Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI)

Executive Summary
- The Navy completed FOT&E of Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) Advanced Processor Build 09 (APB-09) in early FY12.
- DOT&E issued a classified FOT&E report for the A-RCI APB-09 system in November 2012, and found the APB-09 system provides performance similar to previous APBs (not improved or degraded).
- The processing and display for the Wide Aperture Array (WAA), a primary focus for APB-09 software upgrades, suffered from significant technical problems that were discovered during initial operational testing. The Navy developed new WAA software intended to fix the problems, conducted limited additional development testing, and issued the new software to the fleet without operational testing.
- The Navy is completing development of the APB-11 version and operational testing is planned to begin in FY13.

System
- A-RCI is an open-architecture sonar system intended to maintain an advantage in acoustic detection of threat submarines.
- A-RCI uses legacy sensors and replaces central processors with commercial off-the-shelf (COTS) computer technology and software. The program includes the following:
  - A sonar system for the *Virginia* class submarine
  - A replacement sonar system retrofitted into *Los Angeles*, *Ohio*, and *Seawolf* class submarines
  - Biannual software upgrades (called Acoustic Processor Builds (APBs)) and hardware upgrades (called Technology Insertions (TIs)). While using the same process and nomenclature, these APBs and TIs are distinct from those used in the AN/BYG-1 Combat Control System program.
- The Navy intends for the A-RCI upgrades to provide expanded capabilities for Anti-Submarine Warfare (ASW), high-density contact management, and mine warfare, particularly in littoral waters and against diesel submarines.
- A-RCI processes data from the submarine's acoustic arrays (i.e., spherical array, hull array, WAA, and high-frequency arrays) along with the submarine's two towed arrays (i.e., the fat line array consisting of the TB-16 or TB-34 and the thin line array consisting of the TB-23 or TB-29).

- The APB-09 introduced upgraded processing on the high frequency array and the ability to process new pulse types. It also introduced advanced signal processing to improve both detection and display performance for the WAA. The Navy intends for the new software to improve ASW search through attack performance with new enhanced narrowband processing algorithms, to improve performance avoiding threat mines, and to improve situational awareness and contact managements for all missions.

Mission
The Navy's intent for submarine crews equipped with the A-RCI sonar is to complete the following submarine force missions:
- Search, detect, and track submarine and surface vessels in open-ocean and littoral sea environments without being counter-detected
- Search, detect, and avoid mines and other submerged objects
- Covertly conduct intelligence, surveillance, and reconnaissance
- Covertly execute Naval Special Warfare missions
- Perform under-ice operations

Major Contractor
Lockheed Martin Maritime Systems and Sensors – Washington, District of Columbia

Activity
- The Navy completed FOT&E of A-RCI APB-09 in early FY12 in accordance with a DOT&E-approved test plan. The Navy combined testing with the AN/BYG-1 Combat Control System, the *Virginia* class submarine, and the Mk 48 Mod 6 Advanced Common Torpedo (ACOT) and Mk 48 Advanced Capability (ADCAP) Mod 7 Common Broadband Advanced

Sonar System (CBASS) programs. Coordinating these tests provided testing efficiencies while enabling an end-to-end evaluation of mission performance.

- DOT&E issued a classified combined test report for the *Virginia* class submarine, the A-RCI sonar, and the AN/BYG-1 Combat Control system in November 2012 that evaluated the effectiveness and suitability of the A-RCI APB-09 system.
- The Navy began drafting a Test and Evaluation Master Plan (TEMP) for the APB-11 and APB-13 A-RCI variant APBs, and expects to issue it by early FY13. As part of these efforts, DOT&E requested the Navy investigate new methods of land-based testing and onboard simulated target injection methods to augment at-sea operational tests. Operational testing of the APB-11 variant of A-RCI is expected to begin in FY13.

Assessment

- The DOT&E classified FOT&E report for the A-RCI APB-09 system concluded the following regarding test adequacy and system performance:
  - Given the data available and the limitations of the test, DOT&E concluded that no evidence existed to change the conclusions about mission performance from previous reports on A-RCI (not improved or degraded). Specifically,
    - For ASW, A-RCI passive sonar capability is effective against older classes of submarines in some environments, but is not effective in all environments or against modern threats.
    - A-RCI is not effective in supporting operator situational awareness and contact management in areas of high-contact density.
    - A-RCI high-frequency mine performance is not effective for some types of minefields, but meets threshold requirements against some mine types under certain environmental conditions.
  - Testing to examine ASW-Attack and situational awareness in a high-surface-ship density environment was adequate for the system tested but not adequate for the software version fielded. The A-RCI processing for the WAA suffered from system development and software problems, which led to poor performance during the operational testing. The Navy investigated this issue after operational testing was completed and subsequently issued software intended to fix the problems. The Navy conducted some limited developmental testing to confirm functionality; however, the Navy has not conducted operational testing to evaluate the updated software or potential changes to mission performance.
  - Test execution to examine the Precision Underwater Mapping capability was not adequate.
  - Several mine shapes in the Navy's training minefield used for the operational testing were severely corroded, damaged, or buried. DOT&E considered the condition of the mine shapes in evaluating high-frequency sonar detection performance and assessed the testing was adequate for some types of threat minefields.
  - A-RCI continues to be not suitable due to problems with reliability and operator training. For APB-09, the Navy lowered the reliability requirements below the previously measured APB reliability. The Navy also refocused the system's new reliability requirements on the minimum system functions necessary for at-sea operations vice what system functions are required for the mission. While APB-09 met the revised lower reliability requirements, the APB-09 system's reliability was significantly below the sonar reliability demonstrated on *Virginia* class submarines during the IOT&E. For other submarine classes, measured sonar APB reliability is statistically unchanged from previous APBs. After operational testing, the Navy reported that software changes were made to the APB-09 software intended to fix the reliability problems identified in testing; these changes have not been evaluated.
  - The Navy revised the Capability Development Document/Capability Production Document performance requirements for A-RCI APB-09. The revised requirements metric focuses development and testing on the time between the A-RCI system displaying acoustic energy and the operator identifying the target. This new metric favors shorter range detections; therefore, a poorly-performing sonar system (shorter range detections) has the potential of scoring better than a long-range detecting system.
- Due to the A-RCI biannual software and hardware development cycle, the Navy generates and approves the A-RCI requirements documents and TEMPs in parallel with APB development and installation. As a result, the fleet assumes additional risk, since most operational testing is not completed before the system is initially deployed.
- The Navy's schedule-driven process prevents operational test results from directly supporting development of the follow-on APBs. For example, the Navy completed operational testing of the A-RCI APB-09 system in early FY12. Due to the combination of the late completion of testing and the Navy's practice of issuing an updated version every two years, data from APB-09 operational testing could not be included in the development of APB-11.
- The development and testing of APB-09 is an example of the high-risk of schedule-driven development and fielding; operational testing revealed significant performance failures with the WAA that were not discovered in developmental testing. Although the Navy issued new software intended to fix the identified problems after the operational test, submarines deployed with a version of A-RCI that the Navy has not operationally tested.

Recommendations

- Status of Previous Recommendations. The Navy is making progress in addressing 23 of the 30 recommendations contained in the APB-00 to APB-07 OT&E reports. The significant remaining unclassified recommendations are:
  1. Improve the detection and localization performance for submarines operating in high-density surface ship environments. Consider investing in automation that will assist the operator in processing the large amount of constantly changing contact data and determining which contacts pose an immediate collision or counter-detection threat.
  2. Improve operator training such that operators understand and effectively employ new APB functionality when fielded. Many of the newly introduced features in APBs that were designed to improve mission performance were not used consistently during the test.
  3. Evaluate the covertness of the high-frequency sonar during a future submarine-on-submarine test.
  4. Investigate the software reliability problems and institute measures to improve system reliability.
  5. Conduct future ASW testing against a high-end diesel-electric submarine (SSK) target to enable a more complete assessment of A-RCI and BYG-1 performance.
- FY12 Recommendations. The Navy should:
  1. Consolidate the A-RCI and AN/BYG-1 TEMPs into an Undersea Enterprise Capstone document.
  2. Re-evaluate operational effectiveness and suitability of A-RCI on a submarine with the new WAA software.
  3. Address the 21 recommendations for the A-RCI and the AN/BYG-1 systems contained in DOT&E's FOT&E report

on A-RCI APB-09. Some of the significant unclassified recommendations are:
- The Navy should improve its developmental testing processes and metrics used to determine if a system potentially improves effectiveness and suitability and to ensure that the system is ready for operational testing and subsequent fielding.
- Search rate is an important metric for evaluating the ASW search performance. Recently, the Navy issued revised requirements for A-RCI and did not update the platform search rate metric. The new metrics, which assess the difference between the initial operator and post-test laboratory detection times, could improperly result in a poorly performing system (short-range detections) scoring better than a long-range detecting sonar system. DOT&E recommends the Navy re-evaluate the new metrics to improve their robustness under varying environmental conditions and to focus on earlier and longer range operator detections. Also, the Navy should update the operational and environmental conditions for the search rate metric to reflect current threats and threat areas.
- If future minefield testing requires the use of existing fleet training minefields, a minefield video survey to evaluate the condition and location of the mines should be conducted prior the decision to use the minefield for testing.