



**Radioactive Material Transportation  
Requirements for the Department of Energy**

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# Radioactive Material Transportation Requirements for the Department of Energy

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**Abstract.** The Department of Energy (DOE) created the National Transportation Program (NTP) whose goal is to ensure the availability of safe, efficient, and timely transportation of DOE materials. The Integration and Planning Group of the NTP, assisted by Global Technologies Incorporated (GTI), was tasked to identify requirements associated with the transport of DOE Environmental Management (EM) radiological waste/material. A systems engineering approach was used to identify source documents, extract requirements, perform a functional analysis, and set up a transportation requirements management database in RDD-100. Functions and requirements for transporting the following DOE radioactive waste/material are contained in the database: high level radioactive waste (HLW), low-level radioactive waste (LLW), mixed low-level radioactive waste (MLLW), nuclear materials (NM), spent nuclear fuel (SNF), and transuranic waste (TRU waste). The requirements will be used in the development of standard transportation protocols for DOE shipping. The protocols will then be combined into a DOE Transportation Program Management Guide, which will be used to standardize DOE transportation processes.

## INTRODUCTION

DOE made 13,000 shipments of hazardous materials in 1998, 5,000 of which were radioactive material shipments. The DOE radioactive material shipments account for 0.17% (5,000 out of 3 million) of all radioactive material shipments made in the United States (US) in a year and 0.001% (5,000 out of 300 million) of all hazardous material shipments (DOE 1999). However, DOE shipments account for about 75% of the total curies shipped in the US. The number of radioactive material shipments made by DOE will

increase as the sites begin cleaning up contaminated areas and as Foreign Research Reactor (FRR) SNF is shipped back to the US.

This paper describes the process used to develop the transportation requirements management database and possible future work that can be done to enhance the database.

## OBJECTIVES FOR DEVELOPING THE REQUIREMENTS DATABASE

The primary objectives for developing the transportation requirements management database include:

1. Identify all hazardous material requirements associated with the transport of DOE EM radioactive waste/material (HLW, LLW, MLLW, NM, SNF, and TRU waste).
2. Categorize the requirements according to transportation function, waste/material stream {including any specific site/project [e.g., FRR, Waste Isolation Pilot Plant (WIPP)]}, and transportation mode [highway, rail, vessel, or air (The air transportation mode was not part of the project. However, air transport requirements were recorded as they were encountered)].
3. Develop a comprehensive set of requirements that can be used to support the DOE Standard Transportation Protocol development and the Transportation Program Management Guide, which will help to standardize the way DOE transports their hazardous material.
4. Identify ways to reduce the cost of transporting DOE EM radioactive waste/material without affecting operational safety by associating costs to each function.

## SYSTEMS ENGINEERING APPROACH

A systematic approach was used to identify and manage the requirements associated with transporting DOE radioactive material. Hazardous material transportation requirements affecting DOE have been established by the Department of Transportation (DOT), the Nuclear Regulatory Commission (NRC), DOE, other federal and state agencies, and stakeholders.

A systems engineering approach has been used in managing the requirements. Source documents have been identified, requirements extracted, and a functional analysis has been performed. The data is now available to assist in developing a standardized DOE transportation process. In addition, internal and external derived requirements imposed on DOE can easily be identified (these would be requirements imposed on DOE but not on commercial transporters of radioactive waste/material).

RDD-100, a systems engineering software package developed by Ascent Logic Corporation, has been used to manage the data. Using RDD-100 has helped to develop the interrelationships between the requirements, functions, and documents.

## SOURCE DOCUMENTS

Over 127 documents were identified that may apply to transporting DOE radioactive material. Fifty-three were determined to be relevant to the project and classified as source documents. The source documents have been categorized as: regulatory, internal, or external.

**Regulatory documents.** Regulatory documents are defined as documents that have been issued by federal and state agencies and international organizations. They do not include any document generated or issued by DOE or their subcontractors. They may include: the Code of Federal Regulations (CFR), ANSI standards, etc.

The NRC and DOT share primary responsibility for the control of radioactive material transport in the US, based on a Memorandum of Understanding (MOU 1979). In general, DOT regulations (Section 49 of the CFRs) are more detailed. They cover all aspects of transportation, including packaging, shipper and carrier responsibilities, documentation, and all levels of radioactive material from exempt quantities to very high levels. The NRC regulations (10 CFR) are primarily concerned with special packaging requirements for high level radioactive materials (e.g., HLW, SNF, NM). NRC regulation 10 CFR 71.5 requires NRC licensees transporting radioactive material to comply with the DOT hazardous material regulations.

**Internal documents.** Internal documents have been prepared and issued by DOE and/or their support

contractors. They may include: DOE Orders, Records of Decision, Environmental Impact Statements, Implementation Plans, etc. These documents contain requirements that DOE has agreed to follow during the transportation process.

**External documents.** External documents are those that have been published by organizations outside of DOE and the regulatory agencies. They may include documents published by the Western Governors Association or other stakeholders.

## REQUIREMENTS

Source documents were reviewed and requirements extracted and input into RDD-100. Each requirement is documented according to the source document it was extracted from.

The requirements have been categorized as follows (based on the document categorization):

- External requirements – Those extracted from regulatory documents that, if not followed, would lead to illegal operations and possible fines.
- Internal derived requirements – Those extracted from source documents produced and issued by DOE and its support contractors. These are DOE self-imposed requirements.
- External derived requirements – Requirements extracted from source documents that are not regulatory in nature or from DOE (e.g., stakeholder requests). DOE has an option to follow these requirements; however, justification for non-compliance will be required from the organization issuing the document.

The goal was to write each requirement as a single stand-alone requirement that is defensible and measurable. Each requirement is a summary of the verbatim text extracted from the source documents. For example: 49 CFR 173.22(c) states the following:

“Prior to each shipment of fissile radioactive materials, and Type B or highway route controlled quantity packages of radioactive materials (see §173.403), the shipper shall notify the consignee of the dates of shipment and expected arrival. The shipper shall also notify each consignee of any special loading/unloading instructions prior to his first shipment.”

This verbatim statement has been summarized into nine separate requirements three are presented below that deal with transporting highway route controlled quantity (HRCQ) materials. The six other requirements are worded the same as the ones below but the material has been changed to Type B and fissile materials.

1. Pre-shipment notification for HRCQ materials shall include special loading/unloading instructions prior to the first shipment.
2. The shipper shall notify the consignee of the shipment dates prior to transporting HRCQ material.
3. The shipper shall notify the consignee of the expected arrival date prior to shipping HRCQ material.

The focus of the project has been to identify those requirements that deal specifically with transporting hazardous material. Therefore, requirements that apply to all transportation activities (e.g., domestic goods, commercial transport, hazardous materials, radioactive waste/material) were not included.

Currently there are over 5,400 requirements in the database. Each requirement was recorded and sorted by waste/material type (HLW, LLW, MLLW, NM, SNF, TRU waste), transportation mode (highway, rail, vessel,

air), and the topical areas identified in Table 1. Sorting the requirements as they were extracted has saved time during the functional analysis portion of the project because it was easier to work with a smaller set of requirements when dealing with a specific function.

The DOE Senior Executive Transportation Forum has undertaken an initiative to evaluate DOE shipping practices and recommend standardization of those practices where appropriate. The topical areas designated with a “•” in Table 1 are protocol areas that the DOE Senior Executive Transportation Forum is currently standardizing. The other topical areas (designated with a “-” in Table 1) are transportation functions that are followed during the transportation process. The database has been used to identify specific functions and requirements for each protocol area, which is being used in the standardization process.

<b>Pre-Shipment</b>	- Loading
• Notification	- Inspections
• Inspections	- Exclusive use shipments
• Security	- Communication
• Public Information	- Mechanic qualifications
• Routing	<b>Accidents/Incidents</b>
• Training	• Notifications
• Emergency Planning	• Emergency Response
• Carrier/Driver Requirements	• Communications
- Other	• Remediation
- Categorize by DOT material category	<b>Post-Shipment</b>
- Package Material	• Inspections
- Safety	• Radiological Survey
- Mark Packages	- Other
- Label Packages	- Receive Material
- Placard/mark Vehicle	- Unload Transporter
- Prepare shipping documents	- Record Keeping
- License/Registration	- Communication
- Transporter qualifications	<b>General Transportation Requirements</b>
- Determine transportation mode	- Follow hazardous material regulations
<b>Shipment</b>	- Costs
• Transportation Operational Contingencies	- Quality Assurance
• Safe Parking/Safe Haven	- Export
• Tracking	- Import
- Other	- Exemption
- General Shipping requirements	

**Table1: Topical areas.**

## FUNCTIONAL ANALYSIS

A hierarchy of high level functions necessary to perform transportation was developed. Creating a function for each of the topical areas listed in Table 1 developed the hierarchy. Additional sub-functions were created under each of the topical area functions that address specific requirements associated with a transportation mode, waste stream, and/or site/project.

This is illustrated in Table 2, which shows the general shipping function (1.2.4.1) and related sub-functions. The general shipping function is specified by requirements that apply to all shipments of radioactive waste/material by all transportation modes. The first four sub-functions (1.2.4.1.1 – 1.2.4.1.4) apply to all shipments of radioactive waste/material and a specific transportation mode. Those sub-functions that apply to a specific radioactive waste/material stream and all transportation modes are then listed (1.2.4.1.5, 1.2.4.1.6, 1.2.4.1.7, 1.2.4.1.8, and 1.2.4.1.9). Additional sub-functions are developed under each of the specific radioactive waste/material stream sub-functions that deal with a specific transportation mode (1.2.4.1.5.1, 1.2.4.1.7.1, and 1.2.4.1.7.2) and/or a specific project (1.2.4.1.8.1 and 1.2.4.1.9.1). Therefore, the shipping functions and associated requirements that would apply to transporting NM by air would include (from Table 2): 1.2.4.1, 1.2.4.1.1, 1.2.4.1.7, and 1.2.4.1.7.1.

The function number (the number preceding the function name as shown on Table 2) indicates the position of the function on the functional hierarchy. The first number in the sequence indicates the type of hazardous material the function is associated with (1-radioactive waste/material, 2-all other hazardous waste). The second number in the sequence indicates the transportation phase (1-pre-shipment, 2-shipment, 3-accident/incident, 4-post-shipment, and 5-general). The protocol area is indicated by the third number in the sequence (the numbers vary according to the transportation phase). The remaining numbers do not represent specific items but relate to the waste/material stream, transportation mode, and site/project specific functions.

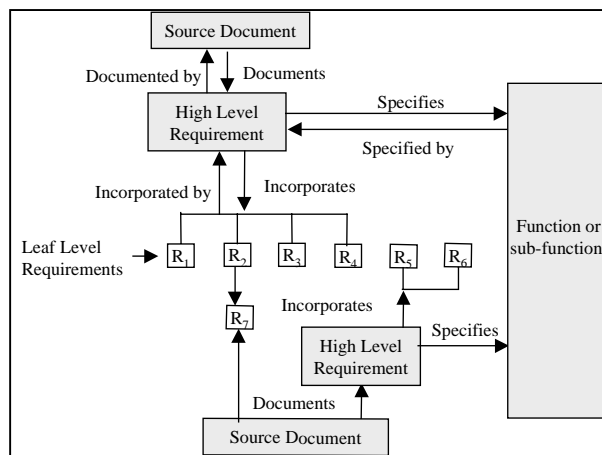
The functions are grouped according to the transportation phase: pre-shipment, shipment, accident/incident, post-shipment, and general. The pre-shipment phase includes all functions that are performed prior to allowing the radioactive waste/material on public thoroughfares. The shipment phase deals with the actual transport of the material. The accident/incident functions deal with notification of, responding to, and cleaning up a radioactive release that has happened during transport. The post-shipment

1.2.4.1 Follow general shipping requirements
1.2.4.1.1 Follow general air shipping requirements
1.2.4.1.2 Follow general highway shipping requirements
1.2.4.1.3 Follow general rail shipping requirements
1.2.4.1.4 Follow general vessel shipping requirements
1.2.4.1.5 Follow HLW shipping requirements
1.2.4.1.5.1 Follow HLW rail shipping requirements
1.2.4.1.6 Follow LLW/MLLW shipping requirements
1.2.4.1.7 Follow NM shipping requirements
1.2.4.1.7.1 Follow NM air shipping requirements
1.2.4.1.7.2 Follow NM vessel shipping requirements
1.2.4.1.8 Follow SNF shipping requirements
1.2.4.1.8.1 Follow FRR SNF shipping requirements
1.2.4.1.9 Follow TRU waste shipping requirements
1.2.4.1.9.1 Follow WIPP TRU waste shipping requirements

**Table 2: General shipping function and sub-functions.**

phase is associated with activities that are performed once the shipment has been received at the destination site. The last grouping, general, is not a transportation phase but is a section for those functions and requirements that do not fit one specific phase.

The interrelationship between the source documents, the requirements, and the functions are illustrated in Figure 1. A source document is reviewed for leaf level requirements (those requirements that summarize a verbatim statement taken from the source document). The leaf level requirements are grouped together into higher level requirements (these were developed at the request of the NTP Integration and Planning Group manager based on input from the protocol working groups). The requirements are associated with a function by specifying all functions that relate to a requirement. Requirements that are repeated in more than one document (e.g., R2 and R7 in Figure 1) are incorporated into the highest level document. For example: a requirement from an external document would be incorporated into the requirement from a regulatory or internal document, a requirement from an internal document would be incorporated in the requirement from a regulatory document. This way there are no duplicate requirements specifying a function or sub-function.



**Figure 1: Interrelationships between source documents, requirements, and functions.**

### FUTURE ENHANCEMENTS

**“Transportation” must be defined.** In other words, at what point in the treatment and transfer of radioactive waste/material from one facility to another does transportation begin and end. Establishing when one operation ends and transportation begins, and when transportation ends and another operation begins, will aid in determining the cost of transportation. For example, is loading material into a transportation package considered part of the transportation phase of a project? In order to ensure the material is properly packaged for transport it needs to be characterized and categorized according to DOT regulations. The categorization will determine the type of shipping package that should be used. This may be a very simple process and easily incorporated into the transportation phase (e.g., for DOE purposes SNF is packaged in Type B containers). However, it could be a very complicated procedure that would not be included within the scope of transportation (e.g., some of the TRU waste being shipped to WIPP needs to be characterized prior to loading into the transport package).

**Requirements.** The transportation requirements management database has been specifically designed to identify hazardous material requirements dealing with the transport of DOE radioactive waste/material. It can be expanded to include the transportation of other hazardous and non-hazardous materials. It presently models less than 1% of all transportation activities. However, this 1% is highly visible and often very controversial with the public because it deals with transporting radioactive waste/material.

The air transportation mode has not been fully developed because it was not part of the project scope. However, when air requirements were encountered while reviewing the source document they were

recorded and sorted into the functional hierarchy. All air transport requirements can be included in the database.

The requirements have been reviewed and agreed upon by the NTP Integration and Planning Group. However, to be an effective tool that can be used by all transporters of radioactive waste/material, the requirements should be presented to and agreed upon by other transportation organizations and regulatory agencies.

**Functional analysis.** Currently the database contains only high level functions. The high level functions need to be broken down into the lowest level of system behavior that can be observed. This will assist in future comparisons. It will also make it easier to identify specific functions that need to be accomplished during the transportation process.

**Cost analysis.** The source document “documents” a requirement, which “specifies” a function, that “consumes” a resource. The resource is generally monetary in the case of transportation. Therefore, in order to determine where costs can be reduced the lower level functions will need to be identified and then costs associated with them.

**Internet access.** The NTP Integration and Planning Group is currently working on putting the database on the Internet. This would allow transporters of DOE radioactive waste/material to have the regulations readily available on their computer broken down by functions and requirements. This will add in helping to standardize the DOE transportation procedures.

### CONCLUSION

A systems engineering process has been used to develop a transportation requirements management database. The process is in the beginning stages (only the requirements and functional analysis has been performed).

The database has been set up to collect, organize, and present all hazardous material transportation requirements established to regulate the transport of DOE EM radioactive waste/material. It is currently being used to review DOE protocol standardization procedures. At the present time the database shows the interrelationships between high level requirements, high level functions, and source documents.

Further enhancements to the database would allow transporters of all materials to determine proper procedures, functions, and requirements they are required to follow to be in compliance with DOT, NRC, international, and other federal and state regulatory transportation requirements. In addition, adding cost information to the database would allow transporters to

more accurately estimate the cost of transporting goods.

## **REFERENCES**

The following references have been cited in the paper:

Code of Federal Regulations, 1999 revisions.

MOU, 44 Federal Register 38690, "Transportation of Radioactive Materials; Memorandum of Understanding," July 2, 1979.

US Department of Energy National Transportation Program, "Transporting Radioactive Materials Answers to Your Questions," June 1999.

## **BIOGRAPHICAL SKETCH OF AUTHORS**

### **THANE W. BOLANDER**

**Biography:** Mr. Bolander has fifteen years experience in systems engineering, safety and risk assessment, hazard analysis, probabilistic risk assessment, and reliability. He has assisted in: identifying requirements for several Department of Energy (DOE) programs, writing safety analysis reports conforming to DOE regulations; performing various types of risk, hazard, and vulnerability assessments; and developing computerized databases for DOE environmental management and systems engineering. He assisted the Department of Defense perform facility hazard assessments and develop reliability models of several missile programs.

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**Biography:** Mr. Fawcett is recognized as a national leader in Transportation Systems Engineering and Stakeholder Involvement Strategies and has a unique blend of experience and education in industrial safety, systems engineering and environmental management. Mr. Fawcett has developed public and industrial safety programs for fixed facilities and transportation campaigns. He also has extensive experience in hazardous materials transportation both as a safety professional, a systems engineer and as an operations manager.