High Fidelity Submarine Command Course and Combat Team training using the Submarine Multi-Mission Team Trainer (SMMTT) Networked with the Hardware-in-the-Loop Weapons Analysis Facility

Steven Wernicki
Naval Undersea Warfare Center
Division Newport
1176 Howell Street
Newport, RI 02841
401/832-8076
wernickist@npt.nuwc.navy.mil

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ABSTRACT: *This paper discusses the development of the interconnection of the Submarine Multi-Mission Team Trainer (SMMTT) at NAVSUBSCOL and the Weapons Analysis Facility (WAF) at NUWCDIVNPT. This capability was quickly developed as a proof-of-concept for Submarine Command Course (SCC) high fidelity training (prior to an in-water exercise) with a Hardware-in-the-Loop (HWIL) torpedo using the latest torpedo software. The purposes of the demonstration were to show the ability to train with the latest torpedo software prior to Fleet release, to train using weapons against high fidelity threat models and in high fidelity tactically significant environments, to leverage the latest exploitation for training purposes, and to use proven High Level Architecture (HLA) connectivity. The demonstration provided the Fleet the new capability to train on the latest tactical configuration prior to release of that weapon to the Fleet, through the novel use of a facility previously only dedicated to weapon development, test, and analysis purposes. The paper reviews the development of the capability, how the capability adds value to SCC and Combat Team training, lessons learned, and potential application to preview Combat Control and Weapon System improvements prior to costly at-sea firings.*

1. Introduction

Efforts to develop a proof-of-concept linking a Submarine Multi-Mission Team Trainer (SMMTT) with the Weapons Analysis Facility (WAF) began in April 2004. The threefold rationale for connecting the systems is a) the need for forces to be able to train as they fight, b) the need for weapon training in tactically significant environments, and c) the need for weapon training systems to match the evolution of the weapon systems, and threats[1]. The goal of the WAF-SMMTT is to provide a means to facilitate the interoperability of an existing combat team training system with a weapon operating in a high fidelity simulated environment[1].

1.1 Background

Traditionally Submarine Multi-Mission Team Trainer (SMMTT) systems located at shore based training Fleet Attack Centers supported only those torpedo variants that are approved for warfighting and have been deployed in great numbers. This presented a problem to Submarine Command Course (SCC) students (formerlay Prospective Command Officer (PCO) and Prospective Executive Officer (PXO) courses) who received their shore based training on a SMMTT and who were then required to utilize more advanced torpedo configurations during their at sea trials. The advanced torpedo configurations represent the next set of torpedo operational improvements targeted for release to the fleet from the Torpedo Advanced Processor Build (APB) cycle. The advanced configurations are employed during SCC and other fleet exercises as a cost savings approach to gather as much real world in-water data as possible while providing the fleet with a useable exercise weapon. Significant savings have been achieved over the years by combining these missions. As a result of this difference in capability, shore-based trainers have not been able to completely prepare SCC classes for their at-sea exercises.

Naval Undersea Warfare Center Division Newport's (NUWCDIVNPT) field representative at the Submarine Learning Center (SLC) facilitated several meetings and option assessments with SLC, the NUWCDIVNPT Undersea Weapons Systems Department, and the Combat Systems Department to address the issue. A number of

options were considered for improvement, and after much discussion and investigation, it was decided to integrate existing torpedo hardware that contains the most recent version of torpedo operational software with the SMMTT. This approach was assessed to have the fastest payoff and was identified by CAPT Lotring, (Commander of the SLC) as the quickest high fidelity approach to satisfy SCC type training while also supporting torpedo APB software initiatives. To accomplish this objective, the Hardware-In-The-Loop (HWIL) Weapons Analysis Facility (WAF) located at NUWCDIVNPT would need to be connected to a SMMTT location.

Typically, tactical HWIL is cost prohibitive for training. In most cases developing a digital emulation of tactical hardware is adequate for training. However, due to the issues mentioned above, existing weapon simulations were not meeting all of the training needs. Given the already existing WAF, this facility could be made available for periodic high fidelity weapon training to supplement the existing team trainer weapon simulated models. The WAF is a real-time, torpedo and countermeasure (CM) hardware-in-the-loop (HWIL) underwater simulator. The WAF has leading edge models for environments and undersea targets, and user-friendly, flexible set-up and analysis tools. The WAF is used for concept design, development, test, evaluation, tactics development, and training. Figure 1 is WAF block diagram.

WAF BLOCK DIAGRAM

FIGURE 1

The SMMTT provides realistic, shore-based training of basic, advanced, team, and supervisory levels for SSN and SSBN. The SMMTT emulates the tactical operation of the Acoustic Subsystem and Combat Control Subsystems. SMMTT reproduces various environments, target types, and ownship operating characteristics to a high degree of realism in real-time for training. Figure 2 is of a SMMTT training session.

SMMTT PICTURE

FIGURE 2

The WAF-SMMTT project plan approved by SLC required, among other things, that a proof-of-concept take place at NUWC the summer of 2004, in order to meet the deadline to support a fall SCC class. Following a successful proof-of-concept demonstration, then development would continue to support an October 2004 SCC at the Submarine School (SUBSCOL) in Groton, CT.

2. Demonstrations

The Demonstrations and Tests were planned with three goals in mind: 1) to demonstrate the training enhancements that the WAF-SMMTT can provide; 2) to verify that the scenarios developed during the demonstrations meet SCC requirements; and 3) to expose any technical challenges associated with integrating the WAF into existing SMMTT systems [2].

2.1 Test and Exercise Descriptions

The June 2004 demonstration was the first actual demonstration of the technical feasibility of this effort. The purpose of the first demonstration was to interconnect SMMTT and WAF as a proof-of-concept for training, prior to an in-water exercise, with a single HWIL torpedo using the latest torpedo software. The demonstration took place between the WAF and SMMTT labs both located at NUWC in Newport, Rhode Island. The scenario used a simple scenario including ownship, a single torpedo launch, and a high fidelity submarine target. The weapon was an ADCAP (Advanced Capability) Mod 6 torpedo, and ownship used the CCS MK2 BLK1C Mod 3 (Trident) Combat Control System. A fiber cable and transceivers were put in place between WAF and SMMTT labs. SMMTT software

modifications were made to the existing SMMTT Mod 6 torpedo server to redirect messaging to the WAF. Software was also added to handle numerous machine dependencies (byte ordering and alignment deltas between Intel and SGI). WAF software modifications included software modifications to support the Mak HLA RTI, and modifications to WAF interface code to support sending torpedo TELCOM data to SMMTT.

FIGURE 3

The October 2004 demonstration first showed the training benefit the WAF-SMMTT provides to the Fleet. Therefore, all involved wanted to choose a demonstration training scenario that would be particularly relevant to today's Naval training needs. For this second test, the main goals were to establish and demonstrate connectivity between the WAF at NUWC and SMMTT at SUBSCOL in Groton, and address previous technology proof-of-concept limitations [3]. For example, processing and interface upgrades were added to support passing countermeasures. The launch "cleanup" and reload functions, and weapon reset process were all upgraded.

SCEN FIGURE

FIGURE 4

The system was also now designed to operate with the BSY-1 or BYG-1 Combat Control Systems, based on the instructor's preference. However, BLK2 weapons will be unavailable when using this temporary software build. This allowed the course instructors the ability to train using and Anti-Submarine Warfare (ASW) scenario with interactions between weapons and countermeasures.

SCEN FIGURE

FIGURE 5

The April 2005 exercise added the capability to train with either ASW or Anti-Surface Warfare (ASUW) scenarios. With the initial technical capability demonstrated, more time was available for additional scenario planning. This allowed time for selecting environments, threats, and problem geometries that instructors found particularly relevant. More time was also included for instructor prebrief prior to training. This provided instructors with more background into what capabilities were available with this connection to a real weapon. Additional debriefing capability was also provided. The WAF weapons fired from the SMMTT system were treated just like in-water fired weapons for debriefing purposes, and the same displays were used to review student performance and lessons learned. Figures 3-7 provide more information on scenario used during this exercise.

SCEN FIGURE

FIGURE 6

SCEN FIGURE

FIGURE 7

SCEN FIGURE

The July 2005 exercise provides a similar capability, but adds connectivity to the SMMTT system at the Naval Submarine Training Center Pacific (NSTCP) in Pearl Harbor, HI. This training uses scenarios tailored to SUBPAC training priorities.

More generally, these exercises demonstrate the novel training opportunities that will be available if the Fleet possesses the ability to create a meaningful tactically significant weapon training environment, in a cost-effective manner. The scenarios selected for weapon training were fashioned to maximize the need for weapon tactical decision-making and the use of weapon wire-guide commands. The scenario also creates tactically relevant situations by introducing environments and threats that will require more complex decisions on the part of students. Any training situation that requires an accurate weapon representation can now be improved by access to the actual weapon hardware during training.

2.2 Technical Issues

The phased approach of testing and demonstrating WAF-SMMTT capabilities provided first-hand knowledge of the technical challenges associated with connecting trainer and HWIL simulators in an HLA federation for real-time training.

Both the WAF and SMMTT developers, along with NUWCDIVNPT Range Department and Information Systems networking subject matter experts evaluated SIPRNET, STU, ISDN connection options. Figure 8 depicts the configuration used for the connection with Groton in October 2004 and April 2005.

For the exercise with NSTCP Pearl Harbor, additional technical issues were identified. Sensitivity to latency issues were discovered with the first tests between Newport and Pearl Harbor. By more carefully tailoring the message subscription and publishing of each system, this issue was successfully overcome.

A major technical consideration is the “fair fight” issue. Even when systems can physically exchange data on an HLA network, that does not mean they understand what they are sending each other. If each system makes different assumptions and uses different algorithms to solve the same problems, it could create an unrealistic simulation, reducing the training value of the federation. Scenario pre-planning was found to be essential to ensure these issues were examined and tested prior to training.

One of the first nuts-and-bolts decisions was to determine what the SMMTT and WAF would simulate and control during the scenario. Each SMMTT and WAF model had strengths and weaknesses, demonstrating again the advantage of training with a federation of systems to attain the most realistic training environment[4].

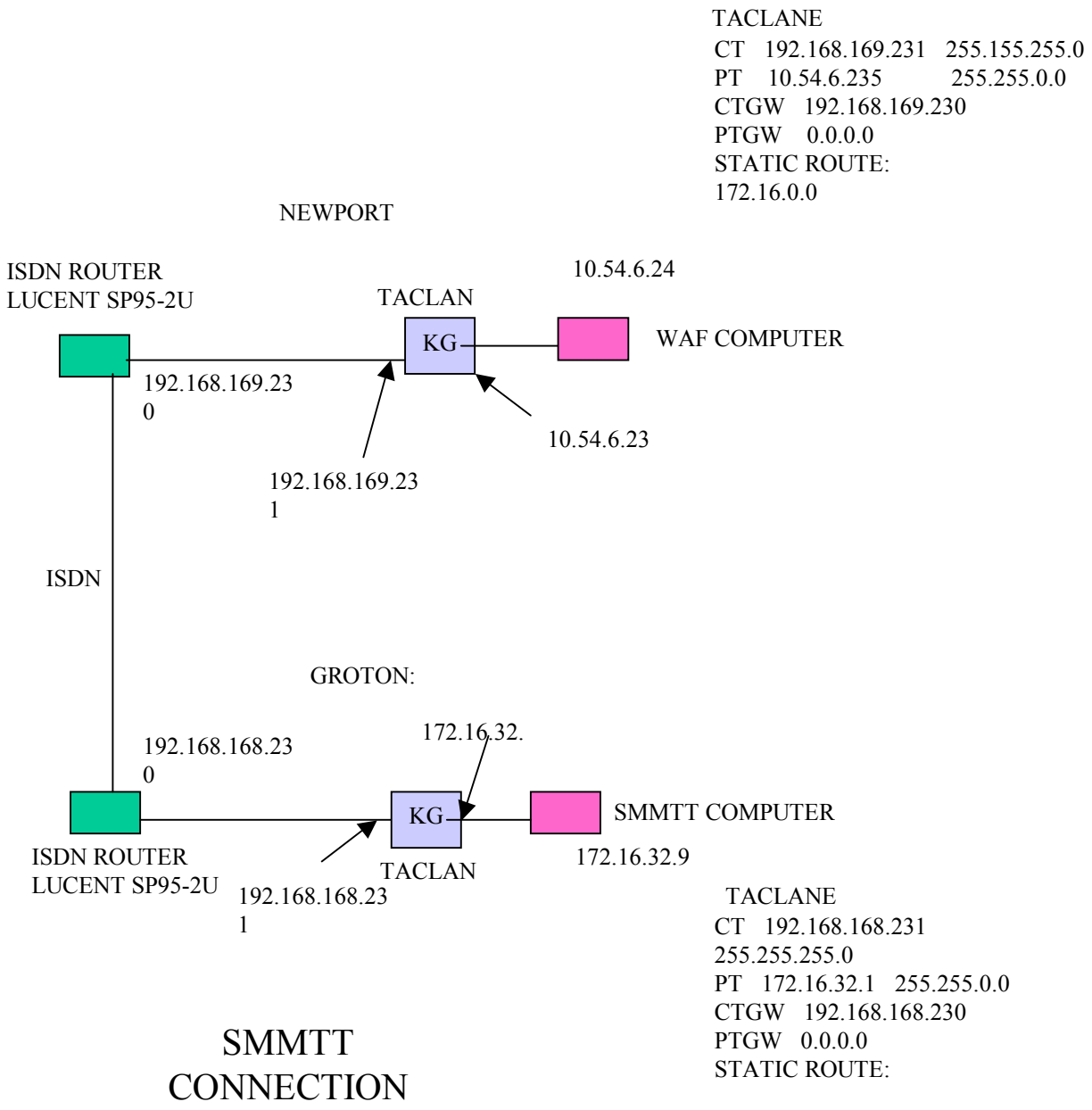

Figure 8 Configuration

2.4 Results and Findings

The October 2004 and April 2005 first provided the technical connectivity challenges to overcome. Once the basic capability was established, then detailed scenario planning provided valuable weapon training to complement the SCC shore-based training time. Ultimately, improved proficiency required both technology and teaming improvements.

Enhanced training was provided through closer training ties between SCC instructors, NUWCNPT, and DEVRON, both at the SUBSCOL team trainer and on the range for the in-water exercises. Improved operator and tactical decision maker training was provided through more realistic weapon performance and access to the latest weapon capabilities. Capability improvements have been identified for a cost effective

production version of this conectivity, instead of recreating a complete set-up each time.

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Upon the completion of these exersises, the WAF-SMMTT team demonstrated results in several areas:

a. the effectiveness of the current WAF-SMMTT configuration in meeting the training needs of the Fleet;
b. the effectiveness of the combined systems in meeting the requirements of the scenarios developed in cooperation with the SCC instructors, and
c. technical challenges that were overcome and how these challenges may affect future exercises.

First and foremost, this series of demonstration revealed that it is relatively easy, and quick to create a federation of legacy systems. Fear of major, expensive changes to their legacy systems has dissuaded many programs from pursuing meaningful interoperability. These demonstrations and training exercises helped the submarine training community to acknowledge that providing high fidelity weapon training need not be painful.

3. Conclusion

3.1 Future Initiatives

This capability also comprises a complete (CCS operator to weapon) system that provides an excellent test-bed. Tactical system developers are anxious to more easily test CCS software upgrade integration with weapon, test weapon APB software for integration with CCS, and even test HSI operator improvements for weapon operability impact.

Other future plans include making the capability more of a "product", which the Fleet can easily initiate during training, and to upgrade the connectivity to be Navy Continuous Training Environment (NCTE) compliant, in order to provide high fidelity weapons to other applicable training and Fleet exercise systems.

3.2 Summary

Summary TBD.

4. References

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5. Acknowledgements

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List of all development team members:

Author Biography

STEVEN WERNICKI Steven Wernicki is an Electronics Engineer for the Naval Undersea Warfare Center, Newport, RI. He has represented submarine sonar training interests on numerous Navy-wide committees in the areas of modeling and simulation, databases, and environmental acoustics. He led the first successful development and implementation of real-time range-dependent propagation modeling in a sonar team trainer system. He served on the CNO sponsored Shallow Water Working Group and drafted the Submarine Warfare Training System requirements for the SWWG. He currently serves as the Project lead for Weapons Analysis Facility Undersea Defensive Systems integration and Weapons training development.