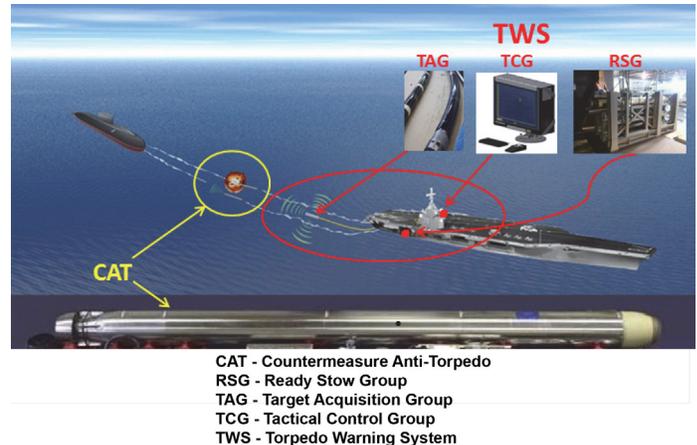


Surface Ship Torpedo Defense (SSTD) System: Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT)

Executive Summary

- DOT&E submitted a classified Early Fielding Report in March 2015 on the Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT) system fielded aboard USS *Theodore Roosevelt* (CVN 71). The completed testing of the TWS (passive) and CAT Engineering Development Model-2 (EDM-2), powered by Stored Chemical Energy Propulsion System (SCEPS), fielded aboard *Theodore Roosevelt* (and previously on USS *George H. W. Bush* (CVN 77) has not demonstrated an effective capability against realistic threat country torpedo attack scenarios.
- The Navy's Quick Reaction Assessment (QRA) of TWS and CAT demonstrated a limited capability to detect and home on certain types of single torpedo threats. However, these versions of the system have not been fully tested and the Navy conducted most TWS and CAT testing in areas with benign acoustic conditions when compared to the expected threat operating areas, which may have biased the results high. Very few of the threat surrogates used during testing were conducting operationally realistic threat torpedo profiles due to safety constraints. Moreover, the lack of adequate testing has stymied the development of optimal tactics, techniques, and procedures and assessment of system availability and reliability, which negatively affects the system's suitability.
- The Navy installed a third version of the TWS and the CAT EDM-2 powered with SCEPS aboard the USS *Harry S. Truman* (CVN 75) during FY15. This version is similar to the permanent system installed on the *George H. W. Bush* in FY13 and includes the TWS Target Acquisition Group, the Tactical Control Group hardware, and two of the four planned CAT Ready Stow Group cradles. The TWS and CAT operational software is the same version installed for *Theodore Roosevelt* deployment to the Fifth Fleet in March 2015. The Navy fielded this version of TWS and CAT when the *Harry S. Truman* deployed in early FY16.
- In FY14 and FY15, the Navy installed a temporary-installation version of TWS and CAT (designated as a roll-on/roll-off system) aboard *Theodore Roosevelt* and conducted a second QRA in the Virginia Capes Operating Areas. Only two of the four planned QRA events and one of the five planned contractor test events were accomplished due to several factors including poor weather.
- The TWS program of record includes a Towed Active Acoustic Source (TAAS) to detect torpedoes using active sonar, but after exhibiting multiple critical reliability failures



during the FY15 QRA, the Navy was unable to field the TAAS aboard *Theodore Roosevelt* as planned, and so, like *George H. W. Bush*, the ship deployed with a passive-only TWS.

- The Navy is currently installing a roll-on/roll-off version of TWS and CAT on USS *Dwight D. Eisenhower* (CVN 69) to support her next deployment and is in various stages of planning and installing the permanent version of the TWS and CAT early fielded hardware on selected CVNs before their next deployments.

System

- Surface Ship Torpedo Defense is a system-of-systems that includes two new sub-programs: the TWS (an Acquisition Category III program) and CAT (will not become an acquisition program until FY16). Combined, TWS and CAT are referred to as the Anti-Torpedo Torpedo (ATT) defense system.
- TWS is being built as an early warning system to detect, localize, classify, and alert on incoming threat torpedoes and consists of three major subsystems:
 - The Target Acquisition Group consists of a towed acoustic array, tow cable, winch, power supply, and signal processing equipment. Data from the array and the ship's radar system are processed into contact tracks and alerts to be forwarded to the Tactical Control Group. The array will be capable of both passive and active sonar operations.
 - The Tactical Control Group consists of duplicate consoles on the bridge and Combat Direction Center (on CVNs) that displays contacts, issues torpedo alerts to the crew,

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- and automatically develops CAT placement presets using information sent from the Target Acquisition Group. The operator will use this console to manage the threat engagement sequence and command CAT launches.
- The Ready Stow Group will consist of the steel cradles housing the CATs. The permanent system consists of four steel cradles and associated electronics, each housing six ATTs at different locations (port/starboard and fore and aft on the CVN).
- CAT is a hard-kill countermeasure intended to neutralize threat torpedoes and consists of the following:
 - The ATT is a 6.75-inch diameter interceptor designed for high-speed and maneuverability to support rapid engagement of the threat torpedo.
 - The All-Up Round Equipment consists of a nose sabot, ram plate, launch tube, muzzle cover, breech mechanism, and energetics to encapsulate and launch the ATT.
 - The tactical CAT is powered by a SCEPS. The battery-powered electric motor CAT is for test purposes only. EDM-2 is the current hardware version of the CAT.
- The Navy developed a temporary version of TWS and CAT (designated a roll-on/roll-off system) in addition to the permanent-installation version. The Navy intends for this version to provide the same function as the permanent one.
 - The Ready Stow Group steel cradles are replaced by two lighter-weight and less-robust aluminum Launch Frame Assemblies that each hold four CATs.

- The Tactical Control Group consists of two consoles contained in a container express box located on the carrier's hangar deck.
- The towed acoustic array, tow cable, and winch are permanently installed on the carrier's fantail. The other components of the Target Acquisition Group are contained in the container express box located on the hangar deck.

Mission

Commanders of nuclear-powered aircraft carriers and Combat Logistic Force ships will use the Surface Ship Torpedo Defense system to defend against incoming threat torpedoes.

Major Contractors

TWS

- Ultra Electronics-3Phoenix – Chantilly, Virginia
- Alion Science and Technology – New London, Connecticut
- In-Depth Engineering – Fairfax, Virginia

CAT

- Pennsylvania State University Applied Research Laboratory – State College, Pennsylvania
- Pacific Engineering Inc. (PEI) – Lincoln, Nebraska

Activity

- The Navy installed a third version of the TWS and the CAT EDM-2 powered with SCEPS aboard *Harry S. Truman* during FY15. This version is similar to the FY13 installation aboard *George H. W. Bush* and includes the permanent installation of the TWS Target Acquisition Group and the Tactical Control Group hardware and two of the four planned CAT Ready Stow Group steel cradles. The TWS and CAT operational software is the same version as installed aboard *Theodore Roosevelt's* roll-on/roll-off system in FY14. The Navy fielded this version of TWS and CAT when the USS *Harry S. Truman* deployed in early FY16. The Navy is currently installing a roll-on/roll-off version aboard *Dwight D. Eisenhower* to support her next deployment and is in various stages of planning and installing the permanent version of the TWS and CAT early fielded hardware on selected CVNs before their next deployment.
- The Navy installed an initial version of TWS and the CAT EDM-2 aboard *George H. W. Bush* and conducted a QRA in the Virginia Capes Operating Areas in November 2013. The *George H. W. Bush*, which deployed with the TWS system and the CAT EDM-2 with the SCEPS propulsion system, returned from deployment to Fifth Fleet Operating Areas in November 2014.
- DOT&E submitted a classified Early Fielding Report in April 2014 on the TWS and CAT system fielded aboard

- George H. W. Bush*. DOT&E submitted a classified update to the Early Fielding Report in August 2014, following the Navy's discovery of an anomaly in the CAT's Safety and Arming device. The Navy developed a correction for the anomaly in the CAT Safety and Arming device but could not install the correction in the fielded CATs due to safety concerns and USS *George H. W. Bush's* operational schedule.
- In FY14 and FY15, the Navy installed a roll-on/roll-off version of TWS and CAT aboard *Theodore Roosevelt* and conducted a second QRA in the Virginia Capes Operating Areas in November 2014. The QRA event was conducted in conjunction with a contractor test event. Only two of the four planned QRA events and one of the five planned contractor test events were accomplished due to several factors including poor weather. During each completed event, a single surrogate threat torpedo was fired at *Theodore Roosevelt* for the TWS system to detect and target. *Theodore Roosevelt's* crew, with the contractor support that accompanied the ship on their deployment, engaged the threat torpedo surrogate with a CAT during some of the events. All CATs that were fired used electric propulsion.
- The Navy's contractor redesigned the active source and the Navy planned to field it aboard *Theodore Roosevelt*, but there was insufficient time and resources to complete development

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and testing prior to deployment. The redesigned TAAS failed during the November 2014 QRA, exhibiting new failure modes and failing in a similar fashion to the older one.

- The Navy fielded the roll-on/roll-off version of the TWS and the CAT EDM-2 powered by SCEPS aboard *Theodore Roosevelt* when she deployed in March 2015 to Fifth Fleet Operating Areas. The ship deployed with a passive-only TWS since the Navy was unable to deliver a functioning TAAS. DOT&E submitted a classified Early Fielding Report on the roll-on/roll-off version of TWS and CAT in March 2015.
- *Theodore Roosevelt* returned from deployment in November 2015. Due to operational limitations, the crew rarely deployed the TWS array during the deployment or while in the Fifth Fleet Operating Areas.
- In February and April 2015, the Navy and Pennsylvania State University Applied Research Laboratory conducted contractor testing of CAT on the Dabob Bay, Washington, and the Nanoose Bay, British Columbia, Canada, acoustic tracking ranges. The testing included runs to develop CAT's salvo capability and to evaluate the CAT's long-range passive fuzing capability.
- In August 2015, the Navy and the Naval Surface Warfare Center Carderock conducted warhead and Safety and Arming device airburst testing at Fort A.P. Hill, Virginia. This testing verified the arming, fuzing, and firing of the ATT warhead.
- In August 2015, the Navy and Pennsylvania State University Applied Research Laboratory conducted CAT contractor testing on the Dabob Bay, Washington, acoustic range. The testing supported developing the CAT's salvo capability.
- In August and September 2015, the Navy, Pennsylvania State University Applied Research Laboratory, and 3Phoenix conducted contractor testing of the TWS and CAT on the Nanoose Bay, British Columbia, Canada, acoustic tracking range. To accomplish this testing, the Navy removed the TWS array from *George H.W. Bush* and installed the repaired TAAS. This testing supported developing the TWS TAAS active waveforms and developing the end-to-end TWS detection and targeting and CAT intercept capability against threat torpedo salvos. On the third day, the TAAS array developed a short on one of the two TAAS transducer strings. The TWS contractor isolated the grounded string of transducers and continued the test with the remaining half of the TAAS transducers and the passive hydrophones.
- The Navy deployed the TWS (passive only system) and CAT EDM-2 powered by SCEPS aboard *Harry S. Truman* when she deployed in 1QFY16. Like the previous deployments, 3Phoenix contractor personnel deployed with the *Harry S. Truman* to operate the TWS system and to train the crew.
- During FY15, the Navy and DOT&E continued development of an enterprise Test and Evaluation Master Plan (TEMP) for the TWS and CAT systems. The Navy made their TWS

Milestone B decision without a TEMP and is not planning to make the CAT system an acquisition program until FY16.

Assessment

- The completed testing of TWS (passive) and CAT EDM-2, powered by SCEPS, fielded aboard *George H. W. Bush* and *Theodore Roosevelt*, has not demonstrated an effective capability against realistic threat torpedo attack scenarios. The Navy's QRAs of TWS and CAT demonstrated limited capability to detect and home on certain types of single torpedo threats. However, these versions of the system have not been fully tested and the Navy conducted most TWS and CAT testing in areas with benign acoustic conditions when compared to the expected threat operating areas, which may have biased the results high. Very few of the threat surrogates used during testing were conducting operationally realistic threat torpedo profiles due to safety constraints.
- Moreover, the lack of adequate contractor and developmental testing has stymied the development of system detection; tracking and alerting software; operator tactics, techniques, and procedures; and assessments of system availability and reliability. Although the Navy and Pennsylvania State University Applied Research Laboratory are able to conduct independent structured CAT testing, 3Phoenix's TWS testing is limited because the prototype TWS arrays are rapidly fielded to the deploying CVN, leaving the 3Phoenix contractors without a full system to continue development. Further, the CVN's assigned operational areas in the Fifth Fleet Theater and the deployed operational profile limited use of the array. Thus, the amount of TWS data collected during the CVN deployments is less than expected.
- The Navy recently delayed the Initial Operational Capability of the TWS and CAT from 2018 to 2022. The Navy required the Program Office to deliver an early capability for the early fielded TWS and CAT. DOT&E assesses the Navy delivered a very limited capability, but that the early fielding approach is causing development delays and has resulted in a 3-4 year delay in delivering the Capability Development Document required torpedo defense capability to the CVNs. Because contractor resources are limited, the same Navy and contractor personnel are building TWS and CAT hardware sets and providing installation and in-service support to the CVNs, while also attempting to develop the required TWS and CAT capability.
- The Navy's decision to add a highly-trained contractor as the acoustic operator to supplement the automated detection and alerting functions of TWS, improved threat detection performance during the FY14 and FY15 QRAs. DOT&E assesses the majority of the TWS's detection and alerting capability is a result of the contractor acoustic operators monitoring the TWS displays to provide early alerts on threat torpedoes. However, the test areas did not offer the same number of opportunities for false alerts as expected in the

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threat area; thus, it is not known if the presence of the operator could also reduce the false alert rate. For safety reasons, the QRA testing was highly structured and allowed the operators to focus on torpedo detections and firing the CAT. Therefore, QRA testing was inadequate to resolve the rate of false alerts or their effect on mission accomplishment.

- *George H. W. Bush's* and *Theodore Roosevelt's* deployments were useful in identifying TWS false alert sources, but system development done using these data needs to be assessed in testing to include the presence of both threat torpedo surrogates and assets that may cause false alerts simultaneously.
- During contractor testing and the FY14 and FY15 QRAs, a properly targeted CAT EDM-2 demonstrated a capability to detect and home on a single surrogate torpedo. However, nearly all of the surrogate threat torpedoes and CATs were operating deeper than most expected threat torpedoes due to safety reasons.
- During FY15, the Navy and Pennsylvania State University Applied Research Laboratory conducted shallower torpedo salvo scenarios that allowed the CATs to track and attack the surrogate threat torpedoes in more challenging areas of the water column. The Navy designed these scenarios to develop salvo tactics where the CATs conduct a coordinated attack on a threat torpedo salvo. During other events, the Navy, Pennsylvania State University Applied Research Laboratory, and 3Phoenix conducted scripted test events to create TWS and CAT detection opportunities and obtain data for TWS waveforms and detection, tracking and targeting software development, and CAT salvo development. Analysis of the test data is in progress; however, observations showed a mix of intercept and miss results in easier environmental areas. These tests were conducted with TWS and CAT developmental software that will not be fielded. The Navy conducted these tests at Dabob Bay, Washington, and Nanoose Bay, British Columbia, Canada. The Navy has not collected adequate data to assess CAT's overall ability to neutralize these threat salvos.
- During the FY15 Nanoose Bay testing, the TWS TAAS operated reliably and demonstrated a capability to alert on and to track targets during the first two days of the test, however half of the array's transducers grounded on the third day of testing. The contractor isolated one of the TAAS transducer strings, which allowed testing to continue. Analysis of the data is in progress, but initial observations suggest that the array was still able to provide active detections when half of

the TAAS transducers were functioning, albeit with a degraded accuracy.

- The Navy developed and fielded a correction for the anomaly in the CAT Safety and Arming device. Analysis is still in progress, but observations from the airburst testing of the Safety and Arming Device and warhead indicates the correction was effective.
- Testing completed in FY15 indicates the new TAAS has both hardware and software reliability deficiencies, which the Navy's contractors are investigating.
- Additional information concerning the testing of TWS and CAT performance aboard *Theodore Roosevelt* is included in DOT&E's March 2015 classified Early Fielding Report.

Recommendations

- Status of Previous Recommendations. The Navy has made some progress on the FY13 and FY14 recommendations. However, the Navy should still:
 1. Complete the TEMP for the TWS and CAT system and an LFT&E strategy for the ATT lethality as soon as possible.
 2. Conduct additional testing in challenging, threat representative environments.
 3. Conduct additional CAT testing using operationally realistic threat target profiles closer to the surface to assess the CAT's terminal homing, attack, and fuzing within the lethality range of the warhead.
 4. Investigate test methods designed to reduce or eliminate the safety limitations that have previously prevented testing against operationally realistic target scenarios. The Navy should consider using geographic separation, range boundaries, and shallow draft ships for future TWS and CAT testing.
 5. Continue to investigate, correct, and retest deficiencies identified with the active source before planning to field TAAS.
- FY15 Recommendations. The Navy should:
 1. Adequately resource the TWS program to build dedicated test assets and conduct adequate dedicated contractor and developmental testing.
 2. Adequately resource the Program Office and its contractors to conduct TWS and CAT system development and testing.
 3. Investigate and implement the 14 outstanding recommendations in the March 2015 DOT&E Early Fielding Report.