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U.S. Advanced Accelerator Applications Program: Plans to Develop and Test Waste Transmutation Technologies

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ABSTRACT

The primary mission of the U.S. Advanced Accelerator Applications (AAA) Program is to establish a national nuclear technology research capability that can demonstrate accelerator-based transmutation of waste and conduct transmutation research while at the same time providing a capability for the production of tritium if required. The AAA Program was created during fiscal year 2001 from the Accelerator Transmutation of Waste (ATW) Program and the Accelerator Production of Tritium (APT) Project. This paper describes the new AAA Program, as well as its two major components: development and testing of waste transmutation technologies and construction of an integrated accelerator-driven test facility (ADTF).

Transmutation of spent fuel and nuclear waste, if successful, could significantly reduce long-term radiotoxicity by destroying actinides and problematic long-lived fission products that may pose serious environmental and proliferation concerns. A key question is whether transmutation can provide a practical waste-management technology option under realistic conditions? To answer this question requires research and development in two areas: (1)transmutation, and (2)systems. Transmutation research and development and system integration studies are based on a structured framework that defines performance requirements, considers all elements of integrated transmutation systems and is focused on identifying and prioritizing those activities that lead to technically-defensible proof-of-performance testing and ultimately, demonstration of waste transmutation.

Transmutation R&D would ensure that material reductions by transmutation meet requirements for impact on the environment and proliferation risk reduction. In addition, transmutation R&D would ensure that minimal waste is generated in the processes of transmutation, material separations, and material recycle. This is to be achieved through the development of non-fertile fuel forms that do not produce additional plutonium

during irradiation, with the primary focus on obtaining adequate fabrication and irradiated performance data. Further development on advanced separations technologies for both spent fuel and recycled transmutation fuel, will focus on effectiveness (fraction separated), waste streams, and potential vulnerabilities to diversion of nuclear materials. Other technology requiring additional development and testing includes long-lived fission product transmutation targets, waste forms, particle accelerator technology (especially pertaining to reliable operations), and high-power spallation target performance.

Systems integration would develop fuel cycle analyses of multi-tier approaches for integrating reactor, fuel processing and fabrication, accelerator, and repository facilities. Materials flow diagrams that integrate separation efficiencies, transmutation conversion rates, and repository requirements are being developed. Approaches to address safety performance, environmental impacts, and proliferation risks will be developed and evaluated. In-depth economic analyses on approaches to transmute wastes and generate electricity will be performed to better focus technology development efforts so they will be compatible with future nuclear system deployments currently considered credible. In addition, systems integration will include tests of the dynamic response of coupled accelerator-driven spallation targets and subcritical reactor systems, building upon the MUSE experiment series at Cadarache.

In addition to the waste transmutation research and development, the AAA Program is to demonstrate coupling of a high power linear proton accelerator, a spallation target, and a sub-critical reactor into an integrated operating system as the proposed *Accelerator-Driven Test Facility (ADTF)*. Proof-of-Performance testing in the *ADTF* will demonstrate technology options for the transmutation of spent nuclear fuel and waste through a series of integrated experiments aimed at demonstrating the performance and practicality of the proposed technologies. Safe and secure operation of a complete system coupling an accelerator, sub-critical reactor, target, fuel, and balance of plant systems, both in normal and abnormal conditions, is to be demonstrated. The ADTF is to include a user facility that allows testing of advanced nuclear materials and fuels, materials science research, experimental physics, and conventional nuclear engineering applications. The facility is to have the capability, through upgrades or additions, to produce tritium for national security purposes, if required.

Unfortunately, the infrastructure needed to support essential nuclear technology development in the 21st century is deteriorating in the U.S. and many parts of the world. Facilities are aging, and the nuclear disciplines vital to our technology base (such as nuclear engineering, nuclear chemistry, physics, materials research, etc.) are in decline. A primary goal of the AAA Program from the outset will be to establish aggressive programs to engage universities and laboratories nationwide in nuclear research and encourage advanced degrees in the nuclear sciences. In addition, efforts to develop and test transmutation technologies within an international collaborative framework, will help to bolster any shortcomings in the existing U.S. nuclear infrastructure and concurrently strengthen some of the international nuclear infrastructure.

In summary, this paper provides a detailed description of the newly formed AAA Program, an integrated effort to develop and demonstrate waste transmutation technology in the U.S. Reference transmutation technologies and backup technology choices are described, as are planned to develop and test these technologies. The focal point of the effort, an integrated accelerator-driven test facility is described, as are plans to complete the facility by 2010.