The Atlas Railcar Project

An Areva-led team has completed the first phase of a DOE contract for designing and fabricating a railcar for transporting used nuclear fuel and high-level radioactive waste.

In 2015, as part of its plans for an integrated nuclear waste management program, the Department of Energy awarded a 43-month, $8.63 million contract to Areva Federal Services for the design and fabrication of prototype railcars for nuclear material transportation. The railcars are intended to be used for large-scale transport of used nuclear fuel and high-level radioactive waste, collectively called high-level radioactive material (HLRM), to interim and eventual permanent storage facilities.

Areva Federal Services, a subsidiary of Areva, is leading a team that includes Kasgro Rail, the fabricator of the only cask car currently certified for HLRM transport, and Transportation Technology Center, a railcar dynamic modeling and testing facility. Conceptual design reviews, meanwhile, are being supported by Stoller Newport News Nuclear and MHF Logistics.

The project has been divided into three phases. Phase 1 includes the conceptual design and dynamic modeling of HLRM transport casks cars (called Atlas railcars) and cask cradles, as well as buffer cars, which provide spacing between the cask railcars and the locomotive, and between the cask cars and the security escort car. During Phase 2, the preliminary design concepts will be submitted to meet the Association of American Railroads' (AAR) requirements for HLRM transport. Fabrication of the prototype cask and buffer railcars will begin during Phase 3.

In October 2016, Areva Federal Services submitted to the DOE its Phase 1 report, *Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Materials, Phase 1: Mobilization and Conceptual Design* (DE-NE0008390), which compiles the work that was completed up to that point.

The following information was taken from the Phase 1 report, which can be found on the DOE website at http://energy.gov/ne/downloads/atlas-railcar-phase-1-final-report.

Changes in railcar configuration

The design of the cask railcar is based on the basic design of the U.S. Navy's M-290 cask railcar, which is the only railcar to be approved for use under the requirements of AAR Standard S-2043, "Performance Specification for Trains Used to Carry High-Level Radioactive Material." The Areva team also selected

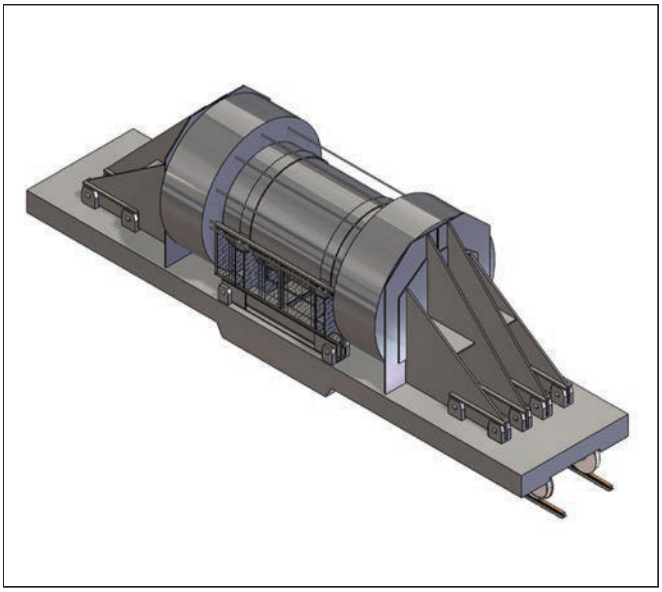

Fig. 1. Family 1 cradle with a TN-40 cask ready for transport.

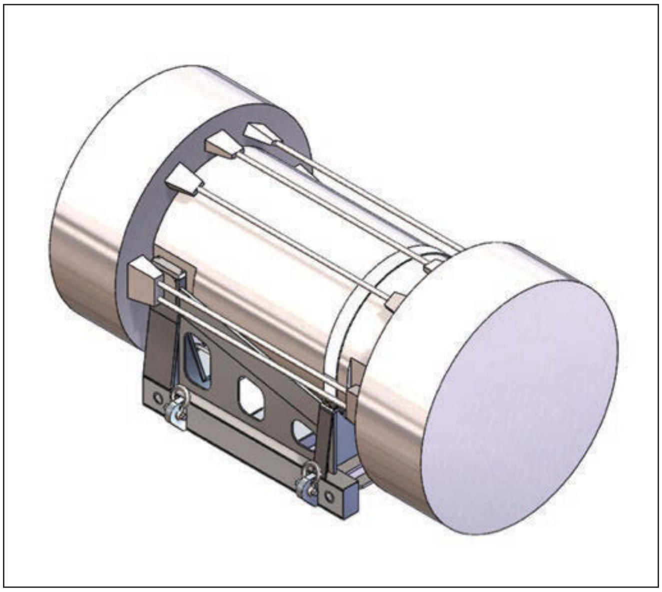

Fig. 2. Family 2 cradle with a TN-68 cask.

the M-290's components, as they are the only existing components used to establish dynamic models that comply with the S-2043 standard.

The first conceptual design used the M-290 trucks with a standard eight-axle railcar configuration. In May 2016, however, the selected M-290 trucks for the eight-axle Atlas railcar and buffer railcar failed initial Phase 2 dynamic modeling simulations. Simulation results indicated that the railcar trucks fail the "hunting" criteria during high-speed stability and dynamic curving simulations. Hunting refers to the self-oscillation of the railcar trucks between the railroad tracks, decreasing railcar stability and railway adhesion.

As a result, and after an evaluation of possible options, the team switched to a 12-axle configuration of the Atlas railcar in early August 2016. It was determined that the 12-axle configuration presents the highest probability of meeting AAR S-2043 requirements while minimizing risk and schedule impacts.

Regulatory requirements

In addition to complying with AAR S-2043, the cask and buffer railcar must be approved to AAR *Manual Standards and Recommended Practices, Section J: Quality Assurance M-1003*. The contract also states that the cask and buffer railcars are to comply with other applicable standards as specified in the Oak Ridge National Laboratory report, *Cask Railcar System Requirements Document*.

As specified by the DOE, a total of 15 separate HLRM transportation cask designs were considered for the development of the conceptual cradle designs and for bounding the Atlas railcar's dynamic modeling requirements to AAR S-2043. In late September 2016, a contract modification added two additional cask models, the HI-STAR 190 SL and XL transport casks, to the list of considered cask designs.

The cask cradles are required to be tall enough and open-ended so that impact limiters can be attached to a cask after the cask is secured to the cradle while on the Atlas railcar. For stability during transport, each cask design will need a cradle designed to position the center of gravity (CG) low. The cask cradle also must be designed to meet the requirements of AAR Interchange Rule 88, which specifies the minimum mechanical requirements for railcars used in interchange commerce service.

The transport casks must meet Nuclear Regulatory Commission regulations, which require HLRM to be shipped in casks certified in accordance with 10 CFR Part 71. The cask cradle and its attachments are to meet commercial-grade requirements.

Design codes used in the development of the conceptual cradle design include ANSI N14.6, "Radioactive Materials: Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More," which was used to provide a lifting criterion for the cradles. The cradles will be required to lift the loaded cask. ASME and ASTM codes were used to provide material properties, primarily material yield and ultimate strengths.

Conceptual cradle designs

Areva was responsible for the conceptual designs of cradles that will accommodate each of the considered transport casks. The conceptual cradle designs were necessary to determine the height of the cask CG above the railcar deck, the weight on each axle, etc., as required to perform analysis and provide supporting information needed for designing the Atlas railcar. The conceptual cradle designs will not be carried through to preliminary or final design under Areva's current contract with the DOE.

Areva divided the initial 15 transport casks into four groups, referred to as "families," based on the cask tie-down methods. This allowed a minimized number of required cradle designs with each cradle grouping containing configurations for each cask.

The four families are described as such:

Family 1: Casks that need end-stops to restrain axial (longitudinal) movement. The casks rest on single or multiple saddles with straps restraining lateral and vertical movement. Casks included in this family are Areva's TN-32, TN-40, and TN-40HT casks and Holtec International's HI-STAR 60, HI-STAR 100, HI-STAR 100 HB, and HI-STAR 180 casks. (Fig. 1)

Family 2: Casks that are restrained axially and vertically by their lower trunnions (or pocket trunnions in some cases). Casks included in this family are NAC International's MAGNATRAN, NAC-STC, and NAC-UMS UTC casks and Areva's TN-68 cask. (Fig. 2)

Family 3: Casks with an integral shear key. Casks included in this family are Areva's MP197 and MP197HB casks and Energy Solution's TS-125 casks. (Fig. 3)

Family 4: Casks with an integral shear key where the cask rests on multiple saddles with vertical movement restrained by a frame. The only cask in this family is Areva's MP187 cask. (Fig. 4)

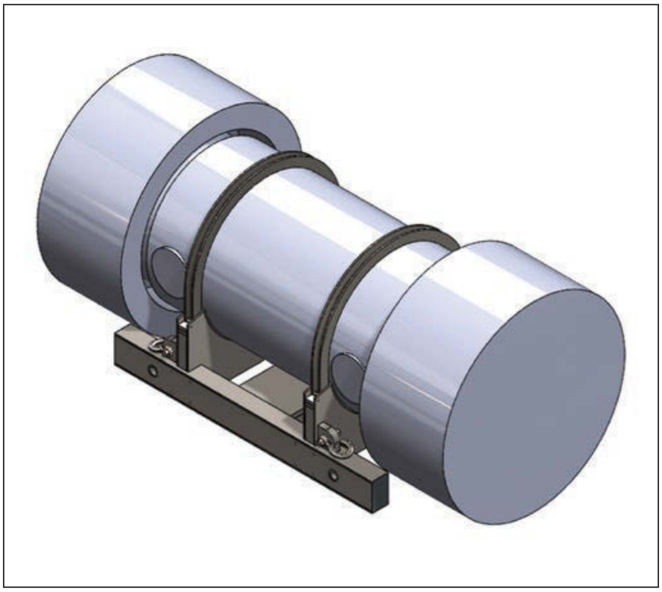

Fig. 3. Family 3 cradle with a MP197 cask.

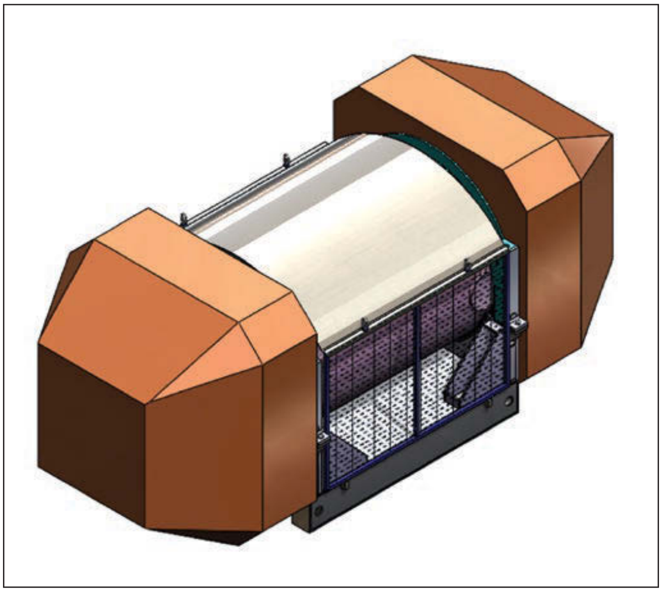

Fig. 4. Family 4 cradle with a MP187 cask.

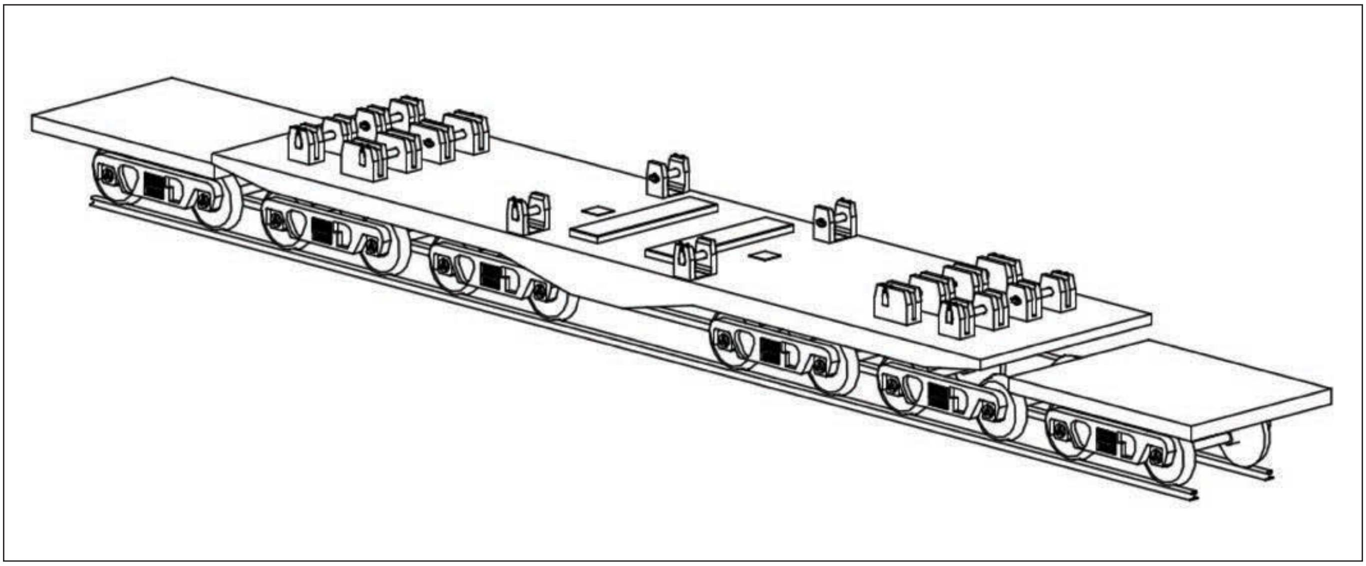

Fig. 5. Atlas railcar standardized attachment components.

The cradle-to-Atlas railcar connection was designed using standard attachment points that accommodate all cradle designs. All conceptual cradle designs were designed to attach to the railcar using the standardized attachment points (Fig. 5). The stress criteria for sizing the conceptual cradle components was based on the 7.5g longitudinal/2g vertical/2g lateral loading, with the resulting loads compared with material yield stress. The lifting criteria applied to the conceptual cradles were conservative in accordance with ANSI N14.6.

The conceptual design of each cradle was evaluated to provide good assurance that a design can be made to support the applied loads. Each cradle is required to support the individual transportation loads. In addition, it was demonstrated that lifting load-path components in the cradle are able to support the combined load of the cradle and package in order to support transfers between modes of transportation.

To accommodate current safety analysis requirements and allow for operational flexibility, the Atlas railcar design must be able to accommodate the up- and down-ending of casks that have bottom trunnions. Table 1 shows the maximum vertical loads for the listed cask design and the location from the Atlas railcar centerline. These loads were used as an input to the railcar design.

The conceptual cradle designs for Families 2-4 are supported longitudinally by the two shear blocks welded to the Atlas railcar, while the Family 1 cradles are supported longitudinally by the end-stop assemblies. All of the cradle designs are supported laterally and vertically by center-pin attachment blocks. The maximum clearance can be calculated using the slot and hole maximum conditions and the smallest pin diameter. This assumes the hole/slot size is not reduced from misalignment, which would reduce the clearance.

Cask rotated on cradle	Load on Railcar (lb.)	Horizontal distance from load to center of railcar (in.)
TN-68	299,500	63.5
HI-STAR 60	234,400	67.56
NAC-STC	298,600	78.6
HI-STAR 180	371,347	81.75
NAC MAGNATRAN	356,000	89.3
NAC-UMS	299,000	89.3
TS-125	315,910	98.0

Table 1. Cask rotation loading.

Conceptual railcar design

The Phase 1 conceptual designs of the Atlas and buffer railcars are primarily focused toward having a feasible prototype railcar design for use with the conceptual cradle designs and the conceptual design of the cradle-to-railcar attachment interface system. The conceptual railcar designs also support the generation of general loading procedures, discussed below.

Kasgro Rail conceptually designed the Atlas and buffer railcars based on the Navy's M-290 cask railcar. As mentioned, the initial eight-axle truck configuration failed dynamic modeling simulations. Both the eight-axle Atlas cask and buffer railcars failed S-2043 requirements in empty and loaded railcar conditions, at moderate to high speeds, in standard elevation conditions, super-elevation conditions, and in some tangent sections.

In response, the Areva team constructed a detailed decision tree to support the evaluation of alternatives to the eight-axle configuration, including the 12-axle railcar configuration. The team determined that continuing to pursue an eight-axle version of the Atlas railcar would increase project risk, specifically in meeting S-2043 requirements, and cause additional project duration. It was also determined that changing to a 12-axle Atlas railcar configuration would significantly reduce current project risk and presents minimal additional schedule impacts. Therefore, the team determined to change from an eight-axle Atlas railcar configuration to a 12-axle configuration, duplicating Kasgro's M-290 cask railcar from the railcar deck down and incorporating the current Atlas cradle-to-railcar attachment interface on the 12-axle Atlas railcar's deck. Fig. 5 shows the conceptual Atlas railcar.

As part of the key design and functional criteria, the Atlas railcar design will include both an electronically controlled pneumatic brake system and a standard freight railcar pneumatic brake system. A remote monitoring system is also to be installed. To allow the placement and removal of cask impact limiters while the cask is loaded on the railcar, the railcar will have a flat deck. Standard, off-the-shelf components are to be used to the maximum extent practical.

The railcar will incorporate jacking and tie-down points so that, if feasible, casks can be loaded vertically and down-ended into the cradle. The jacking and tie-down points would be used to stabilize the railcar and ensure the off-center loads do not transfer through the railcar suspension.

The buffer cars are being designed to meet the AAR S-2043 standard, as are the Atlas cars, but the buffer cars will not carry HLRM. They may, however, be used to carry lightweight items necessary to support loading and unloading procedures and other transportation activities. Nothing on the buffer railcar can obstruct the line of sight between the escort railcar and the Atlas railcars.

Loading procedures

As part of Phase 1 of the railcar project, Areva TN Americas developed general loading procedures for the Atlas railcar. The procedures include descriptions of how to load each of the initial 15 transport casks onto the Atlas railcar, including whether the impact limiters would be attached to the cask before or after the cask is placed on the railcar. The purpose of the general procedures is not to replace any detailed site-specific or cask-specific loading procedures, but to inform the railcar, cask, and cradle designers and users of equipment about the design features and operational requirements needed to accommodate the casks. Whenever possible, the procedures are provided in a general sense and apply to all 15 casks and associated cradles.

The Areva team did not include sequences and associated steps for other activities, such as the unloading of a cask from the railcar. The general loading procedures, however, do identify when a collection of steps could be used for other activities, such as unloading and trans-loading of the transport cask, whether empty or loaded. In many cases, these activities would simply require the user to reverse the order of the provided steps.

The general loading procedures also describe the methodology used to create the procedures, any limitations of use, and applicable assumptions, as well as references to the source information. The procedures are based on the current conceptual designs of the cradles and Atlas railcar, with specific instructions, diagrams, figures, and tables subject to change during final design and fabrication.

Sources

Areva press release, "AREVA Awarded Contract to Design and Fabricate Railcars for Nuclear Material Transportation," (Dec. 9, 2015).

Areva Federal Services, "*Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material, Phase 1: Mobilization and Conceptual Design*" (DE-NE0008390), http://energy.gov/ne/downloads/atlas-railcar-phase-1-final-report, (Oct. 2016). ■

Edited by Tim Gregoire.