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LAYING THE GROUNDWORK FOR A LARGE-SCALE USED FUEL TRANSPORTATION SYSTEM[1]

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Abstract

The US Department of Energy's Office of Nuclear Energy established the Nuclear Fuels Storage and Transportation Planning Project[2] to lay the groundwork for implementing interim storage consistent with the Administration's Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste, including associated transportation activities. Efforts include the development of a system for the large-scale transport of spent nuclear fuel (SNF) that will be necessary in an integrated waste management system. Progress is being made on long lead-time, destination-independent aspects of the transportation infrastructure. The large-scale transportation system for SNF is divided into three primary elements: institutional, operational, and hardware. The institutional element refers to the various forms of stakeholder interaction that must occur for this type of transportation system to be successful. It includes activities like development of a transportation planning framework, work on policy development to support training of local public safety officials, and identification of a route determination process that reflects the interests of a

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[2] Note: in October 2016 DOE's Office of Nuclear Energy reorganized and the former Nuclear Fuels Storage and Transportation Planning Project is now the Office of Integrated Waste Management.

broad cross-section of stakeholders while meeting regulatory requirements and logistical needs. The operational element refers to the activities that must be undertaken to run a large-scale transportation system. This element is currently focused on development of a new SNF transportation routing analysis tool, study of the transportation infrastructure near shutdown nuclear power plants with onsite spent fuel storage that may be de-inventoried first, and development of tools for modeling transportation activities. The hardware element refers to the casks, railcars, and other items necessary to operate the transportation system. This element currently focuses on development of railcars compliant with the Association of American Railroads' Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material*, as well as studies related to the use of rail casks and their ancillary equipment. Substantial progress in all areas of the transportation program is being made on the path toward a fully operational SNF transportation system, and is presented in this paper.

Introduction

The Blue Ribbon Commission on America's Nuclear Future (BRC) made a series of recommendations to the Secretary of Energy in 2012 related to the management and eventual disposition of spent nuclear fuel (SNF). One of its recommendations was to make "prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available" [1]. In response to these recommendations, the Administration published the *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (*Strategy)* [2], and DOE's Office of Nuclear Energy established the Nuclear Fuels Storage and Transportation Planning Project (NFST). The mission of NFST is to lay the groundwork for implementing an interim storage facility, including associated transportation activities. The NFST mission is also focused on meeting the recommendations made in the National Research Council of the National Academies comprehensive report on the safe transport of SNF [3]. This paper presents the work being done on long lead-time, destination-independent elements of the large-scale transportation system that will be necessary for a future integrated waste management system.

Discussion

The large-scale transportation system for SNF is divided into three primary elements: institutional (also known as *intergovernmental and external engagement*), operational, and hardware. A high-level overview of the progress made to date follows for all three elements of the NFST transportation program, with an emphasis on recent activities and near-term future work in transportation planning.

Following recommendations made by the BRC, the focus of the current transportation work is on evaluating removal of spent nuclear fuel (SNF) from nuclear power plant sites that have ceased all operations. In the US, as of fall 2016 there are currently 13 sites that have ceased all operations, and are termed, "the shutdown sites."

Institutional

The intergovernmental and external engagement aspects of transportation planning refer specifically to the interactions between DOE staff and various transportation stakeholders, including representatives of state governments; representatives of Tribal Nations; other federal agencies; scientific and academic institutions; and labor, industry, and citizen groups. It includes activities such as development of a proposed policy and program to provide financial and technical assistance for training emergency response personnel along transportation routes and development of a methodology for identification of transportation routes that reflect the interests of a broad cross section of stakeholders while meeting regulatory requirements.

Outreach to the respective stakeholders is accomplished through mechanisms such as DOE's National Transportation Stakeholders Forum (NTSF), which was established in 2009 as a means for DOE to engage at a national level with states, Tribes, and other interested stakeholders about the Department's shipments of radioactive materials. DOE informs stakeholders of ongoing, upcoming, or tentatively planned shipments of radioactive material and receives input from stakeholders about relevant concerns. Stakeholders and DOE personnel collaborate to identify issues and concerns which may affect transportation operations and to try to find solutions to such issues that are amenable to all parties.

Ad hoc working groups are formed on an as-needed basis to allow for consultation and collaboration between DOE and states, Tribes, and other affected stakeholders. Currently, the NFST program leads two ad hoc working groups directly related to its transportation planning work; the Section 180(c) ad hoc Working Group and the Spent Nuclear Fuel Rail / Routing ad hoc Working Group.

Section 180(c) of the US Nuclear Waste Policy Act of 1982, as amended (NWPA), states that DOE is responsible for providing technical assistance and funds to train public safety personnel in jurisdictions through which SNF or high-level waste is transported to a NWPA-authorized facility. A working group within the NTSF was formed to help develop a proposed policy to implement Section 180(c), including identifying and addressing issues that are important to stakeholders for resolution before transportation of SNF begins. DOE and affected states and Tribal Nations have been working on 180(c) for many years, and recommendations from the National Academy of Sciences (NAS) and BRC have refocused these efforts to address relevant issues before shipments commence [1, 3]. To this end, NFST, in conjunction with states and Tribes and through the Section 180(c) ad hoc Working Group, has conducted a Section 180(c) Proposed Policy Implementation Exercise. This exercise simulated the process for state and tribal governments to apply for and receive grant funding under Section 180(c), including application review by a mock expert panel, assessment of allowable activities, and the grant negotiation process. The exercise was conducted between November of 2014 and June of 2016 and included a full-day workshop at the 2015 annual meeting of the NTSF.

Follow-on discussions evaluated how the process could be improved from both state and tribal perspectives, as well as from DOE staff's perspective. A report will be issued later this year analyzing the exercise, identifying lessons learned, and recommending potential improvements to DOE's current Section 180(c) proposed policy.

Although a site for an SNF interim storage facility or repository has yet to be determined, a standard procedure for selecting routes for shipments may still be developed. In 2014, a draft proposed routing methodology for SNF shipments was developed. This methodology includes identification and implementation of federal transportation regulations and available guidance for such shipments, consideration of lessons learned from previous radioactive material shipping campaigns, and opportunities for stakeholder input. Feedback from stakeholders on this proposed methodology was provided through the NTSF Spent Nuclear Fuel Rail / Routing *ad hoc* Working Group, and will be incorporated into a new draft of the methodology. Using this methodology, it will be possible to determine potential routes from shutdown sites to Class I railroad infrastructure. [Class I railroads in the US are classified as having operating revenues exceeding $250 million dollars per year, and are the major long-distance rail service providers.] Regardless of destination, the primary mode of transportation for SNF to an interim storage facility or repository in the US is expected to be by rail, with the possibility of using dedicated train service. However, not all shutdown sites have direct rail access, requiring use of heavy-haul truck, barge, or a combination of these two modes and one or more transload locations to connect with rail. Evaluating and identifying potential routes from shutdown sites to rail access will help interested parties readily understand the process by which routes are chosen and to what extent they will be able to participate in this process.

In conjunction with cooperative work to develop a routing methodology, DOE has developed a transportation routing tool — the Stakeholder Tool for Assessing Radioactive Transportation (START) — which is also being made available to stakeholders. Training sessions have been held so that stakeholders and DOE will have the same resources available during the SNF route planning process. This is expected to ensure that the process of route selection is transparent and understandable to all stakeholders. Further description of START may be found in the following section and in [4].

Webinars are another key method through which information on matters of interest are disseminated to, and discussed by, the NTSF members. A total of 16 webinars specifically related to spent fuel transport have been hosted since 2013 with topics ranging from high burn-up nuclear fuel to US Nuclear Regulatory Commission regulation of SNF shipments, to SNF casks. In 2016, four webinars dealing with rail transport safety as it applies to spent fuel shipments have been presented.

Operational

The operational aspects of the transportation system are the activities and workings of the system itself. These currently include (1) development and use of computational tools for modeling transportation activities; (2) study of the shutdown commercial nuclear plant sites, and the transportation infrastructure adjacent to them, from which SNF is to be removed; and (3) the planning of procedures to be followed in the transportation of SNF from commercial nuclear power plant sites. Several operational activities are described in greater detail in this section.

The routing analysis tool START is currently being developed. This computational tool uses geographical information system (GIS) data and software to identify potential routes from sites of interest and summarizes them based on characteristics such as distance; travel time; population; and proximity to tribal lands, environmentally protected areas, and emergency responder infrastructure. Version 2.0 of START is currently online; the home page is presented in Fig. 1. It will incorporate improvements made in response to suggestions from the user community, as well as updated infrastructure data and routing algorithms. Currently, START is categorized as Official Use Only, limiting its availability to some stakeholders; however, in 2017 NFST plans to explore development of a version that can be openly used by all interested members of the public.

Figure 1 START version 2.0 homepage.

As of this writing, thirteen so-called *shutdown sites* are storing commercial SNF and have ceased all power producing operations. All of these plants have either completed or begun decommissioning their nuclear power operations. DOE staff have visited all 13 of the shutdown sites to evaluate on-site and nearby transportation infrastructure. On the ten most recent visits, DOE staff were accompanied by representatives from nearby states, Tribes, and the Federal Railroad Administration (Fig. 2).

NFST has prepared a detailed report of the SNF inventory at these sites, the on-site and near-site transportation infrastructure, and past experiences at each site for transporting heavy equipment (e.g., reactor pressure vessels, steam generators) onto or off of the site [5,6]. This report is updated annually as new information becomes available regarding site status. Although an SNF storage or disposal destination has not yet been identified, studies of transportation infrastructure can be used to determine potential routes from the shutdown sites to Class I railroads that can be used to transport loaded casks.

Although much of the transportation planning to date has been applicable to any reactor site and is independent of destination, DOE studies have recently begun to make initial plans for the de-inventory of particular shutdown sites. These analyses go beyond the status of the transportation infrastructure to consider cask loading times, on-site logistics, near-site routes, and estimated costs. Sites studied to date are Big Rock Point (in Michigan), Connecticut Yankee (also known as Haddam Neck), Humboldt Bay (in California), Maine Yankee (in Maine), and Trojan (in Oregon). NFST plans to complete three additional de-inventory studies of shutdown sites in 2017. All sites will eventually be studied in depth to construct preliminary individual site de-inventory plans.

Figure 2 NFST site visit to Vermont Yankee shutdown nuclear power plant.

To effectively plan transportation of SNF, detailed information must be known about the material to be shipped. For example, it must be determined whether the transportation cask containing SNF meets current regulatory requirements for transport. A comprehensive system for the analysis of fuel from the time it is discharged from the reactor to its final disposition has been developed to supply much of the necessary information. This system, the Used Nuclear Fuel Storage, Transportation, and Disposal Analysis Resource and Data System (UNF ST&DARDS), characterizes the SNF to be shipped, addressing such issues as thermal load, criticality, and dose rates [7,8]. With this data, it will be possible to estimate more realistic dose values rather than rely on the overly conservative bounding regulatory assumptions typically used. Better data analysis will enable more efficient transportation of SNF when a destination becomes available. Using a combination of legacy tools and new methods, as well as data from up-to-date information and simulations, routing analyses will be performed. These analyses will include the dose to public due to incident-free transportation. Safety is of paramount importance.

Hardware

The hardware element includes all physical items necessary for operation of the SNF transportation system: transportation casks and railcars to carry them, other transportation conveyances such as heavy-haul trailers and barges, and ancillary equipment such as lifting devices and cask cradles. These various pieces of hardware may be purchased or leased, or the entire transportation system could be contracted for, with the integrating contractor being responsible for supplying all necessary hardware. Design and development work is required for some of the equipment, such as the railcars, which are not currently available.

A highly visible component of the hardware element is the design, prototype fabrication, testing, and approval of a railcar that meets the Association of American Railroads (AAR) Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material*. The AAR is the rail industry organization that develops standards for railcar rolling stock in North America. The focus of the S-2043 standard is to reduce the likelihood of derailment, thereby reducing risk during transport. The S-2043 is the most comprehensive standard published by the AAR and requires the use of state-of-the-art components such as electronically controlled pneumatic brakes. Furthermore, it requires extensive system safety monitoring including location, speed, truck hunting, rocking, wheel flats, bearing condition, ride quality, braking performance, and vertical, lateral and longitudinal acceleration. The railcar development and approval process is expected to take approximately seven years due to the extensive nature of the analysis and testing that is required for AAR approval. An artist's conception of a rail consist compliant with AAR Standard S-2043, including a cask railcar, two buffer cars, an escort car, and locomotives, appears as Figure 3.

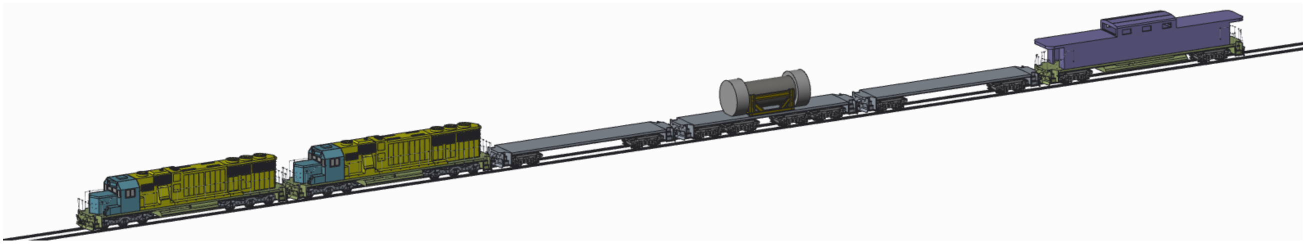

Figure 3 Artist conception of AAR S-2043 compliant rail consist.

In 2015 AREVA Federal Services was awarded a contract from DOE to perform conceptual and preliminary design of S-2043-compliant cask and buffer railcar designs and to produce two buffer railcars and one cask railcar for subsequent physical testing. Based on the current project schedule (Fig. 4), an approved S-2043 rail consist including cask, buffer and escort railcars will be available in March of 2022. Phase 1–Conceptual Design is currently being completed and Phase 2–Preliminary Design has already been initiated.

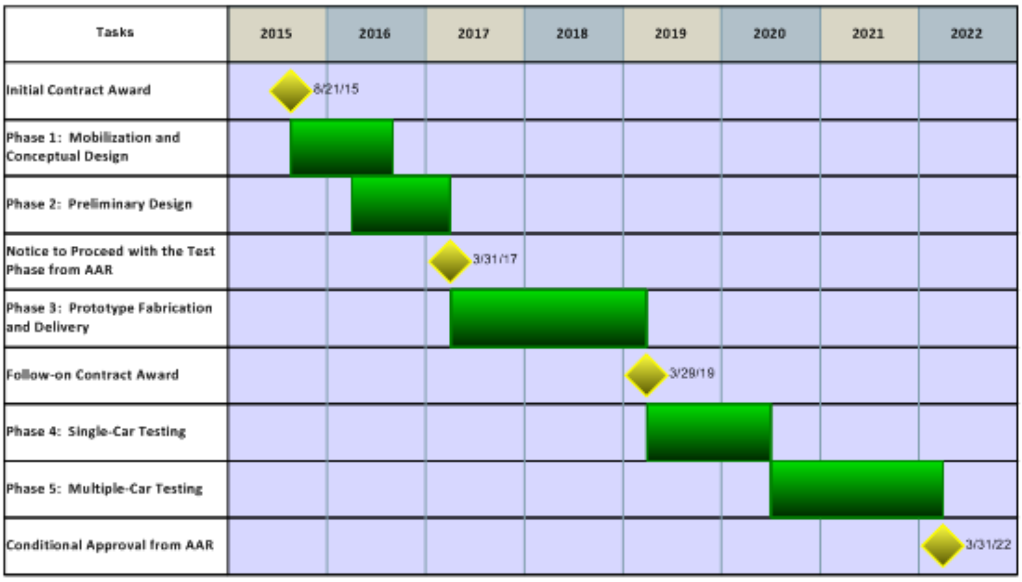

Figure 4 Casks and buffer railcar development schedule.

In addition to rolling stock, the hardware element also includes transportation casks. Although most casks have already been developed and certified, some casks which are certified for storage have not been approved for transportation, and some casks will need additional analysis before they can be certified for high burn-up fuel or damaged fuel assemblies. Furthermore, cost analyses are being performed to determine whether transportation casks should be purchased or leased or if the entire transportation system should be contracted with the integrating contractor being responsible for supplying all necessary hardware. Additionally, long-term planning is necessary to ensure availability of casks, ancillary equipment, and rolling stock. Once the system has begun to operate, maintenance of existing hardware and acquisition of additional equipment will be necessary as de-inventory of sites ramps up. These are all areas of current and future study.

Conclusions

The NFST was established to lay the groundwork for implementing interim SNF storage, including associated transportation, per the Administration’s Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste [2], taking into account recommendations made by the NAS and BRC [1, 3]. While a complete transportation system cannot be developed until a destination site is known, long lead time activities necessary for transportation system development can be addressed now. NFST is proactively planning for the transportation system's institutional, operational, and hardware aspects. These activities will ensure that once a destination site is determined, the transportation system will be available to ensure safe, secure, and efficient movement of SNF from commercial nuclear power reactor sites.

Acknowledgement

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