by Strategic Systems Programs Public Affairs

# Back to the Future with Trident Life Extension

The U.S. Navy's Strategic Systems Programs (SSP) organization has served for more than half a century as the keeper of the most survivable leg of the nation's strategic deterrent—the submarine-launched ballistic missile. Although the program began in response to a Cold War threat, the need for strategic deterrence did not disappear when the Cold War came to a close. Over the past two decades, the United States has succeeded in achieving a sufficient level of cooperation with Russia to significantly reduce the number of warheads each country deploys, but the world is still far from free of the threat of nuclear weapons. On the contrary, a number of other countries are seeking to develop or expand strategic nuclear weapon capabilities that could threaten our national security.

It is SSP's responsibility to ensure that the strategic weapons system (SWS) entrusted to the Navy remains safe, reliable and effective in deterring threats to our national security. As we look to the next 50 years and beyond, SSP's government-industry team will remain a key participant in ensuring our national security by preserving existing capabilities and preparing for the future.

SSP remains wholly focused on the mission of providing credible and affordable strategic solutions to the warfighter. Today, the SSP team is actively engaged in five key areas:

- Enabling deterrence through an assured second-strike capability that is survivable, reliable and credible, with a constant at-sea presence.
- Sustaining the approximately 70 percent of deployed strategic warheads designated for the sea-based leg of the strategic triad under the New START Treaty (an increase from approximately 50 percent under the previous START Treaty).
- Providing for the Trident II (D-5) weapon system to be deployed on *Ohio*-class SSBNs through 2042 and as the initial weapon system for the *Ohio* Replacement through life extension efforts in all the functional subsystems of the SWS.
- Supporting the Program Executive Office for Submarines (PEO Subs) in the continued development of the *Ohio* Replacement SSBN, which will ensure continuation of the sea-based leg of the strategic triad through 2080.
- Partnering with the United Kingdom through the Polaris Sales Agreement to provide the Trident II (D-5) weapon system, which makes up 100 percent of the U.K.'s nuclear deterrent, and to support that system through the 2060s.

SSP is dedicated to meeting the challenges of maintaining our aging strategic weapon system while developing the most survivable leg of the strategic deterrence system of the future.

**Life extension efforts will push the Trident missile's service life beyond that of all five previous systems combined. Toward that end, SSP has aggressively tackled modernization of every subsystem of the Trident II (D-5) Strategic Weapons System — launcher, navigation, fire control, guidance, missile and reentry. Every subsystem is also integral to the overall team effort embodied in the *Ohio* Replacement Program. Just as their dedicated predecessors made it possible to create the first undersea leg of the strategic triad in a mere five years, today's dedicated SSP personnel are ensuring tomorrow's undersea deterrent through the D-5 Life Extension program.**

## A Rich Heritage of Innovation and Expertise

SSP is quickly closing in on its 57th anniversary of service to the security of our nation and the preservation of global stability. The program traces its origins to the Eisenhower administration's landmark 1955 decision to develop a sea-based intercontinental ballistic missile. 1955 was an unsettling year for American security. In May of that year, the signing of the Warsaw Pact created a military bloc of eight communist countries under the sway of the Soviet Union, reinforcing the Communist Bloc's bitter and dangerous rivalry with the United States and its allies. On Nov. 22, only five days after the creation of what was then called the Special Projects Office, the Soviet Union tested its first megaton hydrogen bomb.

The newly formed Special Projects Office was assigned the task of developing the first underwater-launched, solid-fueled ballistic missile. It was vital to America's national interest that this effort succeed, for it would enable the United States to deploy a continuous at-sea deterrent that was impregnable to a first strike by any enemy. This, in turn, would provide a level of strategic security never before enjoyed by any nation.

To meet this daunting challenge, the Special Projects Office initiated the Polaris program, directed by renowned Rear Adm. William F. "Red" Raborn under the watchful eye of the Chief of Naval Operations, the legendary Adm. Arleigh Burke. Development of the submarine-launched Polaris A-1 missile system was not only a remarkable feat of engineering research, development and acquisition, but also a pioneering example of Navy-industry teaming.

The Polaris A-1 went to sea only five years later — on Nov. 15, 1960—when the nuclear-powered ballistic missile submarine USS *George Washington* (SSBN 598) commenced the U.S. Navy's first strategic-deterrent patrol. It was the first of six generations of submarine-launched ballistic missile systems that the program would develop, produce and deploy in the roughly 35 years between 1955 and 1989.

Building on the legacy of excellence established during those years, SSP continues to provide stewardship for the sea-based strategic weapon system. Today, America's unmatched sea-based strategic deterrent consists of 14 *Ohio*-class SSBNs (12 currently operational, and two undergoing in-service refueling) outfitted with the Trident II (D-5) SWS. In addition, four Royal Navy *Vanguard*-class SSBNs are also outfitted with the Trident II (D-5).

## What Is Old Is New Again

Trident II (D-5) was developed in the 1980s and went into service just as the Cold

War came to a close. USS *Tennessee* (SSBN 734) conducted the first operational deployment in early 1990. More than 20 years later, SSP continues to manage this unrivaled weapon system, the most numerous and most survivable component of the nation's strategic deterrence forces.

Life extension efforts will push the Trident missile's service life beyond that of all five previous systems combined. Toward that end, SSP has aggressively tackled modernization of every subsystem of the Trident II (D-5) SWS—launcher, navigation, fire control, guidance, missile and reentry. Every subsystem is also integral to the overall team effort embodied in the *Ohio* Replacement Program. Just as their dedicated predecessors made it possible to create the first undersea leg of the strategic triad in a mere five years, today's dedicated SSP personnel are ensuring tomorrow's undersea deterrent through the D-5 Life Extension (LE) program.

The fact that the Trident II (D-5) is projected to be in service on *Ohio*-class SSBNs until 2042 poses the challenge of ensuring the system's reliability long past its original planned lifespan. Moreover, the same system will constitute the initial load-out of the *Ohio* Replacement and *Vanguard* Successor SSBNs currently in development.

It has been more than a decade since Trident Life Extension options were first discussed. At that time, SSP outlined six alternatives for ensuring a credible submarine-launched ballistic missile program into the 2040s. Leadership determined the best way forward, and full funding of life-extension efforts commenced in 2002. Of the various challenges the life-extension program faced, then-SSP Director Rear Adm. Dwyer noted at the time that "...the biggest challenges involve determining the service life of the three-stage boost motors that comprise the missile propulsion system and modernizing the extremely complex D-5 guidance system and missile electronics."

The work accomplished over the last decade to meet these two key challenges, along with many lesser ones, is producing tangible results. SSP conducted the first flight test of a D-5 LE subsystem—the MK 6 Mod 1 guidance system—in Demonstration and Shakedown Operation (DASO)-23, which took place on *Tennessee* Feb. 22, 2012. This was not only a significant milestone for the LE program, but also an event with considerable historic resonance, since 22 years before, in February 1990, *Tennessee* had served as the platform for DASO-01, thus becoming the first *Ohio*-class SSBN ever to launch a Trident II (D-5) missile.

The flight testing of the MK 6 Mod 1 guidance system, which took place on time and on budget, was a major achievement for SSP's Guidance Branch, which had put significant effort into validating the design with new modeling, simulation and hardware-in-the-loop integration and test capability.

The ability of SSP's Enhanced Ground Test (EGT) program to dynamically test systems in environments that replicate actual missile flight conditions also played an important role. EGT's test cells, which include a thermal-vibe-shock acoustic shaker and an under-wing pod that can be installed on a high-performance aircraft, provided the level of confidence necessary to forego initial missile testing from a land-based launch pad. Conducting the first D-5 missile test of the MK 6 Mod 1 guidance system directly from an SSBN achieved significant savings.

Other key LE components are also making rapid progress. Qualification testing of the LE Flight Control Electronics Package started in February 2012 and is expected to continue for approximately 13 months. Qualification testing of the LE Command Sequencer began in November 2011 and is expected to be completed later this year. Meanwhile, the expected initial flight test of the D-5 Life Extension proofing test missile remains on track for FY14, and life-extended missiles with the full complement of modernized systems are scheduled to begin entering the fleet in 2017.

The life-extension effort has also yielded unexpected benefits for SSP. The Missile Branch and the Guidance Branch both committed at the outset to maximize the use of common processes, procedures and suppliers. This established new avenues of cooperation not only between the branches, but also with industry partners. It included procuring electronics parts and multilayer boards through a common circuit card assembly (CCA) supplier, resulting in a competition that produced significant overall savings on electronic parts. SSP continues to look for and take advantage of such spin-off benefits from the LE effort.

## Beyond Missiles—Shipboard Systems and Warheads

The initial shipboard systems on *Ohio*-class SSBNs were developed in the 1970s and fielded in the 1980s and '90s, so they have required major updating in recent years to address electronics obsolescence. In order to keep pace with technology and reduce cost, SSP developed architecture for the updates based on commercial-off-the-shelf (COTS) components. This yielded many benefits by taking advantage of rapid advances in electronics, such as miniaturization. The first application of COTS-based architecture was the installation of a new navigation system. Among other benefits, it ultimately reduced the number of cabinets required for navigational components from nine to two.

Since that time, use of COTS has enabled SSP to put the shipboard systems on a "refresh cycle" of periodic upgrades to their hardware and software and has reduced both the cost and downtime associated with upgrading. Currently, SSP is installing Shipboard Integration Increment-1 throughout the fleet and in training facilities. It has completed the technical refresh on *Tennessee*, USS *Nevada* (SSBN 733), USS *Pennsylvania* (SSBN 735), USS *Kentucky* (SSBN 737), USS *Alabama* (SSBN 731), USS *Louisiana* (SSBN 743), USS *Rhode Island* (SSBN 740), and USS *Maine* (SSBN 741). Britain's four *Vanguard*-class SSBNs have also received the refresh, as have the U.K.'s Software Facility and its Trident Training Facility (TTF) at Faslane, Scotland. Installation is also complete at the U.S. Trident Training Facilities in Bangor, Wash., and Kings Bay, Ga. This evolution of COTS-based upgrades will continue through 2013 with the six remaining U.S. boats and the second system at TTF Kings Bay.

Meanwhile, SSP continues to be involved in warhead life-extension studies to address the challenges of ensuring the continued reliability of in-service nuclear warheads. At the same time, the SSP-led management team for the MK 5 alteration is proceeding with development of a new arming, fuzing and firing (AF&F) system to refurbish the 30-year-old W88/MK 5 reentry system. The Air Force will then adapt the Navy AF&F for its own MK 12A and MK 21 reentry systems. This project remains fully funded, within budget, and on schedule for a full production unit in December 2018.

## Collaboration for the Future

Along with extending the life of current systems, SSP continues to look for opportunities to collaborate on future possibilities with the many different U.S. programs and

agencies involved in strategic deterrence and undersea platforms, as well as with the United Kingdom.

The U.S. and the U.K. have maintained a shared commitment to nuclear deterrence since April 1963, when President John F. Kennedy and British Prime Minister Harold Macmillan signed the Polaris Sales Agreement. This longstanding agreement, only one year away from its 50th anniversary, remains the foundation of this strategic partnership as each country develops a new class of SSBNs designed to accept the Trident II (D-5) as their initial weapon system. It is worth noting that while Trident II accounts for 70 percent of the U.S. strategic deterrent, it accounts for 100 percent of Britain's. Consequently, we have a responsibility to our U.K. partner and ally to continue building on the success of our tested and fruitful collaboration.

A key component of the *Ohio* Replacement Program is the development of the Common Missile Compartment (CMC) that will support the deployment of the Trident II (D-5) on both the *Ohio* Replacement and *Vanguard* Successor. Despite the recent decision to postpone the planned deployment date of the *Ohio* Replacement by two years in response to current fiscal considerations, SSP is continuing to move forward without delay on the joint effort to develop the CMC.

Here at home, there are many opportunities for collaborating with the U.S. Air Force on future capabilities. SSP is involved in the Air Force-led study examining the possibility of reducing the number of warhead types by developing a common warhead for both land-based and sea-based strategic systems.

The Navy and Air Force are also interested in collaborating on other aspects of strategic systems as the two services face similar budget pressures and the challenge of sustaining and recapitalizing strategic missile systems in a similar timeframe. In addition to exploring areas of potential collaboration in technology development, they are already collaborating on a common fuze and on research and development related to guidance subsystems and propulsion. Electronic systems, ordnance, and tooling and facilities also offer potential opportunities for joint effort.

The degree of future collaboration and commonality will depend heavily on decisions about future sustainment and recapitalization of our strategic ballistic missiles. It is vital that the Air Force and Navy discuss programmatic timelines, plans, current and future system requirements, and other key subjects now to determine where the greatest opportunities are. At least some degree of commonality is possible between current and future missile systems if we communicate early and continue to foster a culture of cooperation.

## On Course for the Mid-21st Century

Building on its rich heritage of technical innovation and expertise, SSP has set course for the new global strategic deterrence environment of the mid-21st century and beyond. Testing remains the cornerstone of the continued viability of our strategic weapon system, ensuring that we collect the important data needed to quantify the system's performance well into the future. Operational tests have continued to demonstrate the outstanding performance and reliability of our SSBN force, with 142 successful test flights of the Trident II (D-5) completed to date.

America's Trident program continues to exceed all of the technical objectives established more than three decades ago, and life-extension efforts, coupled with the *Ohio* Replacement Program, are enhancing our ability to meet recapitalization and modernization requirements. Strategic Systems Programs remains a unique blend of preeminent military, civilian and industry partners dedicated to a unique mission—maintaining stability in our changing world through the excellence of our strategic deterrent.

## The SLBM Family

The dimensions and capability of U.S. submarine-launched ballistic missiles increased dramatically from the early Polaris A-1 to today's long-lived Trident D-5.


| | POLARIS A-1 | POLARIS A-2 | POLARIS A-3 | POSEIDON C-3 | TRIDENT C-4 | TRIDENT D-5 |
|---|---|---|---|---|---|---|
| Length | 28 ft. | 31 ft. | 32 ft. | 34 ft. | 34 ft. | 44 ft. |
| Diameter | 54 in. | 54 in. | 54 in. | 74 in. | 74 in. | 83 in. |
| Weight | 28,000 lbs. | 32,500 lbs. | 35,700 lbs. | 64,000 lbs. | 73,000 lbs. | 130,000 lbs. |
| Range | 1,200 NM | 1,500 NM | 2,500 NM | 2,500 NM | 4,000 NM | >4,000 NM |
| Year Retired | 1965 | 1974 | 1982 | 1992 | 2002 | TBD |