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W76-0/Mk4

The W76/Mk4 reentry body assembly (RBA) on Trident I (C4) and Trident II (D5) strategic weapon systems are a key component of the Nation's strategic deterrent force designed and produced between 1972 and 1987. Meeting this mission will require that the W76/Mk4 RBA be deployed well beyond its original service life of 20 years. W76 refurbishment, scheduled to begin in FY'07, will include re-qualifying the pit, replacing the primary high-explosive, secondary refurbishment, a new arming, fuzing and firing (AF&F) system, and a new gas transfer system.

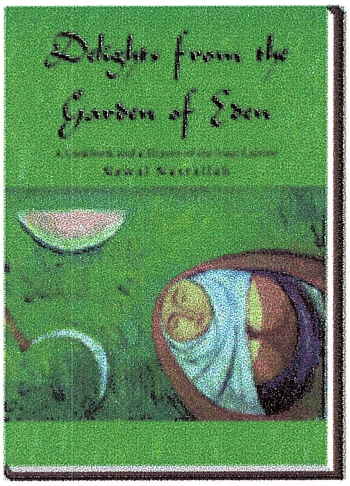
The removal from strategic service of 4 SSBNs will result in the transfer of over 700 W76 warheads to the inactive stockpile.

The MC2912 is the Arming, Fusing, and Firing System (AF&F) designed by Sandia and employed on the W76/Mk4 nuclear warhead. The AF&F's safety features ensure the weapon does not detonate in accidental or other unintended scenarios.

In the early 1990s Sandia undertook to **design** a replacement neutron generator for the W76 nuclear warhead on the Mark 4 reentry body of the Navy's Trident I system. There were several compelling reasons for doing so, including the need to increase the component's **design** margins, simplify its manufacturability, augment its resistance to new profiles of hostile environments, and increase its life span.

The W76 program at Sandia continued to exceed performance expectations in FY98. Through continuous process improvement efforts the Product Realization Team saved $200,000, decreased cycle time by 20 percent, had 19 consecutive successful Quality Assurance Inspection Procedure (QAIP) submittals to DOE, gained sufficient trust of DOE to eliminate the QAIP requirement from one level of the conversion process, and decreased the budget by 17 percent.

Neutron generator subassemblies from retired weapons and other sources have been examined for reapplication to the W76/Mk4 and W78 systems. Enough assets have been identified that need minor modifications to meet near-term needs for the W78, and to reduce stress on the production facility during startup of the MC4380 neutron generator production. These units have resulted in more than $55 million of cost savings for DOE.



Neutron generators present unique challenges for **design** engineers. The physics of these devices are complex: they function as miniature linear accelerators, to produce deuterium-tritium reactions in order to generate neutrons. Consequently, their **design** parameters are sensitive to minute variations. They must be designed for ruggedness against severe environments such as acceleration, vibration, high voltage, radiation, and mechanical impulse. In the past, we have always relied on an iterative **design** process involving numerous physical tests and whatever modeling tools were practical at the time.

Neutron generators also present tough challenges for production engineers. These devices necessarily contain exotic materials that require special fabrication processes, and they must be manufactured for high reliability over many years. Processes such as brazing, welding, plating, metallizing, material deposition, and encapsulation must be performed to very high DOE quality-control standards.

The neutron generator recertification program for the W76/Mark 4 benefited in concrete ways from DOE's investment in supercomputing and advanced design and production technologies. Sandia's production facility began delivering the new MC4380 neutron generators in October 1999. The ASCI and ADaPT initiatives, together with supporting research activities, have provided outstanding capabilities to perform this stockpile responsibility with greater confidence.

In 1999 the MC4380 Neutron Generator and its MC4378 Timer, MC4705 Voltage Bar, MC4148 Rod, MC4437 Current Stack, and MC4277 Neutron Tube were qualified for use in the Navy's W76 weapon system. This culminated a multi-year development effort which included the transfer of production capability from the Pinellas Plant to Sandia. This is the first weaponized neutron generator to employ a focused ion-beam neutron tube for higher reliability, the first produced at Sandia, and the first Sandia component with radiation hardness requirements to be qualified without underground testing.

The W76/Mk4 Enhanced Fidelity Instrumented-A unit will collect structural dynamics response data and investigate in-flight body dynamics. The unit was conceptualized, designed, built, qualified, and delivered in 24 months for a Navy flight test. The design includes modular telemetry in the physics package volume, and the highest data rate and battery energy density of any joint test assembly. The project involved Sandia, Los Alamos National Laboratory, Pantex, DOE/AL, Lockheed Martin, and the Navy.

The first W76 Enhanced Fidelity Instrumented-A (EFI-A) Reentry Body (RB) and Type 2G High Fidelity Flight Test Unit were successfully flown in February 1999. Sandia was the project integrator for development, building, and qualification of the flight test units. The EFI-A experiment provided valuable data using a newly designed, state-of-the-art telemetry system. The data has increased our understanding of the missile/RB interactions, internal RB shock/vibration environments, and RB dynamic behavior. The EFI-A was the first W76 flight test body to collect first-stage ignition data.

A life extension study was conducted during 1999 for the W76/Mk4 Reentry Body Assembly by

Sandia, Los Alamos, DOE, Navy Strategic Systems Programs, US Strategic Command, Lockheed Martin Missiles and Space, and ITT Industries. The study identified design options, production and certification plans, and cost estimates. Sandia's conceptual design for the replacement Arming, Fuzing, and Firing (AF&F) subsystem was expected to come close to meeting the important goal of costing one-quarter of the W88/Mk5 AF&F cost.

The Nuclear Weapons Council (NWC) approved the Block 1 refurbishment plan for the W76 in March 2000. The Block 1 refurbishment of the warhead (about one quarter of all W76 warheads) will focus on the high explosive, detonators, organic materials, cables and addition of a new Acorn gas transfer system. The Block 1 refurbishment will also add a new arming firing and fusing (AF&F) system. The FPU of Block 1 will be available by the end of FY 2007, and Block 1 production is planned for completion in FY 2012. During the Block 1 production, a decision will be made to either continue Block 1 retrofits on the entire W76 stockpile, change to a Block 2 retrofit that could include other options, or stop the retrofit altogether. The Block 2 effort, if approved by the NWC, would continue from FY 2012 to FY 2022 to refurbish the remaining W76 warheads.

The US Navy W76-0/Mk4 Joint Test Assembly (JTA) redesign achieved First Production Unit status in August 2001, following a successful development flight test in February 2000. The redesign replaced sunset technology components in the existing 20-year-old JTA, which is used to test the continued conformance of a denuclearized version of the War Reserve (WR) warhead. The new JTA collects significantly more state-of-health and critical performance data from onboard the Reentry Body (RB), as part of the core surveillance program. Aging concerns, the non-availability of replacement components used in original designs, and a desire to modernize nuclear safety features requires a refurbishment of the W76/Mk4 RBA for it to meet the extended service life. This should be accomplished in a planned, methodological manner to prevent possible weapon downtime and the total consumption of the National Nuclear Security Agency (NNSA) nuclear weapons complex capacity that could occur if a critical problem were identified. The US Navy Strategic Systems Programs (SSP) requested and the Nuclear Weapons Council Standing and Safety Committee (NWCSSC) approved a joint Department of Defense (DOD)/DOE Phase 6.2/6.2A Study, which was initiated on 19 October 1998. The study was conducted under the W76/Mk4 Project Officers Group (POG). The results of the study were briefed by the W76/Mk4 POG to the NWCSSC on 8 December 1999 and to the Nuclear Weapons Council (NWC) on 13 March 2000.

Study ground rules included the following:

- Modernize nuclear detonation safety features (to Mk5-like interface)
- Consider W76/Mk4 on Trident II (D5) only
- Current W76/Mk4 Military Characteristics (MCs) and Stockpile-To-Sequence (STS) were baseline
- Plan for a one-time refurbishment process (DOD and NNSA)
- Plan for total stockpile quantities reflected in the current Long Range Planning Assessment (LRPA)
- Production duration goal of 10 years or less
- Goal for a post-refurbishment life extension of 30 years

Emphasis was placed on meeting performance requirements over the extended life and minimizing the cost of necessary refurbishment.

The drivers for refurbishment are fourfold:

1. The W76/Mk4 is the most critical element of our nation's strategic deterrent and cannot be allowed to be degraded by a serious aging problem;
2. The W76/Mk4 Dual Revalidation Program has shown that even though components are aging gracefully, there are some negative changes;
3. The Stockpile Surveillance Program cannot predict failures; rather, it only detects them when they appear and when it may be too late to prevent degradation; and
4. The Navy has expressed the desire to retain an average system age of no more than 30 years, compatible with life extension of the Trident Weapon system.

The POG-recommended refurbishment option meets the life extension requirements for the W76/Mk4, while enhancing surety and providing increased targeting flexibility and effectiveness. Careful examination of technical, certification, and compatibility issues have identified no unacceptable program risks. DOD and NNSA costs have been identified to the degree appropriate for this phase of the program. Based on these factors, the POG recommended refurbishment of the

W76/Mk4 beginning on 1 April 2000.

In 2002 the W76-1/Mk4A Life Extension Program successfully completed its second year of development engineering, achieving several significant milestones:

- Numerous reviews, including the Customer Requirements Review, and the Arming, Fuzing, and Firing Subsystem and Joint Test Assembly Conceptual Design Reviews.
- Completion of two reentry body Model Validation Tests and our first Joint Ground Test in support of structural and thermal model validation and environmental specification.
- Delivery of our first flight test bodies in support of the Demonstration and Shakedown Operation Navy flight test in FY03.

The MC4380A Neutron Generator was designed and qualified for the W76-0/Mk4 Trident warheads to provide additional margin in radiation environments. This intensive two-year project successfully supported the stockpile needs without the benefit of underground tests. The effort began in August 2000 and was completed in April 2002, followed by completion of the first production unit in May 2002 and delivery of the first units to the Navy and the UK in the summer of 2002.

The W76-1 Arming and Fuzing Subsystem (AFS) integrates radar, flight computer, and diagnostics in a single compact assembly. The design met aggressive cost goals through use of commercial off-the-shelf parts, innovative packaging, and automated production processes. The AFS is part of the W76-1 Arming, Fuzing, and Firing system, and tested in the Navy FCET-30 flight test. The project team delivered the first two AFS flight test units on schedule.

Sandia has responsibility for the integrated arming, fuzing, and firing (AF&F) system of the W76-1/Mark-4A life extension program. Science-based design tools will permit us to perform the redesign of this complicated and critical assembly at lower cost and with higher quality than was previously possible. The redesigned unit will combine advanced fuzing options, modern nuclear safety improvements, and enhanced reliability. Moreover, we are incorporating surveillance features into the unit so that its "state of health" can be assessed in the field with minimal intrusion.

Qualification of the new W76-1/Mark-4A AF&F will involve both testing and simulation using tools provided by science-based stockpile stewardship. We must conduct a variety of environmental tests in the laboratory to evaluate the unit's performance under various normal and abnormal conditions. We will perform system flight-tests with de-nuclearized payloads to achieve flight environment conditions that cannot be simulated in the laboratory. Radiation tests using aboveground simulators will provide radiation effects testing for most spectra of concern. Parameters derived from all these categories of tests will be incorporated into computational models that can calculate system performance over a broader and more intense range of conditions.

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http://www.globalsecurity.org/wmd/systems/w76.htm
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