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STATEMENT OF

ADMIRAL KIRKLAND H. DONALD, U.S. NAVY

DIRECTOR, NAVAL NUCLEAR PROPULSION PROGRAM

BEFORE THE

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SEAPOWER AND EXPEDITIONARY FORCES SUBCOMMITTEE

ON

NUCLEAR PROPULSION FOR SURFACE SHIPS

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Introduction

Mr. Chairman, distinguished members of the Seapower and Expeditionary Forces Subcommittee, thank you for inviting me here today to testify on Integrated Nuclear Power Systems for Future Naval Surface Combatants.

The Naval Nuclear Propulsion Program began under the leadership of then-Captain Hyman G. Rickover in 1948. It began with a vision of harnessing the power of the atom to propel a submarine, freeing it from internal combustion engines. While a seemingly impossible feat at the start, Admiral Rickover not only saw his vision come to reality on January 17, 1955, when USS NAUTILUS steamed out of New London, Connecticut—UNDERWAY ON NUCLEAR POWER—he continued on to revolutionize marine powerplants for cruisers, aircraft carriers, and deep-diving submersibles. More so, the virtually limitless power, endurance, and flexibility afforded by these plants revolutionized naval warfare by providing the capability of sustainable, persistent combat power to quickly respond where needed around the globe.

Admiral Rickover developed an organization bound by a few simple core principles: technical excellence, quality, integrity, cost-consciousness, concern for personnel, and proper stewardship of the environment. Today, as the fourth successor to Admiral Rickover, I oversee and support 103 reactor plants in 81 nuclear-powered warships, the Submarine NR-1, and four training and test reactor plants. Since 1955, we have safely operated more than 5,800 reactor years and steamed over 136 million miles.

I am responsible for the research, design, development, acquisition, testing, maintenance, operation, and training of personnel for the Navy's nuclear propulsion applications; and also for the direct supervision of the Bettis and Knolls Atomic Power Laboratories, Bechtel Plant Machinery, Incorporated, the Expended Core Facility at the Naval Reactors Facility in Idaho, and naval reactor prototype plants. As specified in Executive Order 12344 and later set forth in Public Laws 98-525 [1984] and 106-65 [1999], Director, Naval Reactors, has statutory authority for oversight and direction of all aspects of naval nuclear propulsion. I fulfill these responsibilities through the management and oversight of a network of dedicated research labs, training facilities, plus the nuclear-capable shipyards, and equipment contractors and suppliers—the nuclear industrial base.

Unparalleled Record of Performance

Our nuclear safety record is unparalleled. U.S. nuclear-powered warships have safely operated for more than half a century without experiencing any reactor accident or any release of radioactivity that had an adverse effect on human health or the quality of the environment. The Program has consistently limited personnel radiation exposure more stringently than the civilian nuclear power industry or other Government nuclear programs have. No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal lifetime radiation exposure limit or the Federal annual limit in effect at the time. In the last decade, the average annual radiation exposure for operators has dropped to about one-eighth of the average annual exposure the typical American citizen receives from natural background radiation exposure. Simply put, the average American will receive more radiation from cosmic and natural terrestrial sources than our operators get from operating our nuclear propulsion plants.

This low occupational exposure record has been achieved by putting priority on the safety of our operators and the public, and then translating that priority to reality through rugged, conservative plant designs.

That record of safety pays off in many ways. One important example of this is our access to ports, both domestic and foreign. Nuclear-powered warships are welcomed today in over 150 ports in more than 50 countries worldwide, allowing them to carry out their mission without constraint.

Typical Naval Nuclear Propulsion Plant

In naval nuclear propulsion plants, fissioning of uranium atoms in the reactor core produces heat. Since the fission process also produces radiation, shielding is placed around the reactor to protect the crew.

U.S. naval nuclear propulsion plants use a pressurized-water reactor design, which has two basic systems: primary and secondary. The primary system circulates ordinary water in an all-welded, closed loop consisting of the reactor vessel, piping, pumps, and steam generators. The heat produced in the reactor core is transferred to the water (which is kept under pressure to prevent boiling). The heated water passes through the steam generators, where it gives up its energy. The primary water is then pumped back to the reactor to be heated again.

Inside the steam generators, the heat from the primary system is transferred across a watertight boundary to the water in the secondary system, also a closed loop. The secondary water (which is at relatively low pressure) boils, creating steam. Isolation of the secondary system from the primary prevents water in the two systems from intermixing, keeping radioactivity out of the secondary water.

In the secondary system, steam flows from the steam generators to drive the main propulsion turbines, turning the ship's propeller and the turbine generators, which supply the ship with electricity. After passing through the turbines, the steam is condensed into water, and feed pumps return it to the steam generators for reuse. Thus, the primary and secondary are separate and closed systems, in which constantly circulating water transforms energy produced by the nuclear reaction into useful work.

There is no step in this process that requires the presence of air or oxygen. This, combined with the ships' capability to produce oxygen and purified water from seawater, enables the ship to operate completely independent of the Earth's atmosphere for extended periods of time. In fact, the length of a submerged submarine patrol is limited primarily by the amount of food the ship can carry for the crew.

Advantages of Nuclear Power

Nuclear propulsion gives our warships virtually unlimited endurance at high speed, worldwide mobility, and unmatched operational flexibility. Without the encumbrances of fuel supply logistics, our nuclear-powered warships can get to areas of interest quicker, ready to enter the fight, and stay on station longer than their fossil-fueled counterparts.

On September 11, 2001, the nuclear-powered aircraft carrier USS ENTERPRISE (CVN 65) was on her way home from a 6-month deployment when she learned of the deadly terrorist attacks on the U.S. via satellite television. Even before receiving orders, ENTERPRISE executed a right full rudder order and was within striking distance of Afghanistan less than 11 hours without the need to pre-position a logistics train. This is just one example of the flexibility that nuclear power brings.

Nuclear submarines similarly benefit from the improved mobility and endurance, but also gain the tactical advantage of stealth afforded by unlimited submerged operation and the virtually limitless energy to power the onboard sensors.

We have successfully built and operated nine nuclear cruisers in the past. They were originally designed to escort nuclear-powered aircraft carriers, thereby giving large portions of carrier battle groups unrestricted operational flexibility. Although these cruisers performed superbly for many years, limited resources drove their obsolescence: the Navy chose not to update their combat systems in the age of more modern *Aegis* systems.

As ship designs advance to incorporate capabilities and warfighting needs that require more sustained energy (such as high-powered radars), nuclear propulsion—with its associated high energy density that comes without the need for large onboard fossil fuel tanks and fuel supply lines—is a viable design option. The recently submitted Report to Congress on Alternate Propulsion Methods for Surface Combatants and Amphibious Warfare Ships comes to the same conclusion.

We continue to improve the maintainability and affordability of nuclear propulsion through constant analysis of technical feedback from the Fleet and innovation from our laboratories. The experience we have gained has driven us to stick to our principles of ruggedness, reliability, redundancy, and safety, while capitalizing on new technologies and ideas. In so doing, we have striven to simplify designs and operating procedures, make components last longer, and better integrate systems.

The underlying principles involved in naval nuclear propulsion plant technology have not changed since Admiral Rickover first developed them. In the ensuing years since Admiral Rickover first briefed the Joint Committee on Atomic Energy, major technological advances have improved the performance and reduced costs of naval nuclear propulsion plants. For example:

- Since the 1960s, Naval Reactors has achieved a 30-percent increase in energy density of naval nuclear propulsion plants.

- Life-of-ship cores have become a reality for our submarine force. For example, the originally installed core in USS NAUTILUS had a life of 2 years; the USS VIRGINIA core is expected to last 33 years.

- Current surface ship cores have a 15-fold increase in energy content compared to surface ship designs in the 1960s.

- The design for our newest aircraft carrier propulsion plant, the GERALD R. FORD class, reduces the reactor department manning by 50 percent as compared to crewing requirements for NIMITZ-class ships.

- Propulsion plant maintenance requirements for the GERALD R. FORD-class ships are 30 percent less than for NIMITZ-class carrier propulsion plants. This decreased maintenance can be directly translated into increased operational availability.

The Question of Cost

While the formidable advantages of nuclear propulsion come with some cost, those costs are often mischaracterized. Construction of nuclear-powered ships requires integration of a sophisticated nuclear quality control and testing infrastructure into the process. Construction must be done correctly—up front—as many of the nuclear systems are, in practicality, inaccessible throughout the life of the ship. In addition, the acquisition cost for submarines includes all of the propulsion fuel necessary to support a ship throughout her lifetime. Although nuclear-powered aircraft carriers require a midlife refueling, the cost of about 23 years of reactor fuel is included in their upfront acquisition cost. Finally, we require nuclear-powered ships to be properly maintained and disposed of.

The advantages provided by nuclear propulsion increase the acquisition costs of the ship being procured. Studies conducted by the Navy in FY06 indicate that this upfront acquisition premium averages $600M per ship. When comparing life-cycle costs, the nuclear propulsion premium varies from 0 to nearly 40 percent, depending on ship operational tempo, service life, and mission requirements. These cost premiums need to be weighed against the operational advantages provided when making decisions on propulsion type. For example, when the Analysis of Alternatives for what is today the GERALD R. FORD-class aircraft carrier was completed in the mid 1990s, it was decided that nuclear power was the best choice as operational benefits outweighed the projected life-cycle cost premium of less than 10 percent. Current analyses indicate that nuclear propulsion is now the optimal choice—both economically and operationally—for aircraft carriers.

Selection / Training of People

As Director, Naval Nuclear Propulsion, I am responsible for maintaining the high standards first established by Admiral Rickover for selecting, training, and qualifying nuclear personnel. The availability of nuclear power for future ships is dependent on continued safe and effective operations by highly trained and competent personnel, both at sea and in port.

Since inception, over 114,900 officers and enlisted technicians have been trained in the Program. The officer selection process accepts only applicants who have high academic standing in colleges and universities. All personnel receive 1-2 years of training in both theoretical knowledge and practical experience on operating reactors that mirror those used in today's ships. Even after completing this training, the personnel must spend several months qualifying on the ship to which they are assigned before manning a key watchstation. In addition to the training and qualification program, multiple layers of supervision and inspections are used to ensure a high state of readiness and compliance with safety standards. When a ship's reactor is in operation at sea, there are senior enlisted technicians and officers on duty with a combined total of, on average, 40 years of experience in naval nuclear propulsion. The cost of maintaining this personnel community is accounted for in the total life-cycle cost calculation that will be evaluated against other potential alternatives. Into the foreseeable future, my training pipeline has the capacity without further infrastructure investment to produce the additional personnel required by future classes of nuclear ships currently being debated.

Maintenance and Disposal

We maintain our nuclear-powered ships to the high standard needed to ensure propulsion plant integrity. Nuclear propulsion is an unforgiving technology requiring numerous complex maintenance actions that cannot be deferred. Over the years, we have reduced the maintenance to only those actions that have to be done to operate the ship safely and reliably. For example, we have designed the next-generation aircraft carrier propulsion plant with a 30 percent reduction in required maintenance. We have also developed a maintenance infrastructure capable of accomplishing the maintenance as efficiently as practicable. When the proper investments in preventative maintenance are made throughout the life of the ship, a nuclear-powered warship's availability is equal to or better than fossil-fueled counterparts. These costs are included in the life-cycle cost considerations made in deciding naval ship propulsion types.

Admiral Rickover's cradle-to-grave responsibility across the propulsion plant lifetime mandates proper disposal of nuclear-powered ship reactor cores—and the ships themselves. Environmentally-conscious disposal of nuclear-powered ships has been ongoing since the mid-1980s. The technical complexities and costs of these efforts are well documented and well understood. Again, disposal costs are accounted for in the total life-cycle costs for nuclear-powered ships.

The above costs must be considered and balanced against the operational advantages afforded by nuclear power and projected affordability and availability of other fuel sources over the life of the ship when making the propulsion plant design choice. The Navy evaluates alternate propulsion methods for naval ship concepts, based on a varying set of factors. Mission and operating requirements and capability, balanced against the state of technology and total ownership cost, should drive the decision regarding the type of propulsion for a given platform.

Nuclear-Powered Ship Construction

Construction of nuclear propulsion plants requires unique skills, infrastructure, and administration to ensure that the high standards essential to safety and effectiveness are built into each component and the finished, integrated product. These attributes apply to many aspects of nuclear-powered ship construction—including areas outside of reactor core loading and propulsion plant testing evolutions, such as:

- Robust nuclear engineering, nuclear quality, nuclear test, and radiological controls organizations, having experience sufficient to preclude costly errors, delays, and rework.

- Facilities infrastructure, including lifting and handling, specialized assembly facilities, electrical power service, laboratory services, demineralized water production, testing infrastructure, and ship's crew support.

- Qualification and capacity of workforce, including trades, engineers, testers, inspectors, radiological control personnel, radiation health personnel, medical personnel, and corporate management.

- Certification of material and production processes, including nuclear-grade cleanliness, quality control, welding, non-destructive testing, radiological controls, radiation shielding, material identification and control, dosimetry, and radiography.

- Implementation of infrastructure, training, and processes and procedures required for naval nuclear propulsion security and force protection of a facility handling nuclear material.

- Capability, certification, support systems, and special tools and equipment to conduct nuclear testing, including turnover of operational control to ship's force.

- Onsite Government representation to support and oversee nuclear work.

- Contractor indemnification from nuclear liabilities.

- Strict adherence to environmental controls and ready response to emergencies.

- Authorization to safely handle and store radioactive materials associated with nuclear propulsion plants.

Northrop Grumman Newport News (NGNN) and General Dynamics Electric Boat (EB) are the Nation's two authorized and experienced nuclear construction shipyards. Both shipyards have been in this business since the 1950s. Today, NGNN builds and overhauls our nuclear-powered aircraft carriers and both EB and NGNN build submarines. NGNN previously built nuclear-powered cruisers in the 1960s and 1970s. The nuclear-capable shipyards are well below their capacity, both in new construction and maintenance. These existing nuclear-capable shipyards have sufficient capacity to accommodate nuclear-powered surface ship construction, and therefore there is no need to make the substantial investment in time and dollars necessary to generate additional excess capacity.

In addition to nuclear capable shipyards, as the Navy considers propulsion choices for future warships, the following matters apply to the nuclear propulsion alternative:

- We would use the existing nuclear industrial base to build the components for any additional nuclear-powered ships. We estimate that the increased workload could save the Navy 5-9 percent on propulsion plant component costs for new construction aircraft carriers and submarines through economies of scale and by applying the infrastructure overhead cost to a larger number of ships. Exact savings would be dependent on the number of new nuclear-powered surface ships. The additional workload would also bolster our fragile industrial partners, who are operating below their current capacity.

- The choice of propulsion for the Navy's next-generation cruiser will be driven by the mission requirements of that platform. If the Navy determines that this mission dictates the need to supply large amounts of energy for sustained periods, nuclear propulsion would compete favorably.

- Any new nuclear propulsion plant design effort would draw upon existing reactor plant designs to the maximum extent practical to minimize design cycle time and cost to promote commonality and capitalize on lessons learned. Ship specific design features and the degree to which reuse of existing technology is feasible would be determined once the Navy requirements are identified. Naval Reactors currently has a robust design force ready to meet the Navy's needs.

- Recruiting and retaining the best people we can find to operate our ships is key to our success. We continue to meet our goals, both in quality and in quantity. I see this as an advantage for the Navy: as all of our platforms become more technologically advanced, we will continue to need high-quality people.

In summation, the Naval Nuclear Propulsion Program stands ready to provide safe, reliable nuclear-propulsion plants for naval ships where appropriate both from a mission need and affordability standpoint. The Navy and the Defense Department have processes in place for ensuring that nuclear-propulsion is adequately considered in a fact-based analysis of alternatives regarding which type of propulsion is appropriate for naval warships. My program will continue to play a key role in that process.

Thank you for the opportunity to speak before this committee. I look forward to a continuing dialog on this topic. I will be happy to answer any questions at this time.