Trident Launch Training Anytime, Anywhere
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Since its inception in 1960, the Trident ballistic missile submarine's sole mission has been strategic deterrence.

America's 18 Tridents, each with the capacity to carry 24 multi-warhead nuclear missiles, provide the sea-based "leg" of the triad of U.S. strategic deterrent forces. By concealing the exact location of our nuclear arsenal at any given time, these Ohio-class submarines aim to deter potential aggressors from ever considering a first strike.

There are two crews to a Trident, each operating on a roughly three-month-on, three-month-off schedule. In their roles, training is everything; hopefully they should never have to put their skills into actual practice.

But knowing exactly what to do, and how to overcome any potential foul-up, is key to their mission of deterring a world war. Anything short of overwhelming military strength combined with an extreme level of technological and operational know-how, could work to embolden potential attackers.

The Johns Hopkins University Applied Physics Laboratory (APL), located in Laurel, MD, has been involved in the Trident program for more than 35 years, evaluating the performance of the Trident weapon system, analyzing patrol data and making recommendations.

In the early 1990s, engineers at APL started to look into the idea of using personal computers as a tool for training crewmembers for Tridents and other submarines. They developed a number of PC-based tools to teach principles of submarine ship control for various classes of U.S. and U.K. submarines.

These simulators operate on laptop PCs and provide a portable and realistic means for learning how to drive submarines, and for practicing emergency procedures such as flooding recovery or collision avoidance. Available anywhere a PC can be found, the simulators act to supplement the ship control training gained in the full-scale diving trainers stationed at U.S. and U.K. submarine bases.

A year ago, they released the PC-based Trident Launcher Simulator (TLS). Using Microsoft Windows-equipped standard PCs on a local area network, the software enables a 12-man team to operate a simulated Trident launching system in countdown-to-launch scenarios.

"The trainer is a detailed, realistic model of the Trident launcher system—all of its logic and functionality down to the sounds that valves make when they open and close," said Paul Biegel, training systems program manager in the Strategic Systems Department at APL.

It is being used in Trident Strategic Weapon System electronic classrooms both in the U.S. and U.K., and can be run on laptops during cruises. Biegel manages the project, and Jon DuBro, assistant training systems program manager, leads it.

"Simulation-based training is a great way to train," said DuBro. "Essentially—and I hate to express it this way—it's almost like a video game for missile technicians. There are still some people who look at it as typical computer-based training. But once they sit down with it, at the end of the day they say they're amazed at what it can do." Quipped one instructor, "We'll have to beat students back with sticks to keep them away from this thing."

The TLS encompasses a lot more than just the "fun" element. For one thing, it is inexpensive compared with alternative training methods. It also enables missile technicians (MTs) to train practically anytime and anyplace. And its ability to replicate real-world phenomena continues to amaze people who use it.

Mock-Up Missile Tubes

The launch of a Navy Trident ballistic missile involves several systems working together in unison.

They include navigation, hovering, missile compensation, fire control and launcher. Collectively they form the submarine-launched ballistic missile (SLBM) weapon system on board the Trident.

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The PC-based TLS, as its name implies, only focuses on the launcher. The launcher subsystem, spanning more than half the length of the submarine, consists of the equipment necessary to launch 24 missiles in rapid succession. A launch consists of pressurizing the 24, four-story-tall launch tubes during a countdown, and ejecting the 60-ton missiles with enough energy to get them to the surface without damage.

Up to 15 MTs are required to man this subsystem. Each MT has a battle station position and a unique role in carrying out a launch. In order to maintain the high level of preparedness necessary to operate the weapon system, training has to be constant. This training is the responsibility of the Navy's Strategic Systems Programs (SSP).

Training usually comes in two forms: instructional courses and hands-on operational training. Most of it takes place at the Trident Training Facilities under the auspices of SSP, located at the two Trident submarine bases: Kings Bay Naval Submarine Base in Georgia and Bangor Naval Submarine Base in the state of Washington.

Key in the MTs' skills is the ability to be prepared for equipment failures and to respond to worst-case scenarios. There is a plethora of potential failures during a launch, but training exercises to maintain these troubleshooting skills cannot be performed on missile tubes that hold active missiles; obviously, faults cannot be purposely inserted into an active tube.

To fill this hands-on training void, the Trident submarine community has built full-scale simulators, or "Team Trainers," located at the two Trident bases. These mock-up labs contain four missile tubes with actual weapon systems equipment. The lab closely represents what is aboard the submarine, but with fewer than the full compliment of 24 missile tubes.

Aside from Demonstration and Shakedown Operations (DASOs)—which consist of at-sea test launches—the Team Trainers provide the best approach for training sailors on how to operate the launcher subsystem and for maintaining critical troubleshooting skills. But because these facilities are in high demand, training time there is limited. Prior to going to sea, crews typically can access the Team Trainer for only two weeks at most.

"More importantly, they have limited opportunity to train as a team during fault-induced, worst-case situations," noted Biegel.

Going Virtual

APL's PC-based Trident Launcher Simulator (TLS) is an answer to this problem.

Under the direction of the SSP branch in charge of crew training (Code 15), APL developed the TLS to enable MTs to learn and maintain critical skills necessary to operate the launcher subsystem. Essentially, the TLS is a functional representation of the launcher subsystem brought to the personal computer platform. With it, all or most of the launcher battle stations crew can participate in countdown exercises without being subject to the time constraints imposed upon them by the Team Trainer.

"The goal was to capture that Team Trainer and all of its components and bring that functionality to a computer, so that users can do the operations they'd normally do during a countdown," said DuBro. "And a key factor is the capability to insert equipment failures so that users can learn the appropriate procedures to get around these failures."

Biegel emphasizes that the TLS is an inexpensive supplement to the Team Trainer, but not a replacement.

Obviously, with the TLS users cannot gain the tactile feel of operating the real equipment or the "muscle memory" associated with operating a certain piece of equipment. "But it can provide a powerful tool to understand how the equipment works and what will happen when certain actions are performed," observed Biegel. "You build the cognitive skills."

MTs can now train wherever there is a computer present, alleviating the bottleneck associated with the Team Trainers.

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"MTs only have so much time to train in the real lab, and that's where you actually get the muscle memory—like what it takes to override a valve," said Senior Chief Petty Officer Kelly Jaeger of SSP. "Doing that over and over again in the lab isn't very realistic because with six ships on one coast and eight on the other, and two crews to each ship, your lab time is very limited—that's the bottleneck.

"With the PC simulator, setup or breakdown takes no time at all—you can load what you want in just a couple of minutes. And whereas with the Team Trainer you can fit in only about three countdowns a day, with the PC system you can do three countdowns in about two hours."

"Users have the opportunity to go over scenarios and situations multiple times without wasting valuable time in the full-scale simulators," said DuBro.

The training branch of SSP has incorporated the TLS into its training curriculum, giving instructors the capability to demonstrate concepts discussed during lectures without scheduling time in the Team Trainers. "In giving MTs the operational knowledge to supplement hands-on training in a full-scale simulator or on the actual system, the TLS increases the value of time spent training with real equipment," added DuBro. And minimal or no hardware purchases are required.

Released about a year ago, the TLS is being used both at shore-based facilities and on Trident submarines. At each facility, the software was installed in existing electronic classrooms, which include as many as 12 computers connected via a local area network (LAN).

"Crewmembers are able to train as a team and learn how to work together to get around problems that may occur during a launch countdown," remarked DuBro. "You want to be able to train these guys in the most stressful situations: What happens if a valve fails; what happens if I can't open that hatch; what happens if I get an alarm telling me I've got water in the missile tube pressurization piping."

Linking Battle Stations via LAN

Modeling and simulation combined with advanced in computer technology have led to new possibilities in computer-based training (CBT).

Conventional CBT usually allowed for training only on just one or a limited number of tasks. "Interaction with the CBT application was often 'canned' and 'hard-coded,' which produced repeatable and predictable results," Biegel explained.

With the PC-based simulator concept, modeling and simulation captures much of a system's functionality. "Depending on the fidelity of the simulation models, a student can train on multiple tasks using a single PC-based application."

The TLS consists of a graphical user interface (GUI)—a virtual representation of the system's equipment found in the missile compartment and the missile control center—with a simulation executing in the background.

The GUI is designed so that users can quickly recognize it and intuitively perform typical launch countdown operations. By using mouse-clicks, users can operate valves, throw switches, push buttons and even manipulate replaceable components.

The graphical displays provide the visual stimuli and provide constant feedback to users' actions, replete with animation and sound effects.

"The GUI allows an MT to perform almost any action that can be performed during a launch countdown, including the ability to perform corrective actions in accordance with standard casualty [i.e., fault recovery] procedures," Biegel said.

"In addition to functionality, we've also added sound capabilities, so that you can hear what you hear on a submarine. And when you have multiple people training at once and all the sounds are coming in, it makes for a lot of confusion—which is the confusion you want to have because it's what really happens on the submarine. You're going to have sounds all over the place," DuBro added.

The software has representations of all 24 missile tubes, of the relays that make up each missile tube

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logic control assembly, and of functional apparatuses such as pneumatically operated valves.

Simulated failures and malfunctions—more than 100 of them—can be inserted into the system, providing realistic behavior in the failed state.

Among other things, it enables crewmembers to work as a team to handle crisis situations as they occur. A failure or casualty insertion scheduler allows an instructor to coordinate the insertion of the selected faults.

There are also models of external systems such as a simplified model of the fire control system, which controls the sequence of events during a launch countdown and provides important events to the launcher subsystem.

Using existing computers and a local area network, an entire crew can collectively conduct a training exercise as if it were in the Team Trainer or on the submarine. Each crewmember can man a battle station and concentrate on the specific responsibilities for that position.

"The actions of each user affect the other users participating in the training session. With this capability, a complete countdown can be conducted with each launcher battle station represented," observed Biegel.

The software offers additional GUI features for instructors or senior personnel leading team-training exercises. That includes the ability to create and save multiple training scenarios, with a unique set of simulated failures. A selected set of failures can then be saved to a scenario file and reused during later training sessions. The GUI also enables an instructor to control events that would typically be triggered by subsystems external to the launcher subsystem. In addition, participants' actions can be monitored in real time, and reviewed after the training exercise using the action log.

Single users can use the software as well, but they have to perform the actions of all battle stations. This could prove to be challenging for less-experienced personnel, so the single-user mode is more suited for senior sailors who would use it to refresh their skills.

Mixing Training With Entertainment

In use for a little over a year, the software "has exceeded all our expectations," said Jaeger. And according to Lieutenant Commander Michael Balkus, deputy for training at SSP, "One of our original goals was to supplement the Team Trainer. But this is literally a launcher system. It surprised us—its capabilities went so much further than we ever imagined."

It also gets away from the compartmentalized learning approach. Said Jaeger, "With the launcher simulator software, students are able to get a big picture of everything that's happening, whereas normally in the Team Trainer they're in their own battle station separated from the others—and [in the Team Trainer] it takes a long time to build up to where you get the big picture."

Once MTs start using it, they're hooked.

"As more people see it and more people utilize it, the more they get used to it," said Balkus. He tells a story of a demonstration he once carried out for a group of students.

"That afternoon they started at 1:00 p.m. and could have left at 3:00 p.m. But we were chasing the guys out at 5:00 p.m. It was a great learning experience for them and they were actually excited about it."

He admits that in getting people to try it, he has an easier time with the younger generations. "Younger guys are much more open to it—it's the older guys who are hard to convince, who think they have to work on hardware."

Jaeger added, "People like me really see the benefit. We have to drag people into the classroom, and then before you know it, two or three hours have passed. All of a sudden, they don't want to leave."