability is similar to the capability on P-3C aircraft.
- The FOT&E did not fully examine the capability of MAC across all operational conditions, representative operational environments, and target types.
- DOT&E submitted an FOT&E report on the P-8A's wide-area ASW search capability with the MAC Phase 1 system in December 2015. The report also updated DOT&E's assessment of the ASW mission capability provided by the MAC system on the P-3C aircraft.
- The Navy plans to install MAC system software and display improvements on the P-8A with Increment 2 Engineering Change Proposal (ECP) 2 in FY15 and FY16 and conduct the P-8A aircraft wide-area ASW search assessment in mid-FY16.

System
- The MAC system is an active sonar system composed of two types of sonobuoys (source and receiver) and an acoustic processing and aircraft mission computer software suite. It is employed by the Navy's maritime patrol aircraft (P-3Cs and P-8As) to search for and locate threat submarines in a variety of ocean conditions.
- MAC replaces the Navy's current Improved Extended Echo Ranging (IEER) system, which employs non-coherent sources to produce loud sounds that reflect off submarine targets. MAC employs new coherent source buoys that enable multiple pings, optimized waveforms, and various ping durations, none of which the legacy IEER system provided. The Navy is planning a series of enhancements to the MAC software and improvements to the MAC buoys.



- To plan MAC missions, the Navy has updated the Active System Performance Estimate Computer Tool (ASPECT)/Multi-static Planning Acoustics Toolkit previously used to plan IEER system missions.
- The Navy intends to employ MAC on P-3C and P-8A aircraft in a limited set of acoustic environments. Future increments of MAC will be employed on P-8A aircraft and in a wider variety of acoustic ocean environments in order to span the operational envelope of threat submarine operations. MAC will be the primary wide-area acoustic search system for the P-8A.
- MAC is expected to have fewer effects on marine mammals and the environment than the legacy IEER system.

Mission

The Navy intends for P-3C and P-8A crews equipped with MAC to support the search, detect, and localization phases of the ASW mission. MAC is particularly focused on large-area active acoustic searches for threat submarines.

Major Contractors
- Lockheed Martin – Manassas, Virginia
- Sparton Electronics Florida, Inc. – De Leon Springs, Florida
- Ultra Electronics, Undersea Sensor Systems Incorporated (USSI) – Columbia City, Indiana
- Boeing Defense, Space, and Security – St. Louis, Missouri

Activity
- The Navy completed integrating the MAC Phase 1 system onto the P-8A aircraft and conducted FOT&E of the P-8A's early wide-area search capability with the MAC from March 2014 through February 2015. The Navy completed IOT&E of the MAC Phase 1 system on the P-3C Multi-mission Aircraft in October 2013. The Navy conducted the operational testing in accordance with a DOT&E-approved test plans.
- DOT&E submitted an FOT&E report on the P-8A's wide-area ASW search capability with the MAC system

in December 2015. The report also updates DOT&E's assessment of the ASW mission capability provided by the MAC system on P-3C aircraft.
- The Navy and DOT&E commenced developing a Test and Evaluation Master Plan (TEMP), which includes deferred MAC testing and plans for the MAC Phase 2 improvements. To efficiently utilize test resources, DOT&E required the test program be consistent with and utilize MAC events programmed in the approved P-8A Increment 2 TEMP. Because future MAC testing is planned to occur on the P-8A, the Navy intends to integrate the Phase 2 MAC test plan into the P-8A Increment 3 TEMP.
- The Navy and DOT&E started development of the P-8A Increment 2 ECP 2 FOT&E test plan, which allow the Navy to evaluate the P-8A's MAC system software and display improvements and complete deferred testing with diesel electric submarines.

Assessment
- DOT&E assessed that the MAC system provides the P-8A and the P-3C aircraft with a wide-area ASW search capability in some environments and for select target scenarios, but that MAC falls short of what the fleet identified as the capability needed to protect high-value units. Although testing identified P-8A's higher speed and revised buoy field installation tactics reduced the search field buoy installation time, DOT&E assessed MAC detection performance was similar to the P-3C's performance and independent of the aircraft platform. Testing identified that detection performance strongly relies on the characteristics of the ocean environment and the tactics employed by the target to evade detection. Testing to understand the effects different threat types and environments have on performance will continue through FY19 in conjunction with the P-8A Increment 2 test program.
- The P-8A FOT&E and the P-3C IOT&E did not fully examine the capability of MAC across all operational conditions, representative operational environments, and target types. DOT&E agreed to limit testing of the initial phase of MAC because the Navy planned to install MAC system software and display improvements on P-8A during Increment 2 ECP 2 and conduct additional testing to evaluate the P-8A's wide-area search capability in FY16.
- Although the MAC system demonstrated a detection capability against evasive undersea targets, acoustic operators were expected to quickly distinguish system submarine detections from a variety of non-submarine clutter detections, some of which appeared target-like. Complicating this task, completed test analysis identified that the MAC system detections of target and non-target clutter varies with environmental conditions and likely target types. The data also show operators are only able to recognize a small fraction of valid system submarine detections as a possible target and spent time assessing and prosecuting false targets.
- The Navy uses ASPECT/Multi-static Planning Acoustics Toolkit to develop MAC search plans and to estimate theoretical system performance. In addition to the incomplete environmental databases used by ASPECT when modeling many threat operating areas, the planning tool performance estimates are highly dependent on the wide-range of potential mission planning input parameters estimated by the mission planner. As a result, ASPECT performance estimates can widely vary when compared to test results. The Navy's Oceanographic Office is updating these environmental databases, focusing first on forward operating areas. Since ASPECT does not have a good estimate for the operator recognition of the submarine target, it overestimates ASW detection performance.
- Additional information is detailed in DOT&E's classified FOT&E report on the P-8A with MAC System dated December 2015, and the IOT&E report on the MAC System on P-3C aircraft dated July 2014.

Recommendations
- Status of Previous Recommendations. The Navy is making progress on the FY13 and FY14 recommendations. The status of significant unclassified recommendations remaining include:
  1. The Navy Program Office is investigating fleet exercise data to assess detection performance and to gather data for developing future algorithm and software improvements. The fleet exercise data include new environments where the fleet operates in peacetime. The Navy is planning the outstanding MAC operational testing against different target types. This testing will be in conjunction with P-8A Increment 2 ECP-2 FOT&E.
  2. The Navy has not completed development of a sustainable MAC training program or completed the formal updates to tactics guidelines and documentation.
  3. The Navy has not developed processes for aircrews to better understand the environmental conditions in the search area. The Navy developed a complex process for estimating the environmental conditions in operational test areas to improve ASPECT predictions; however, the process is not timely or usable by typical aircrews. The Navy should continue to investigate methods for aircrews to measure environmental conditions in the search area and to adjust the MAC search plan appropriately when the conditions change.
  4. The Navy is investigating the MAC system's capability for longer-range detections based on the environmental conditions in the search area.
- FY15 Recommendations. The Navy should implement the recommendations found in DOT&E's P-8A with the MAC system FOT&E report. DOT&E provided 14 recommendations to improve the MAC system performance and 6 recommendations to improve test realism, minimize test limitations, and improve data collection. Significant unclassified recommendations include:
  1. Investigate and develop tactics to improve the operator's ability to transition system detections to high confidence target detection. Consider measures to balance operator

workload and update search plans based on the actual conditions experienced in the search area.
2. Investigate the system's capability for longer-range detections based on the environmental conditions in the search area.
3. Investigate and develop improvements to the ASPECT planning system and the supporting databases.