Protecting Our Undersea Warfighters From Underwater Explosions

By Gary Sivak and Dinah Luneke

This high priority HPCMP project was run at the ASC MSRC by Dr. Joseph M. Ambrico, in support of engineers at the Naval Undersea Warfare Center, Division Newport. System Utilization: 54,500 hours on the HP SC-45.

In a tense military situation, a friendly submarine dives to avoid a hostile intruder. A near-miss underwater explosion from a mine or torpedo violently rocks the ship. The extremely tough submarine hull remains intact and watertight, but everyone and everything inside have been fiercely shaken. Has vital equipment been damaged? Are systems still operational? Most importantly, are the weapons handling system, torpedoes, and torpedo tubes still functional for a possible counter-attack? These are the questions that the underwater shock study by Dr. Ambrico and his team are helping to answer.

Project Applicability

"Shock qualification is the process of demonstrating that ship structures and equipment brought aboard a submarine will survive and not become a hazard to other systems or personnel during or after an underwater explosive event," according to Dr. Ambrico. "This process involves either an actual hardware shock test, or computational simulation and analysis."

This project also supports a more theoretical R&D-oriented implosion scenario. The issue concerns a volume filled with air that is set at atmospheric pressure, such as a stowed unmanned underwater vehicle subjected to sea pressure, which fails catastrophically by imploding as a result of an underwater explosion shock wave. The implosion can release an additional shock wave that is similar to an explosion in its effects. If such a secondary shock wave initiates close to the hull of a submarine or within a torpedo tube, it can potentially cause significant damage to the sub.

Project Motivation

This project's high priority status arose from Dr. Ambrico supporting large scale Underwater Explosion (UNDEX) shock qualification of the new VIRGINIA class nuclear fast-attack submarine's Weapons Handling Module. Test personnel discovered shock response problems with the weapon stowage cradles on this new sub. Testing had to be delayed until these serious problems were resolved. Numerous design modification concepts needed to be analyzed quickly to determine if the solution required extended shutdown for a large redesign or if a smaller design fix could be found that would result in only a minor delay.

Simulation Details

Computational structural mechanics (CSM) was the primary focus of Dr. Ambrico's research. The work was theoretical in the sense that the researchers were simulating the actual submarine's stowed hardware's response to shock loading. The software packages utilized were commercial codes, i.e., ABAQUS and LS-Dyna, available at the ASC MSRC.

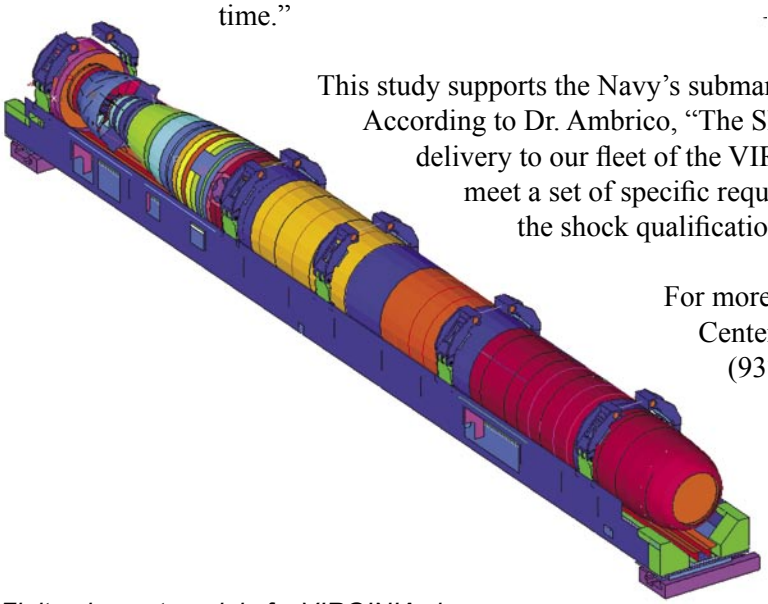
Shock qualification barge test of the VIRGINIA class Weapon Handling Module. (Photo courtesy of the Naval Undersea Warfare Center.)

These non-linear transient dynamic finite element simulations can be extremely large and detailed, especially when the method of shock qualification is analysis (rather than test). Models can have up to two million degrees of freedom, and may be run for up to 250 milliseconds of simulation time. Such analyses require significant computing power, which was the reason for this HPC project.

The Need for Power

"The ASC MSRC had the licensed software we needed, the computer speed, and available CPUs," Dr. Ambrico explained. "Running on the ASC MSRC high performance

site allowed us to run much larger jobs with detailed analysis, and to perform multiple runs at the same time."



Finite element model of a VIRGINIA class weapon handling cradle holding a torpedo.

This study supports the Navy's submarine programs for the military's undersea warfighters. According to Dr. Ambrico, "The Shock Qualification process was a necessary step in the delivery to our fleet of the VIRGINIA class nuclear fast-attack submarine as it has to meet a set of specific requirements. By running these analyses, we can accomplish the shock qualification process in a shorter time and with less cost."

For more information, please contact the ASC MSRC Service Center at *msrchelp@asc.hpc.mil*, or (888) 677-2272 or (937) 255-1094.