SSN 774 *Virginia* Class Submarine

Executive Summary

- The Navy conducted a *Virginia* class FOT&E event in FY13 that examined the submarine's ability to support Naval Special Warfare (NSW) missions using an installed Dry Deck Shelter (DDS).
- DOT&E issued a classified report in October 2013 on the results of the FOT&E. DOT&E concluded that:
  - *Virginia* class submarines are capable of hosting the DDS system.
  - *Virginia* class submarines can remain covert during NSW missions in some environments against some threat forces. The Navy's metrics for assessing this covert capability was a binary probability that cannot reasonably be assessed by testing so it was not used in DOT&E's assessment.
- In May 2013, DOT&E issued a classified report on a combined FOT&E event that occurred in FY11.
  - The first portion of the report assessed the *Virginia* class submarine's ability to operate under-ice and to conduct Anti-Submarine Warfare (ASW) in the Arctic.
  - The second portion of the report assessed the *Virginia* class submarine's susceptibility to detection by passive acoustic arrays.
    - DOT&E concluded that the *Virginia* class submarine is effective at supporting general operations in the Arctic but remains ineffective at ASW against some targets, which is unchanged from the results of previous testing reported on by DOT&E.
    - DOT&E also concluded that the *Virginia* class submarines are among the quietest submarines in the world and are difficult to detect with passive acoustic sensors. Like all other classes of U.S. submarines, when operating at high speeds *Virginia* class submarines become more susceptible to detection by passive acoustic sensors.
- DOT&E issued a separate November 2012 classified report on a combined FOT&E event that began in FY11 and extended into FY12. This report assessed the *Virginia* class submarine's performance with the Navy's latest combat system and sonar suite. DOT&E concluded that the modernization of the combat system and sonar suite did not change the performance of the *Virginia* class submarines for the missions tested.

System

- The *Virginia* class submarine is the Navy's latest fast attack submarine that is capable of targeting, controlling, and launching Mk 48 Advanced Capability torpedoes and Tomahawk cruise missiles.

- The Navy is procuring *Virginia* class submarines incrementally in a series of blocks. The block strategy is for contracting purposes, not necessarily to support upgrading capabilities.
  - Block I (hulls 1-4) and Block II (hulls 5-10) ships were built to the initial design of the *Virginia* class.
  - Block III (hulls 11-18) ships will include the following enhancements:
    - A Large Aperture Bow array will replace the spherical array in the front of the ship.
    - Two *Virginia* payload tubes will replace the 12 vertical launch tubes. Each payload tube is capable of storing and launching six Tomahawk land attack missiles used in strike warfare.
  - The Navy has not designed Block IV and beyond ships.

Mission

The Operational Commander will employ the *Virginia* class submarine to conduct open ocean and littoral covert operations in support of the following submarine mission areas:

- Strike Warfare
- Anti-Submarine Warfare
- Intelligence, Surveillance, and Reconnaissance; Indications and Warnings; and Electronic Warfare
- Anti-Surface Ship Warfare
- Naval Special Warfare
- Battle Group Operations

Major Contractors

- General Dynamics Electric Boat – Groton, Connecticut
- Huntington Ingalls Industries, Newport News Shipbuilding – Newport News, Virginia

Activity

- In November 2012, DOT&E issued a classified FOT&E report on the modernized *Virginia* with the Advanced Processor Build (APB) 09 sonar and combat control systems.
- In May 2013, DOT&E issued a classified report on *Virginia*'s ability to conduct operations in the Arctic environment and the submarine's susceptibility to low-frequency passive acoustic sensors.
- During November through December 2012, the Navy conducted developmental and operational tests to assess the ability of the *Virginia* class submarine to perform NSW missions with a DDS installed. DOT&E issued a classified report in October 2013 on the results of the FOT&E.
- The Block III design requires shock testing of the Common Weapons Launcher and the *Virginia* Payload Tube (VPT) hatch. The VPT hatch shock qualification test series to support the first Block III delivery in August 2014 was scheduled for April 2013. However, the test series is on-hold due to a work stoppage at the Aberdeen Test Center. The Program Office is planning to restart the test series in early 2014.
- The Navy is performing a verification and validation of the Transient Shock Analysis (TSA) modeling method used for the design of *Virginia* class Block III items. The TSA modeling method is scheduled to be accredited in April 2014.
- The Navy has planned an update to the Vulnerability Assessment Report to include the Block III modifications for January 2015.

Assessment

- The October 2013 DOT&E classified report details *Virginia*'s ability to host NSW missions from a DDS and concluded the following:
  - *Virginia* class submarines are capable of hosting the DDS system.
  - *Virginia* class submarines can remain covert during NSW missions in some environments against some threat forces. Testing was not sufficient to fully evaluate the covertness of the class during DDS operations against expected threats. DOT&E's report provided estimates for probability to remain covert based on the data available. Furthermore, the Navy's primary metric for assessing success in these missions is a binary probability, which is infeasible to measure.
  - Operational testing was adequate for an assessment of the *Virginia* class submarine's effectiveness and suitability for NSW missions using a DDS only against a low-end threat. The Navy's Commander, Operational Test and Evaluation Force (COTF) did not conduct test execution in accordance with the DOT&E-approved test plan. Specifically, COTF failed to collect positional data from the assigned simulated opposing forces, which limited the ability to assess covertness during these operations. Additionally, the testing did not provide data to address acoustic vulnerabilities during NSW operations using a DDS.
  - The *Virginia* class submarine is suitable for NSW operations using a DDS; however, the Navy identified shortcomings in the *Virginia* class in testing.
    - Space limitations onboard the submarines restrict movement to and from the control room, which potentially impedes the ship's ability to execute damage control procedures in the event a casualty occurs during NSW operations using a DDS.
    - During conditions of low visibility, including nighttime operations, Special Operations Force (SOF) members on the surface may have difficulty seeing the photonics mast of a submerged submarine, which is used to guide the movement of the SOF as they return to the submarine.
    - The Navy made modifications to the SEAL Delivery Vehicle (SDV) Auxiliary Life Support System (ALSS) used in some DDS operations. These modifications allow for increased air pressure and as a result, more available man-hours to support missions. The *Virginia* class air supply system to pressurize the ALSS does not support operating at the higher pressures.
- The May 2013 DOT&E report on *Virginia*'s operational capabilities in the Arctic and the *Virginia*'s susceptibility to low-frequency passive acoustic detection concluded that:
  - Testing was adequate for an assessment of effectiveness and suitability to support general Arctic operations and of the susceptibility of the submarine to detection by passive acoustic sensors. The Navy conducted the testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan but data were not available to conduct the desired quantitative assessment because the Navy did not retain the data following the testing.
  - *Virginia* class submarines are effective at supporting general operations in the Arctic but remain ineffective at ASW against some targets, which is unchanged from previous testing reported on by DOT&E. During testing, the *Virginia* class submarine was hampered with a failure of its sonar system's TB-29 towed array. The failure of the towed-array affected the submarine's performance because it provided the longest-range detections of acoustic contacts. However, these arrays are known to be fragile and do frequently fail during operations.
  - As part of the operational testing, an evaluation of the Depth-Encoded Ice-Keel Avoidance (IKA) mode of the Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) sonar system was included. Ice-keels extend down from the ice canopy above the submarine when operating in regions of the Arctic covered by ice. This Depth-Encoded IKA mode uses active sonar with the intention of providing operators with location, size, and depth of ice-keels so that the submarine can avoid colliding with them. The testing showed that the Depth-Encoded IKA is fundamentally limited by the precision to which a submarine can know the

propagation path of the active sonar and as a result, the Depth-Encoded IKA is unable to achieve the threshold for accuracy established by the Navy.
- *Virginia* class submarines are difficult to detect with low-frequency passive acoustic sensors. Like all other classes of U.S. submarines, when operating at high speeds *Virginia* class submarines become more susceptible to detection by passive acoustic sensors.
- *Virginia* class submarines provide less Arctic capability than the *Seawolf* and improved *Los Angeles* class submarines. Some regions of the Arctic are characterized by tight vertical clearances between the shallow ocean floor below and the thick ice canopy above. *Virginia* lacks a hardened sail, and is therefore limited in the thickness of ice through which the submarine can safely surface.
- The *Virginia* class submarine is operationally suitable for supporting general Arctic operations but suffers from some reliability shortcomings:
  - The IKA modes of the A-RCI sonar system reliability require improvement to support extended periods of challenging under-ice operations. After a decade of development and fielding, no hardware or software variant of A-RCI has come close to the Navy's reliability requirement, which is based on an operational need. More reliable sonar processing hardware is typically brought onboard because of the poor A-RCI reliability.
  - The common methods of removing carbon dioxide and hydrogen waste gas consistently failed during operations in the cold Arctic environment.
  - The handling system for the *Virginia* class submarine's Buoyant Cable Antenna, used for communications during operations under the ice canopy, is susceptible to freezing preventing subsequent deployment or retrieval.
  - The *Virginia* class submarine suffers from excessive condensation in the cold Arctic environment. In general, this is an insulation problem since water vapor will condense on any surface with a temperature below the local dew point. Excessive condensation has the potential to cause problems with electronic systems.

- DOT&E's classified report on *Virginia*'s modernization FOT&E, issued in November 2012, concluded the following:
  - *Virginia*'s operational effectiveness is dependent on the mission conducted. The modernization of the sonar and fire control systems (A-RCI and AN/BYG-1) with the APB 09 software did not change (improve or degrade) the performance of the *Virginia* class for the missions tested. DOT&E's assessment of mission effectiveness remains the same for ASW; Intelligence, Surveillance, and Reconnaissance; High-Density Contact Management; situational awareness; and Mine Avoidance. DOT&E's overall assessment of Information Assurance remains unchanged from IOT&E, although the new software represents an improvement in Information Assurance over previous systems.
  - Although *Virginia* was not effective for some of the missions tested, it remains an effective replacement for the *Los Angeles* class submarine, providing similar mission performance and improved covertness.
  - Testing to examine ASW-attack and situational awareness in high-density environments was adequate for the system software that was tested but not adequate for the software version that the Navy fielded. After completion of operational testing, the Navy issued software changes intended to address the severe performance problems observed with the Wide Aperture Array. The Navy has not completed operational testing on the new software, which is fielded on deployed submarines. DOT&E assesses that the late fix of the array's deficiencies is a result of the Navy's schedule-driven development processes, which fields new increments without completing adequate developmental testing.
  - The Navy collected adequate data to assess the suitability of the sonar and fire control systems. Insufficient data were collected to reassess the suitability of *Virginia*'s hull, mechanical, electrical, or electronic systems; however, these data were not expected to demonstrate significantly different reliability compared to what was observed in IOT&E. Of note, the installation of the new APB 09 on *Virginia*'s A-RCI sonar system will degrade the reliability of the sonar system on these submarines relative to what was demonstrated in the IOT&E.

Recommendations

- Status of Previous Recommendations.
  - The Navy has made progress in addressing 23 of the 30 recommendations contained in the November 2009 classified FOT&E report. Of the seven outstanding recommendations, the significant unclassified recommendations are:
    1. Test against a diesel submarine threat surrogate in order to evaluate *Virginia*'s capability, detectability, and survivability against modern diesel-electric submarines.
    2. Conduct an FOT&E to examine *Virginia*'s susceptibility to airborne ASW threats such as Maritime Patrol Aircraft and helicopters.
  - The following recommendations from the FY12 Annual Report remain open and the Navy should work to address them in the upcoming fiscal year:
    3. Coordinate the *Virginia*, A-RCI, and AN/BYG-1 Test and Evaluation Master Plans and utilize Undersea Enterprise Capstone documents to facilitate testing efficiencies.
    4. Complete the verification, validation, and accreditation of the TSA method used for *Virginia* class Block III items.
    5. Repeat the FOT&E event to determine *Virginia*'s susceptibility to low-frequency active sonar and the submarine's ability to conduct Anti-Surface Warfare in a low-frequency active environment. This testing should include a *Los Angeles* class submarine operating in the same environment to enable comparison with the *Virginia* class.

- FY13 Recommendations. The *Virginia* DDS and Arctic reports generated 16 recommendations. The following are unclassified recommendations listed in the October 2013 FOT&E report. The Navy should:
  1. Reconsider the metrics used to assess *Virginia* class submarine's ability to covertly conduct mass swimmer lockout operations using the DDS.
  2. Evaluate the possible acoustic vulnerabilities associated with SDV employment.
  3. Seek additional evaluations of *Virginia* class operations with a DDS to improve understanding of deployment time for operations and operationally evaluate covertness.
  4. Confirm that the access to and from the Control Room during DDS operations meet the requirements of the Submarine Safety Program for accessibility and are sufficient to provide for adequate damage control in the event of casualties.
  5. The Navy should investigate and implement methods to aid the SOF in identifying the submarine during operations in conditions of low visibility.
  6. Investigate modifying the reducer in the air charging system to allow higher air pressure for the SDV Auxiliary Life Support System in order to provide increased flexibility for SDV missions that can be hosted from *Virginia* class submarines.
  7. Re-evaluate the accuracy requirements for the IKA sonar modes and investigate the calibration of those modes.
  8. Continue the reliability improvement program for the TB-29 towed-array or pursue the development of a new array.
  9. Improve the reliability of the A-RCI IKA sonar modes.
  10. Modify atmosphere control subsystems to operate properly in the freezing waters of the Arctic Ocean.
  11. Modify the handling system of the Buoyant Antenna Cable to prevent its freezing in the cold Arctic environment.
  12. Continue to collect data on the susceptibility of the *Virginia* class to low-frequency passive systems and conduct a more quantitative assessment (e.g., determine detection ranges for different ship postures).