Proceedings of the 18th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2016
September 18-23, 2016, Kobe, Japan

Paper No. 3048 **Preparing for large scale multi-modal spent fuel logistics in USA and China**

Author: Pascal Chollet
Affiliation: AREVA TN

Abstract

The nuclear industry needs an extremely safe, reliable and efficient logistics system to support its routine activities. AREVA TN has been a key player in the nuclear industry for over 40 years, supporting the industry by supplying packages and organizing transportation of radioactive material worldwide. Focusing on the back-end industry, around the recycling activities, AREVA TN routinely manages transportation of highly radioactive materials such as spent nuclear fuels, and vitrified residues and sensitive nuclear material such as MOX fuel. Such sensitive nuclear materials are transported in packages and with transport equipment featuring very high technologies. The transportation of these sensitive nuclear materials also requires large organizations, long-term planning and management of multiple interfaces for safety and security.

This paper will give some examples of AREVA TN's experience in international transport for the back-end industry, emphasizing the need for planning with key milestones to successfully organize such transports. The paper will also consider the timelines of future back-end projects in the USA , and China which will feature large scale logistical organizations and for which planning has already started.

.

Introduction

Nuclear power plants around the world generate significant volumes of used nuclear fuel. As the nuclear power industry extends around the world, and due to the lack of final disposal repositories as well as to the limited reprocessing capabilities, the inventories of used nuclear fuel will continue to accumulate at nuclear power plant sites. With regards to logistics, it can be noted that the consequence of such lack of final disposal repositories and of such limited reprocessing capabilities is that volumes of used nuclear fuel being actually transported are quite small. Such transports, even representing small volumes on a worldwide scale, do require the highest attention and are usually performed with highly sophisticated logistical capabilities. Used fuel transport occurs routinely in France, as well as in Japan, Sweden, UK and Russia to a lesser extent. In France, where the La Hague reprocessing plant treats used fuel from all the French reactors and from foreign reactors as well, the transports of used nuclear fuel have routinely, and from the dawn of industry, been operated by AREVA TN, who set-up a large-scale state-of-the-art logistical system ensuring the safe and efficient nuclear logistics in the public domain. Similarly, to support the sustainable development of their nuclear program, China, and the United States will also need to set-up a safe and efficient large-scale used fuel logistics system in the short term. In view of the ambitious nuclear programs of countries like China and the situation in the United States, this paper will review the main milestones and timeframes to successfully organize a comprehensive and efficient used fuel nuclear logistics system to safely transport used fuel in the public domain.

1- Typical logistical scheme to La Hague reprocessing plant

The La Hague reprocessing plant handles all the used fuel from the French nuclear power plants as well as used fuel from other nuclear plants worldwide, and it even treats used fuel form research reactors.

The typical logistical scheme to La Hague reprocessing plant involves a multi-modal system composed of road, rail, and sometimes maritime transport means, as well as multi-modal terminals to allow the safe transfers of packages from one transport mean to another.

Used fuel is collected from nuclear power plants, or from temporary storage facilities (dry or wet), using licensed Type-B packages. Based on an overall logistical program shared with key stakeholders, the packages are transported, using this multi-modal system, up to the reprocessing plant where fuel assemblies are unloaded for re-processing.

Generally speaking, used fuel from French and European power plants are mostly transported by rail up to the Valognes rail-to-road terminal located 25 km from the La Hague site. Only a few French nuclear reactors located close to La Hague allow the transport of fuel directly by road to La Hague. The Valognes terminal is dedicated to the deconsolidation of transports for appropriate and timely deliveries to La Hague. The Valognes terminal is also a site where maintenance of rail equipment is conveniently operated by the AREVA TN team.

Used fuel from overseas reactors, such as Japanese or Australian, are transported by boat to the AREVA TN dedicated nuclear port in Cherbourg, and then delivered by road to the reprocessing site of La Hague.

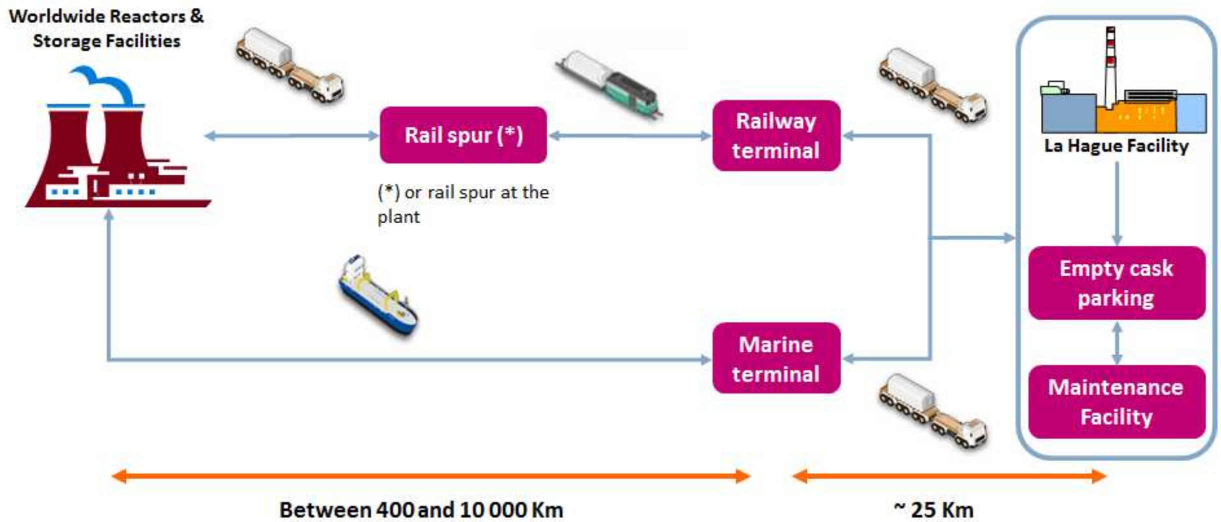

Figure 1: Typical logistical scheme to La Hague reprocessing plant

The 50 years operations of this plant has allowed the development of a strong and comprehensive logistical system, governed by one single entity, in charge of both transports and package management, involved in every steps of operations from the long-term planning, the preparation of transport, the design and obtaining of needed licenses and authorizations, the operations, the risk evaluation and management, the real-time tracking and emergency response preparation, the communication with customers, suppliers and authorities, and the issues related to public acceptance of transport.

2- AREVA TN's comprehensive logistical system

The AREVA TN comprehensive logistical system was first implemented almost 50 years ago, and to this date is still composed of the same key components:

- Human resources with world-class expertise,
- Strong management processes,
- Solid supply chain, and
- Dedicated equipment.

Human resources and expertise

AREVA TN human resources are located in Europe, Africa, the United States, Japan, Korea and China. Even though AREVA TN has business activities in other areas of the world, its human resources are mostly located close to where customers are located, thus enhancing communication. A total of 1400 employees are dedicated to logistics activities (transport and packages), including 140 nuclear material truck drivers and 60 nuclear freight forwarders for domestic and international transports. Employees benefit from a strong database of experience thanks to extensive worldwide operations in the past 50 years. This experience is fed back into the AREVA TN processes, in line with a rigorous quality system, thereby ensuring intensive training by which lessons learned are incorporated and assimilated for continuous improvement. Many of AREVA TN experts contribute to international organizations such as the World Nuclear Transport Institute (WNTI) and IAEA to develop a common understanding of various independent national regulatory issues and to propose future regulatory evolutions. They routinely interact with a number of nuclear safety authorities which contributes to a thorough understanding of safety options and safety demonstrations, as well as to a strong network in case of emergency or unexpected safety-related issues.

Management processes

In support of the experts and of operational resources, management plays a key role for the implementation of a safe and efficient nuclear logistics. An early choice of AREVA TN management was to define a centralized organization for all activities world-wide, from engineering to transport operations, even including a unique center for emergency response. This centralized organization covers each year on average 3 000 transports in the front-end of the nuclear cycle and another 3 000 transports in the back-end – *including over 200 used fuel casks transported each year*, in any mode of transport (rail, sea, road). *As of today, over 75 000 LWR used fuel assemblies, including more than 16 000 high burn up fuel assemblies.* This centralized organization provides management with the unique control of these sensitive operations world-wide, and it enhances the ability to manage crisis – *In AREVA TN, 4 to 6 crisis management drills are implemented each year* - taking the best possible operational feed-back into consideration – *In AREVA TN, over 1 000 formal lessons learned have been integrated into the system*.

Supply Chain

The organization of radioactive material transport requires a reliable supply chain which understands customer constraints and stakes, and which is able to implement the high quality requirements of the industry. For AREVA TN, the management of the supply chain is a crucial function involving regular audits and inspections as well as support programs and training to maintain the supplier at the highest level of motivation and expertise. *AREVA TN manages a panel of more than 200 suppliers to handle the transports of radioactive materials world-wide*.

Dedicated Equipment

The transport of used fuel requires specific equipment which AREVA TN designs, owns and maintains. Equipment required for used fuel logistics is determinant in the shaping of the overall logistical system as well as for the overall used fuel program, and it largely contributes to the system’s efficiency. Additionally, the management of dedicated equipment provides for the best guarantees in terms of equipment control, and in terms of maintenance and compliance with the corresponding safety analysis reports. Furthermore, using dedicated equipment reduces the risk of contamination of logistics equipment that could, at some point in time, find itself employed in the conventional transport industry.

3- Key milestones and timeframe to set-up a typical comprehensive logistical system

a. A typical full scale used fuel multi-modal nuclear logistics system, such as the one designed for France, requires a long time to be set-up in a given country. We can divide this overall process into three phases, namely a Long-term Phase for actions needed from the beginning, a Mid-term Phase for actions in the mid-range of the process, and a Short-term Phase for the latest actions needed prior to the start of operations (T0). Looking at the French experience, the Long-term Phase started approximately 15 years before T0, the Mid-term Phase started approximately 10 years before T0, and the Short-term Phase started approximately 5 years before T0.

b. Each Phase can be divided into major steps as presented below.
    - i. Long-term Phase (12 to 15 years to T0)
        1. Step 1: Definition of the overall scheme
            - a. Transport features and applicable regulations, codes and standards
            - b. Assets / sizing (package fleet, equipment, team)
            - c. Resources needed
            - d. Resources
            - e. Suppliers charters and types
            - f. Transport management model
        2. Step 2: Long-term planning
            - a. Key implementation phases
        3. Step 3: Process design
            - a. Logistics scheme
            - b. Key processes and procedures
    - ii. Mid-term Phase (8 to 10 years to T0)
        1. Step 4: Key selections
            - a. Supplier selection and qualification
            - b. Resources system ramp-up and training
            - c. Assets acquisitions
        2. Step 5: Implementation
            - a. IT tools development
            - b. Physical protection and Safety programs
        3. Step 6: Information and preparation

a. Public acceptance program
b. Emergency response preparation
c. Media support, training

iii. Short-term Phase (3 to 5 years to T0)

1. Step 7: Scheduling
    a. Transport authorizations
    b. Transport scheduling
2. Step 8: Transport operations
    a. Transport preparation
    b. Packaging and loading
    c. Transport performance
    d. Tracking
    e. Emergency response
    f. Continuous improvement implementation

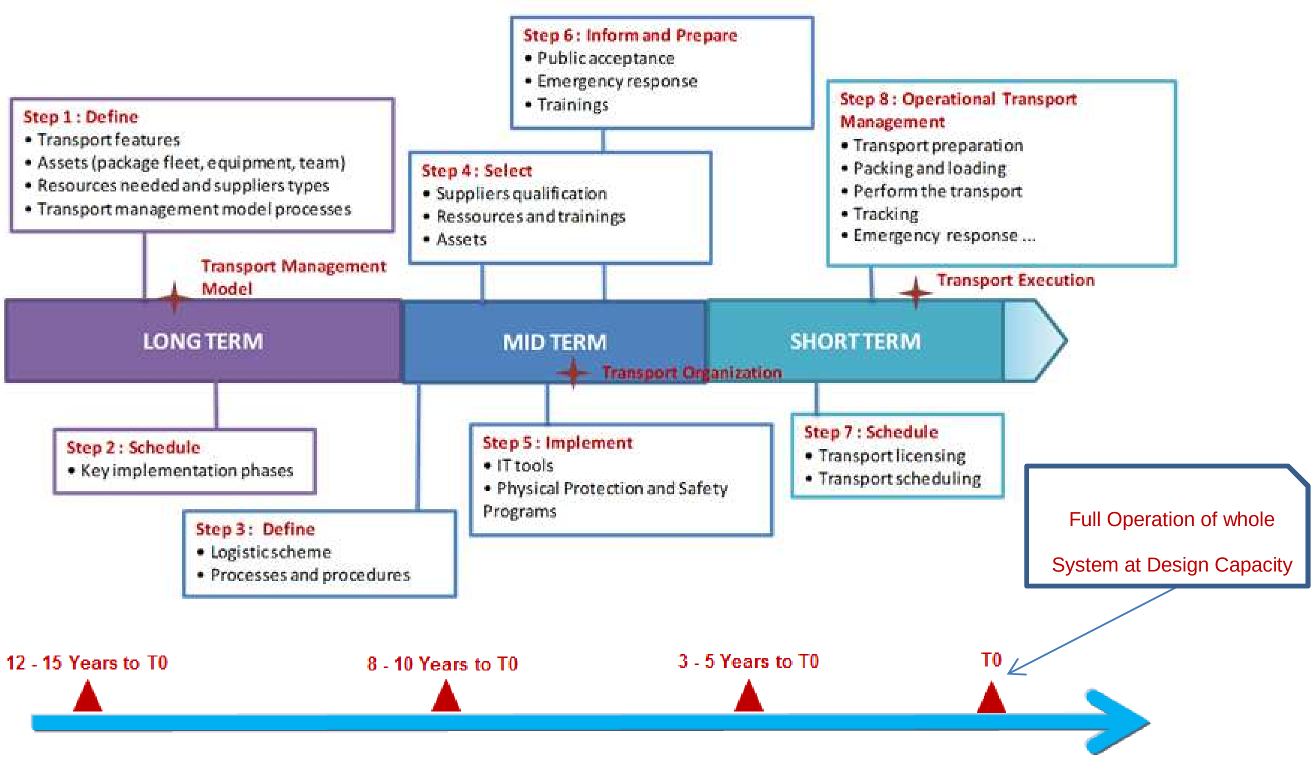

Figure 2: Typical timeframe for a full scale multi-modal used fuel logistical system:

4- The situation in the United States

a. Due to a lack of back-end options, used nuclear fuel in the United States has been accumulating on reactor sites, firstly filling the reactor pools, then being transferred to on-site interim dry storage facilities. The license of such on-site dry interim storage sites limits the number of used nuclear fuel assemblies allowed to be stored on site, thus threatening the life duration of the nuclear power plants (NPPs) and increasing the risk of early shutdown. Power companies have been searching for solutions to manage this risk, such as removing used fuel from reactor pools and creating additional storage. The Department of Energy (DOE) being in charge of used fuel, a number of projects have been launched to evaluate options, including the transport in the public domain of used fuel from the storage sites to a centralized storage site located off-reactor-site. Due to the long distances between nuclear power plants in the United States, it is assumed that transportation to off-site storage sites will be long-distance, and therefore regulations and standards have been established for both the design of railcars and for the transport of used fuel by rail. Such railcars are being designed with advanced safety features to meet the stringent requirements specified by the railroad industry for these highly sensitive transports. AREVA TN has already obtained the NRC license for its used fuel transport casks (The MP-197HB allows transport in the public domain of canisters even containing high burn-up fuel that were previously stored on NPP sites), and industry follows suit by studying the feasibility of canister transports as well.

b. In 2015, DOE assigned a budget and awarded AREVA a contract to design and fabricate prototype railcars dedicated to the transport of used fuel and high-level radioactive materials to such centralized storage site. The project is quite preliminary in the process. It is expected that the complete set-up of an industrial full-scale logistical system to remove used fuel from the US utilities to a centralized storage site will require numerous stakeholders to be aligned for the preparation, for a common understanding of business-sound investments and for an industrial acceptance from the supply chain - notably from the conventional rail industry, and from the public as well. It will require as well strategic political or administrative guidance to define the roles and responsibilities of industrials versus government (DOE). Needless to say, it is likely to take years for proper set-up, as referred to in the "*Typical timeframe for a full scale multi-modal used fuel logistical system*" shown in

Figure 2.

5- The situation in China

a. China has decided to implement a closed cycle policy with recycling of used nuclear fuel. It is estimated that a ramp-up of used fuel transportation will happen between 2025 and 2030 reaching approximately 200 transports per year by the time the recycling plant is able to receive used fuel and begin operations in 2030. Then transports will continue to grow at a steady pace to fulfill the closed cycle policy for each and every nuclear power reactor in China. During this early ramp-up period, it is assumed that used fuel will be transported from various coastal NPPs to a centralized storage site, whose location is not yet decided, for recycling. A number of key assets, a full-scale process, and a strong supply chain will be required at that time to achieve this ramp-up within the required safety level of the Chinese authorities, with the acceptance of the public in highly populated areas where reactors are located today, and with the needed optimized economics induced by the unavoidably long transport distances to deliver fuel. As in other nuclear countries, clear regulatory requirements, definition of roles and responsibilities between industry and government, and long-term planning will be key success factors. Without them, industry might hesitate to invest, fail to prepare, and neglect economics efficiency.

b. It can be assumed that preparation for such large-scale nuclear transports of used fuel across China will take many years, as it is the case for every other country. Benchmarks from other countries and experience sharing on large-scale used nuclear fuel transport will probably benefit the Chinese nuclear industry in achieving its target for 2030 without risk.

Conclusions:

Used fuel transportation in the public domain requires a fully integrated logistical system to guaranty the highest safety and efficiency, as required by the Chinese nuclear industry. Experience from France, where industry and administration aligned objectives over fifty years ago for the development of their nuclear industry, demonstrates that 10 to 15 years are required to develop a safe and efficient full-scale logistical scheme to safely and efficiently deliver used fuel across populated areas. Countries such as the United States and China are in the very early stage of such nuclear logistics design. International benchmarks and support from experienced companies such as AREVA TN should contribute to safe and efficient development of such challenging logistical programs, to the benefit of the nuclear back-end industry as a whole.