AN/BYG-1 Combat Control System

Executive Summary
- Although the Navy planned to complete AN/BYG-1 Advanced Processor Build (APB) 2007 version testing before the first APB-07 submarine deployed, this did not occur due to a lack of an available submarine test asset. Subsequently, the Navy completed testing in September 2010.
- The Navy completed development of the APB-09 version and operational testing is planned for FY11.

System
- AN/BYG-1 is an open-architecture submarine combat control system for analyzing and tracking submarine and surface ship contacts, providing situational awareness, as well as the capability to target and employ torpedoes and missiles.
- AN/BYG-1 replaces central processors with commercial off-the-shelf computer technology and software. The Navy installs improvements to the system via an incremental development program. The program includes the following:
  - A combat control system for the *Virginia* class submarine
  - A replacement combat control system backfit into *Los Angeles*, *Ohio*, and *Seawolf* class submarines
  - Biannual software upgrades called APBs and hardware upgrades called Technology Insertions (TI). While using the same process and nomenclature, these APBs and TIs are distinct from those used in the Acoustic Rapid Commercial-Off-the-Shelf (COTS) Insertion (A-RCI) program.
- The Navy intends improvements to provide expanded capabilities for anti-submarine and anti-surface warfare, high density contact management (HDCM), and the targeting and control of submarine weapons.
- The Navy is also developing AN/BYG-1 for use on the Royal Australian Navy *Collins* class diesel electric submarines.

Mission
Submarine crews equipped with the AN/BYG-1 combat control system are able to complete the following submarine force missions:
- Analyze submarine sensor contact information to track submarine and surface vessels in open-ocean and littoral sea environments.
- Employ heavyweight torpedoes against submarine and surface ship targets.
- Receive strike warfare tasking, plan strike missions, and employ Tomahawk land attack cruise missiles.
- Receive and synthesize all organic sensor data and external tactical intelligence to produce an integrated tactical picture.

Major Contractors
- General Dynamics Advanced Information Systems – Fairfax, Virginia
- General Dynamics Advanced Information Systems – Pittsfield, Massachusetts

Activity
- Although the Navy planned to complete AN/BYG-1 APB-07 testing before the first APB-07 submarine deployed, this did not occur due to a lack of an available submarine test asset.
- The Navy conducted an AN/BYG-1 APB-07 Anti-Submarine Warfare search rate test, an HDCM operational test, and a Strike Warfare test in October 2009 in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and test plan. The test events were combined with the testing of the A-RCI APB 07 sonar upgrades and the new TB-34 towed array. The Navy conducted a second HDCM test event in May 2010, in conjunction with Low Cost Conformal Array operational testing, to test specific features of the APB-07 software that were not tested in the initial event.
- The Navy conducted an Information Assurance vulnerability evaluation of APB-07 in October 2009, and completed the Information Assurance testing with a penetration test of the system in December 2009.
- The Navy began installing the AN/BYG-1 APB-09 system on operational submarines in 2010. DOT&E expects to sign the AN/BYG-1 APB-09 TEMP in FY11.

Assessment
- The Navy's practice of bi-annually updating the BYG-1 software and hardware appears to qualitatively improve technical performance, but insufficient test data exists from

APB to APB to measure and quantify the improved mission capability across the mission areas.

- Preliminary test results on APB-07 performance indicate the following:
  - BYG-1 APB-07 performance in the HDCM scenarios was mixed. While improvements were observed, the test ship was not able to meet the BYG-1 target localization requirements when operating either at periscope depth or deep.
  - Information Assurance testing was inadequate to fully evaluate the system. The vulnerability evaluation uncovered some potential vulnerable areas in the system, but the penetration test was unable to breach the system. However, this conflict could not be resolved because the Navy Information Operations Command (NIOC) did not release their penetration testing methodology and it could not be determined to what level the penetration test attempted to exploit the potential vulnerabilities. NIOC did not want their techniques released to future test platforms in order to maintain the effectiveness of their test techniques.
  - Overall, AN/BYG-1 APB-07 appears to be suitable, demonstrating above-threshold reliability and availability.
- The APB-07 Information Assurance test revealed some discrepancies between how NIOC shares information between the acquisition and testing communities. DOT&E is working with the Office of the Secretary of Defense for Acquisition, Technology and Logistics; the Commander, Operational Test and Evaluation Force; and NIOC to assure data are shared similarly between the communities and that future test events will provide sufficient data to adequately evaluate and report on the systems being tested.

- Despite completing test events in October 2009 and May 2010, the Navy has not completed data reconstruction and has not provided all relevant data to DOT&E.
- The Navy has achieved some testing efficiencies by combining operational testing of several programs into consolidated test events. Since testing is interdependent, the consolidation of A-RCI, TB-33, TB-34, and AN/BYG-1 TEMPs into an Undersea Enterprise Capstone document would increase testing efficiency and enable a full end-to-end evaluation of submarine capability in the applicable mission areas.

Recommendations
- Status of Previous Recommendations. The Navy has satisfactorily addressed all but three previous recommendations. Recommendations that still need to be addressed involve developing requirements to allow APB comparison, developing platform level metrics, and implementing an event-based schedule.
- FY10 Recommendations. The Navy should:
  1. Assure that sufficient data are collected during future penetration tests such that the attack can be reconstructed in detail.
  2. Address the major deficiencies found during the Information Assurance vulnerability evaluation.
  3. Assure data collection occurs in a manner that supports a complete and timely assessment.
  4. Consolidate the A-RCI, TB-33, TB-34, and AN/BYG-1 TEMPs into an Undersea Enterprise Capstone document.