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Radioactive Waste Transportation Systems Analysis and Program Plan

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RADIOACTIVE WASTE TRANSPORTATION
SYSTEMS ANALYSIS AND PROGRAM PLAN

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FOREWORD

This report was prepared by Oak Ridge National Laboratory in cooperation with the Office of Waste Isolation and is part of the National Waste Terminal Storage Program. The principal objective of this program is to establish facilities in various deep geologic formations at several locations in the United States which will safely dispose of commercial radioactive waste. According to federal regulations, such wastes must be delivered to a federal repository for terminal storage. The Office of Waste Isolation Transportation/Logistics Study addresses problems associated with shipping these wastes to National Waste Terminal Storage facilities.

RADIOACTIVE WASTE TRANSPORTATION SYSTEMS ANALYSIS AND PROGRAM PLAN

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ABSTRACT

The objective of the Transportation/Logistics Study is to ensure the availability of a viable system for transporting the wastes to a federal repository in 1985. In order to accomplish this objective, a systems analysis of waste transportation has been directed by ORNL to determine the problems that must be solved and to develop a program plan that identifies which problems must first be pursued. To facilitate this overall approach and to provide for short- and long-range waste management, logistics models have been developed to determine the transportation fleet requirements and costs. Results of the study are described in this report.

EXECUTIVE SUMMARY

The identification of potential problems in nuclear waste transportation has been made, based on analyses of a large number of issues anticipated to impact nuclear material transportation in the United States between now and the year 2000. The most important problem issues were reviewed and selected for their relevance to the Office of Waste Isolation Transportation Logistics Study. Emphasis was placed on potential problems that were expected to have a severe or moderately severe impact between now and 1985—the target date for initiating the transport of waste to a repository. These problems involve regulatory uncertainties, railroad reluctance to transport nuclear material, risk assessment, cask facility interface requirements, low-level TRU waste shipping containers, security requirements, cask ownership, and water transport.

In order to address these concerns, a program plan has been developed in which 39 activities have been identified and divided into functional areas of responsibility. This plan is summarized in Fig. S-1 in where some of the more significant activities are noted.

Major activities that must be addressed in order to develop a viable transportation system involve the design, fabrication, testing, and licensing of suitable waste packages. These are covered in the first four topics shown in Fig. S-1. A number of preliminary studies must be pursued vigorously and completed on time since they will be required to establish design and performance criteria for the waste packages. These studies will be initiated in FY 78, as well as overall program planning and coordination functions that will be continued throughout the life of the program. Work in these areas are covered in the fifth and sixth topics of Fig. S-1.

The last two topics involve logistics and environmental assessment work. Logistics studies need to be stressed in FY 78 and FY 79 to develop information regarding cask fleet requirements and to pinpoint specific transportation problems related to the repository site selection. An environmental assessment of radioactive waste transport will then need to be developed as part of the overall environmental impact statement for the federal repository.

FIG. S-1. SUMMARY OF THE TRANSPORTATION PROGRAM PLAN

	FISCAL YEAR								
	78	79	80	81	82	83	84	85	
1. SPENT FUEL CASK		1	2	3	4		5		
2. LICENSING ACTIVITIES FOR SPENT FUEL CASK									
3. TRU WASTE SHIPPING PACKAGE	6	7	8	9			10		
4. LICENSING ACTIVITIES FOR TRU WASTE SHIPPING PACKAGE									
5. PLANNING AND COORDINATION		11	12	13	14	15		16	
6. CASK PERFORMANCE CRITERIA DEVELOPMENT									
7. LOGISTICS	17	18	19				21		
8. ENVIRONMENTAL ASSESSMENT OF RADIOACTIVE WASTE TRANSPORT									

SPENT FUEL CASK

1. CONCEPTUAL DESIGN COMPLETE
2. FINAL DESIGN COMPLETE
3. MODEL DESIGN COMPLETE
4. MODEL FABRICATION AND TESTING COMPLETE
5. FABRICATE PROTOTYPE

TRU WASTE SHIPPING PACKAGE

6. PRECONCEPTUAL DESIGN COMPLETE
7. CONCEPTUAL DESIGN COMPLETE
8. FINAL DESIGN COMPLETE
9. MODEL DESIGN, FABRICATION AND TESTING COMPLETE
10. FABRICATE PROTOTYPE

PLANNING AND COORDINATION

11. COMPLETE CASK FACILITY INTERFACE CRITERIA
12. CASK OWNERSHIP POLICY DETERMINED
13. SPENT FUEL CASK SECURITY REQUIREMENTS ESTABLISHED
14. FEDERAL TRANSPORTATION SYSTEM EVALUATION COMPLETED
15. ACCIDENT RESPONSE PREPAREDNESS STUDY COMPLETE
16. COORDINATE CASK AND PACKAGE FABRICATION

LOGISTICS

17. COMPLETE TRANSPORTATION COST STUDY
18. STUDY TRU WASTE LIMITS
19. EFFECT OF AWAY FROM REACTOR FACILITY ON REPOSITORY OPERATIONS
20. DEVELOPMENT OF REPOSITORY MANAGEMENT MODELS
21. EVALUATION OF REPOSITORY MANAGEMENT MODELS

1. INTRODUCTION

Waste transportation will form an integral part of the nuclear industry, irrespective of the options regarding reprocessing; therefore, its technical and political problems must be solved in order to ensure the long-range viability of the nuclear power industry in this country. Packaging and transportation systems for a few types of nuclear fuel cycle wastes now exist. Some of these systems will require modification or improvement as federal waste repository requirements are identified; systems for other fuel cycle wastes will be developed as needed.

The Office of Waste Isolation (OWI) authorized the Pilot Plant Section of the Chemical Technology Division at Oak Ridge National Laboratory (ORNL) to conduct a survey of the existing radioactive materials transportation system and to develop a comprehensive program plan that will ensure the availability of a transport system in 1985 capable of moving commercial radioactive waste in appropriate packages to a federal waste repository. The program plan is to consider spent fuel, low-level TRU waste (LLT), high-level waste (HLW), intermediate-level waste (ILW), and cladding hulls, with initial emphasis being placed on the first two types of wastes. This program would be the first of its kind aimed specifically at ensuring the movement of wastes to a federal repository on a specific time schedule.

It is important to note that, in accordance with OWI's direction, emphasis has been placed on developing an overall transportation systems approach to solving the problems. This implies, for example, that logistics capabilities must be developed to perform the necessary sensitivity analyses on all waste forms to be transported to the federal repositories. These capabilities are also necessary for long-range waste management. This approach would enable nontechnical problems to be addressed in an effective way. Only by taking a long-range view of the entire transport system and identifying all the logistic, political, and legal problems that affect this system will it be possible to maximize the likelihood of achieving the programmatic objectives.

2. PROGRAM DEVELOPMENT

To meet the stated objective, a scoping study was conducted to identify problem areas that could, if not recognized and solved, restrict the movement of waste in 1985. The need for rapid development of background information for the study necessitated the development of an aggressive plan to organize and utilize the expertise of a group of people already knowledgeable in the field of radioactive materials transport and to extract information through a series of meetings and reports. Four organizations that appeared to best meet the programmatic needs were chosen, and each was awarded a subcontract to supply information based on their particular area of expertise. The subcontractors were Nuclear Assurance Corporation (NAC), Rockwell International, Rocky Flats Plant (RFP), Battelle Pacific Northwest Laboratories (PNL), and Allied-General Nuclear Services (AGNS). Reports were prepared on the information developed for OWI.

The information then formed the framework of a series of concerns (presented in Sect. 3) which are identified as having the potential to seriously interfere with the overall programmatic objective. The potential problems identified as most important have consequences that may impact the overall state of future preparedness for transporting nuclear waste. Other important

concerns relate to the imposition of unnecessarily severe and costly restrictions on nuclear waste transportation, public and carrier acceptance, and the involvement of interested parties in planning and decision making.

As a result of these concerns, a series of actions were identified which are expected to help mitigate these problems. These actions, as discussed in Sect. 4, are aimed at developing all aspects of a nuclear waste transportation system and are scheduled so that their completion dates will facilitate and support the design, licensing, and fabrication efforts required to build adequate numbers of shipping containers. Failure to make certain important decisions in a timely manner can affect the overall program.

3. PROGRAMMATIC CONCERNS

The identification of potential problems in nuclear waste transportation is based on the analyses of a large number of issues anticipated to impact nuclear material transportation in the U.S. between now and the year 2000. These analyses were performed by the individual subcontractors, and also in part by PNL, in the related project "Energy Material Transportation Now Through 2000,"⁴ which was sponsored by the Energy Research and Development Administration.

The most important problem issues were reviewed and selected based on their relevance to the OWI Transportation Logistics Study. Emphasis was placed on potential problems that are expected to have a severe or moderately severe impact between now and 1985, the target date set for initiating the transport of waste to a federal repository. Some of the concerns are in areas that are the responsibility of the Department of Energy (DOE) or other federal agencies and therefore are not the direct responsibility of the OWI Transportation Logistics Study.

The problem issues are identified below, and each is stated as a concern. Each concern is followed by a brief explanation.

3.1 Regulatory Uncertainties

Concern

Both federal and state regulations governing the packaging and shipment of radioactive material are evolving. What appears to be relatively minor changes in acceptable regulatory criteria can evoke major changes in the design, licensing, and carriage of the packages.

Basis of Concern

General concerns regarding regulatory uncertainties can be categorized into five generic areas: agency authority, waste acceptance criteria, safeguards, radiation standards, and acceptable risks. Each is discussed below.

3.1.1 *Agency authority*

Both the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) regulate various facets of radioactive materials shipment. The line of authority is fairly well defined between NRC and DOT; however, it is not as well defined elsewhere, such as between these and other federal agencies (e.g. the Environmental Protection Agency (EPA), Interstate Commerce Commission (ICC), etc). Each agency continues to review its responsibilities to the public and changes or interprets its regulations as it perceives the need. The lack of focus and specific guidelines leaves the shipper uncertain as to where responsibilities lie and also affects the willingness of private industry to assume long-term risk of capital funds.

In addition, regulations at the state and local levels are being considered in various parts of the country which may needlessly restrict the free flow of nuclear materials and impose severe economic and logistical burdens.

The Hazardous Materials Transportation Act (49 U.S.C. 1801), which became effective January 1975, delegates very broad authority to the DOT to issue and enforce regulations for the purpose of ensuring the safe transportation of hazardous materials, including radioactive materials. The Act provides that any state or local regulation that is inconsistent with a DOT regulation is preempted unless the local regulation (1) affords an equal or greater level of protection and (2) does not unreasonably burden commerce. Several states and cities have proposed or enacted laws concerning the shipment of nuclear materials that exceed existing federal requirements. The list includes, New York City, New York State, Connecticut, Indiana, and Cincinnati, Ohio. The states of Washington, Oregon, Minnesota, and Illinois have similar legislation pending.

Although the federal government is currently challenging the city of New York's right to ban shipments of radioactive materials across its jurisdictional boundaries, the government may be reluctant to challenge many local or state governments at the same time. While anticipated litigation is in progress, the existence of local transport regulations could result in the imposition of severe economic penalties on nuclear waste transportation.

3.1.2 *Waste acceptance criteria*

Other uncertainties about future regulations relating to the transportation of nuclear waste are anticipated to impact logistic planning and systems development. For example, under current regulations, nontransuranic, low-level wastes (LLW) can be disposed of at commercial burial grounds. The potential imposition of regulations defining limits for which waste is classified as LLW (requiring shipment to a repository) may result in a substantial increase in the amount of waste material to be transported and disposed of in a federal repository. An upper limit for nontransuranic waste of 10nCi/g is already in effect in South Carolina, Illinois, and Kentucky. The repository acceptance criteria for spent fuel and reprocessing waste must also be set before final package designs can be initiated. Failure to establish this criteria in a timely manner will delay the entire program.

3.1.3 *Security*

It is expected that by the time a federal repository is operational, transportation security requirements similar to those imposed on special nuclear materials may be extended to cover spent fuel and radwaste. Such regulations may be required to protect against sabotage activities, or to prevent unauthorized diversion. Thus the safety analysis that is required to obtain the NRC Certificate of Compliance may have to demonstrate compliance with the Code of Federal Regulations (CFR), Title 10, Section 71 (Packaging and Transportation) and Section 73 (Safeguards). If the analysis is reviewed by two separate groups within NRC, each having different requirements and objectives, the procedure for obtaining a Certificate of Compliance will become more complicated.

3.1.4 *Radiation standards*

The lack of a specific methodology for establishing reasonable limits for new federal safety and radiation standards may result in the imposition of unrealistically severe restrictions on nuclear waste transportation.

Shipments of nuclear materials are generally transported in routine commerce via conventional transportation systems and are subject to the same accident environments as nonradioactive cargo. Packaging standards and shipping regulations designed to protect the public and transportation workers from excessive exposure to radiation during and after shipment of nuclear fuel and waste are found in Title 10 (Energy, NRC) and Title 49 (Transportation, DOT) of the CFR. The regulations include certification criteria used for packaging Type B and large-quantity shipments.

Because of the low external dose rates permitted, public exposure will be minimal. Exposures in this range will be similar in magnitude to normal background radiation. However, if governmental agencies conclude that exposures from radioactive materials shipments are not as low as reasonably achievable (ALARA), some tightening of the radiation dose standards could follow. This could result in changes in the definitions of Type A and Type B quantities for radioactive materials [49 CFR 173.389 (e)], or in changes in allowable package dose rate specifications [49 CFR 173.393 (i) and (j)]. Such changes could have serious implications on the design and capacity of packages used to transport nuclear waste. The application of such standards could become counterproductive and result in the need for many more shipments each with lower external dose rates.

3.1.5 *Acceptable risks*

The current lack of a federal policy on acceptable risk levels and on trade-offs between safety and economics may result in the imposition of unnecessarily stringent safety requirements, which would, in turn, make the cost of transporting nuclear waste unnecessarily expensive. This concern emphasizes the need for a policy on acceptable risk levels based on safety standards which are (1) reasonable, (2) based on safety-economic value comparisons, and

(3) generally consistent with the shipping standards for both nuclear and nonnuclear hazardous materials.

3.2 Railroad Reluctance to Transport Nuclear Materials

Concern

The reluctance of the railroads to carry nuclear materials must be resolved in order to establish confidence that crucial railroad service will be available for the future transport of nuclear waste.

Basis of Concern

This reluctance seems to be based on several factors. One factor relates to the railroads' analysis of relative monetary return versus risk potential. The degree of risk involved in nuclear material transport is a strong deterrent, particularly since nuclear materials would compromise only a small portion of the railroads' business. Another significant concern is whether the railroads will be liable for damages resulting from an accident, successful diversion, or sabotage of nuclear materials in transit. A related concern is whether an accident might close down a section of track for an extended period of time and thereby seriously disrupt other rail transport and also create additional public relations problems. Finally, the railroads identify the lack of risk assessment, based on demonstrated failure thresholds of shipping containers, as an important reason to question the adequacy of nuclear material transportation safety in the railroad environment.

The railroads are attempting to ensure, in part, that they receive a complete release from any and all liability regardless of whose failure or negligence caused the accident. Additionally, they would place the costs involving repair and or replacement of damaged railroad property, or cost of defense of any claims, entirely on the shipper. They also wish to reserve the right at all times to refuse to move a shipment, with or without cause, unless the shipment is already in transit.

The Board of Directors of the Association of American Railroads has recommended that railroads act only as contract carriers rather than common carriers. If permitted to do this, the railroads could subject utility operators and others to their unilateral restrictions, which include, among other things, the use of special trains for shipment of spent fuel from nuclear reactors to storage or reprocessing sites and possibly for the return trip of the empty, but internally contaminated, casks. These special trains would be subject to speed, passing, and no-other-freight restrictions. It is virtually certain that if these restrictions become effective, they will also be imposed on HLW shipments and, very likely, on shipments of other nuclear wastes.

3.3 Risk Assessment

Concern

The lack of risk assessment capabilities based on demonstrated failure thresholds of shipping containers is an impediment to public and carrier acceptance of nuclear material shipments.

Basis of Concern

The lack of risk assessment capabilities is one of the more important concerns expressed by carriers and some special interest groups. Some have expressed a concern that existing regulations are not stringent enough and, as a result, would like to require absolute safety for shipments of radioactive materials, irregardless of the type or associated activity. Absolute safety is, of course, impossible to achieve and is not imposed on other shipments of hazardous materials. However, developing a relationship between regulatory criteria and actual accident conditions would reduce the level of criticism which has been directed at current risk assessment methods and would be understandable by more of the nontechnically oriented community.

3.4 Accident Response Preparedness

Concern

Uncertainty about the extent of accident response preparedness and public liability could result in increased adverse reaction of carriers and the general public to the transportation of nuclear waste materials.

Basis of Concern

Uncertainty exists concerning the potential effectiveness of accident response plans, particularly at state and local levels. The NRC Radiological Emergency Response Operations Course provides an educational program for local authorities and public safety service personnel. The question remains whether a sufficient number of trained personnel would be available at the site in a timely manner should a serious nuclear transportation accident occur. Lack of adequate response capabilities may become an important basis for adverse carrier and public reaction to the transportation of nuclear waste materials.

The Price-Anderson Act (42 U.S.C. 2210) provides financial protection for both the licensee and the public. Licensees of nuclear facilities are required to have private insurance available through insurance pools. Currently, the pools provide a maximum of \$125 million in coverage. Beyond this level, the federal government will indemnify licensees up to a maximum of \$560 million, the absolute limit of liability. Carriers of nuclear material do not participate in the insurance pool, and the maximum extent of their liability is uncertain. The NRC is

currently considering whether the Price-Anderson system should be extended to specifically provide for separate indemnity agreements to cover nuclear materials in transit. However, a North Carolina district judge recently determined that the \$560 million Price-Anderson liability limit was unconstitutional. Should his opinion be sustained in appeal, the carrier could be liable for damages in excess of the Price-Anderson indemnity limit.

3.5 Cask Facility Interface Requirements

Concern

Lack of definite waste-receiving specifications and cask-handling criteria for the waste storage facilities will delay the cask design effort and compress the licensing and fabrication schedule.

Basis of Concern

Without detailed knowledge of waste package sizes, physical and radioactive characteristics of the waste, etc., it is impossible to design the shielded shipping packages to transport the waste efficiently and impossible to optimize the logistics of the cask movements. Cask interface problems, both at the waste-generating and repository sites, must be resolved early in the cask design phase.

In addition, if needed specifications are not decided upon in the near future, there may be insufficient time to design the casks, complete the certification procedure, and then fabricate a sufficient number of new casks by 1985.

3.6 Low-Level TRU Shipping Containers

Concern

Alpha-contaminated waste shipments are currently being made in shipping containers which may not meet NRC requirements in the near future.

Basis of Concern

Low-level alpha waste shipments from the defense program are being moved by rail in government-owned ATMX rail cars. The Safety Analysis Report on Packaging (SARP) for this shipping system has been submitted to the NRC. However, the package has not been tested under accident conditions. For this and other reasons, a license may not be granted. In addition, new regulations that become effective in June 1978 (10 CFR 71.42) require that plutonium-containing packages maintain two effective lines of containment following exposure to the hypothetical accident conditions. As a consequence, new designs for the low-level alpha waste shipping package may be required before commercial waste material can be shipped by rail to federal repositories.

3.7 Security Requirements

Concern

Security requirements, developed for the protection of some waste shipments, may result in the need to establish a government transportation network to move those materials from their point of origin to their final destination. Such a decision could impose a serious economic burden on the government.

Basis of Concern

Security requirements for most waste materials are in a state of evolution. Government controls and couriers for the more strategically sensitive materials may be required. These requirements may lead to the establishment of a government-controlled transportation network. Advantages of such a network include the ability of armed escorts: (1) to operate in any state, (2) to utilize government communications networks that are already established, and (3) to utilize government facilities in emergencies (such as military bases). However, the cost to the government of such a system is high, and a decision on whether to pursue this goal needs to be made soon.

3.8 Cask Ownership

Concern

The question of ownership of the shipping cask fleet required to service a federal waste repository should be investigated to determine whether it should reside with the government or private industry. Results may be affected by the decision on where the government takes title to the waste material.

Basis of Concern

Waste shipping casks will have to conform to not only NRC and DOT requirements but also those of the federal repository. The cask fleet that must handle all waste forms will be large and the economics of buying versus leasing from private corporations should be investigated if it is decided that the government will be responsible for providing any part of the transportation link between generation, storage, and disposal site.

Private industry has and can produce the needed casks but will not become involved unless there is sufficient economic incentive. A determination must be made as to what business considerations must be dealt with so that private industrial capabilities can be analyzed.

3.9 Water Transport

Concern

Uncertainties exist as to the availability of an adequate water transportation system for radioactive waste material within the confines of the U.S.

Basis of Concern

Previous shipments of large quantities of highly radioactive material in the U.S. have been made by truck and rail. Very little effort has been directed toward the possibility of utilizing navigable waterways to transport nuclear waste material. Although there have been international shipments of uranium hexafluoride, fresh fuel, etc., to and from the U.S. by ship, the only efforts to study the problems of barge shipment within the confines of the U.S. involves the American National Standards Institute Committee N 552. This committee is developing a report on the current status and potential problems of radioactive material waste shipments by barge.

Approximately 100 planned and operating nuclear power plants are sited on navigable waterways. Several of the proposed reprocessing plants will be sited on or adjacent to waterways. It is also possible that spent fuel storage facilities may be built on navigable waterways.

Commercial barge companies have given very little consideration to transporting nuclear waste materials by water since there had been no previous demand for this type of service. Regulatory control of large shipments will probably fall under the DOT Materials Transportation Bureau. At this time, the U.S. Corps of Engineers and the U.S. Coast Guard disclaim any regulatory responsibility. However, this situation could easily change when actual shipments are to be made.

4. PROGRAM PLAN

The purpose of the program plan is to describe in detail the activities necessary to ensure the availability of the transportation system to service NWTS facilities in 1985 and to show the relationships between these activities.

The program plan addresses all important transportation-related action items and how they interact in order to ensure an integrated approach to the problems. Oak Ridge National Laboratory, as manager of the Transportation Logistics study, was asked by OWI to assume the responsibility of (1) developing the comprehensive program plan, (2) updating it as required, and (3) coordinating work performed by outside contractors in support of it. As part of the program management functions, policies that affect the program and studies performed by appropriate organizations are to be identified by ORNL, in concert with OWI, to develop sufficient background information to permit establishment of the policy by OWI or DOE as necessary.

The current federal policy is that the government will take title to spent fuel, after it has been irradiated in a reactor, for long-term storage and or disposal. In addition, LLW (possibly TRU-contaminated) will also be generated by reactor operations and might be shipped to a repository for disposal. The program plan is geared to ensure that a viable transportation system will be operating in time to move these wastes to a National Waste Terminal Storage (NWTS) facility in 1985. Because of the long lead time required to design, license, build, and operate a fleet of shipping packages, it is vital that the initial design phases be addressed early and vigorously in the program. If government policies evolve that effectively change the type of wastes to be shipped to a federal facility, the program plan can be modified as required. If, at some time in the future, it is determined that private industry will design, license, fabricate, or own the shipping packages, then they would assume responsibility and control for those parts of the transportation system. This program plan does not mean the government will perform all the activities shown but will initiate, either in-house or offsite, those necessary to ensure the availability of the transportation system to service NWTS facilities in 1985. This is particularly true of the activities that must be started very early (e.g., cask conceptual design) while there are still many uncertainties.

Action items addressing the design and licensing of packages for reprocessing-related wastes (HLW, LLW, and cladding hulls) are not given in the program plan. Should government policy be modified to permit the reprocessing of spent fuel, the program plan will be modified at that time to plan the activities necessary to ensure the safe shipment of those wastes to a federal repository.

4.1 Program Organization

The program plan has been developed by identifying various topics (see Table 4.1) that must be addressed and organizing them into functional areas of responsibility. Each topic is broken down into individual action items as are shown in the program plan. The program plan is presented in the form of a bar net chart (Fig. 4.1) and is included in an envelope in the back of this report. The numbers of the individual action items shown in the program plan correspond to the subsection numbers of Sect. 4.2, where the topics are described (e.g., 4.2.13-Fabrication of Spent Fuel Casks is described in 4.2.13). Table 4.1 identifies all topics in the program plan, the functional area responsible for originating the activity, and the topic number.

It is recognized that basic policies governing the waste-related activities are developed by the DOE, who have ultimate responsibilities for the NWTS program and related transportation activities. Thus the first functional responsibility identified in the program plan relates to DOE policy decisions that must be made which affect the transportation program.

The second functional responsibility shown in the program plan is that involving OWI. Their prime responsibility is to manage the overall waste program and to locate, design, build, and license a waste repository for operation by 1985. The OWI initiated the Transportation Logistics Study in recognition of the fact that the transportation system would be a vital part of a viable waste management system.

Table 4.1. Project activities

<u>Activity number</u>	<u>Activity</u>	<u>Originating group and date</u>
1	Cask/facility interface criteria	Planning, FY-78
2	Evaluation of existing waste packages for long-cooled spent fuel shipments	Information gathering, FY-78
3	Spent fuel canisterization	Information gathering, FY-78
4	Shipping package performance criteria	Planning, FY-78
5	Design of spent fuel casks	OWI, FY-78
6	Design and fabrication of scale models of spent fuel casks	OWI, FY-80
7	Test procedures for spent fuel cask scale models	Cask performance, FY-80
8	Testing spent fuel scale models	Package fabrication, FY-81
9	SARP preparation for spent fuel casks	Planning, FY-80
10	Security in spent fuel and radioactive waste shipments	Planning, FY-78
11	Risk evaluation of the spent fuel cask	Planning, FY-79
12	Ordering of long lead-time materials for spent fuel casks	Package fabrication, FY-82
13	Fabrication of spent fuel casks	Package fabrication, FY-83
14	Environmental effects of spent fuel cask accidents	Environmental assessment, FY-83
15	Cask ownership	Policy, FY-78
16	OWI spent fuel study	OWI, FY-78
17	Study of spent fuel cask fleet requirements	Planning, FY-78
18	Impact of AFR facilities on transport systems	OWI, FY-79
19	Preconceptual design of TRU waste shipping packages	Planning, FY-78
20	Design of TRU waste shipping packages	OWI, FY-78
21	Risk analysis for TRU waste shipments	Planning, FY-79

Table 4.1. Project activities (cont'd)

<u>Activity number</u>	<u>Activity</u>	<u>Originating group and date</u>
22	SARP for the TRU waste shipping package	Planning, FY-80
23	Design and fabrication of scale models of TRU waste shipping package systems	OWI, FY-80
24	Establish test procedures for TRU waste shipping package systems	Cask performance, FY-80
25	Testing of TRU waste shipping package systems	Package fabrication, FY-80
26	Ordering long lead-time materials for TRU waste shipping packages	Package fabrication, FY-82
27	Fabricating TRU waste shipping packages	Package fabrication, FY-83
28	Update environmental effects and risks of TRU waste shipments	Environmental assessment, FY-81
29	Environmental impact statement for waste transport	Environmental assessment, FY-79
30	Evaluate impact of varying TRU waste limits	Information gathering, FY-78
31	Accident response preparedness	Planning, FY-80
32	ALARA	Risk evaluation, FY-78
33	OWI economics study	OWI, FY-78
34	State and local regulations	Planning, FY-79
35	Logistics models for reprocessed wastes	Planning, FY-78
36	Logistics models for repository management	OWI, FY-80
37	Carrier/industry/government interface	Cask performance, FY-78
38	Federal transport system study	Policy, FY-78
39	Feasibility of barge shipments	Planning, FY-79

The transportation program management responsibilities which involve the third, fourth, and fifth functional areas identified in the program plan include *policy* evaluation, program *planning* and coordination, and *information gathering*; these responsibilities have been assigned to ORNL. In the role of program manager, ORNL will help coordinate the transportation-related work that will be accomplished throughout the various DOE laboratories and elsewhere in support of this program.

The *policy* function involves identifying policies that need to be formulated, developing the appropriate background information, and making recommendations to the policy makers. Policy activities necessary in the next few years are identified, and it is anticipated that further policy activities will develop as the program continues.

Proper *planning* and co-ordination is the most important function of the Transportation Program manager and involves the integration of all the other activities. This will be an ongoing role throughout the life of the transport program and operation of the NWTS facilities. The planning activities anticipated in the near future are identified in the program, and more will be added continuously.

The *information gathering* function is assigned as a responsibility of the Transportation Program manager. The presently anticipated information gathering needs are shown in the program plan.

The sixth functional responsibility is that of *logistics*. This was anticipated from the first to be a very important part of establishing the transportation system, which is why it has always been used as a part of the study title. This work is being performed by ORNL, where computer programs for logistics have been developed and are now operational.

The thrust of the logistics work has two main goals: (1) to provide data on the amounts of transportation equipment required and preliminary transportation cost estimates during the early stages of the program and (2) to provide a means for managing the transportation system during the lifetime of the operating facilities. In order to do this, the logistic models utilized must be able to perform meaningful calculations early in the program, yet have the flexibility to be used for management of the transportation system at a late date. These logistics models, developed at ORNL, are described in Sect. 4.3 and Ref. 5, and are believed to be capable of handling these requirements. This activity is expected to continue through the operation of the NWTS facilities.

Action items that apply to the more technical functions of *performance criteria*, *package design*, *package fabrication and testing*, *risk evaluation*, and *environmental assessment* are also described in the program plan.

The items listed in the area of *performance criteria* must be completed to provide necessary input into the design and testing of the shipping packages. Work identified in package design area involves LLT waste packages and spent fuel casks. While major emphasis in the immediate future will be placed on these two containers, a low level of design-related effort will be continued on HLW, ILW, and cladding hulls packages. In this way, areas of commonality in package design will be emphasized to ensure rapid programmatic expansion involving these packages should government policy toward reprocessing be modified.

The *package licensing* function involves the preparation of a SARP in sufficient detail to show that all federal requirements are met. Development of the SARP will require close coordination and interaction between this function and the package design, fabrication and testing, and risk evaluation.

To provide factual information on the behavior of packages under severe accident conditions, package models must be built and tested. This work is included within the functional responsibility of *package fabrication and testing*. The development of such information should also be useful in providing factual accident-related information to special interest groups and the general public.

The functional responsibility of *risk evaluation* involves studies to evaluate the risk to the general public of shipping wastes to the federal repository. Also involved is a study of what effect ALARA requirements may have, if any, with respect to waste shipments.

The Environmental Impact Statement that is required to license a federal facility will include a section on transporting waste packages to and from the facility. The functional responsibility to develop this information is included within *environmental assessment* and is identified in the program plan.

4.2 Action Required

The action topics, identified by number in Table 4.1, are described from point of inception until they are completed or lead into a subsequent action item. The length of time required by each action item is easily identified in the program plan and is also discussed in the text.

4.2.1 *Cask/facility interface criteria*

The spent fuel shipping casks, to be constructed by the mid-eighties, must be compatible with the handling facilities at the repository. Away-From-Reactor (AFR) storage facilities, and reactors. The criteria for the cask facility interface must be specified well in advance of the final cask design effort.

In order to obtain the necessary data to specify both the shipper and receiver cask facility interface criteria, an *information gathering* study will be conducted in cooperation with facility design and cask design organizations. This study will take approximately 6 months during FY 78 and will produce a set of recommended package design criteria (see Sect. 4.2.5). The criteria would be forwarded to OWI for review and acceptance. The review within OWI would involve several groups and results are anticipated by the end of FY 78. All package designs are expected to be affected by the conclusions.

4.2.2 *Evaluation of existing waste packages for long-cooled spent fuel shipments*

A number of shipping casks have been fabricated and licensed for transporting short-cooled spent fuel assemblies. A study is required to determine whether these casks are adequate, economical, and operational for shipments of long-cooled spent fuel from reactors to AFRs and or to a federal repository. The effort required to modify the casks so that they may accept canisterized fuel assemblies must be identified. Questions involving whether the

Certificate of Compliance would have to be amended or reissued need to be addressed. This study should be completed by the end of FY 78.

4.2.3 *Spent fuel canisterization*

The location of a spent fuel canisterization facility will have a significant affect on the spent fuel package design as well as fleet size requirements. The magnitude of these effects should be determined during FY 78 in order to permit the development of contingency plans for the design of spent fuel casks.

4.2.4 *Shipping package performance criteria*

Cask performance criteria will be developed for packages that will be shipped from AFRs to a federal repository. The criteria will be written to ensure that the packages will be capable of surviving both severe transport accidents as well as severe accidents that might occur in the facilities to which and from which the packages will be shipped. The criteria may be transport-mode dependent and will be applied to shipping package design and testing to help ensure public and carrier acceptance.

4.2.5 *Design of spent fuel casks*

One of the major efforts in the overall OWI program involves the design of spent fuel casks capable of moving spent fuel from AFRs to a federal waste repository. The cask design effort will take approximately 2 years to complete. This effort, initiated by the Engineering Studies Section of OWI, must closely mesh with other related studies identified in this program. For example, the cask facility interface requirements (see Sect. 4.2.1) and the packages performance criteria (see Sect. 4.2.4) will influence this work. The design effort should be completed at the end of FY 80.

4.2.6 *Design and fabrication of scale models of spent fuel casks*

Testing of scale models is expected to play an important role in obtaining an NRC Certificate of Compliance. Design of the models will parallel the final design of the spent fuel casks. A contract will be initiated for spent fuel model designs in late FY 80. The design and fabrication of the models should be completed in FY 82. There must be a strong interaction between the model design effort and the spent fuel cask design effort. Models of the spent fuel cask should be ready for testing in FY 81 and FY 82.

4.2.7 *Test procedures for spent fuel cask scale models*

The physical testing procedures for the spent fuel cask models need to be established. The testing must address NRC requirements and any additional cask performance criteria (see Sect. 4.2.4) which must be met by the design. Development of the testing program will be a functional responsibility under *cask performance criteria*. The testing procedures should be completed in early FY 81.

4.2.8 *Testing spent fuel scale models*

Physical testing of scale model spent fuel casks to demonstrate compliance with NRC standards and ensure compliance with the cask performance criteria is expected to begin in mid-FY 81 and last for about 2 years. A suitable testing site will be selected to ensure the proper measurement equipment is installed. Both scale models and a prototype cask will be tested. Results will influence the risk evaluation and environmental assessment programs.

4.2.9 *SARP Preparation for spent fuel casks*

The SARP should be initiated approximately 6 months after the start of the final design for the spent fuel casks (midyear FY 80). The SARP will receive information on the final design effort (Sect. 4.2.5). Information generated in the *risk evaluation* (Sect. 4.2.11) will be incorporated into the SARP. It will be the functional responsibility of *licensing* to submit the SARP to NRC and modify the SARP in accordance with NRC review. This activity will follow the entire licensing procedure from initial preparation of the SARP through issuance of a NRC Certificate of Compliance. It is expected that this effort will continue for several years, extending through FY 83.

4.2.10 *Security in spent fuel and radioactive waste shipments*

Early in FY 79, a contract will be initiated to study security requirements that could affect, or that should be applied to, spent fuel and radioactive waste shipments. Information will be gathered during FY 79. Information developed in this study will be applied to spent fuel cask design and design of TRU waste shipping packages.

4.2.11 *Risk evaluation of the spent fuel cask*

A contract will be initiated in mid-FY 79 for a risk evaluation of the spent fuel cask under the NRC accident requirements. The project is scheduled to start shortly after the cask design work has started, and results will be utilized to adjust the cask design should it prove necessary. Results will also influence the preparation of the spent fuel SARP (Sect. 4.2.9) as well as the environmental impact statement for the repository (Sect. 4.2.29).

4.2.12 *Ordering of long lead-time materials for spent fuel casks*

As the licensing procedure for spent fuel casks progresses to the point where an issuance of a Certificate of Compliance appears likely, orders need to be placed for materials which require a long lead-time for delivery. Timely ordering of these materials will ensure their availability during cask fabrication. The responsibility for selecting appropriate suppliers and ordering materials for the spent fuel casks would probably reside with the OWI Engineering Studies Section. Critical materials for the prototype cask will be ordered during FY 82. Long lead-time items for the general cask fleet need to be ordered in FY 83. This effort will require close coordination with the organization fabricating the cask so that the necessary materials are available when needed.

4.2.13 *Fabrication of spent fuel casks*

Fabrication of a prototype spent fuel cask is expected to start in early FY 83 and should be completed early in FY 85 (a period of 2 years). Fabrication of the remaining spent fuel casks should commence in FY 84 and will be a continuing project as cask fleet requirements increase. The cask fabricator will be responsible for developing and implementing a suitable quality assurance program before fabrication is initiated.

4.2.14 *Environmental effects of spent fuel cask accidents*

As a result of tests performed on spent fuel cask models (Sect. 4.2.8), the radiological and nonradiological effects of accidents can be determined. Radiological effects will be evaluated as a function of package design and accident severity. The probability that certain accidents may occur can be established, and, as a result, the risk of shipping spent fuel can be determined.

4.2.15 *Cask ownership*

It must be determined who will build and operate the cask fleet that services a federal repository. Several options are available, ranging from complete government ownership and operation to ownership and operation by private industry. A study will be initiated late in FY 78 to collect background and economic information pertaining to the cask ownership. This study should require ~ 4 months and will culminate in a background paper on cask ownership. The information will be transmitted to OWI for review early in FY 79. After review, OWI may transmit the information to DOE for a decision on cask ownership. A decision is required by mid-FY 79 in order to efficiently integrate the efforts of private industry with the Transportation Logistics Program.

4.2.16 *OWI spent fuel study*

The executive order indefinitely delaying fuel reprocessing has changed the federal design basis for a waste repository. Originally, a repository was to store only reprocessing wastes. A repository will now have to be designed to store spent fuel assemblies, and a conceptual design study for spent fuel storage is in progress. The OWI will also shortly begin a systems study on spent fuel disposal. This particular study will be initiated in mid-FY 78 and will address the entire spent fuel disposal system, starting with the storage pools at the reactors and covering all subsequent activities, including transportation, packaging, storage, and disposal. Alternative locations to be studied for fuel storage facilities and repositories will require comprehensive evaluation of the transportation facilities required and their associated costs in order to complete the systems analysis required of this study. Consequently, logistics calculations for the various transportation system alternatives and combinations will be performed to support the system analysis segment of this study.

4.2.17 *Study of spent fuel cask fleet requirements*

The size of the cask fleet required to transport spent fuel from the reactors to AFRs and repositories will have a pronounced effect on the fabrication schedules. The number of casks required will be a function of cask capacity, the amount of fuel to be moved, and location of storage facilities. A study to evaluate the cask fleet size will be initiated in late FY 78. The study will primarily involve logistics calculations during FY 79. These calculations will contribute to the spent fuel cask conceptual design study (Sect. 4.2.5) to help evaluate various initial cask designs. These calculations will take into account the effect of changes in AFR and repository locations and must also incorporate various nuclear growth rate scenarios. The results of the study would provide input to the final spent fuel cask design effort and could also assist in managing spent fuel shipments.

4.2.18 *Impact of AFR facilities on transport systems*

Early in FY 79, it is anticipated that a study will be needed to investigate how potential AFR facilities might affect the transportation systems. Receiving rates and storage capacities assumed under various scenarios will be examined. A report outlining the impact of AFR facilities on the transport system will be prepared; the findings will be reviewed by OWI at the end of FY 79. This study will interact with the spent fuel cask fleet work (Sect. 4.2.17).

4.2.19 *Preconceptual design of TRU waste shipping packages*

It is likely that some existing TRU waste shipping packages will not be adequate for use in 1985. This study is to be initiated in mid-FY 78 and should be utilized to develop preconceptual package designs, evaluate the advantages and disadvantages of those concepts, and develop preliminary design criteria for the shipping package.

4.2.20 *Design of TRU waste shipping packages*

TRU wastes will be moving to a federal repository in 1985. An approved truck and rail shipping package system must be available by that date. A contract will be initiated by OWI for designing a TRU waste shipping package system in early FY 79. The design will be divided into two phases, a conceptual and a final design. New package concepts developed in the preconceptual design of TRU waste shipping packages (Sect. 4.2.19) will be evaluated. The conceptual design will occupy approximately 6 months. The final design of the TRU packages will be initiated in mid-FY 79. The final design effort is expected to last approximately 1 year, until late FY 80.

4.2.21 *Risk analysis for TRU waste shipments*

As part of the licensing procedures, it is important to determine the effect of accidents on the TRU waste shipping packages. Presently, much of the TRU waste is packaged in 55-gal drums which might be crushed or otherwise abused in various mishaps. A program to evaluate the risk of these shipments will be initiated early in FY 79 and is expected to take about 9 months. Information developed is expected to influence both the TRU waste shipping package design (Sect. 4.2.20) and the SARP (Sect. 4.2.22).

4.2.22 *SARP for the TRU waste shipping package*

Prior to the completion of the TRU waste shipping package design, the contract for SARP preparation will be initiated. The contract will call for SARP preparation to begin in FY 80 and continue until a Certificate of Compliance has been obtained. The SARP will be submitted to NRC where the review procedures are expected to last about 2 years. During this time, the SARP will be updated or modified as necessary to satisfy all NRC requirements. The Certificate of Compliance is expected to be issued about the end of FY 82.

4.2.23 *Design and fabrication of scale models of TRU waste shipping package systems*

Scale models of TRU waste shipping package systems need to be designed and fabricated for subsequent testing to obtain a Certificate of Compliance. This effort will be initiated by OWI early in FY 80. This effort will require about 8 months and will interact closely with the final TRU waste package design effort (Sect. 4.2.20). Fabrication of the scale models will take place during FY 80, and models should be available for testing by the end of FY 80.

4.2.24 *Establish test procedures for TRU waste shipping package systems*

The test requirements for TRU waste shipping package systems will have to be established prior to the time when scale models are subjected to accident-type tests. The test procedures will reflect the shipping package performance criteria which have been developed (Sect. 4.2.4).

4.2.25 Testing of TRU waste shipping package systems

Physical testing of TRU waste shipping package systems (or models) to demonstrate compliance with NRC standards is expected to occur in late FY 80 and early FY 81. The tests will follow the established testing procedures (Sect. 4.2.24).

4.2.26 Ordering long lead-time materials for TRU waste shipping packages

As the licensing procedure for TRU waste shipping package systems progresses to the point where issuance of a Certificate of Compliance appears likely, materials which require a long lead-time for delivery need to be ordered. Timely ordering of these materials will ensure their availability during fabrication of the waste package systems. The OWI will have responsibility for selecting appropriate suppliers and placing the necessary orders. Critical materials need to be ordered 6 to 9 months before the start of package fabrication.

4.2.27 Fabricating TRU waste shipping packages

Fabrication of the initial TRU waste shipping package system needs to begin during FY 83. This will be a continuing effort since the number of shipping packages will increase as the volume of waste being shipped to a repository increases. Responsibility for developing appropriate fabrication facilities and implementing a suitable quality assurance program lies with OWI.

4.2.28 Update environmental effects and risks of TRU waste shipments

As a result of tests performed on TRU waste shipping packages (Sect. 4.2.25), the radiological and nonradiological effects of accidents can be determined.

4.2.29 Environmental impact statement for waste transport

An environmental impact statement (EIS) covering waste transport to several potential repository locations needs to be prepared by late FY 79. This information will be incorporated into the overall EIS for each repository location. Preparation of the information will require support from logistics and waste shipping package designs (Sects. 4.2.5 and 4.2.20). The EIS needs to address the number of waste shipments expected, anticipated routes, exposure to workers and general population, and potential accident scenarios.

4.2.30 *Evaluate impact of varying TRU waste limits*

Changing the lower limit for alpha contamination in the definition of TRU waste could drastically affect the quantity of material to be shipped and placed in a waste repository. A study to develop background information will be initiated mid-FY 78. This information will be developed with the aid of a logistics study and will be submitted to OWI in early FY 79. The OWI may send the information to DOE and may request the establishment of a different limit for alpha contamination requiring shipment to a federal repository. Results will affect the TRU waste shipping package fleet requirements.

4.2.31 *Accident response preparedness*

In mid-FY 80, a contract will be initiated to develop information on federal accident response capabilities and how they can affect the states and local areas through which waste shipments to a federal repository will be made. The study should take ~ 1 year, and the results will be reported to OWI for formulation of a position on accident response and to determine whether further interaction with state and federal officials is necessary.

4.2.32 *ALARA*

A 6-month study will be initiated to develop a position on the effect of lowering external dose rates of waste shipping packages. The study, which should be completed at the end of FY 78, will consider nonradiological as well as radiological impacts of dose rate reduction on individual packages. Information will be transmitted to OWI, who may accept or modify the results as necessary, to develop a position paper on the ALARA question. Results of this position will affect spent fuel cask design work.

4.2.33 *OWI economics study*

The OWI has contracted with TRW, Inc., to perform an economics study. This study has as its objective the development, evaluation, and analysis of cost data for the geological waste repository program and, as such, includes consideration of transportation costs and logistics. The study has recently been expanded to include the development of pricing estimates for a one-time government charge to utilities for storage and disposal of spent fuel. The additional scope requires an analysis of the entire logistics system, from reactors to geological disposal including interim storage in AFR water basins or other surface storage facilities.

In support of these requirements, economic information relating to transportation costs for various spent fuel shipment scenarios will be generated. Several different geographical locations for AFRs and repositories will be investigated. This work to support the economic study will extend at least through mid-FY 78.

4.2.34 *State and local regulations*

Many states and municipalities have passed legislation restricting or prohibiting the shipment of nuclear material through their jurisdictional areas. The impact on waste transportation logistics of these restrictions must be identified. A study will be initiated identifying the state and local regulations that would affect spent fuel and TRU waste shipments. The study will be conducted during the last part of FY 79 and will interact with the Federal Transportation Study (Sect. 4.2.38). Logistics support will be required.

The final report summarizing the impact of state and local regulations will be transmitted to OWI for review. OWI may formulate an official position relating to the various state and local regulations in FY 80.

4.2.35 *Logistics models for reprocessed wastes*

Under current executive order, reprocessing of spent fuel has been indefinitely deferred. However, should this policy be modified, then a repository may be required to store wastes produced during fuel reprocessing. Logistics models simulating the transportation of reprocessing wastes (HLW, ILW, and cladding hulls) need to be developed. This task will be undertaken during FY 78. A report describing the models will be transmitted to OWI for their review in FY 79.

4.2.36 *Logistics models for repository management*

As repository designs become finalized, a need will develop for the logistics models to be capable of managing the overall waste transportation systems that will bring wastes into a repository. Practical operating constraints and other factors will have to be added to the existing logistics models to accomplish this objective. These models will then be able to schedule the movement of the shipping fleet to ensure a steady flow of material to the repository. The arrival and departure of shipping packages must be integrated with repository operation in order to levelize the repository work load and also to effectively utilize the shipping fleet.

Development of the detailed management models is a long-term study and will take ~ 2 years. This project will be initiated early in FY 80 and will use as a basis the logistics models that have already been developed and are operational at ORNL.

4.2.37 *Carrier/industry/government interface*

It is important to establish a dialog between waste carriers (particularly railroads), industry, and government groups who have an interest in ensuring the safe movement of waste from its shipping point to a federal repository. Results of this dialog will be utilized in shipping package design.

4.2.38 *Federal transport system study*

It is generally assumed that transportation functions within the civilian nuclear reactor fuel cycle will be performed by private industry. It is also possible to establish a transportation system at the back end of the fuel cycle that is, in whole or in part, operated by the federal government. The federal government is already involved in nuclear transportation to a limited extent. The initial rationale for establishing a federal transportation system is increased security; however, cost-effectiveness has now become an important factor. The study needs to address the advantages and disadvantages of a federal transportation system. A report containing the results of the study will be forwarded to OWI and probably on to DOE during late FY 79. The results of a DOE decision will then be reflected in an updated program plan.

4.2.39 *Feasibility of barge shipments*

Little information is available on the feasibility of shipping spent fuel by barge. Advantages are that large shipments, while relatively slow, can carry many casks in a single haul. Because of the potential desirability of having an alternate mode of transport available to truck and rail, a study should be undertaken on the feasibility of such water shipments. The investigation is expected to start mid-FY 79 and be completed late FY 79.

4.3 Logistics Models

Mathematical modeling waste shipment logistics is an effective way to provide input to program planning and long-range waste management functions. ORNL has developed several logistics models for use in parametric studies, contingency planning, and management of transportation network. Those models will enable ORNL to determine shipping schedules, optimize routes, determine most probable transportation modes, minimize costs, minimize personnel exposure, etc. Such information will permit OWI to specify waste-receiving rates at various facilities in order to balance work loads, to evaluate surge capacity requirements, and to estimate projected shipping cask fleet sizes. The programs are tailored to utilize information on the types of waste being received, capacity and location of repositories, location of waste-generating facilities, shipping distances, time required to make a shipment, equipment availability, above ground storage capacities and locations, projected waste throughput rates, etc.

Two logistics models have been developed. The Low-Level Waste Model evaluates the optional transportation policies for shipping waste directly from the source to a final destination without any intermediate stops. The Spent Fuel Logistics Model can be used to evaluate the optimum transportation policy for shipping spent fuel from nuclear power plants to an AFR storage facility and the subsequent transshipments from the AFR to a repository. This model can also treat direct shipments to a repository. Application of these models is not limited to the shipment of low-level waste or spent fuel but could be applied to any commodity that would be shipped within the constraints noted. With a minor amount of modification, the models could be used to study the logistics of transporting reprocessing waste.

A brief description of the logistics models developed is given below. A more detailed description of the models is contained in Ref. 5.

4.3.1 *Low-level waste logistics model*

A logistics model has been developed to help determine the optimum shipping policies for LLT waste from generating sites to federal repositories. The model is currently capable of handling 15 waste generation sites, 10 federal repositories, and covers a 30 year time span. Several repository constraints, such as maximum receiving rates and total storage capability, are also incorporated in the model. Optimality is evaluated by minimizing an objective function, such as system transportation costs, radiation exposure to the population, etc.

4.3.2 *Spent fuel logistics model*

A program has been written to provide detailed shipping cost information which is affected by the shipping policies for unprocessed spent fuel from reactor sites to an AFR, and from there to federal repositories. The interaction between the AFR facilities and geologic disposal facilities is a function of allowable shipping rates from the AFR facility, receiving rates, and ultimate capacity of the repository. The program assumes that any reactor can ship to any AFR facility, which in turn can ship to any repository. Direct shipments from a reactor site to a geologic disposal facility are also assumed to be a viable alternative. The model will determine the optimal waste destinations subject to operating constraints at the reactor, the AFR sites, and disposal sites.

4.3.3 *Program for scheduling shipments of spent fuel*

Another code, the Spent Fuel Shipping Schedule Program, has been written in order to provide input information to the Spent Fuel Logistics Model. This latter program will utilize specific shipping requirements and will calculate a yearly fuel shipping schedule for each nuclear reactor. Such shipping requirements include: the method by which backlogged fuel is worked off, when shipments are initiated, what mode or modes of transport are utilized, and whether partial-load shipments are allowed. The program will incorporate these requirements with the information contained in the Nuclear Reactor Data Base to perform the calculations.

4.3.4 *Spent fuel transportation cost program*

This program utilizes the shipping schedules developed for each nuclear reactor to calculate the cost of transporting the fuel to AFR sites and or repository facilities. The cost data are used in the Spent Fuel Logistics Model as the economic basis for calculating the optimal logistics plan. The program contains a data base of rail and truck freight rates for transporting spent fuel. Special train charges can be included in the overall transportation cost if desired. This program also estimates the size of the cask fleet required to transport the required amount of spent fuel to the AFR sites or repositories.

4.3.5 *Nuclear reactor data base*

Transportation-related information concerning nuclear power reactors has been collected and organized in a computerized data base. For each reactor, the data base contains the following information: name of reactor, location (city, county, state, latitude, and longitude), type of reactor, generating capacity, operating utility, date of actual or expected operation, modes of transport available, and actual and projected spent fuel discharges through the year 2010. The data base contains 208 entries representing all power reactors in commercial operation, under construction, or on order.

Since only firmly committed reactors are identified in the data base, additional entries have been included to represent the reactors which are assumed in Nuclear Electric Generating Capacity Projections that would be constructed during the 1990s and in subsequent years but are not now on order.

4.3.6 *Shielded waste shipping cost model*

An existing ORNL computer code has been modified to permit the study of cask shipping costs as a function of specific cask characteristics. The code,⁶ called PACRAT, can be utilized to evaluate the effect of source size, source thermal and radioactive properties, shielding material, etc., on the cask size and weight and, consequently, on overall shipping costs. The source can be either HLW or spent fuel.

5. EXISTING PROGRAMS

A number of organizations are involved in transportation studies and tests. In some cases the recommended action items described in Sect. 4.2 are addressed, in part, by the programs of these organizations but are still identified as a building block of the overall program plan. In any case, knowledge of these programs is essential to avoid duplication of effort and to maximize the likelihood of success of the program. This section identifies many of the radioactive material transport-related programs that are currently in progress.

5.1 Department of Energy Transport R & D Program

The DOE has several programs in transport R & D. The objectives of the DOE programs are to: (1) develop the data and methodology for evaluating risks and environmental effects of the shipments of fuels and wastes; (2) ensure DOE's development of fuel cycle transport technology and systems optimized for safety, security, cost, and operating efficiency; (3) carry out package and vehicle testing in support of this technology; (4) develop a comprehensive body of consistent and supportable safety standards for the transport of fuels and wastes in DOE energy programs; and (5) produce informational exchange systems and methods to inform the energy industry and the general public of the nature, risks, and safety precautions involved in the transport of fuels and waste from energy programs. The following programs form the basis of the nuclear transport-related effort sponsored by the DOE.

5.1.1 Office of Waste Isolation Canister Envelope Study

The DOE, through OWI, is sponsoring a canister envelope and waste packaging study to determine what limitations might be imposed by the rest of the repository system on the HLW canisters and other waste packages. This study will establish canister acceptance criteria which are compatible with all handling equipment and determine whether the transportation system would impose any additional constraints on the canisters. Rockwell Hanford Operations is the program manager of this study, and subcontractors include: Science Applications Inc., Battelle Columbus Laboratories, and Kaiser Engineers, Inc.

5.1.2 *Energy material transport problems through the year 2000*

The national transport system is being examined at PNL to identify trends and problems that could cause future difficulties in the transport of nuclear and other energy materials. This is an ongoing project that was started in 1974.

5.1.3 *Safety and economic study of special trains*

The objective of this study, also by PNL, is to evaluate the safety and economics of special trains for the shipment of nuclear fuel materials and to compare them with those of regular trains. A special train is one generally limited to hauling a single cargo (such as spent fuel) to a single destination and usually has speed or other restrictions placed on it.

5.1.4 *Physical parameters of transport accidents*

Since 1972, Sandia Laboratories in Albuquerque, New Mexico, has been studying the physical parameters affecting general cargo in severe transportation accidents. The results of this study for the air, highway, and rail modes have been published. Starting in late 1975, the study was expanded to include large packages, such as spent fuel casks.

5.1.5 *New standards for package safety qualification tests*

Another Sandia Laboratories project, started in late 1975, has the objective of using the results of the physical parameters study to develop new, modal-related, regulatory test standards which will produce more realistic accident damage environments for smaller Type B packages.

5.1.6 *Risk assessment*

Since 1972, PNL has been developing a methodology for assessing the risks associated with the shipment of nuclear fuels and wastes. This methodology will be utilized to quantify such risks. Several reports have already been published.

5.1.7 *Full-scale crash tests*

Until the initiation of this project, there has been virtually no full-scale testing under severe transport accident conditions of vehicles and packagings for nuclear materials. Sandia Laboratories, Albuquerque, is carrying out a series of scale model and full-scale tests to improve our understanding of analytical and scale modeling techniques for assessing transport safety under severe accident conditions.

5.1.8 *Impact analysis program*

The dynamic analysis of a shielded radioactive materials packaging subjected to a 9-m (30-ft) drop onto an unyielding surface is such a complex problem that there are no definite solution techniques that can be applied. Since late 1974, Los Alamos Scientific Laboratory has been studying impact phenomena for the purpose of developing computer codes in order to provide a more precise prediction and dynamic analysis of accident impacts.

5.1.9 *Dynamic properties of packaging materials in transport accidents*

Transport risk assessment, impact, and other dynamic analyses of nuclear packages require good data on the dynamic properties of the structural materials used in fabrication of such packages. In 1975, Battelle Columbus Laboratories began a study to develop dynamic materials properties data by studying the structural responses of shipping casks under transport accident conditions.

5.1.10 *Testing of large obsolete casks*

Large Type B packagings for nuclear materials are usually quite expensive, frequently making the fabrication of full-scale prototypes for tests and evaluations impractical. Because of this situation, there is a shortage of data on the behavior of large, massive packages under normal and hypothetical accident conditions. A project was initiated at Oak Ridge National Laboratory in 1972 to test obsolete casks in order to obtain valid, full-scale, experimental data. These old casks are subjected to a thorough engineering analysis, followed by destructive testing.

5.1.11 *Transport accident environmental data bank*

In all risk assessment and transport accident studies that have been carried out thus far, it has become evident that a single source of data for transport accident environments is badly needed. The studies in progress at Sandia Laboratories, Albuquerque, on physical parameters of transport accidents resulted in the acquisition of a large volume of transport accident data. To avoid losing this data and to make it accessible to any future users, Sandia has established the Transport Accident Environmental Data Bank.

5.2 Department of Transportation

The Department of Transportation does not have a significant research and development effort involving transport of radioactive materials. Their primary role is one of regulating such shipments. In that effort, regulations have evolved that now require the reporting of each incident that occurs as a direct result of the radioactive materials carried any time in the course of transportation. A description of accident experience as well as an analysis of radioactive material incident reports is available.⁷

6. REFERENCES

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