THE DEVELOPMENT OF FUNCTIONAL REQUIREMENTS FOR THE OCRWM WASTE ACCEPTANCE AND TRANSPORTATION SYSTEMS

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ABSTRACT

This paper discusses the development of the Physical System Requirements-Accept Waste and Transport Waste (PSR-AW and PSR-TW) documents. These documents are being used by OCRWM as the program level technical baseline for the waste acceptance and transportation systems. Based on a functional analysis approach, these documents include results in the form of boundary diagrams, function hierarchy trees, function description tables containing a compilation of requirements, architecture tree and tables, and functional flow diagrams. The approach used ensures the flowdown and traceability of relevant requirements during the waste acceptance and transportation systems development.

INTRODUCTION

The Nuclear Waste Policy Act (1) (NWPA) authorizes DOE to enter into contracts with owners of spent nuclear fuel (SNF) and high level waste (HLW), of domestic origin, for the acceptance of title, subsequent transportation, and disposal of such wastes. The Secretary of Energy, in his November 1989 report to Congress (2) (DOE/RW-0247) announced an initiative for spent fuel acceptance in 1998. In the same report the Secretary also announced an initiative to establish improved management structure and procedures. In response, the Office of Civilian Radioactive Waste Management (OCRWM) performed a management study and the Director of OCRWM subsequently issued the Management Systems Improvement Strategy (3) (MSIS) on August 10, 1990. MSIS called for a rigorous implementation of systems engineering principles with special emphasis on functional analysis.

The functional analysis of the operating phase of the Nuclear Waste Management System (NWMS) was conducted in six parts: a) the Overall NWMS System, b) Accept Waste, c) Transport Waste, d) Store Waste, e) Dispose of Waste, and f) Exploratory Studies Facility.

This paper sets out to discuss the development of the functional requirements for the Waste Acceptance System (WAS) and the Waste Transportation System (WTS) by identifying its functions, requirements and architecture, including its interfaces with other parts of the NWMS.

APPROACH

As a first step in the functional analysis approach, the missions of Accept Waste function and the Transport Waste function was defined. Based upon the NWPA, the mission of the WAS is to transfer custody, f.o.b. carrier, of SNF and HLW from all purchaser's/producer's to DOE/RW at the purchaser's/producer's facility. Once the waste has been accepted the WTS will transport the SNF and/or HLW from the purchaser's/producer's facilities to, and between, NWMS facilities in a manner that protects the health and safety of the public and of workers and the quality of the environment, makes effective use of financial and other resources, and to the fullest extent possible uses the private sector. The functional analysis for the Accept Waste and Transport Waste missions is intended to:

- Identify the functions that must be performed by the WAS and WTS, and each of its elements to fulfill the Accept Waste and Transport Waste missions;
- Specify the corresponding requirements imposed on each of the functions; and
- Select the conceptual architecture that will be used to satisfy the requirements.

The functional analysis was performed by a team of technical experts from across the OCRWM program, in accordance with the Physical System Requirements/Functional Analysis Management Plan (4). This process resulted in the "Physical System Requirements Accept Waste" (PSR-AW) and "Physical System Requirements Transport Waste" (PSR-TW) reports (5,6).

The functional analysis process is iterative. Thus, there are several distinct steps, each containing progressively more detail, and each leading to three important pieces of information:

- Functions,
- Requirements, and
- Architecture.

Functions are simple statements of purpose, defining what the system must do; requirements indicate how well the function must be accomplished; and architecture represents a piece of the actual physical system that satisfies a corresponding requirement. This triad of functions (F), requirements (R), and architecture (A) is needed to completely describe and understand the system at each level and to set the stage for the next lower level.

Figure 1 illustrates the sequential F-R-A approach that was implemented by a team of technical experts in accordance with the Physical System Requirements/Functional Analysis Management Plan. These experts were supported by a regulatory review team who extracted all potentially relevant requirements from the source documents.

Beginning with the mission statement, the technical experts assigned a set of applicable requirements from those provided by the regulatory review team, and provided an architectural concept. At this point, the mission statement became the parent function which the technical experts

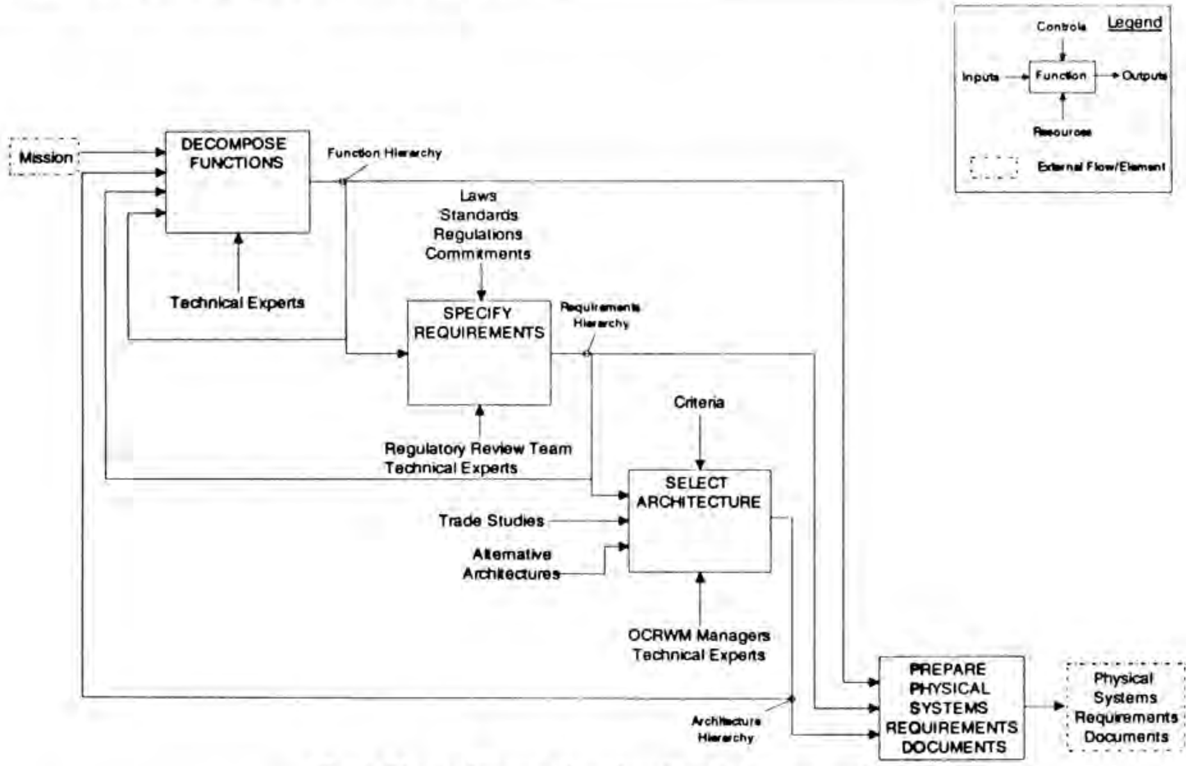


Fig. 1. Physical system functional analysis approach.

decomposed into a set of functions that are both necessary and sufficient to satisfy the parent. Requirements were assigned and architectural concepts provided for each function, establishing the basis for further decomposition. Eventually, a level of detail is reached within the function hierarchy that cannot be supported with either specific requirements or specific architecture. This can lead to some differences in the level of detail for functions, requirements, and architecture contained within these reports.

The functional analysis process must consider all phases of a system's life cycle. For the Accept Waste and Transport Waste missions, the time period covered by this functional analysis is from the initial issuance of the NWPA of 1982 through the receipt and verification of the last shipment of waste for disposal.

RESULTS

The PSR-AW and PSR-TW reports include the results of the functional analysis in the form of functional requirements and architecture supported by function hierarchy, boundary diagrams and functional flow diagrams. Figure 2 illustrates the boundaries between the Manage Waste Disposal function, the purchasers/producers, the Nuclear Waste Fund, and its environment. The environment identified on Fig. 2 is defined as anything and everything outside the direct control of the OCRWM program. Requirements were extracted initially from a set of source documents (Table I) and allocated to the functions. Although additional source documents have been and will continue to be reviewed, it was determined that the scope and detail contained in the initial set of source documents are sufficient to specify an initial set of requirements.

Figures 3 and 4 displays the functions deemed necessary to fulfill the Accept Waste and Transport Waste missions. As indicated, the numbering scheme which uniquely identifies function titles is based on using 1. at the first level, 1.X at the second level, 1.X.Y at the third level, etc. This scheme, which permits traceability between functions and subfunctions, is used throughout the results of the physical system functional analysis.

The reports contain function description tables for each of the functions, including an identification of inputs to, and outputs from, each of the functions. These tables also include a compilation of the corresponding requirements that are determined to be appropriate for each function. In general, if a requirement is applicable to all functions at a given level in the hierarchy, it is assigned to their parent function in order to avoid unnecessary repetition.

Requirements can be one of three types: constraints, which are requirements imposed on the function by sources external to OCRWM (e.g., Congress, Environmental Protection Agency, Nuclear Regulatory Commission, other DOE offices); performance requirements which are imposed on the function by OCRWM (n.b., requirements extracted from 10 CFR Part 961 are considered to be performance requirements); and interface requirements which apply to the inputs to, or outputs from, the functions and may be imposed either by external sources or by OCRWM. The sum of the requirements assigned to the input and the corresponding output is the interface requirements for any given interface. The numbering convention used for the identification of requirements in these tables is as follows: for example, 1.1C1: the first constraint (C) assigned to function 1.1; 1.1P1: the first performance requirement (P) assigned to function 1.1; 1.1I1a: the first interface requirement assigned to input (I) 1 to function 1.1; and 1.1O1a: the first interface requirement assigned to output (O) 1 from function 1.1. Each requirement that has been extracted from a source document has the appropriate reference noted. Others that have not yet been firmly decided are noted as "TBD, pending DOE/OCRWM decision."

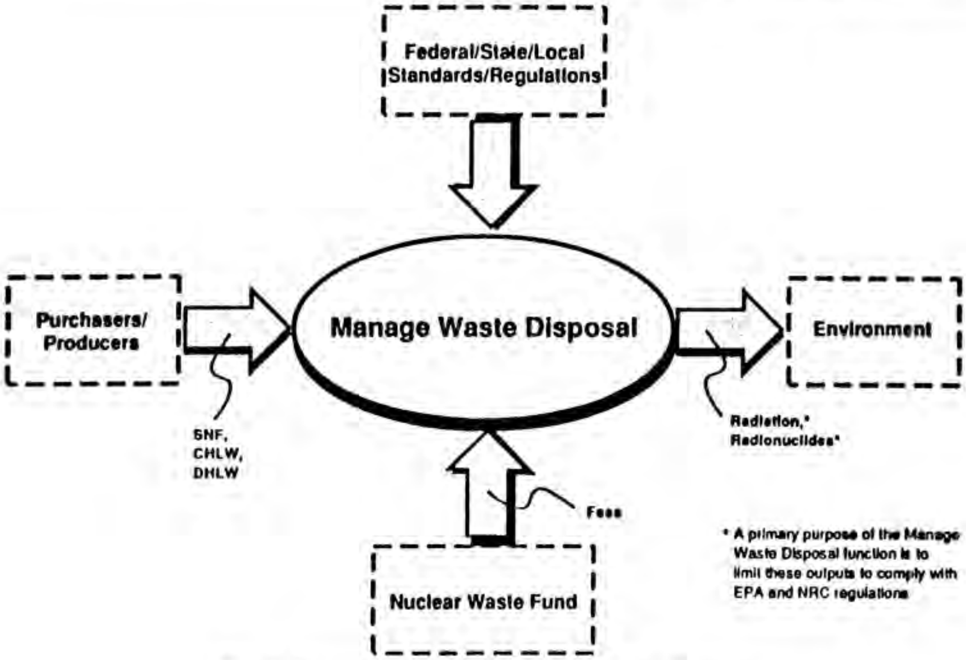


Fig. 2. Manage waste disposal boundary diagram.

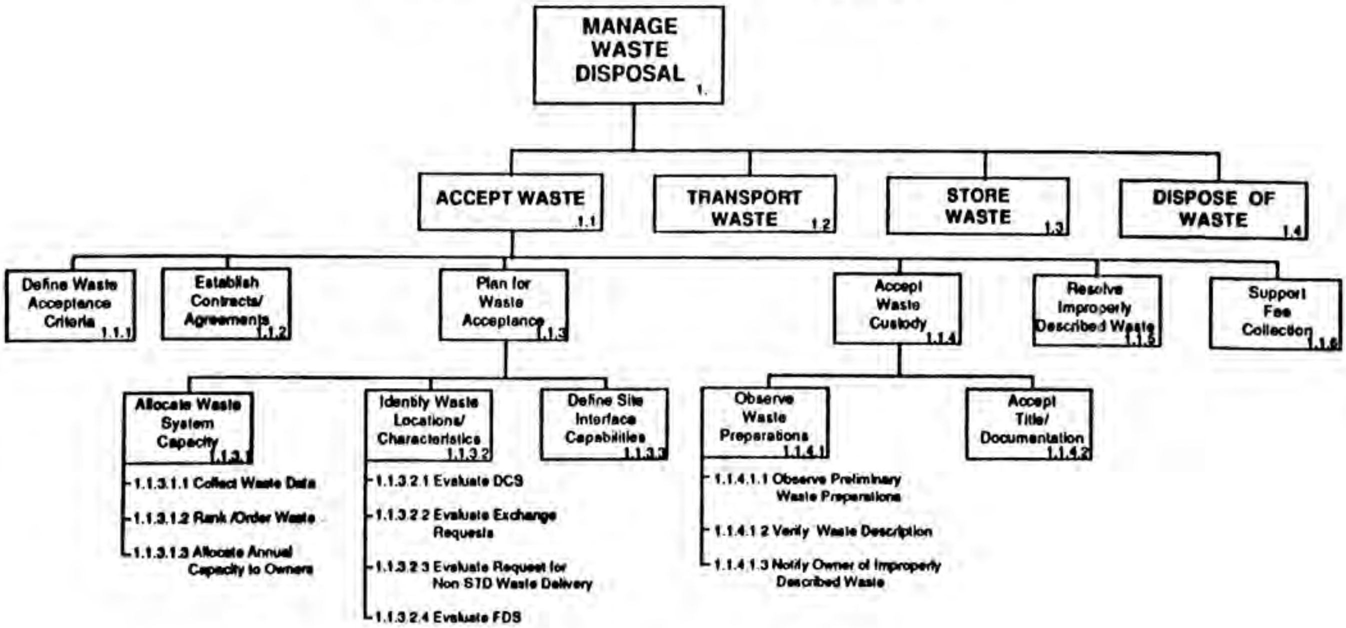


Fig. 3. Accept waste function hierarch.

Architecture is defined herein to be that part of the system actually built, found, or selected to perform a function subject to its stated requirements. Each report contains Architecture Tables which identify the specific requirements to be satisfied by each architectural concept, a rationale justifying the need for the architecture, and a description of the Concept. Figures 5 and 6 show the architecture tree for the WAS and WTS respectively.

Interfaces indicate either a flow between functions as in a sequence of activities, or a necessary fit between architectures. They are also either internal interfaces which are contained entirely within the function structure or external interfaces which interact with functions outside of the function structure. Prior to the preparation of detailed designs, only interfaces that indicate a flow between functions can be explicitly described. A visual display of the interfaces is illustrated in the functional flow diagram (Fig. 7).

CONCLUSION

The baselined PSR-AW and PSR-TW documents contain functional requirements for the WAS and WTS and is serving as the basis for further development of the WAS and WTS. These documents serve as a sound requirements baseline and provide the foundation upon which the system engineering process (Fig. 8) can be carried out. These documents are especially useful for ensuring the traceability of requirements between the OCRWM program and its individual projects.

TABLE I

Source Documents Containing Requirements in the PSR-AW and PSR-TW

Document	Identifier Document Description
29 USC 651 et seq.	Occupational Safety and Health Act
NWPA-42 USC 10101	Nuclear Waste Policy Act
10 CFR 20	Standards for Protection Against Radiation
10 CFR 21	Reporting of Defects and Noncompliance
10 CFR 60	Disposal of High-Level Radioactive Wastes in Geologic Repositories
10 CFR 70	Domestic Licensing of Special Nuclear Material
10 CFR 71	Packaging and Transportation of Radioactive Material
10 CFR 72	Licensing Requirements for the Independent Storage of Radioactive Wastes
10 CFR 73	Physical Protection of Plants and Materials
10 CFR 74	Material Control and Accounting of Special Nuclear Material
10 CFR 961	Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste
49 CFR 171	General Information, Regulations, and Definitions
49 CFR 172	Hazardous Materials Tables and Hazardous Materials Communications Regulations
49 CFR 173	Shippers - General Requirements for Shipments and Packagings
49 CFR 174	Carriage by Rail
49 CFR 176	Carriage by Vessel
49 CFR 177	Carriage by Public Highway
49 CFR 392	Driving of Motor Vehicles
DOE/RW-0214	Quality Assurance Requirements Document
DOE/RW-0239	The DOE Position on the MRS Facility
DOE/RW-0247	Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program
DOE ORDER 1540.1	Materials Transportation and Traffic Management
DOE ORDER 5000.3A	Occurrence Reporting and Processing of Operations Information
DOE ORDER 5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials
DOE ORDER 5480.11	Radiation Protection for Occupational Workers
MOA RW/DP	Memo of 7/14/86 on Policy for Shipping DHLW to a Civilian Radioactive Waste Repository
Presidential Memo	Memorandum of 4/30/85 on Disposal of Defense Waste in a Commercial Repository
Bartlett Letter to Sanda	Letter of 2/14/92 on DOE's Obligation to Accept SNF Pursuant to NWPA and 10 CFR 961

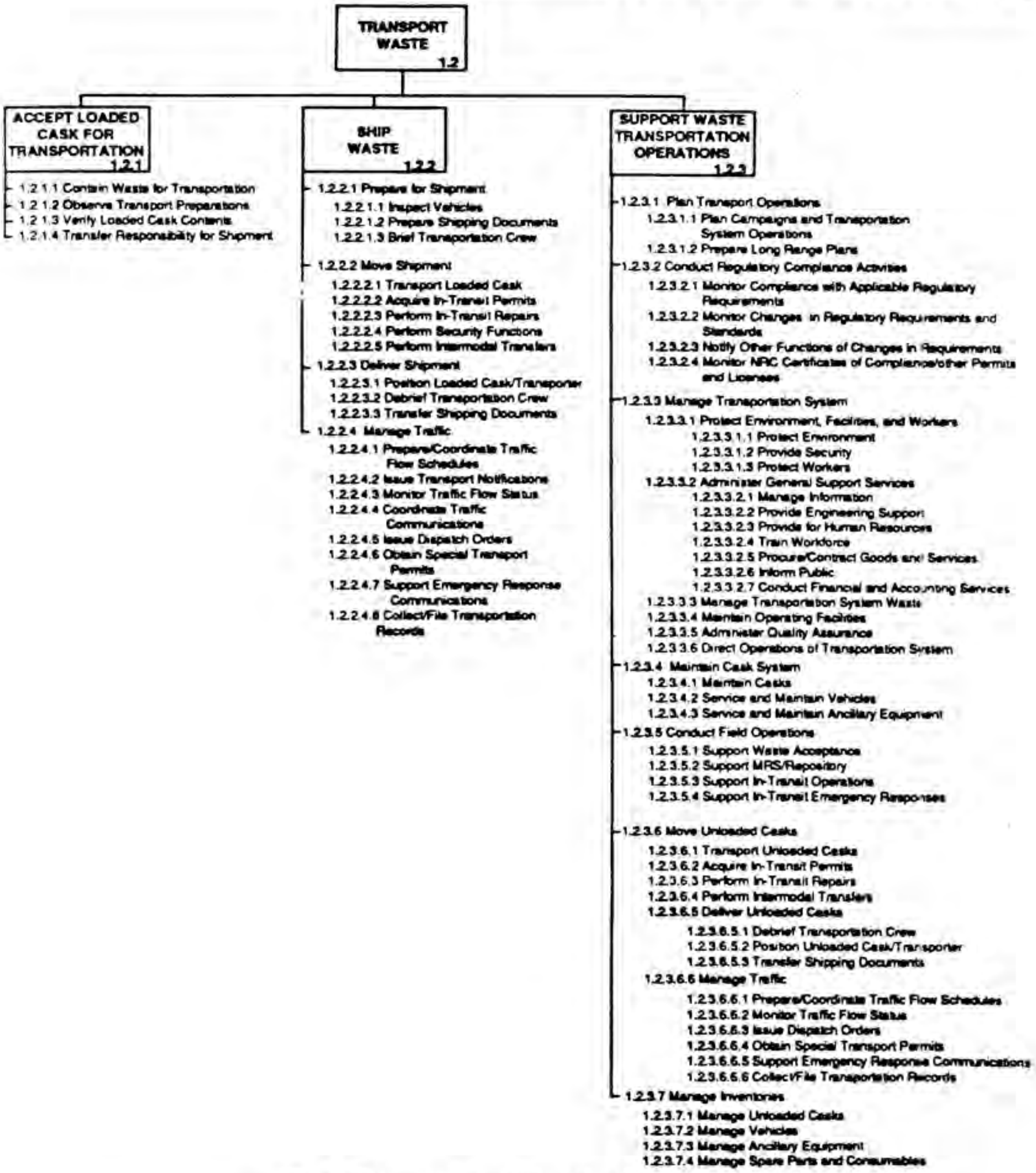


Fig. 4. Transport waste function hierarchy.

REFERENCES

1. NWPA (Nuclear Waste Policy Act), 1983. "Nuclear Waste Policy Act of 1982," Public Law (PL) 97-425, 42 USC 10101-10226, Washington, D.C. This Act includes Amendments PL 100-203 (Dec. 22, 1987) and PL 100-507 (Oct. 18, 1988).
2. DOE (U.S. Department of Energy), 1989. Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program, DOE/RW-0247, Washington, D.C. [DOE/RW-0247].
3. MSIS, "Management Systems Improvement Strategy," Memorandum dated August 10, 1990, from Dr. John W. Bartlett, Director, OCRWM, Washington, D.C.
4. Technical Document Management Plan, "Physical System Requirement/Functional Analysis Management Plan", Memorandum dated December 20, 1991, from RW-32, OCRWM, Washington, D.C.
5. DOE (U.S. Department of Energy), August 1992. Physical System Requirements - Accept Waste, DOE/RW-0369, Washington, D.C. [PSR-AW].
6. DOE (U.S. Department of Energy), April 1992. Physical System Requirements - Transport Waste, DOE/RW-0352, Washington, D.C. [PSR-TW].
7. DOE (U.S. Department of Energy), January 1992. Physical System Requirements - Overall System, DOE/RW-0334P, Washington, D.C. [PSR-OS].

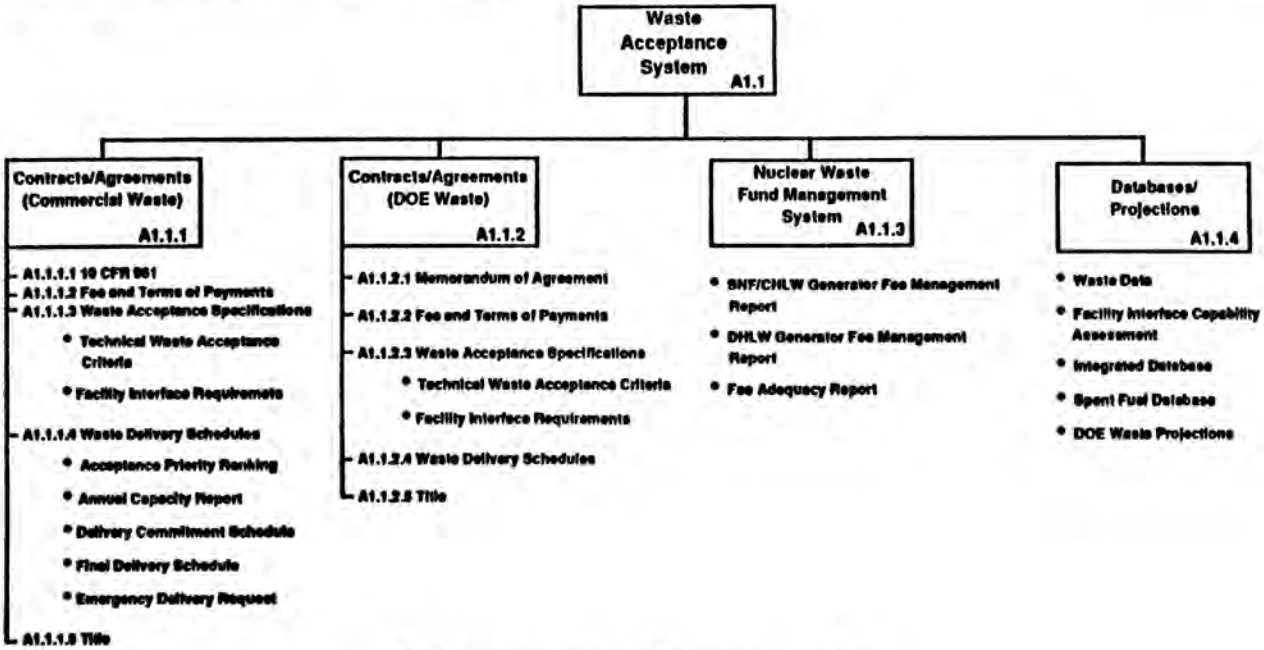
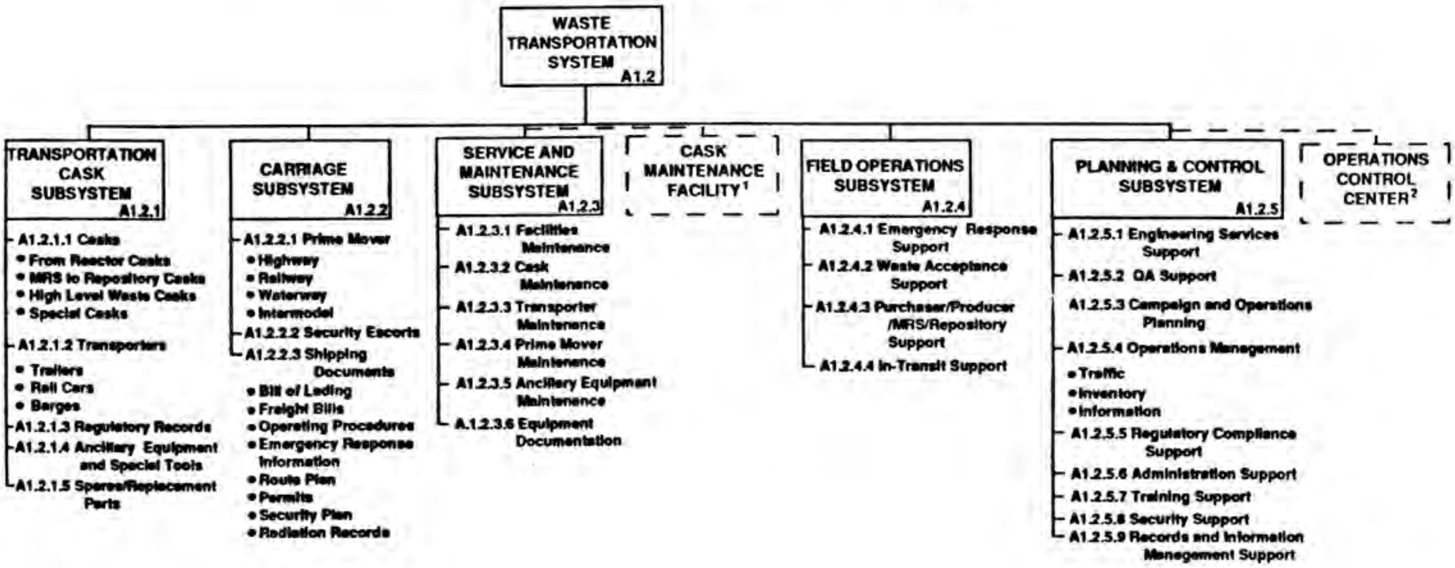


Fig. 5. Accept waste architecture hierarchy.



1. The CMF is colocated with the MRS

2. The location of the OCC is yet to be decided

Fig. 6. Transport waste architecture hierarchy.

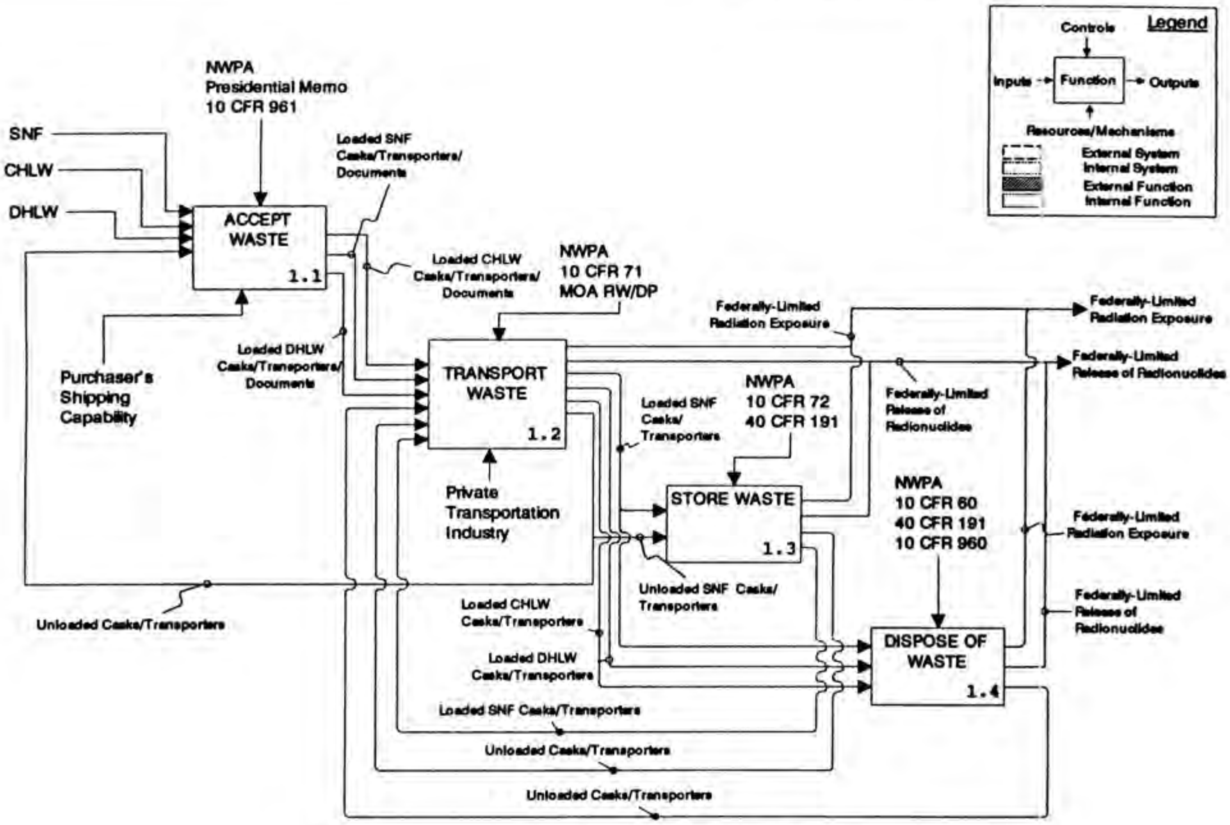


Fig. 7. Manage waste disposal functional flow diagram.

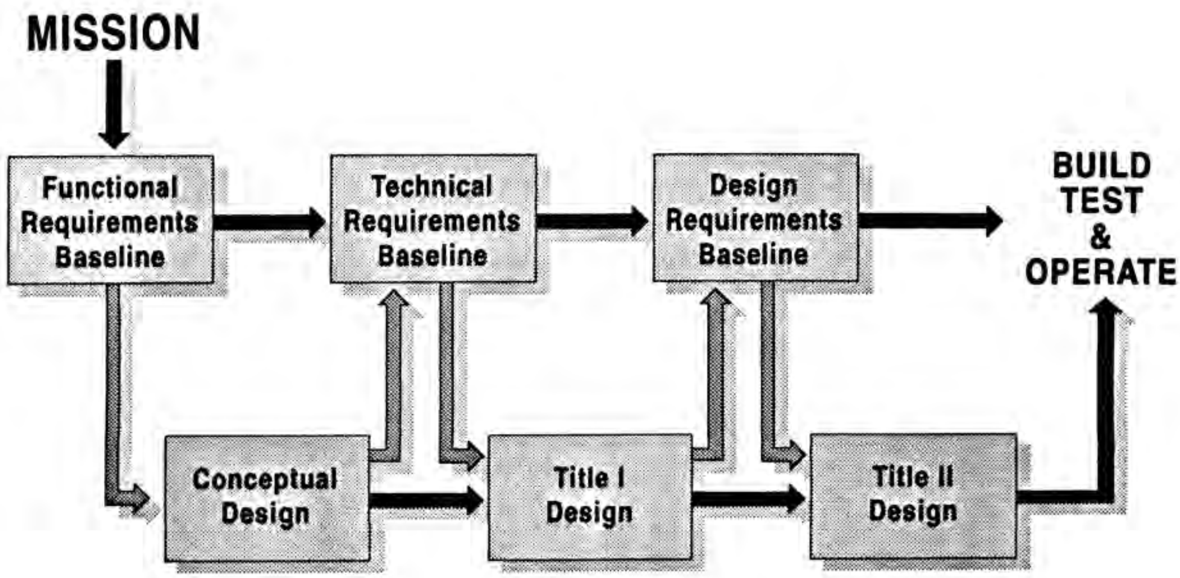


Fig. 8. Implementation of systems engineering during the design process.