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ABSTRACT

A system engineering approach is being applied to organize and develop relations among the people, hardware, and software of the Transportation Operations System (TOS), which will be a component of the Federal Waste Management System, being developed for the U.S. Department of Energy's Office of Civilian Radioactive Waste Management (DOE/OCRWM). The five major TOS subsystems are (1) Planning and Control, (2) Carriage, (3) Servicing and Maintenance, (4) Field Operations, and (5) Casks. TOS development objectives include flexibility to meet fluctuating demands over the lifetime of the project (over 40 years); proven capability and integration of all subsystems and components; ability to meet waste generator needs; and ability to match transport capabilities to Federal Waste Management System fuel requirements and waste receipt rates.

INTRODUCTION

The Transportation Operations System (TOS), which will be part of the Federal Waste Management System (FWMS) being developed by the U.S. Department of Energy's Office of Civilian Radioactive Waste Management (DOE/OCRWM), will interface with more than 100 utility-owned reactors, a waste repository, possibly a Monitored Retrievable Storage (MRS) facility, and other support facilities. Under normal operating conditions, the TOS will be responsible for the shipment of more than 3000 metric tons of uranium (MTU) per year throughout the United States. This transportation activity will encompass a highly complex operation, far exceeding any spent fuel shipping program implemented to date. To ensure that the system is adequately developed and all of its functions are identified, a systems engineering approach is being applied to develop the TOS. This work was approved as part of the DOE/OCRWM program through DOE's Chicago Operations Office, and the work is being carried out by the Transportation Operations Project Office (TOPO) in Oak Ridge, Tennessee.

BACKGROUND

Spent fuel is currently transported on a very limited scale in the United States and on a larger scale in Europe. These transport operations are, in general, not technically complex; nevertheless, the development of the transport system necessary to meet the requirements of the Nuclear Waste Policy Act (NWPA) will be logistically complex. The complexity results from the large number of waste generators the system must serve; the many interacting schedules that must be developed, integrated, and coordinated; and the anticipated interactions between various elements of government that will be required, some in the course of routine operations and some to maintain system licenses. In addition, resolutions of present and future waste transportation institutional issues may contribute to increased logistics complexity by imposing additional operating requirements and constraints. For these reasons it is vital to describe TOS, to identify development and implementation issues for the described system, and to assign responsibilities for their resolution. This effort will permit timely development of the TOS in concert with the development of other elements of the waste system with which it must interface.

This paper presents a description of the system for transporting radioactive waste that may be deployed to accomplish the assigned system mission, which includes (1) accepting spent nuclear fuel (SNF) and high-level radioactive waste (HLW) from waste generator sites and (2) transporting them to the FWMS destination facilities. Several draft OCRWM documents, including

the Waste Management System Requirements, have described the mission.

Development and presentation of the system description constitute an essential step in the system engineering process. The system description presented here contains, in part, the following key elements: (1) irradiated fuel and waste casks; ancillary equipment; (2) truck, rail, and barge transporters; (3) cask and vehicle traffic management organizations; (4) maintenance facilities; and (5) other operations elements. The description is for a fully implemented system, which is not expected to be achieved, however, until several years after initial operations. In the early years of system operation, such elements as cask fleet, cask maintenance facilities, and operations staff can be expected to be in a state of construction and/or acquisition.

According to this concept description, major extension of current technology will not be required to complete the development and deployment of the TOS. There will be advantages gained, however, from using improvements in technologies. For example, one such improvement will be the expected increase in legal weight truck and rail cask capacities currently being developed in the OCRWM Cask System Development Program (CSDP).

DEVELOPMENT STATUS

This system description has not been approved by DOE. It is being reviewed by TOPO in Oak Ridge, Tennessee, and the Transportation Projects Office (TPO) managed by the DOE Chicago Operations Office and, therefore, may be subject to change. However, this description contains all of the elements of a comprehensive transportation system and utilizes the functions that will be carried out by FWMS.

SUMMARY DESCRIPTION OF THE TOS

The TOS will be an organized assembly of people, hardware, and software. The people -- who may be employed by DOE, a prime contractor to DOE, or a private industrial concern under contract, or combinations of these -- will manage the system by planning, implementing, directing, and controlling it and performing the necessary transport-related activities. Hardware will encompass the facilities and the equipment needed to carry out the system mission, including cask systems, training facilities, and communications equipment. Software will include documented information of all kinds (e.g., procedures, policies, operating plans, training materials, responsibility assignments, and data) and computer programs.

The system description presented below is a schematic, hierarchical characterization of the assembly of the elements of the TOS that depicts a logical breakdown of the system. This breakdown is intended to identify unique functional elements of the system in such a way that assignments can be made for the development of these elements and that progress in system development can be planned and tracked. Some of these elements will be mostly made up of people, such as the planning and control subsystem. Some will consist primarily of equipment; for example, the casks subsystem will be made up of hardware (casks, transporters, ancillary equipment) and software (operating and maintenance procedures, cask design documents, certificates of compliance).

The TOS will involve a large transportation fleet (perhaps 100 or more cask-vehicle units) and highly regulated facilities, equipment, and operations. The system will also involve large organizations of people concerned with administering or conducting complex transport-related activities. These activities will be undertaken both within the envelope of the system's operations and at the boundary of the system in interactions with other systems (including regulators). In addition, the TOS will involve complex procedures and logistics tools that will make possible the orchestration of many simultaneous and sequential shipping campaigns while accommodating operations needs and day-to-day disruptions in schedules.

COMPOSITION OF THE TOS

The TOS has been broken down into five major subsystems: Planning and Control; Carriage; Servicing and Maintenance; Field Operations; and Casks. Fig. 1 illustrates this breakdown.

The Planning and Control subsystem performs the planning, implementing, directing, and controlling functions necessary to the operation of the total system. This subsystem controls the operations of all TOS subsystems as well as the interfaces with other systems internal and external to the FWMS. It also manages the personnel who work in the system. The Carriage subsystem performs the functions involved with transporting cask systems containing SNF and HLW from points of origin to destinations and returning unloaded cask systems to origin points for reuse or to other locations for

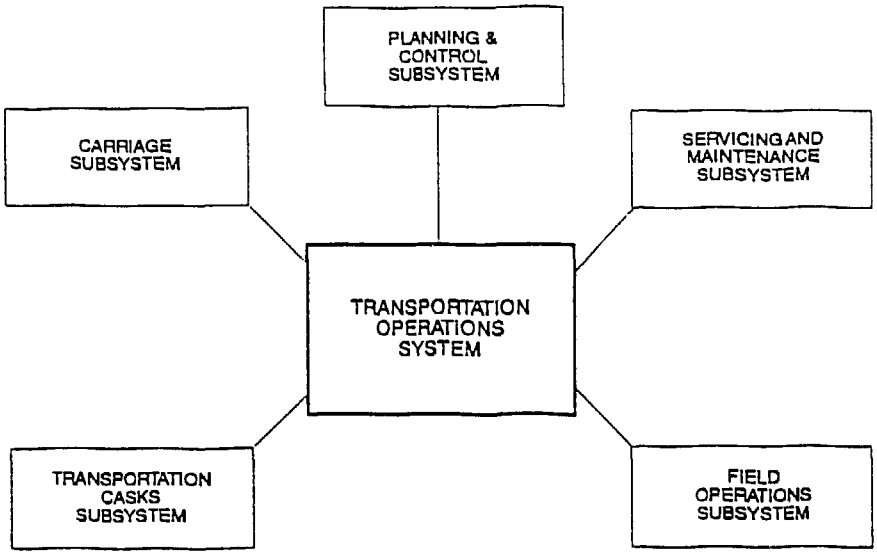

FIGURE 1 SUBSYSTEM BREAKDOWN OF THE TRANSPORTATION OPERATIONS SYSTEM (TOS)

storage or maintenance. The Servicing and Maintenance subsystem maintains all equipment and facilities that are part of the TOS. The Field Operations subsystem includes field service functions that will provide support at facilities where SNF or HLW are accepted for transport to FWMS facilities, and also provides both training and advice to FWMS facility operators as required and to emergency response authorities if requested. The Cask subsystem provides certified casks and vehicles necessary for the safe transport of SNF and HLW in the public domain.

Each of the five major subsystems is described schematically in Figs. 2 through 6. Each figure presents a breakdown, by element and -- in some cases -- subelement, of the subsystem being described. The first of these five subsystems, the Planning and Control subsystem (Fig. 2), is broken down into nine elements: TOS Manager, Engineering, Long Range Planning and Analysis, Information Management, Quality Assurance, Operations Management, Compliance, Administration, and Training. One of the elements, Operations Management, is broken down further to illustrate its major sub-elements. Each of the system elements will ultimately be broken down into its lowest level components. For example, the Information Management element is expected to include equipment (computers), facilities (rooms for the computers and offices for operating personnel), software (procedures, computer programs, organization diagrams), and people (computer operators, librarians, records clerks). Each element will be responsible for certain key functions. For example, several key functions of the Engineering element include special projects engineering, equipment design and improvement, and cask Certificate of Compliance and facility license support.

The Carriage subsystem (Fig. 3) is broken down into five major components: Highway Carriage, Rail Carriage, Waterway Carriage, Intermodal Transfer, and Physical Security In-Transit. This breakdown reflects the importance of modal involvement and security during shipment.

The Field Operations subsystem (Fig. 4) also includes five major elements: Facility Interface Equipment, Waste Acceptance Operations, Facility Interface Information, Waste Generator Technical Support, and Emergency Response Operations Support. These elements reflect the importance of interface activities between the transport system and those outside the TOS.

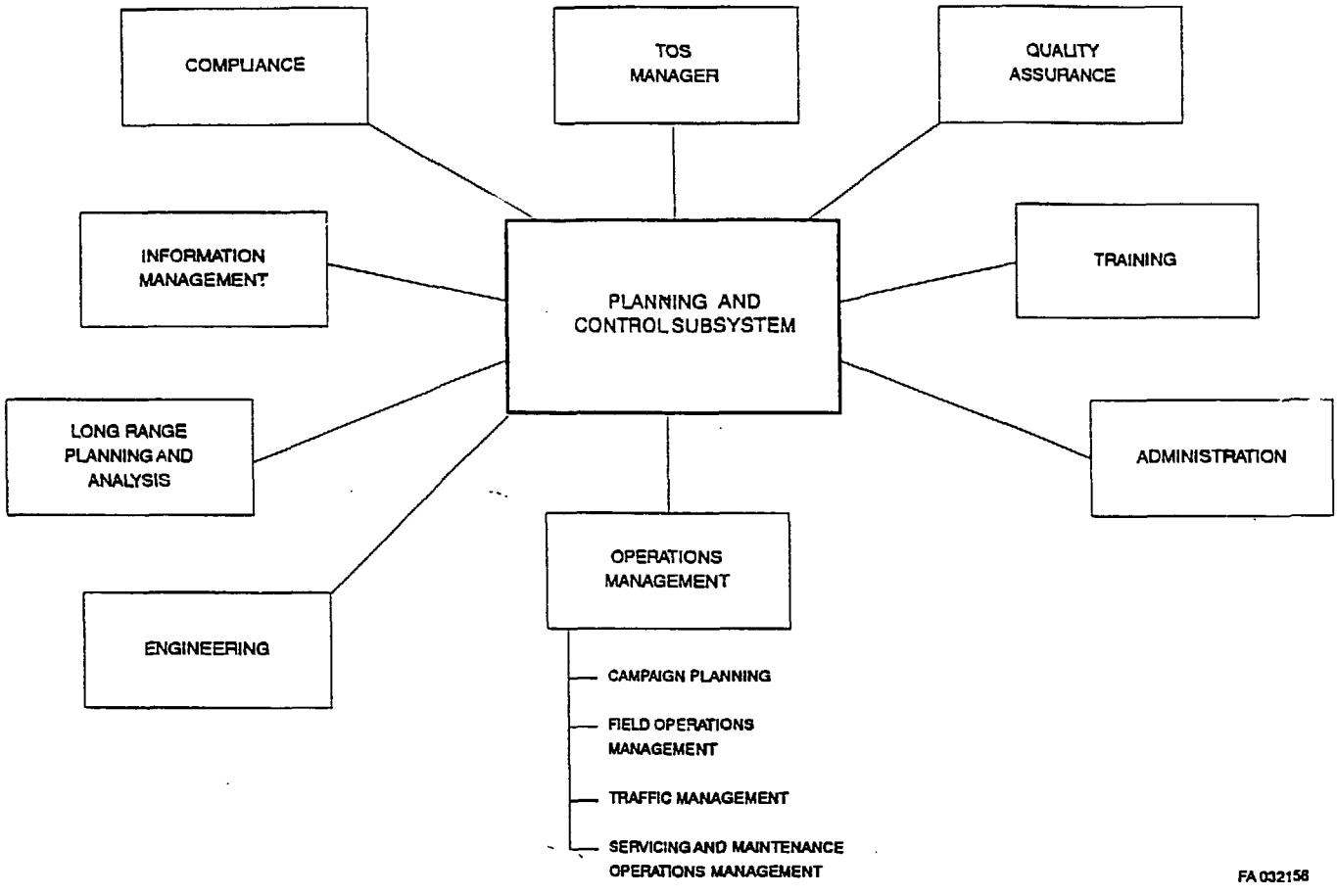

FIGURE 2 ELEMENTS OF THE PLANNING AND CONTROL SUBSYSTEM

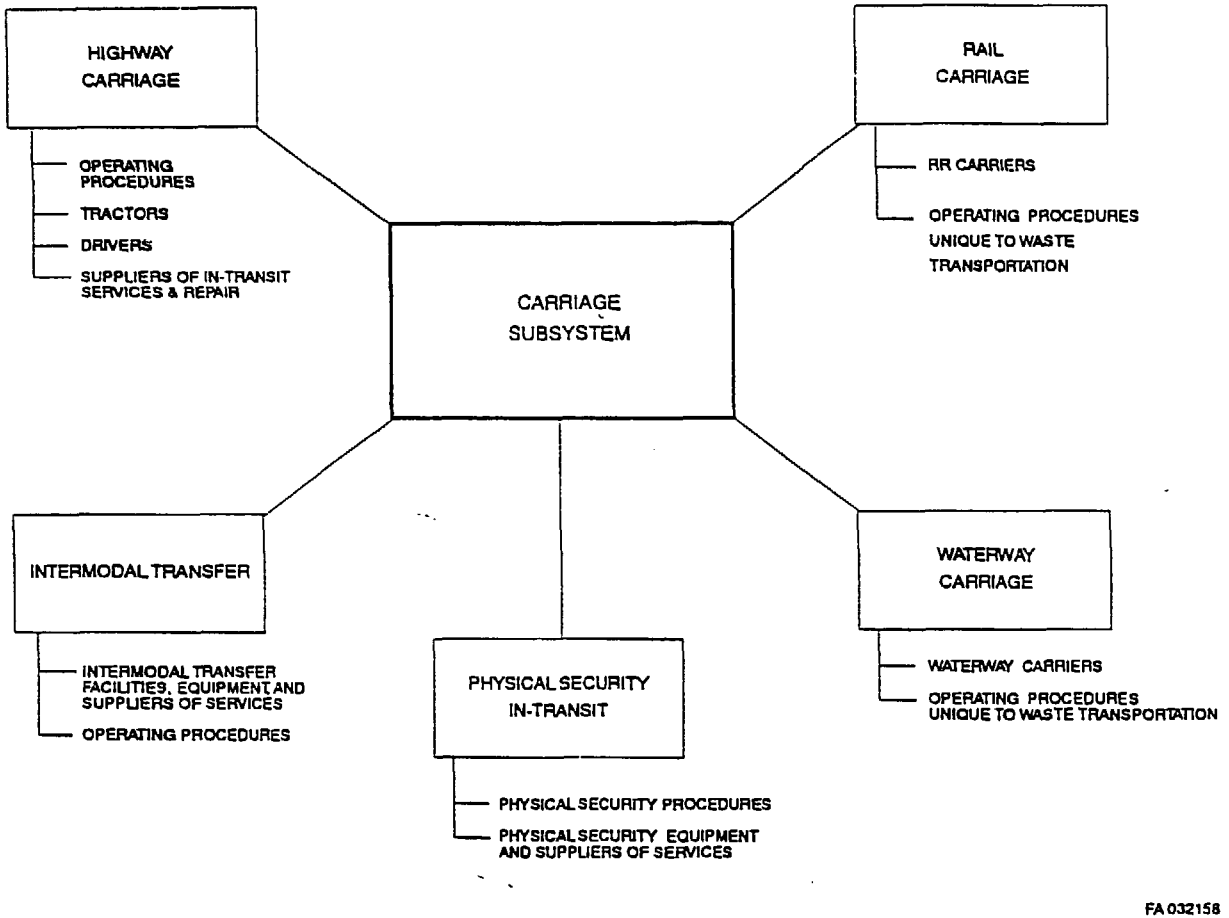

FIGURE 3 CARRIAGE SUBSYSTEM

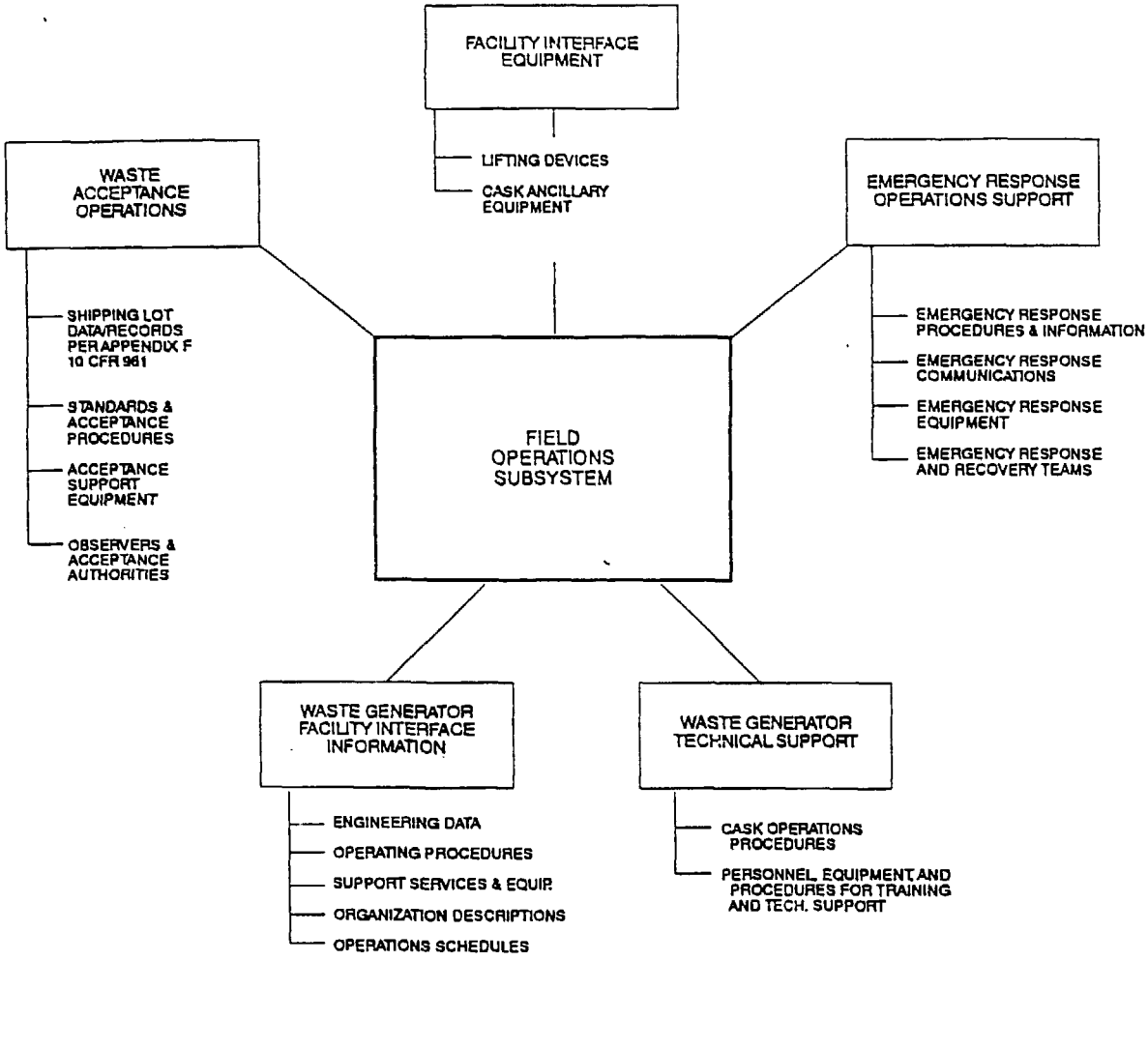

FIGURE 4 FIELD OPERATIONS SUBSYSTEM

Fig. 5 illustrates the breakdown of the Servicing and Maintenance subsystem. This subsystem consists of three elements: Support System Facilities Maintenance, Cask and Ancillary Equipment Servicing and Maintenance, and Transport Vehicle Servicing and Maintenance. These elements reflect the importance of maintenance not only of the cask and vehicle, but of the TOS facilities also.

Finally, the Cask subsystem (Fig. 6) is broken down into three elements: From-Reactor Cask Systems, MRS-to-Repository Cask Systems, and Commercial and Defense High-Level Waste Cask Systems.

These five subsystems reflect the importance of the various materials and waste packages that the FWMS must be capable of handling. However, at the current state of development of the TOS, in which the operation performance requirements of the system have not been established, the complete identification of the components in terms of specific hardware, people, and software has not been completed. Specification of the system and details of the major components will continue to evolve through the implementation of the system engineering process.

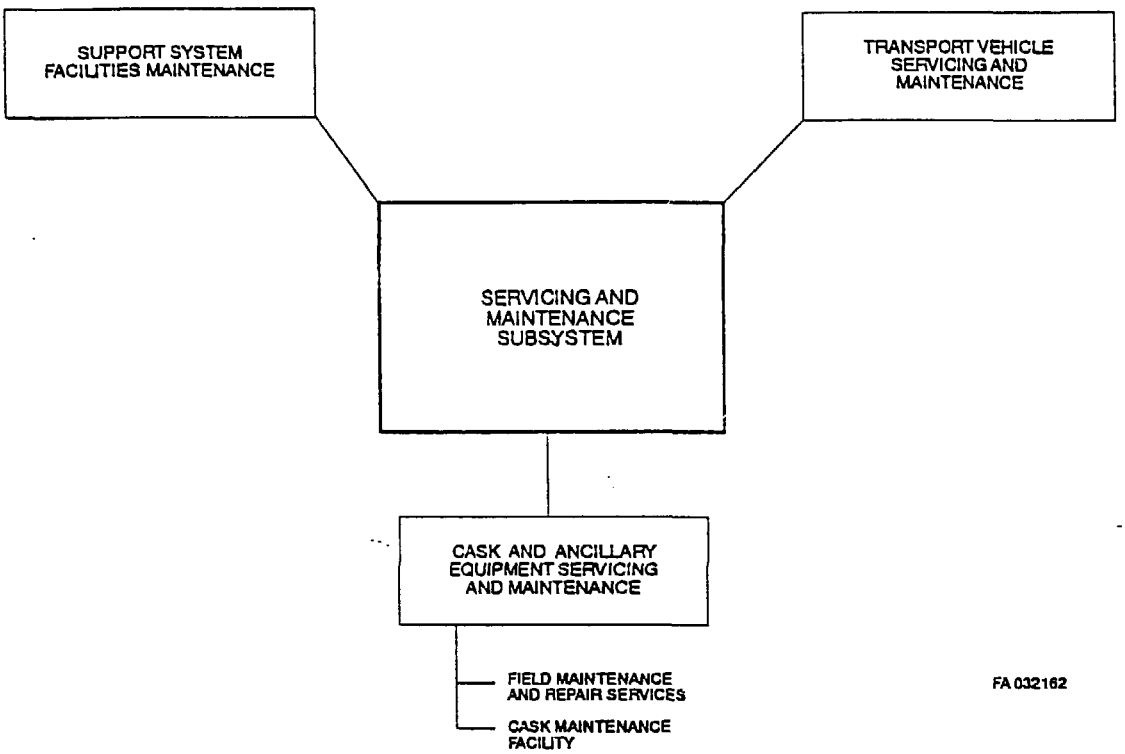

FIGURE 5 SERVICING AND MAINTENANCE SUBSYSTEM

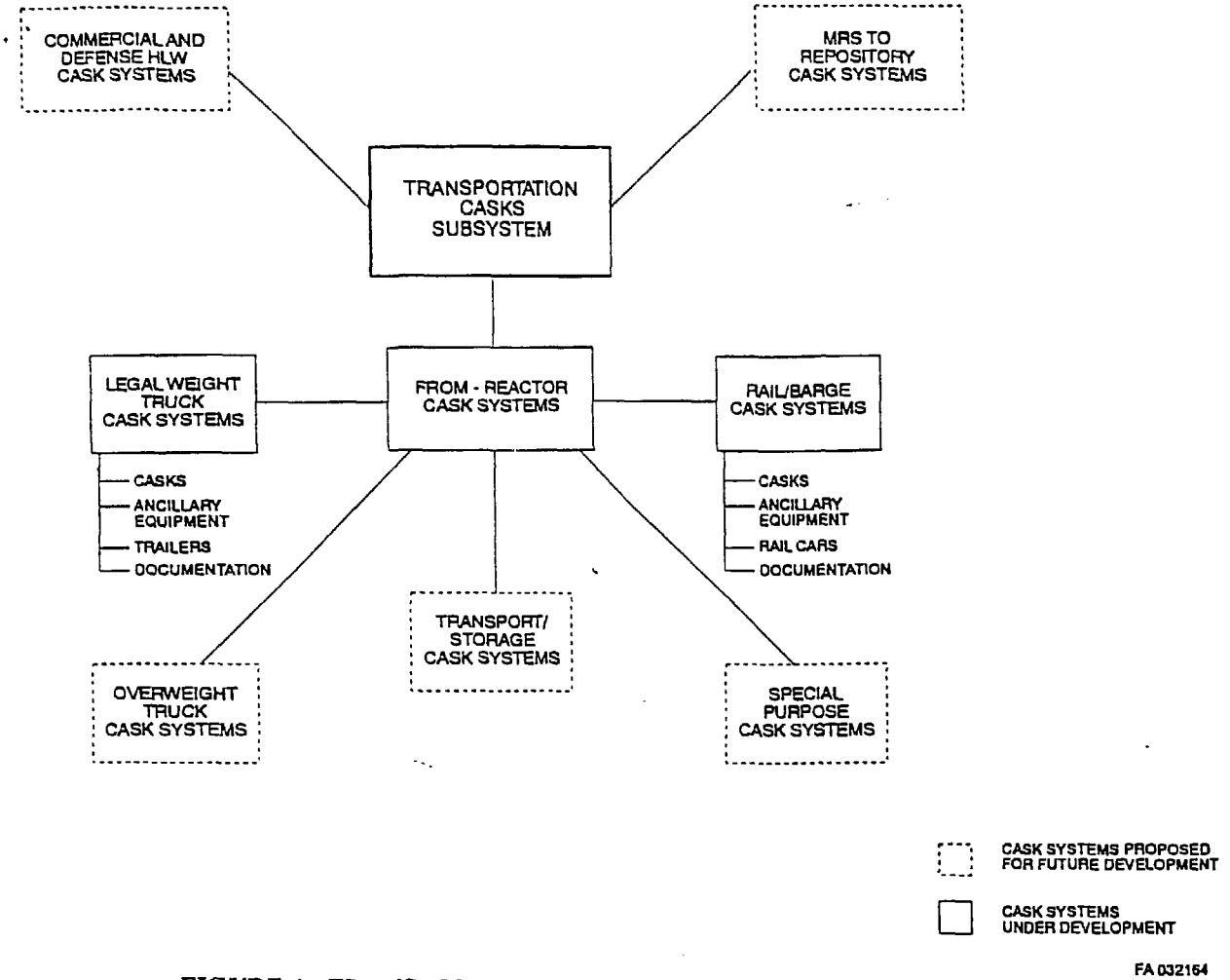

FIGURE 6 TRANSPORTATION CASKS SUBSYSTEM

RELATIONSHIPS TO OTHER SYSTEMS

The relationships of the TOS to other systems with which it interacts are not illustrated in the figures. These external systems include: waste generator facilities and operations, FWMS facilities, government agencies, and Indian tribal governments. Examples of interactions include the physical interactions between a cask and the waste generator facilities and FWMS facilities in which it will be handled, the planning interactions that will take place between the TOS's campaign planners and the facilities operations planners, and the notification interactions between the TOS's traffic managers and the designated officials of State governor's offices.

SUMMARY

The TOS will be logistically and organizationally complex. It will have to operate in a manner that ensures that shipments can be made from multiple sites on a continuous basis for at least a 40-year period, even though the specific sites, equipment requirements, and payloads will vary significantly, both across sites and across time, as the system evolves. Current efforts to develop this system are directed toward ensuring that its elements are appropriate, integrated, and proven; that the needs of the waste generators are accommodated; and that the receipt rate and fuel requirements at the FWMS facilities are constantly matched with the transport capabilities.