Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

SEP 3 0 1996

96-MSD-172

Mr. John T. Conway, Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W., Suite 700
Washington, D.C. 20004

Dear Mr. Conway:

DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 92-4, COMPLETION OF TANK WASTE REMEDIATION SYSTEM (TWRS) COMMITMENTS 3.6.c, 3.7.h, AND 3.7.i

Attached are the U.S. Department of Energy (DOE), Richland Operations Office (RL) deliverables for the following DNFSB Recommendation 92-4 Implementation Plan, Revision 1 commitments:

- Commitment 3.6.c required submittal of a schedule for development and issuance of the Westinghouse Hanford Company (WHC) TWRS Management Plan and associated documentation. Included in the commitment were schedules for a TWRS Systems Engineering Management Plan (SEMP) and the TWRS SEMP Implementing Procedures (Commitments 3.7.h and 3.7.i). Commitment 3.6.c was partially completed by a submittal to you on March 30, 1995. With the submittal of Commitment 3.7.h and 3.7.1 deliverables as described below, Commitment 3.6.c is now considered complete.

- Commitment 3.7.h required development of the TWRS SEMP Implementing Procedures. Attachment 1 (WHC-IP-1231, Revision 0, dated May 15, 1996) submits the SEMP Implementing Procedures and completes this commitment.

- Commitment 3.7.i required the development of a revised TWRS SEMP. Attachment 2 (WHC-SD-WM-SEMP-002, Revision 0, dated February 5, 1996) submits the revised SEMP and completes this commitment. This document was originally identified as DOE/RL-93-0106.

If there are any questions regarding this matter, please contact me, or your staff may contact Carol L. Sohn of the Management Systems Division at (509) 376-8523.

Sincerely,

John D. Wagoner
Manager

MSD:HJW

Attachments (2)

cc w/attachs:
R. Guimond, EM-2
R. Izatt, EM-2
J. Tseng, EM-4
M. Hunemuller, EM-38
M. Whitaker, S-3.1

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TITLE: MISSION ANALYSIS	Approved by J. D. Thomson, Manager TWRS Technical Integration

AUTHOR:	F. J. Orsag
AUTHOR ORGANIZATION:	WHC

1.0 PURPOSE

The purpose of this procedure is to provide guidance for performing a Mission Analysis (MA), and for preparing the MA Report (MAR). This procedure will be applied as directed by the *Tank Waste Remediation System Systems Engineering Management Plan* (SEMP) (WHC 1996).

The purpose of performing the mission analysis is to transform a problem or problem statement into a well defined mission statement with clear mission boundaries and identified top level requirements. A MA identifies; (1) the mission inputs or initial state; (2) the mission outputs or desired final state; (3) the mission boundaries and interfaces; and (4) the mission requirements. The mission statement contains a top level function suitable for functional decomposition in accordance with the *Functions & Requirements (F&R) Analysis and Allocation Procedure* (WHC 1996).

2.0 SCOPE

This procedure applies to Tank Waste Remediation System (TWRS) Projects in accordance with guidance in paragraph 4.0, and the graded approach described in Appendix A of the SEMP.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The Westinghouse Hanford Company (WHC) is responsible for establishing appropriate practices for development of Mission Anaylses at the Hanford Site. The responsible organization is the WHC organization that needs a MA performed. The responsible organization shall use the graded approach in Appendix A of the SEMP to determine the need for, and appropriate level for a MA. Some things that should be considered in this determination include:

- Are specifications, data requirements document, or satisfactory upper level requirements available? (If satisfactory requirements have been developed than a MA is not necessary.)
- Does it make sense?
- Has the U.S. Department of Energy (DOE) requested a MA?

If satisfactory requirements have been developed, then a MA is not necessary. If the requirements are not available, but a function or task has been defined, then the MA procedure can be tailored to include only the requirements development portion. In general this procedure should be tailored to reflect only what is needed, or wanted, for a specific activity.

A MA should be performed only when it makes sense. Performing a MA on an ongoing project, with well-defined requirements is unnecessary, but justifying the requirements might be applicable. DOE may request a complete or tailored MA to fulfill their needs. The grading and tailoring should be coordinated with the customer and the program office responsible for system integration, and approved by the responsible program manager prior to implementation. The responsible organization will also identify the analysis team and provide the required resources to support the analysis.

The responsible organization should accomplish the following:

1. Obtain needs and wants from the customer.
2. Maintain communication with the customer.
3. Establish a plan and schedule for accomplishing the MA.
4. Develop a plan for support of the team and administration of the material developed by the team.
5. Assemble a team for performing the MA.
6. Ensure all required input documentation and materials are available.
7. Contribute to defining top-level measures of success.
8. Coordinate information exchange with related groups.
9. Perform review of the analysis.
10. Obtain final approval and release of the MAR.

The Responsibilities of the MA team are as follows:

1. Perform the MA as outlined in this procedure.
2. Prepare the MAR.
3. Resolve review comments.

5.0 PROCEDURE

The MA procedure consists of:

1. Preliminary activities.
2. MA.
3. Preparation of a MAR.
4. Post Analysis Activities.

5.1 Preliminary Activities

Preliminary activities include:

1. Identifying and organizing the MA team.
2. Establishing the schedule for MA workshops and review meetings.
3. Collecting mission-related source materials.

The size and composition of the MA team, the duration of the activities and schedules required, and the materials that must be collected and analyzed depend on the extent of systems engineering (SE) documentation required and the tailoring as determined by the graded approach.

The MA team will include personnel with broad technology, management and SE expertise in the disciplines required to perform the analysis. The team shall include personnel with expertise in specialty disciplines as described in 4.1.4 of the SEMP appropriate to the entire life cycle of the mission. An important member of the team is the customer (DOE) representative to correctly interpret the customer's expectation for the team. Senior management personnel with an understanding of user needs, operational goals, and other related Hanford Site systems, missions, and programs shall be made available to provide guidance and assistance. Program control, cost analysts, life-cycle cost, and scheduling expertise shall be available to the team on an as needed basis.

A MA typically involves individual research, workshops, team meetings, reviews, trade studies and engineering analyses as appropriate. An engineer experienced in performing a MA should lead the team meetings and workshops and be responsible for developing the MAR. System analysts and recorders may be used to support the analysis. Trade studies and engineering analyses must be structured to provide the results described in 4.2.

Source documentation related to the mission definition will be collected by the analysis team. Source materials provide information on the following:

1. User needs, goals, and objectives (Hanford Mission Plan, Justification of Mission Need [JMN], statement of work [SOW] [if available], etc.).

2. Current conditions of existing system (surveys, assessments, etc.).

3. The problem (SOW, program summary, etc.)

4. Applicable constraints, requirements, policies, and interfaces that may control or affect the performance of the mission (Code of Federal Regulations (CFRs), DOE Orders, WHCs, higher level requirements, etc.)

5. Other related programmatic issues and documentation (*Hanford Federal Facility Agreement and Consent Order* [Tri-Party Agreement] [Ecology et al. 1996], Multi-Year Program Plan [MYPP], etc.).

5.2 Mission Analysis

The MA is part of the integrated engineering process as shown in Attachment A. The MA consists of the following ten steps. The first two steps are usually accomplished in parallel, the middle six steps are usually accomplished in order, and steps nine and ten must be accomplished after step eight is completed. However, the steps can be accomplished in parallel or "out of order" if determined necessary because of schedule or other prevailing reasons. Care must be exercised to ensure that all steps are accomplished if not accomplished in order.

1. Identify the customers and define customer needs.

2. Define the mission initial conditions.

3. Define the acceptable end state.

4. Define the system life-cycle.

5. Define the system boundaries and external interfaces.

6. Prepare a problem statement.

7. Prepare a mission statement.

8. Identify mission-level requirements.

9. Determine test and evaluation (T&E) methodology.

10. Define mission measures of success.

A MA yields a mission statement that describes WHAT must be done to transform an unacceptable initial state into an acceptable end state. The mission statement establishes the top-level System Function Definition.

Accomplishing the MA requires the identification and use of the results of appropriate systems analyses. Accomplishing parametric studies, systems analyses, and trade studies is extremely important to the MA task. Studies shall be conducted, as necessary, to resolve conflicts, determine appropriate values, identify and quantify risk factors, identify and evaluate technological constraints, develop and analyze life-cycle support and costs and quantify mission objectives. The rigor of these studies shall be appropriate to the grading of the MA being conducted. For example, a MA and associated trade studies and analyses for the program level, must be of sufficient rigor and breadth for a DOE Headquarters led Systems (Mission) Requirements Review. Additional guidance on systems analysis is contained in the Alternative Generation and Analysis Procedure.

5.2.1 Identify the Customers and Define Customer Needs

The first step in the MA process is to identify the customers and determine their needs or requirements. Users and customers refer to everyone in the customer organization, everyone who uses, maintains or operates the system, everyone who pays for the system, the special interest groups, and other affected stakeholders.

The users/customers stated needs should then be interpreted in the customers' frame of reference. The user needs are the performance and logistic characteristics desired by the customer. It is a wish list to be analyzed thoroughly with compromises made, constraints, including budgets, considered and priorities determined. Suitable tools, such as Quality Function Deployment (King 1987), should be used to transform customers desires into prioritized and analyzed needs. Reviews should be held periodically to inform the customers of actions taken on the needs.

Some important considerations for this activity are:

1. Establish realistic objectives.
2. Set priorities for each of the stated needs.
3. Understand the customer's viewpoint.
4. Communicate with the customer - speak the customer's language.

5.2.2 Define the Mission Initial Conditions

The MA team will define and describe the present programmatic and physical conditions. It will include the conditions that the mission is to change and the conditions that will be unchanged. The initial conditions of concern will be described. Some major topics to consider are existing attributes, variables, products, or processes to be considered for treatment by the mission. The MAR will document the initial state of each major topic and will provide rationale for including the topic in or excluding it from the mission.

5.2.3 Define the Acceptable End State

The MA team will establish and describe the desired programmatic and physical end state to be achieved by executing the mission. The end state of major topics will be described. The major topics are the variables, processes, or products that will be treated by the mission. The MAR will document the desired end state of each major topic and relate the end state to the mission objective(s).

5.2.4 Define the System Life-Cycle

The Life-Cycle Definition is important to defining the system boundary and external interfaces. Systems will be designed and conceptual operational scenarios will be developed for the full life-cycle within the mission. The operational scenarios and operation and maintenance (O&M) concepts shall be developed to the detail necessary for the MA being conducted. For example, an operational scenario and O&M concept for the Site could contain general statements about planned acquisition, operations, maintenance, and training strategies while a MA for a vehicle would contain details on how the vehicle would be maintained and operated. A MA will develop the system life cycle and operational scenarios through all phases of system development, including system conceptual definition, development and design, construction, training, operation, support (maintenance) and disposal. The Life Cycle Definition will be included in the MAR. An O&M concept shall be initiated in this effort and further developed during requirements development (paragraph 4.2.8). To facilitate the development of life-cycle costs, it is essential that development of an O&M concept be given consideration as early as possible in the concept development stage of the system.

5.2.5 Define the System Boundaries and External Interfaces

The MA team will identify the boundaries of the system, the environment in which the system will exist, and all external system interfaces.
The system environment consists of anything that may affect both the mission itself and the system that will perform the mission. The three primary boundary types are characterized as follows:

1. Boundaries that define the physical system limits.

2. Boundaries that define the organizational and programmatic system.

3. Functional interfaces between the system of interest and external systems.

This task will also identify all external interfaces that could affect the mission, including the following:

1. Constraints, which are requirements imposed by external systems or organizations, and that cannot be changed except by the external entities.

2. Mission inputs.

3. Mission outputs.

4. Resources consumed and mechanisms applied in performing the mission.

Organizational or programmatic interfaces can arise from the following:

1. Agencies that have authority to impose requirements on the mission development process and the mission's end products.

2. Oversight committees.

3. Site interfaces.

Programmatic interfaces will be documented in the MAR. Mission constraints, as well as the agencies imposing the constraints, will also be documented in the MAR.

5.2.6 Prepare a Problem Statement

The purpose of this step is to translate the customer's expression of need into a problem or need statement in engineering terms.

The problem statement describes what is wrong or unacceptable about the initial conditions and why the conditions must be changed. The problem statement will document the general nature and scope of the problem to be solved and to identify the mission needs to be satisfied by solving the problem. The problem statement will be included in the MAR.

5.2.7 Prepare a Mission Statement

The mission statement describes the overall scope and objectives of the mission. A mission statement is a statement of WHAT must be done to transform an unacceptable initial state into an acceptable end state. It provides a description of results, which once achieved, would satisfy the customer's need or solve the customer's problem. It defines the overall top-level function to be performed by the system. The assumptions that have to be made to enable preparation of the mission statement are identified and analyzed. A schedule to resolve the assumptions is also developed. The programmatic risks associated with the mission statement and enabling assumptions must be assessed and quantified. A mission statement, supporting rationale and associated risks will be included in the MAR.

5.2.8 Identify Mission-Level Requirements

Mission-Level requirements tell how well the top-level function must be performed to accomplish the mission. Development of the Mission-Level requirements for the entire life cycle of the system including system conceptual definition, development and design, construction, training, operation, support (maintenance) and disposal is extremely important. These requirements are either externally imposed or mission driven. The externally imposed requirements (i.e., constraints) are developed during collection of requirements documentation during the Preliminary Activities, 5.1, and Identification of the System Boundaries, 5.2.5. Constraints are defined as requirements imposed by external sources that cannot be changed by the system developer. Mission-driven requirements are based on the desired end states and the desired performance. Systems analyses will be used to develop the mission driven requirements. The MAR will contain a list of constraints and mission-driven requirements.

5.2.9 Determine Test and Evaluation Methodology

The MA team will determine the methodology for verification of all mission level requirements. The verification can be accomplished by actual tests of the mission requirements or by integration of lower level test results or by a combination of the two methods. Integration is accomplished to ensure that the combination of results of the tests of lower level elements results in a verification that the system meets mission level requirements. The verification can be accomplished by review, test, demonstration, inspection or analysis, as appropriate. A T&E Plan will be initiated to provide additional details on design and conduction of the test activities.

5.2.10 Determine Mission Measures of Success

The MA team will determine the appropriate system Measures of Success (MOS). The MOSs are selected based on the system's predicted technical performance - usually the ones most critical to mission success. They assess the degree to which the system design meets the mission requirements. The MOSs may include key requirements, measures of effectiveness or key decision measures. The MOSs will be the basis for further decomposition into lower level technical performance parameters that can be tracked for the life of the system.

5.3 Mission Analysis Report

The MAR documents the results of the MA. This report provides the necessary input for the next level of functional decomposition. The MAR will follow the general format and content shown in Attachment A, but can be tailored based on the grading criteria contained in Appendix A of the SEMP. The MAR will be identified as a Supporting Document per WHC-CM-6-1 (*Standard Engineering Practices*), EP 1.12, and WHC-IP-1026, (*Engineering Practices Guidelines* [WHC 1995]).

5.4 Post-analysis Activities - Report Review and Approval

All MA objectives must be met before submitting the MAR. The customer and the responsible organization must agree that the MA has been satisfactorily performed. A formal or informal Systems Requirements Review can be the basis for review and acceptance of the MA. The minutes of the review, with completed action items, will show customer acceptance of the MA as performed. Acceptance of the MAR can also indicate that the customer has accepted the MA.

The MA will be concluded by the preparation, approval, and release of the MAR.

6.0 REFERENCES

IEEE P1220, 1994, *Standard for Application and Management of the Systems Engineering Process*, Final Draft, Institute of Electrical and Electronics Engineers.

IS-632, 1994, *EIA Engineering Standard, Systems Engineering*, Final Draft, The Electronic Industries Association.

King, B., 1987, *Better Designs in Half the Time, Implementing QFD*, GOAL/QPC, Metheun, Massachusetts.

Orsag, F., 1996, *TWRS Systems Engineering Manual*, "Alternatives Generation and Analysis Procedure," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996, *Tank Waste Remediation Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995, *Engineering Practices Guidelines*, WHC-IP-1026, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

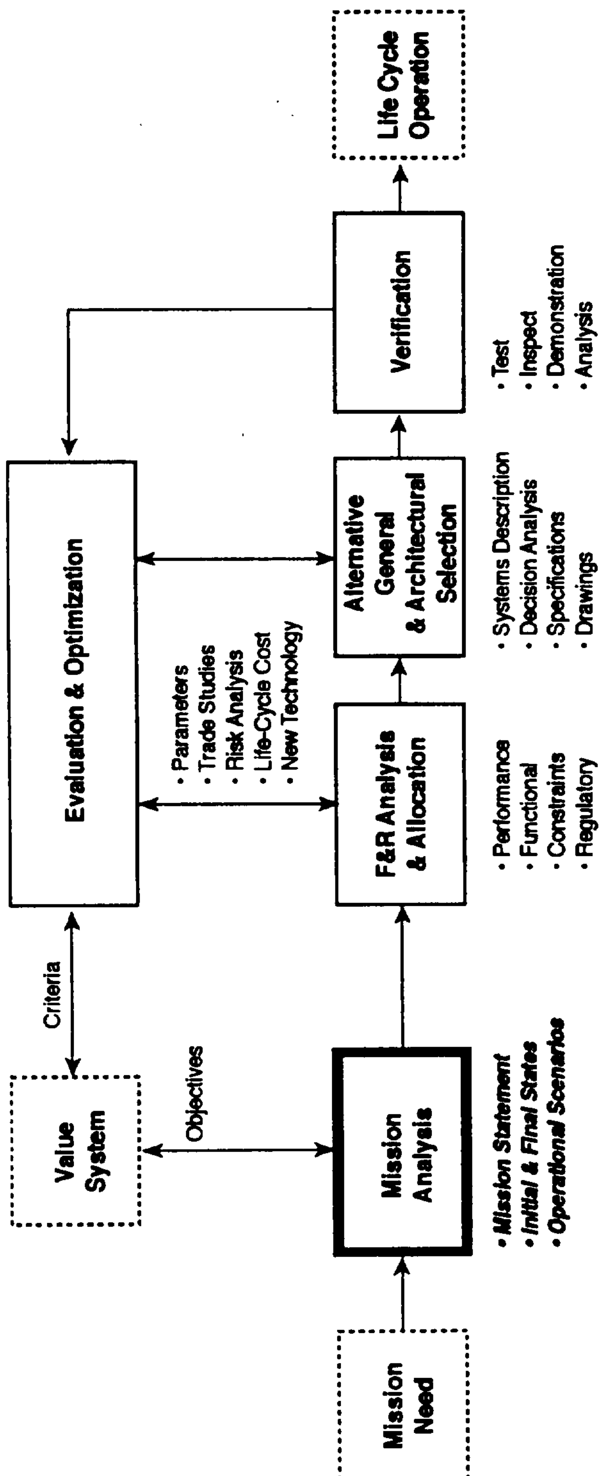
WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A TWRS Systems Engineering Process
Attachment B Table of Contents of Mission Analysis Reports

Attachment A

TWRS Systems Engineering Process



Attachment B

Table of Contents of Mission Analysis Reports

TITLE:

FUNCTIONS AND REQUIREMENTS ANALYSIS AND ALLOCATION

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to provide guidance for performing the functions and requirements (F&R) analysis and allocation step of the engineering process (Attachment A). The instructions include the tasks required to complete a comprehensive F&R.

The main objective of the F&R analysis is to provide a hierarchy of functions and requirements that supports the development of a traceable and defensible top-down system architecture. The architecture is used to develop the Work Breakdown Structure (WBS), which provides integration with the cost and schedule baselines.

This main objective is accomplished by:

1. Developing a complete and integrated functional framework for the entire system.

2. Developing and allocating appropriate requirements to the system functions.

3. Maintaining requirements traceability.

4. Keeping a current, complete, and validated F&R database for use in generating technical specifications.

The F&R procedure starts after top level functions and requirements are available from a completed Mission Analysis (MA) or provided from another source, i.e., Design Requirements Document, Statement of Work, etc. The parent function(s) for the first iteration through the F&R procedure are the top level functions and requirements. The inputs for the next iteration, and all subsequent iterations, are the sub-functions from the previous F&R analysis and the architectures developed in the *Alternative Generation and Analysis* (AGA) and *Decision Management* (DM) procedures (Orsag 1996a, 1996f). The F&R analysis is performed to decompose the parent function into sub-functions and the requirements that define the performance of the sub-functions. The outputs of the F&R analysis, functions and requirements, are inputs to the DM and AGA Procedures, which are then used to generate the alternatives and select the architecture (preferred physical system concept) for each function. The method to verify that the requirement has been satisfied is then determined. The entire Systems Engineering (SE) Process is accomplished in an iterative manner, one level at a time and applies to all levels of detail, from the mission level function down to completion of the functional analysis, when the F&R for the lowest level single object that can be built, constructed, or purchased are developed.

The F&R process and this procedure are most efficiently conducted by the use of concurrent engineering or Integrated Product Teams (IPTs). An IPT is formed for each function. This team develops the functions and associated requirements and then participates in the DM and AGA efforts to develop the appropriate architectures. Team members then participate on the teams formed for each for the next lower levels to provide continuity and guidance. The teams consists of full-time members from the cognizant engineering group, SE, and safety and part-time representation from any of the specialties needed for that function. The selection of the specialties needed is the responsibility of the full-time members of the IPT or as directed by management.

2.0 SCOPE

This procedure applies to all technical development and documentation activities associated with the F&R analysis. This procedure will be applied as directed by the *Tank Waste Remediation System System Engineering Management Plan* (SEMP) (WHC 1996). This procedure should be graded and tailored according to Appendix A of the SEMP.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The cognizant engineering organization responsible for a function, in coordination with the program or project office, should accomplish the following activities:

1. Define the scope of the F&R analysis.
2. Assemble and support the F&R analysis team.
3. Develop the detailed schedule for F&R analysis activities.
4. Ensure input documentation, tools, and materials for the F&R analysis are available.
5. Ensure proper reviews and approvals of resulting F&R documentation and entry of the functions and requirements into the Tank Waste Remediation System (TWRS) Technical Baseline.
6. Notification to the proper organization that the F&R Analysis for a function has been completed and the next step, the architecture selection process (DM and AGA Procedures), needs to be initiated.

The responsibilities of the cognizant engineering organization doing the F&R analysis are:

1. Develop the F&Rs as described in this procedure.
2. Perform requirements validation.
3. Coordinate review activities and incorporate comments before final approval and submission of the new F&Rs in the revisions to the Requirements Allocation Sheet (RAS) and Change Control Documentation.
4. Document the analysis results.

The TWRS Technical Integration Organization shall:

1. Maintain a current, complete validated Requirements Management and Assured Compliance System (RMACS) database.
2. Input the changes to the RMACS database on receipt of properly signed and coordinated Change Control Forms.
3. Provide access to the database for use during the F&R development process.

5.0 PROCEDURE

The F&R analysis, as part of the engineering process, is performed interactively with the process of generating system architectures and developing test and evaluation methodology (see Attachment A). The F&R process develops functions, requirements, and provides source data for architecture concept development. Functions are descriptions of what the system must accomplish. Requirements are statements of how well the functions must perform. These function descriptions and requirements are the basis for the development of architecture concepts and the tests verify that the requirements have been satisfied by the component or system.

Results from the architecture development are used to evaluate the identified functions and requirements impact on the system design. The iterative F&R process is monitored and controlled by evaluation and optimization tools:

- AGA or trade studies - the process of comparing or trading the strength and weaknesses of alternative approaches or attributes (*Alternative Generation and Analysis*, WHC-IP-1231) (Orsag 1996a).
- DM - the process of selecting the preferred function or requirement based on the data produced from a trade study (*Decision Management*, WHC-IP-1231) (Orsag 1996f).

- Risk analysis - the process of estimating the potential for an undesirable event and the consequence of the occurrence. Risk is used as an evaluation criteria during trade studies and DM (*Risk Management*, WHC-IP-1231) (Orsag 1996c).

- Parametric analysis - a technique for comparison of alternatives that uses graphs of the relationships between two or more quantities (requirements) influenced by one or more other variables (parameters) to determine the optimal value for the requirement (WHC-IP-1231, AGA procedure) (Orsag 1996a).

- Life-cycle cost analysis - determination of the total cost for the acquisition of the system including development, construction, operations, maintenance, and decommissioning (*Life-Cycle Costs*, WHC-IP-1231) (Orsag 1996e).

- Technical performance measurements - evaluation that predicts the future performance of a physical system, subsystem, or component and compares the prediction to the required performance (*Technical Performance Measurement* WHC-IP-1231) (Orsag 1996d).

The TWRS SE process should be accomplished one level at a time. The parent function is divided into the next level of sub-functions, then the requirements for the sub-functions are developed and the AGA and DM Procedures are used to generate alternatives and select the architecture (design solution) for that level. After the architecture selection the methodology for verifying the requirements developed during that iteration is determined. Then the F&R Procedure is used again to develop the functions and requirements for the sub-sub-functions. F&R Analysis and Allocation is complete, for each iteration, when the functional boundaries are completely understood, all of the requirements defining the lower level function are known, and at least one design solution that can accomplish the function and satisfy the requirements can be visualized.

5.1 Functional Analysis

The SE approach to functional analysis begins with an examination of the entire system and defines what the system must do to satisfy the mission need.

Functional analysis consists of: (1) function decomposition; (2) function definition; and (3) development of functional relationships. The beginning condition for the first functional analysis is the MA results. Subsequent iterations of the F&R analysis use the higher level functional analysis as input. The output of the functional analysis is a completely defined function set that accomplishes the input (i.e., parent) function(s).

5.1.1 Function Decomposition

Function decomposition consists of dividing a well-defined function (parent function) into sub-functions (siblings). A "rule of thumb" is that there should be between two and seven sub-functions. Less than two usually infers that the parent was not defined correctly and more than seven suggests that there could be another level in the hierarchy or that some functions could be combined. The sub-functions shall be both necessary and sufficient to accomplish the parent function. The functions and sub-functions are expressed in a verb-noun or noun-verb phrase combination such as Transfer Tank Waste. Functions are numbered and identified from top down so that sub-functions are recognized as part of larger functions (i.e., 4.2.1.1 is a child of 4.2.1). The results of the functional decomposition can be shown in a hierarchy diagram (Attachment B).

5.1.2 Function Definition

Function definition is the development and documentation of the necessary task, action, or activity that must be accomplished to execute the function. The textual function definition should include the scope of applicability with a statement of inputs, outputs and beginning and ending conditions. A functional requirement, which is a verifiable statement that defines how well the function must accomplish the activity or what the function must be able to do, could be an output of this step.

5.1.3 Function Relationships

The development of function relationships is accomplished to define:

- The relationship between the parent and sub-functions.
- The relationship between sibling functions (interfaces).
- The relationship between sibling functions and other functions (external interfaces).

Numerous graphical techniques can be used to assist in this activity. A functional hierarchy diagram (Attachment B) is used to show the relationship between the parent and sub-functions. N Squared (N^2) diagrams (Attachment C) is one technique used to develop and graphically portray interface relationships The N^2 diagrams relate the inputs and outputs of sibling functions to one another and to functions and entities external to the sibling functions. These diagrams clearly identify interfaces to be tracked.

Functional dependencies, relationships, interfaces, and timing can be developed and shown by use of a variety of tools such as:

- Behavior Diagrams (BD) (Attachment D). A BD is a precise and complete description of system behavior showing time flow and hierarchically decomposed inputs and outputs. BDs use a rigorous modeling language to describe system behavior.
- Functional Flow Block diagrams (FFBDs) (Attachment E). A FFBD shows the sequential relationships of all functions that must be accomplished.

- Integrated Computer Aided Manufacturing Definition (IDEF0s) diagrams (Attachment F). An IDEF0 is a graphical depiction of the Structured Analysis and Design Technique, which describes systems behavior in a hierarchical manner with focus on activities, inputs and outputs, controls and mechanisms.

- Time-Line Analysis (Attachment G). Time-Line Analysis considers functional durations and is normally used to support the design process for operations, test, and support functions. It shows the concurrence, overlap, and sequential relations of an activity and identifies time critical functions. Time critical functions are those that affect reaction time, down time, or availability.

5.2 Requirements Analysis

Requirements analysis develops verifiable statements of how well the functions must perform. Requirements analysis consists of: (1) developing the requirements applicable to the sub-function(s) identified in the functions analysis; (2) allocating those requirements to sub-function(s); (3) resolution of conflicting or ambiguous requirements; and (4) validating the requirements. Inputs to the requirements analysis process are: (1) the latest function decomposition; (2) the previous system architecture; and (3) trade studies or other valid requirement sources. The output of the requirements analysis is adequate detail to clearly and completely define the function(s) performance.

5.2.1 Requirements Development

Requirements applicable to functions shall be identified and developed. They include functional requirements, constraints, interface requirements, and performance requirements. Requirements establish why and how well system products must perform in quantitative terms and define the environments in which the system products must operate.

Requirements shall:

- State what needs must be fulfilled by the function.
- Contain value with tolerances.
- Not contain or reference design solutions.
- Be derived from outputs of the function, based on the inputs.
- Be stated with a "shall" to remove any doubt.

A good requirement is:

- Necessary - if you can accomplish the function without this requirement, it is not needed.

- Verifiable - you must be able to verify the requirement by examination, analysis, test, or demonstration. "Requirements that cannot be measured are meaningless and should not be used." (*Life Cycle Asset Management* [DOE 1996]).

- Attainable - the requirement must be technically feasible and cost effective.

5.2.1.1 Functional Requirements. Functional requirements are verifiable statements that define how well the function must accomplish the activity or what the function must be able to do. Functional requirements are developed from function definitions in the early phases of the system analysis and are developed into quantified performance requirements (see 5.2.1.3). An example of a functional requirement is "Waste shall be removed (from the Miscellaneous Underground Storage Tank [MUST]) to the extent required for turnover of the tanks to closure."

5.2.1.2 Constraints. Constraints are requirements that are imposed on the functions by an exterior agency or group. Constraints cannot be changed by the performing organization. Changes must be approved by the external agency or group responsible for the constraint. Constraints include Federal and state regulations and standards, U.S. Department of Energy (DOE) Orders, DOE directives, stakeholder values, and formal agreements. Constraints are selected based on their applicability to the system being developed. An example of a constraint is "Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any given year an effective dose equivalent of 10 mrem/yr (40 CFR 61.92)."

5.2.1.3 Performance Requirements. Performance requirements are quantitative verifiable statements imposed on functions that have been defined through analysis from constraints, functional definitions, or higher level performance requirement(s). They can be changed during the requirements development activity by the performing organization. An example of a high level performance requirement is "Tank waste retrieval shall remove a minimum of 99 percent of the tank waste inventory." Another example of a performance requirement is "The waste solutions shall be transferred ... at a maximum waste temperature of 82 °C (180 °F)."

5.2.1.4 Interface Requirements. Interface requirements are quantitative statements of necessary inputs for a function to perform and provide the necessary output. An example of an interface requirement is "The waste transfer system shall receive 480 volts, 3 phase power, 60 hertz, at 100 kva from the facility power distribution system."

5.2.2 Requirements Allocation

The requirements previously identified for the parent function (inherited requirements) shall be allocated (or passed down) to the appropriate sub-functions. Some requirements will be applicable to all the sub-functions but some will require decomposition. To determine the decomposition that will deliver a balanced set of requirements, an allocation analysis shall be performed. Balanced requirements are developed by analysis to equalize the individual requirements design impact based on the overall mission need. The allocation analysis shall use analyses, development tests, or trade studies to derive numerical values for the lower level requirements. The combined values of the lower level requirements must equal the parent requirement. The allocation analysis shall consider the following: (1) allocating requirements such that interface requirements are minimized; (2) balancing requirements over the system elements; and (3) allocating requirements that translate into directly measurable quantities (i.e., ease the verification process).

5.2.3 Requirements Validation

Validation is the process of establishing credibility in the requirements. Validation of the requirements ensures that a system built to the requirements will satisfy the mission need. Validation is accomplished by analyzing, simulating, or modeling the performance of the requirement(s), and ensuring that the analysis, simulation, and models are representative of the real world. An example would be the comparison of simulation results with the actual results of a test, breadboard tests that predict actual performance, sub-scale tests that are proven to be indicative of full-scale results. Requirements are validated at a given function level prior to moving to the next sub-function level.

5.2.4 Interface Between Decision Management, Alternative Generation and Analysis, and the Functions and Requirements Procedures

After the F&R analysis step, the DM and AGA Procedures are accomplished to generate the alternatives and select the architectures to perform the generated functions. The DM Procedure provides detail on how to continue with the next step of the SE Process.

5.2.5 Requirements Allocation Sheet

The F&Rs are documented on a RAS for submittal to TWRS Technical Integration for data entry (see Attachment I). The RAS must be accompanied by a Change Request (CR). The RAS form ensures the requirements developer provides all of the necessary information to update and maintain the database. The sample form includes italicized explanations for each part of the form.

5.2.6 Change Control Process

The change control process for entering the newly developed functions and requirements into the RMACS system is covered in the *Hanford Site Technical Baseline Configuration Control Procedure* (Vann 1996). A CR (Attachment I) is initiated by the personnel responsible for the F&Rs. The Change Request provides adequate justification for the change and appropriate approval and coordination signatures. Processing of the CR package for review and approval is in accordance with the above procedure (Vann 1996). Attachments to the CR that describe the changes can include the RAS (as described above), delta files generated by the Requirements Management System Browser, textual information in electronic or hard copy format, and other supporting data as required to update the database and process the CR.

6.0 REFERENCES

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

DOE, 1996, *Life Cycle Asset Management*, DOE Order 430.1, PMG05, U.S. Department of Energy, Washington, D.C.

Orsag, F., 1996a, *TWRS Systems Engineering Manual*, "Alternative Generation and Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996b, *TWRS Systems Engineering Manual*, "Mission Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996c, *TWRS Systems Engineering Manual*, "Risk Management," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996d, *TWRS Systems Engineering Manual*, "Technical Performance Measurement," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996e, *TWRS Systems Engineering Manual*, "Life Cycle Costs," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996f, *TWRS Systems Engineering Manual*, "Decision Management," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Vann, J., 1996, *Configuration Management*, WHC-IP-1117, CCP-01, Westinghouse Hanford Company, Richland, Washington.

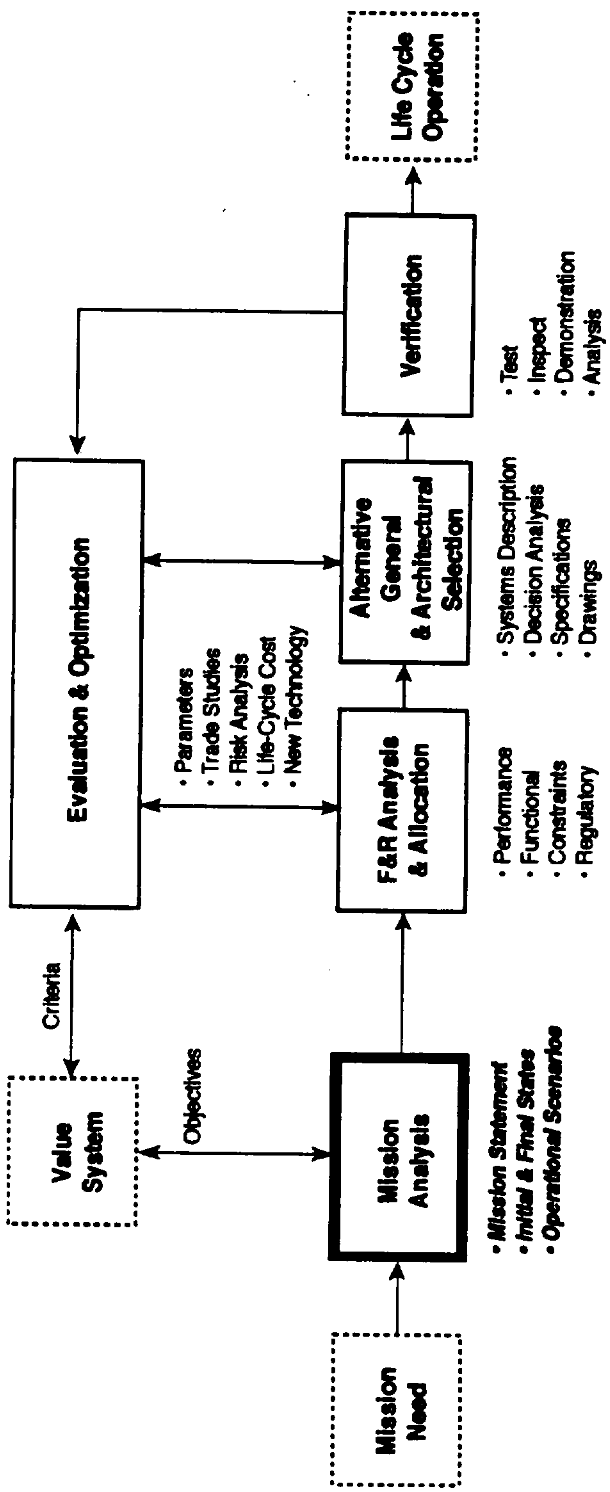
WHC, 1996, *Tank Waste Remediation System System Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A The TWRS Systems Engineering Process
Attachment B TWRS Functional Hierarchy
Attachment C N2 Diagram
Attachment D Behavior Diagram
Attachment E Functional Flow Block Diagram
Attachment F Integrated Computer Aided Manufacturing Definition
Attachment G Maintenance Time Line Analysis and Format
Attachment H Requirements Allocation Sheet Example and Format
Attachment I Change Control Form
Attachment J Priority Planning Method

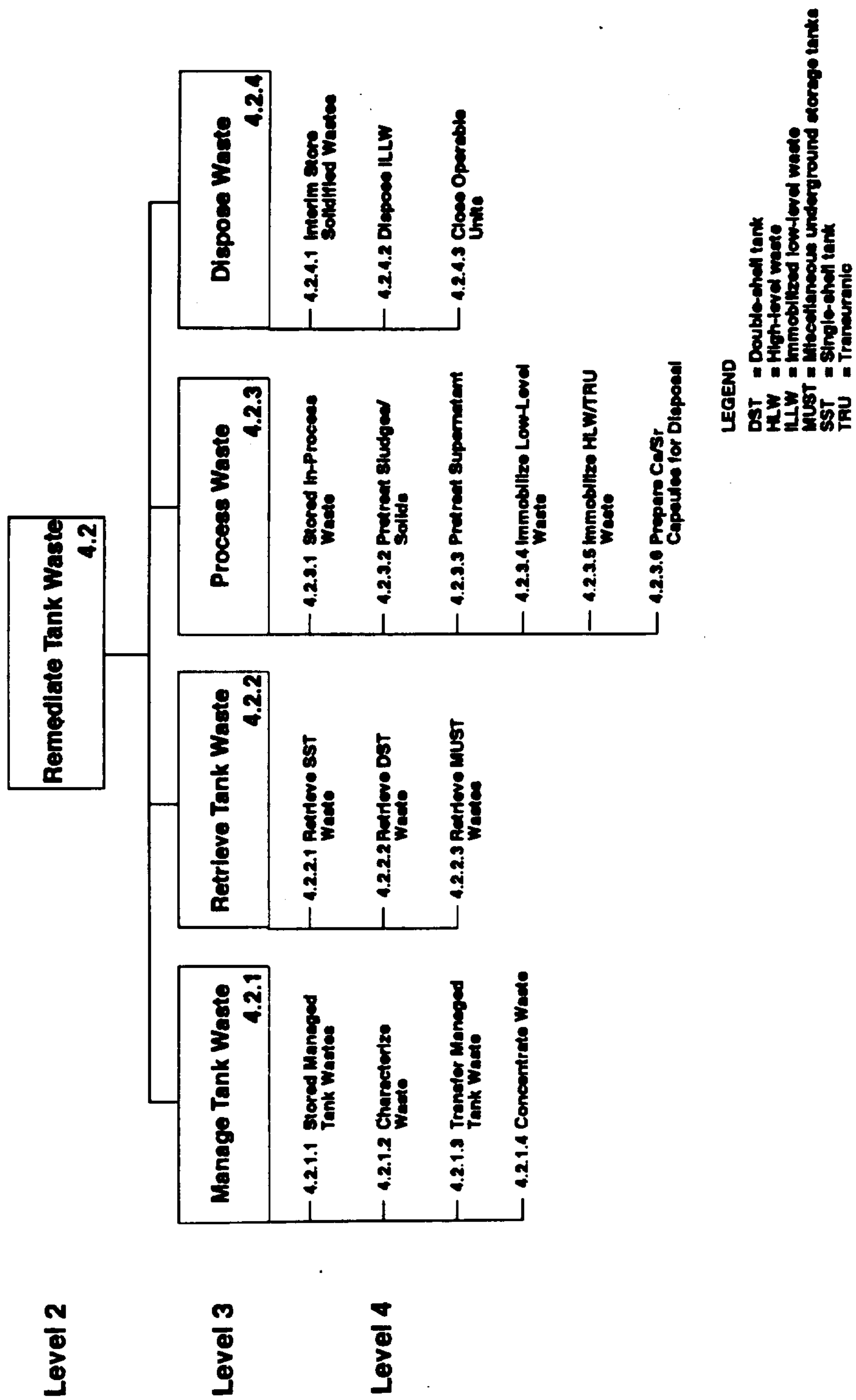
Attachment A

The TWRS Systems Engineering Process



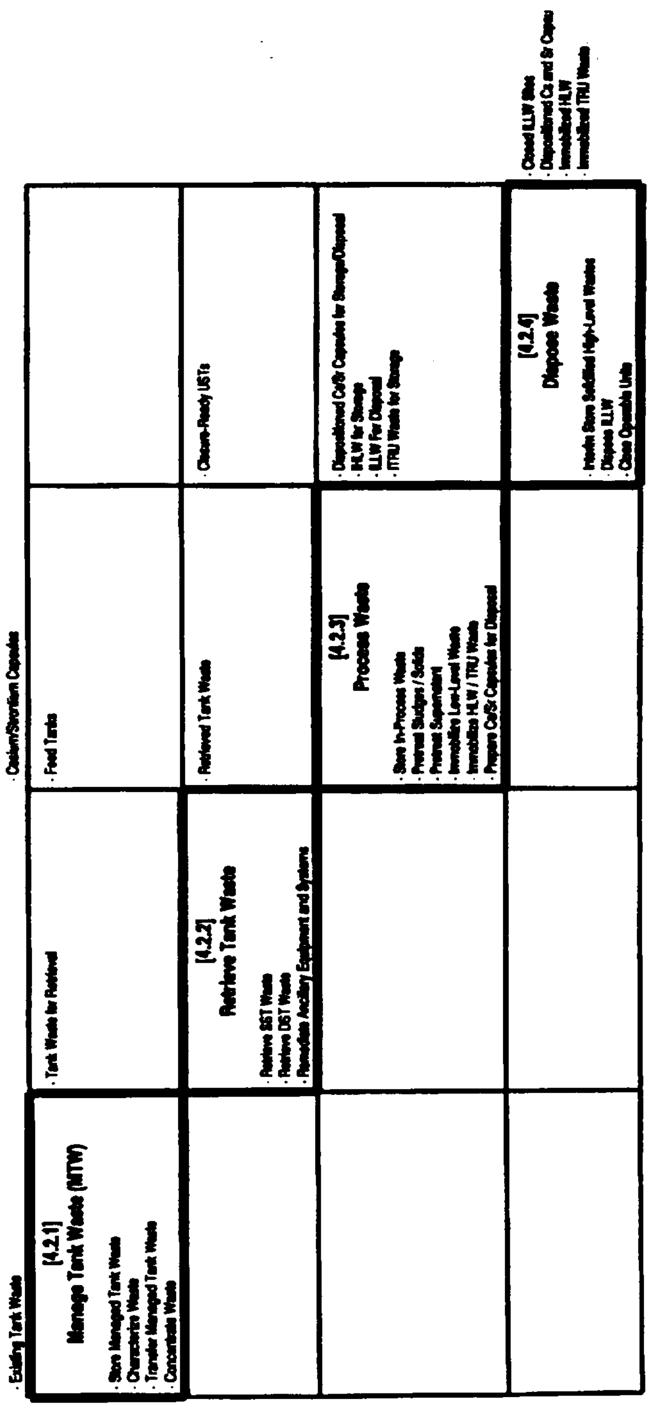
Attachment B

TWRS Functional Hierarchy



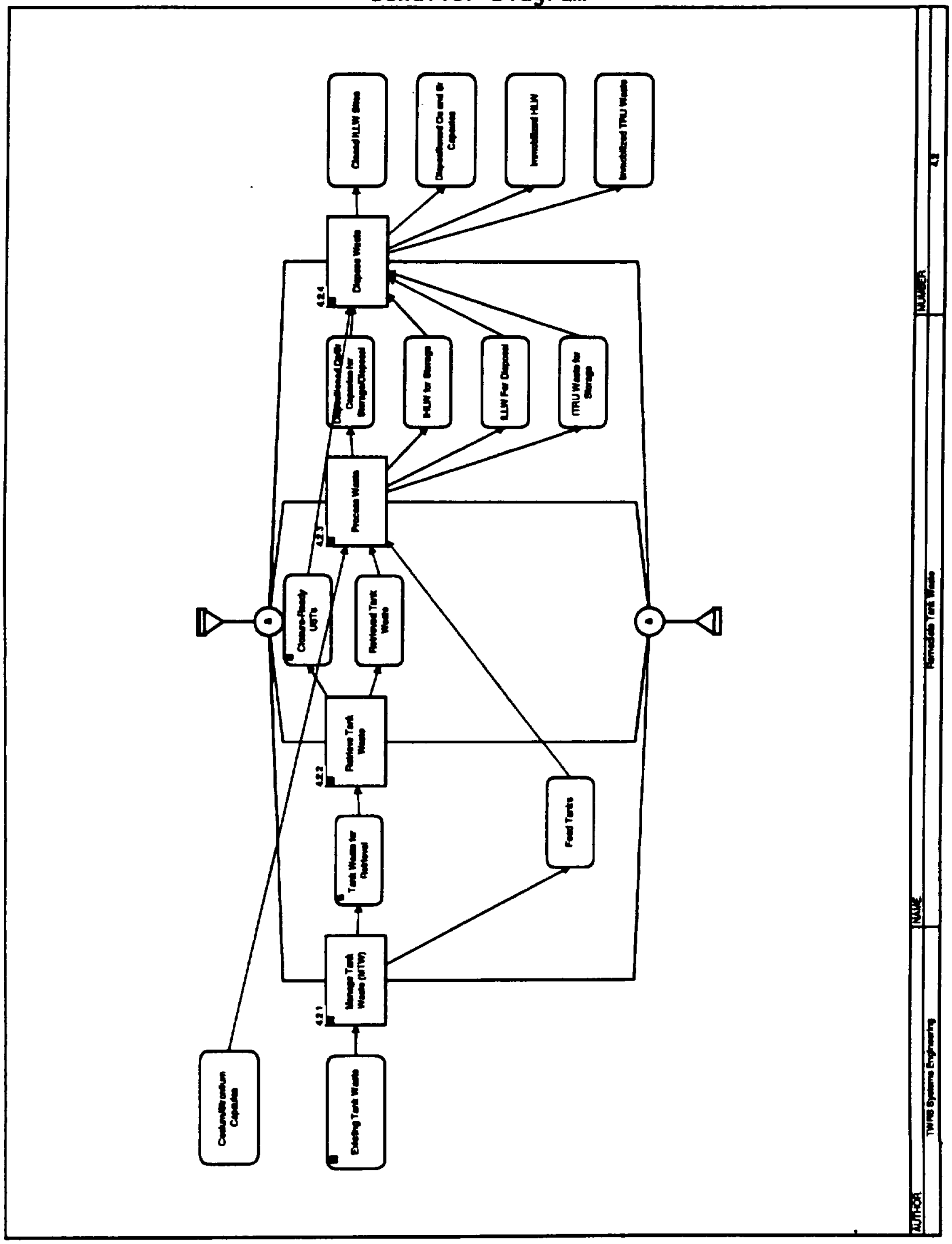
Attachment C

N2 Diagram



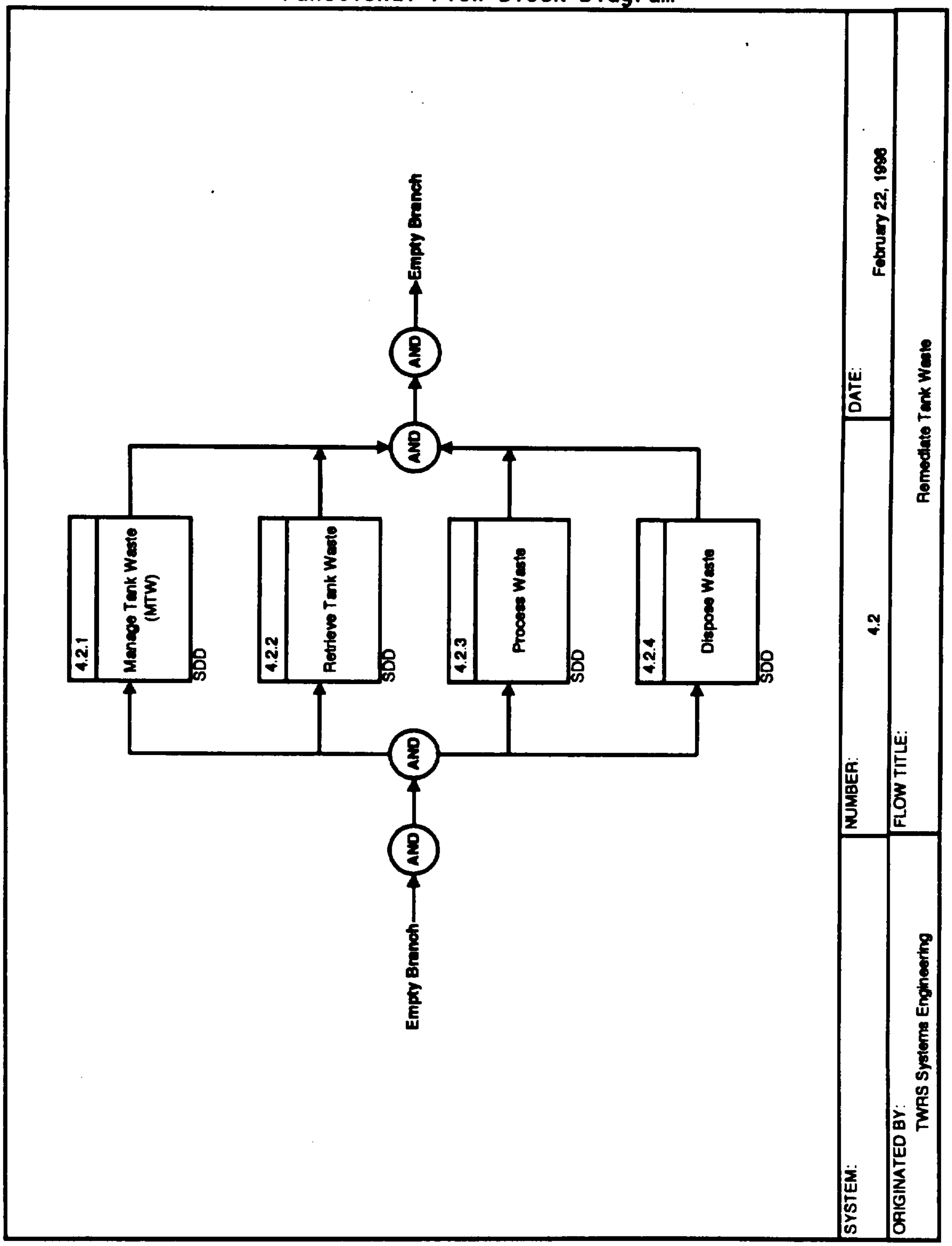
Attachment D

Behavior Diagram



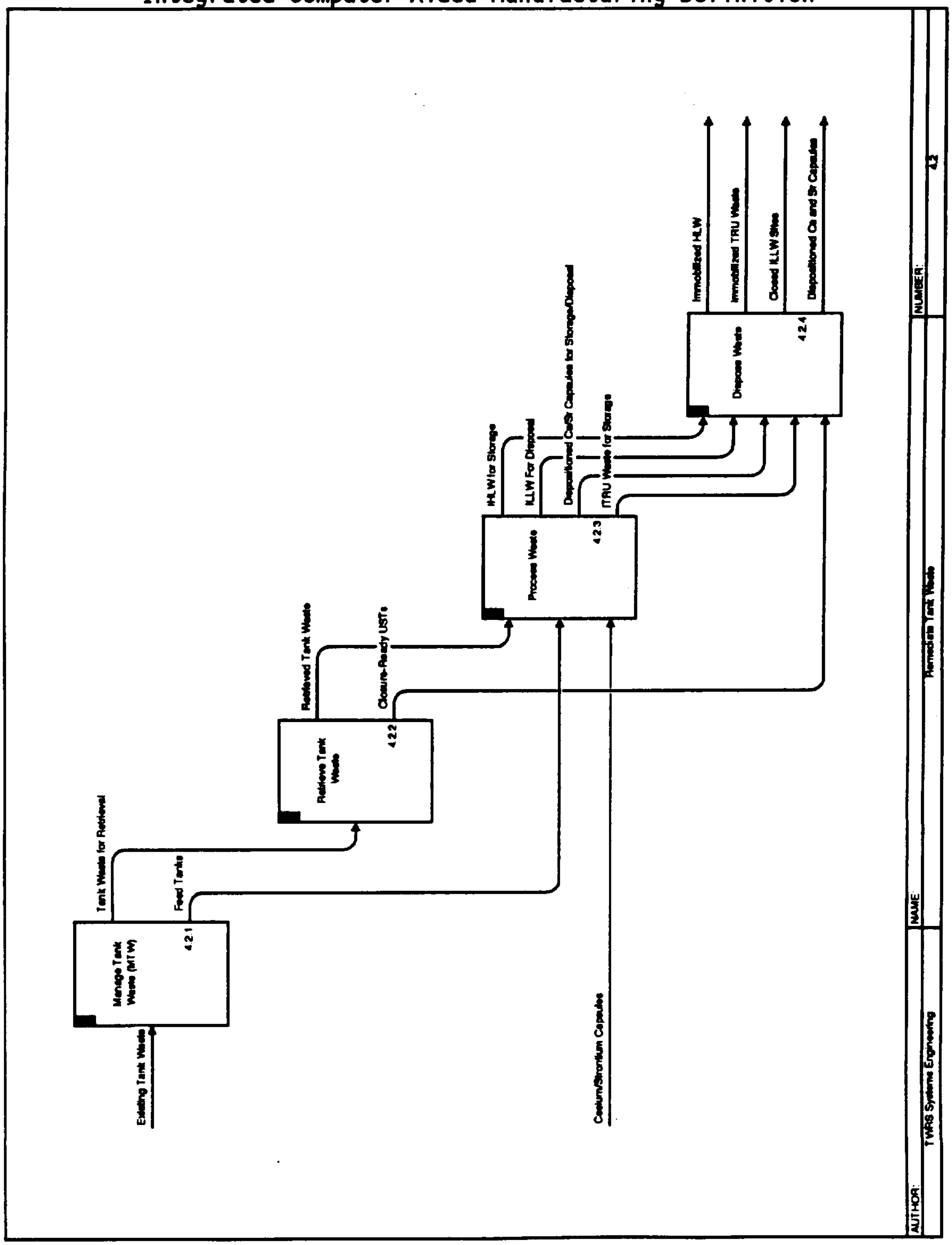
Attachment E

Functional Flow Block Diagram



Attachment F

Integrated Computer Aided Manufacturing Definition



Attachment G

Maintenance Time Line Analysis and Format

TIME LINE SHEET	(A) FUNCTION - PERFORMANCE PERIODIC MAINT ON VC DISTILLER	(B) LOCATION - ENGINE ROOM 3	(C) TYPE OF MAINT - SCHEDULED 200 HR PM
(D) SOURCE - FFBD 37.5X3	(E) FUNCTION & TASKS - RAS 37.5X37	(F) TIME - HOURS (.5, 1.0)	

TASK SEQ.#	TASK	CREW MEMBER	(F) TIME - HOURS
.01	INSPECT COMPRESSOR BELT	A2	.3H
.02	LUBRICATE BLOWDOWN PUMP	B1	.2H
.03	CHECK MOUNTING BOLTS	B1	.1H
.04	CLEAN BREATHER CAP	B1	.1H
.05	CLEAN FOOD STRAINER	C1	.5H
.06	REPLACE OIL	B1	.2H
.07	REPLACE FILTER	C1	.4H
.08	REPLACE V-DRIVE BELT	D1	.9H
.09	CLEAN & INSPECT CONTROL PANEL	C1	.1H
.10	INSTALL NEW DIAPHRAGMS	A2	.7H
.11	CLEAN CONTROLS	B1	.1H

TOTAL MANHOURS — 3.6 MH
ELAPSED TIME — 1.0 H

Attachment H

Requirements Allocation Sheet Example and Format

MAJOR FUNCTION NAME: STORE WASTE MAJOR FUNCTION NO: 4.2.1.1.

		FUNCTION	
FUNCTION NUMBER AND NAME	SAFETY CLASS	REQUIREMENTS	SYSTEM ELEMENT NUMBER
This column provides traceability to upper level functions and requirements. An indentured numbering system is used to preserve this traceability. 4.2.1.1.1.1.3 Control DST waste level		This section states what the system must do. FUNCTION DESCRIPTION: The waste in the DSTs shall be maintained between a maximum limit to prevent overfilling of the tank, and a minimum level to prevent bottom uplifting of the tank's steel liner. Controlling the waste level includes monitoring the level, detecting and responding to abnormal conditions (i.e., levels outside the allowable range), and controlling the level control equipment. This section describes how well the system must perform the function. REQUIREMENT(S): The Requirement Reference (REQ REF) provides traceability to the source of the requirement. REQ REF: OSD-T-151-00007, Rev. H-6 1.0 Primary tank liquid level for Tanks AN, AP, AW, and SY shall be a maximum of 422 inches and a minimum of 6 inches. 1.1 Primary tank liquid level shall be a minimum of 6 inches during ventilation system operation. 2.0 Primary tank liquid level for Tanks AY and AZ shall be a maximum of 364 inches. 2.1 Primary tank liquid level for Tanks AY and AZ shall be a minimum of 64 inches during ventilation system operation. (Ref. SD-RE-TI-008, SD-RE-TI-041, HW-394-32, and HW-81666)	This column provides traceability of functions and requirement to architectures and specifications. W-314 UPGRADE SYSTEM ITEM NO: XXX

ORIGINAL DATE:____________ FLOW DIAGRAM TITLE:______________________ FLOW DIAGRAM NO:_______

REVISION DATE:____________ PROGRAM ID:________________

Attachment I

Change Control Form (2 sheets)

5. SSPP Planning Sheet Number	6. Planning Sheet Title
7. Presenter Name/Organization/Phone/MSIN	
8. Project Manager's Name/Organization/Phone/MSIN	
9. Technology Name	10. Technology Acronym
11. Technology Manager	12. Technology Contact
13. Owner's Company	14. Owner's Organizational Name
15. Owner's Manager	16. Owner's Technical Representative
17. Custodian Organization Name	18. Custodian Contact Name
19. Purpose of Request Guidance [ ] Obtain Resources [ ] Class I Change [ ] Class II Change [ ] Authorize Work [ ]	
20. Priority of This Request as Prepared by Requesting Process	The Priority Planning Method is to be executed by the Requesting Process providing their view of where this work fits.
21. Purpose of Request (short narrative):	

SPACE BELOW TO BE USED BY WAB PROCESS		
Review Date:		
ACTION TAKEN:	Priority of This Request After WAB Review	The Priority Planning Method executed by the WAB may produce a different result. Differences with PPM of the Requesting Process will be discussed.
Approved:	WAB Chair Signature	
Work Queue:	WAB Chair Signature	
Disapproved:	WAB Chair Signature	Disapproval Reason:

Attachment I (cont'd)

22. DOE Program Acronym	23. DOE Program Name	
24. DOE Program's Cognizant Manager	25. Cost Recovery Method	
26. Funding Organization	26A. Code	26B. Name
27. Estimated Amount	28. Funding Type	
29. Category of Service Rework [] Modification [] Enhance [] New Design []		
30. Work Management Method Used		
31. Start Date	32. End Date	33. Implementation Date

34. Describe Business Need Being Satisfied

35. Address Funding Availability/Limitations

36. Address Resource Requirements

37. Cross-functional resources required? [] Yes [] No

37A. If cross-functional resources are required, describe cross-functional management plan.

TOTAL RESOURCES REQUIRED

38. FTE Requirements for Major Project Life Milestones

39. Facility Resources for Project Life

40. Additional Resource Requirements

41. Address Support Issues With Recommendations

42. Address Staffing Recommendations

Attachment J

Priority Planning Method

Insert output of PPM here. The PPM software can be processed by either the work activity team or by the chair of the WAB.

TITLE:

ALTERNATIVES GENERATION AND ANALYSIS

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE AND SCOPE

The purpose of this procedure is to identify and analyze alternative choices or accomplish what is commonly referred to as "trade studies." Alternatives may be of any form, where there needs to be a selection made from two or more options. Examples are functions, requirements, concept, design, hardware, software, procedure, personnel, infrastructure, or combinations of them. The alternatives are analyzed against the decision criteria that will be used to select the preferred alternative.

2.0 SCOPE

This procedure applies to the analysis of alternatives throughout the Systems Engineering Process (Attachment A) from the Mission Analysis (MA) through Decontamination and Decommissioning (D&D). It describes the steps necessary to develop and analyze alternatives throughout the program-level and project-level workscope. The procedure described here is intended to be independent of organizational structures. The use of the terms "program" and "project" are intended to indicate differences in the technical nature of the various decisions, not to imply relationships within an organizational structure that also uses the terms "program" and "project" to distinguish between components of the organization.

The following sections of this procedure describe the process of developing and analyzing alternatives. This procedure is used in conjunction with the *Decision Management* (DM) Procedure (Orsag 1995d) and the *Risk Management* Procedure (Orsag 1995c). Attachment B shows the interaction of the three procedures with data and products, further discussed below, being transferred between the procedures. The DM Procedure is used to select the preferred candidate from the viable alternatives. The DM Procedure describes selection of the decision criteria used in this procedure and the process used to plan and track the decision making activities and to document the selected alternative. The Risk Management Procedure provides identified risk allocation and evaluation information that is used in analysis and decision-making.

The objectives of Alternatives Generation and Analysis (AGA) are to:

1. Identify alternatives, or validate previously identified alternatives.

2. Analyze the alternatives.

3. Document the alternatives analysis process in sufficient detail to support the decision-making process.

3.0 DEFINITIONS

1. Alternative A concept, design, hardware, software, procedure, personnel, infrastructure, or combinations of them.

2. Constraint A requirement that is imposed by external organizations (e.g., U.S. Congress, U.S. Department of Energy [DOE] Orders, U.S. Environmental Protection Agency [EPA]).

3. Decision Criterion A factor that is used to select a preferred alternative. A decision criterion may be quantitative or qualitative.

4. Decision Maker An individual who has the responsibility for making decisions.

5. Function A logical element of a system that achieves an objective (e.g., store waste).

6. Performance Measure A metric by which an alternative shall be analyzed, usually expressed in terms of quantity, quality, coverage, timeliness, or readiness. It should be noted that performance measures are strongly related to decision criteria. Performance measures are parameters that are evaluated (quantitatively or comparatively) in order to measure the performance of an alternative on various decision criteria. Each "value" (end, means, or process) for a decision is typically translated into a performance measure so that it can be used as a decision criteria.

7. Requirement How well the system needs to perform a function. The extent to which a function must be executed, generally measured in terms of quantity, quality, coverage, timelines, or safety. Requirements are tradable by the system designer.

8. Trade Study A common term used for the method of evaluating alternatives of any type or kind. Alternative evaluation and trade study is often used synonymously and are treated the same in this procedure. A common distinction is that alternative evaluation is used for the higher level (pre-conceptual and early conceptual phases) and trade study is more appropriate for lower levels.

9. Value A concept or ideal that is important in making decisions. Values may be "end" values (important for their intrinsic relationship to the decision maker), "means" values (important because they lead to some important end point), or "process" values (important because they give confidence and involvement to the appropriate individuals).

4.0 RESPONSIBILITIES

4.1 Sponsor Organization

The sponsor organization is either the program or project office that needs to accomplish a trade study. The sponsor organization provides oversight and adequate funding and helps define the scope.

Due to specific and perhaps unique needs of programs and projects, tailoring of the application of this procedure may be required. A graded approach, in accordance with the instructions in the *Tank Waste Remediation System Systems Engineering Management Plan* (SEMP) (WHC 1995a), shall be used to tailor the application of this procedure to the specific needs of the program or project. For example, some trade studies, for low risk and known actions, require only engineering judgement while trade studies on high risk and unknown technology need extensive and thorough analyses. However, all analyses need to be documented to provide traceability for actions taken. The content of the AGA Report (Section 5.7) should also be graded and tailored to reflect the requirements of the project. The changes and grading must be approved by the lead organization (see Section 4.2 below) and documented within relevant planning documents.

4.2 Lead Organization

The Tank Waste Remediation System (TWRS) engineering organization, responsible for the specific function, is the lead organization for overseeing the development and analysis of alternatives for their function. The lead organization, in conjunction with the sponsor organization, will define the workscope and provide sufficient resources and support to accomplish the activity.

4.3 Studies and Analysis Organization(s)

The lead organization determines the organization(s) responsible for performing the studies and analyses. This responsibility includes the systematic generation of alternatives using the procedures described below or the preliminary screening of already identified alternatives, the development of the alternatives to the extent that objective evaluations of the alternatives can be made, and the evaluation of each of the alternatives on the criteria identified by the decision maker (see the DM Procedure [Orsag 1995d] for a description of the decision maker responsibilities and the alternative selection process). The analysis organization is responsible for providing the information in the format requested by the decision maker.

5.0 PROCEDURE

AGA starts with the notion that alternatives have been, or need to be, developed and well informed decisions made to select among the alternatives or that there is a need to address a decision from some previously defined problem. The Decision Plan (from the DM Procedure [Orsag 1995d]) provides the problem statement and the alternatives to be considered or provides guidance on generating the alternatives. The alternatives are then screened against the criteria in the Decision Plan. Those alternatives that obviously do not meet the criteria are rejected and the remaining alternatives are analyzed across the set of decision criteria specified by the decision maker.

The process associated with generating and evaluating alternatives is iterative. The iterative process may start with a quick look at the alternatives that address the decision that has to be made. As the requirements become more detailed and quantified, the alternatives become more complete and refined to allow initial screening. The screening eliminates those alternatives that are inadequate (i.e., "GO" or "NO GO" assessment). The process of analyzing alternatives may generate additional considerations that suggest revisiting the alternative selection process.

This section provides a step-by-step description of AGA. Attachment C shows the steps in the AGA process. The steps shall be accomplished by the responsible organization.

5.1 Preliminary Activities

Preliminary activities are required to:

1. Prepare a work plan. (See *Engineering Practice Guidelines, Engineering Work Plans*, WHC-IP-1026 [WHC 1995b]). The sponsor organization in coordination with the lead organization shall prepare a work plan for accomplishing the AGA. The work plan shall address the driver for generating and analyzing alternatives. The driver is similar to decision framing (see the DM Procedure [Orsag 1995d]). The work plan shall include a statement of the decision required, the appropriate technical information needed, an estimate of the efforts, and schedule.

2. Identify and organize the AGA team. The lead organization will determine the composition and organize the team to accomplish the analysis. The composition of the team, especially the specialties on the team, will vary depending on the decision.

3. Collect technical and related source materials identified in Section 5.1(1) above.

5.2 Develop Problem Statement

The development and coordination, with the decision maker, of the problem statement is imperative to develop the true objective of the analysis. The problem statement must interpret the Decision Plan (from DM Procedure [Orsag 1995d]) from the analysis perspective and:

- Clarify the objectives.
- Clearly define the issues of concern.
- Bound the problem so that it can be understood.
- Establish the approach.
- Define measurable criteria so that the true objectives are measured.

Value-Based Performance Measures for Hanford Tank Waste Remediation System (TWRS) Program (Keeney and von Winterfeld 1996) contains a list of performance measures that have been generated for the TWRS Program. These performance measures will be used, if appropriate, in the analysis and evaluation of alternatives and will be referenced in the problem statement if applicable.

5.3 Identify Constraints and Assumptions

The constraints and assumptions that influence the identification and analyses of alternatives need to be identified and considered during trade studies.

Constraints are externally imposed restrictions that impact the total freedom of the decision maker or analysis effort. The constraints are beyond the control of the manager and provide limitations on the alternatives and the analysis. They may be budgetary, funding, schedule, technical options, legal, regulatory, organizational policy, or procedures, but they shall be identified and documented to provide bounds that are imposed on the solutions.

Assumptions are used to reduce extremely complex situations to problems of manageable proportion. They are limitations or restrictions, internally imposed by the manager or analyst, on the analysis process. The selection and use of these assumptions need to be clearly identified and justified so that the decision maker knows the complete basis for the development and evaluation of the alternatives.

5.4 Alternative Generation, Development, and Screening

The alternatives to be considered may be provided by the decision maker in the Decision Plan or generated. The methods used to generate the alternatives and descriptions of the alternatives shall be documented. Methods may range from informal brainstorming to formal experimental design. For example, the AGA team may use a combination of experience, brainstorming, imagination, and interpretation to generate alternatives. Afterwards, statistical techniques such as formal experimental design may be employed to finalize on the list of alternatives and the rationales for them. The selected methods shall be documented in the AGA Report (Section 5.7).

A list of acceptable alternatives shall be generated and documented. A description table is one typical format that would be acceptable to document the alternatives. The tables contain descriptive information about the alternatives, rationale for choosing the alternatives, the enabling assumptions that were made to allow further progress, and the required analyses for resolving the assumptions. Other formats that present this information are acceptable.

The process of generating alternatives yields a list of candidate alternatives that meet a minimum set of conditions. The alternatives are then developed in sufficient detail to permit the preliminary screening of these alternatives according to those conditions.

A screening is required to reject the alternatives that do not satisfy the minimum set of conditions (e.g., the functions, requirements, and performance measures associated with the alternative). The alternatives are analyzed against the screening criteria as "GO/NO GO." An alternative shall either satisfy the screening criteria or be rejected. The results of the screening shall be documented in the AGA Report (Section 5.7).

5.5 Data Collection and Generation

Data that can be used to analyze each alternative against the decision criteria shall be generated. To perform further analysis and evaluation of the alternatives, additional information and detail will be needed for each alternative. The information needed can fall into many categories; operational scenarios, costs, and design concepts are just three.

The analysis may require defining an appropriate operational scenario. The definition should include quantifying the operating mission in terms of start-up dates, mission duration, interfaces with other operations, capacities, support requirements for utilities, operating staff, maintenance, storage, analytical services, specialty engineering services, etc. The alternatives should be pictured in the operating environment in which they will function to verify the interfaces are fully understood.

Development of viable cost information may be difficult but is useful in developing cost-benefit relationships to help differentiate between alternatives. The use of "top-down" analysis can provide a cost basis for projected physical and performance characteristics. The "bottoms-up" technique is more hardware or product oriented and the system cost is built up based on the cost of all the components. The top-down technique is usually used in the early stages of the project and the bottoms-up when all the components have been identified.

Development of alternative design concepts serves to define each alternative to the extent necessary for a valid technical comparison. Developing design concepts requires a certain level of design information (e.g., process flow diagrams, mass balance, equipment list, layouts, cost estimates, and schedule). The level of detail will vary depending on the decision. The work plan shall provide the necessary information on the statement of the decision and the criteria by which alternatives are generated.

Attachment E contains descriptions of design concept alternatives and evaluations.

The data used shall be documented in the AGA Report (Section 5.7).

5.6 Evaluation and Analysis

The inputs to this step are a list of screened alternatives (see Section 5.4), the data developed in Section 5.5 above, and the decision criteria (from the work plan and the Decision Plans provided by the decision maker). The evaluation activity generates performance data for each of the alternatives on each of the relevant decision criteria. Because not all the conditions surrounding the decision or the decision criteria are known with certainty, the decisions will have to be made under conditions of uncertainty. There are numerous methods that can be used in the decision process and the analyst needs to structure the analysis and data presentation to reflect the method that will be utilized by the decision maker. Examples of some of the methods commonly used (or decision criterion) are listed below:

- Dominance, where one alternative is clearly superior, and provides for the greatest benefit in all possible future scenarios.

- Wald (Maximin), the most pessimistic. The alternatives evaluated to determine the worst possible result for each course of action. The alternative selected gives the most desirable of these results.

- Plunger (Maximax), the most optimistic. The alternative is selected that gives the largest positive payoff under any future occurrences.

- Savage (Min-Max Regret), to minimize the possible bad consequences. The alternative is selected that minimizes the difference between absolute maximum payoff that can be obtained and the payoff for that alternative.

- PERT/CPM (Program Evaluation and Review Technique/Critical Path Method) is used to plan, schedule, and control large-scale efforts. This method develops integrated schedules and predicts the probability of meeting a schedule.

- Optimization Techniques (linear, goal, dynamic, programming). A technique to find the best most optimal solution. Linear is limited to a single objective, goal programming provides a solution that comes as close as possible to reaching all goals, dynamic programming provides for a solution of extremely complex problems with multiple interactions.

- Simulation/Modelling. A technique to permit better understanding of the process being modeled and evaluate the consequences of various changes in the process.

The analysis team should determine which techniques are most appropriate for application to the problem. The Decision Maker and Action Officer should understand and agree with the technique to be utilized by the analysis team.

- Probabilities, computing the most probable outcome.

Further information on decision making methodology and criterion can be found in *An Introduction to Management Science, Quantitative Approaches to Decision Making* (Anderson 1979), *Life-Cycle Asset Management, Good Practice Guide to Engineering Tradeoff Studies* (DOE 1995), and *Economic Analysis for Decision Making* (USAMETA 1985).

The output could be a matrix of alternatives by decision criteria or any other form of output desired by the decision maker. A Decision Theory-Payoff Matrix showing expected values and utilities described in *Standard Engineering Practices* (WHC 1988) could be another form of output. The matrix may include alternatives that were not a part of the original set of candidate alternatives. These additional alternatives may be suggested by logical variations encountered during the evaluation process, thus, opening the door to synthesizing the preferred architecture from a combination of more than one analyzed alternative.

5.6.1 Perform Analyses

Analyses shall be performed to differentiate the alternatives based on how well each alternative satisfies the decision criteria. If it seems appropriate to include additional alternatives, such alternatives will be coordinated with the Decision Maker/Action Officer and analyzed in accordance with this procedure. These additional alternatives can include newly identified alternatives or alternatives that are synthesized from several of the existing alternatives. The results of the analyses shall be objective in nature and formatted to facilitate alternative selection (see the DM Procedure). The analyses may include trend information, life-cycle cost information, programmatic, technical, and environmental health and safety risk analyses, and comparison information (see Attachment E).

5.6.2 Programmatic Risk Analyses

The analyses performed to differentiate between the alternatives provide a quantitative value for how an alternative performs relative to a given decision criteria. This value is a "best estimate" based on a certain set of assumptions, estimates, and analysis techniques. The estimates will be uncertain (e.g., the exact cost, or completion date, or waste volume cannot be estimated precisely). The uncertainties with respect to estimating the performance, cost, or schedule of an alternative with respect to the performance measures is programmatic risk. This programmatic risk must be analyzed and utilized to differentiate between alternatives. Each alternative evaluation shall have a corresponding description of uncertainty/risk.

In addition to analyzing/estimating the risk, the sources of, and contributors to risk will be identified. The following are possible sources of programmatic risk:

- Validity of assumptions used in estimating performance.
- Higher-level alternative decisions/policy issues not yet resolved.
- Uncertainty in the performance of technology.
- Uncertainty in parametric estimates of costs (e.g., scaling factors, staffing levels, etc.) and schedules.

The extent that the various sources of risk contribute to the risk for each alternative will be specified and documented.

A graded approach will be taken to the level of detail needed for programmatic risk analysis. The least detailed approach is to define the possible range of scores for each matrix entry (e.g., identify highest and lowest possible, as well as the "best estimate"). The most detailed approach produces a probability distribution over the range of possibilities. An intermediate approach is to define a few, say three, points in the range and assign probabilities (summing to 1.0) to each point. The level of detail to which risk is analyzed should be determined by what information the decision maker(s) want, the ability/cost to produce the information, and the degree of risk for the specific performance measure relative to other risks. The level of detail to be used in analyzing risk should be specified in either the decision plan (provided by the decision maker) or the work plan for this decision.

Potential Enhancements to Addressing Programmatic Risk in TWRS (Brothers et al. 1996) provides additional guidance and direction on performing risk analysis for the TWRS Program.

5.6.3 Sensitivity Analysis

The purpose of the sensitivity analysis is to validate the analysis and decision process to show that small changes do not alter the relative ranking of the alternatives. If small changes can alter the ranking, the decision maker must be informed and the analysis process modified to reflect the desires of the decision maker. A minor change may also provide additional viable alternatives to be considered. The sensitivity analysis should evaluate the impacts of relaxing requirements or improving technical capabilities or reducing uncertainties in cost estimates. The analysis should also identify the changes needed to desensitize the selection process. *Life-Cycle Asset Management, Good Practice Guide to Engineering Tradeoff Studies* (DOE 1995) provides additional information on performing a sensitivity analysis.

5.6.4 Matrix of Alternatives and Decision Criteria

A matrix containing alternatives by decision criteria shall be generated. Entries in this matrix shall summarize how well each alternative performs with respect to the decision criteria. Attachment D illustrates an example matrix for Sub-Surface Barrier (SSB) alternatives against a set of decision criteria.

5.7 AGA Report

This section describes the minimum information required to:

- Document the AGA analyses.
- Provide the information requested by the decision maker.
- Provide historical record of analyses used to justify the decisions made.

5.7.1 Numbering and Hierarchy

The document shall be designated a supporting document and assigned a category of AGA (e.g., WHC-SD-AGA-XX) per *Standard Engineering Practices* (WHC-CM-6-1). A TWRS Document Listing shall be generated and maintained to show this document relative to its predecessor, supporting analyses, and successor documents.

5.7.2 Format

The AGA Report shall conform to the following format:

1.0 Decision Analysis Summary, summary to give decision maker enough information to make the decision.

2.0 Problem Statement, from Section 5.2 with clarifying information.

3.0 Constraints and Assumptions, from Section 5.3.

4.0 Decision Criteria, from Decision Plan.

5.0 Analysis of Alternatives, from Sections 5.4 through 5.6.

5.8 Post Decision Activities

After an architecture has been selected by the decision maker, the following activities are necessary to allocate the requirements to physical systems, develop requirements that are based on the architecture selected and update the appropriate documentation.

5.8.1 Allocate Requirements to Architecture

The requirements that were allocated to the functions are allocated to the architectures that were selected to accomplish the functions. If multiple architectures were selected to accomplish one function or one architecture for multiple functions, then an allocation analysis should be performed to properly allocate the requirements.

5.8.2 Derive Architecture Specific Requirements

The selection of an architecture will sometimes require the development of requirements, and constraints that are specific to that architecture. For example, if the design solution for a function of Transfer Liquid is a truck, then constraints on road transportation become applicable and requirements relating to size, weight, capacity, construction, etc. will need to be developed. The requirements and constraints developed for a truck will be much different from those that would be developed if a pipeline was selected to accomplish the same function.

5.8.3 Document

The following actions shall be taken to update the existing documentation after the architecture is selected:

- Update the Requirements Allocation Sheet to include the architecture.
- Develop the Change Control Documentation (*Configuration Management*, WHC-IP-1117, CCP-02 [Vann 1995]) to update the Requirements Management and Assured Compliance (RMACS) with the architecture and derived requirements.
- Develop the Configuration Items and update the Work Breakdown Structure (WBS) to reflect the selection of the architecture.
- Develop the methodology for verifying that each requirement is satisfied by the architecture selected.
- Develop the Measures of Effectiveness (MOE) that will be used in the Test and Evaluation (T&E) and Technical Performance Measurement (TPM) Procedures. MOEs are the values used to track the system performance and verify that selected requirements have been met.
- Update the Baseline System Description to include the architecture selected. The update should include sufficient information to describe the design concept and communicate the implementation of the architecture.
- Coordinate with the Risk Program for any risks developed or determined in this procedure.

6.0 REFERENCES

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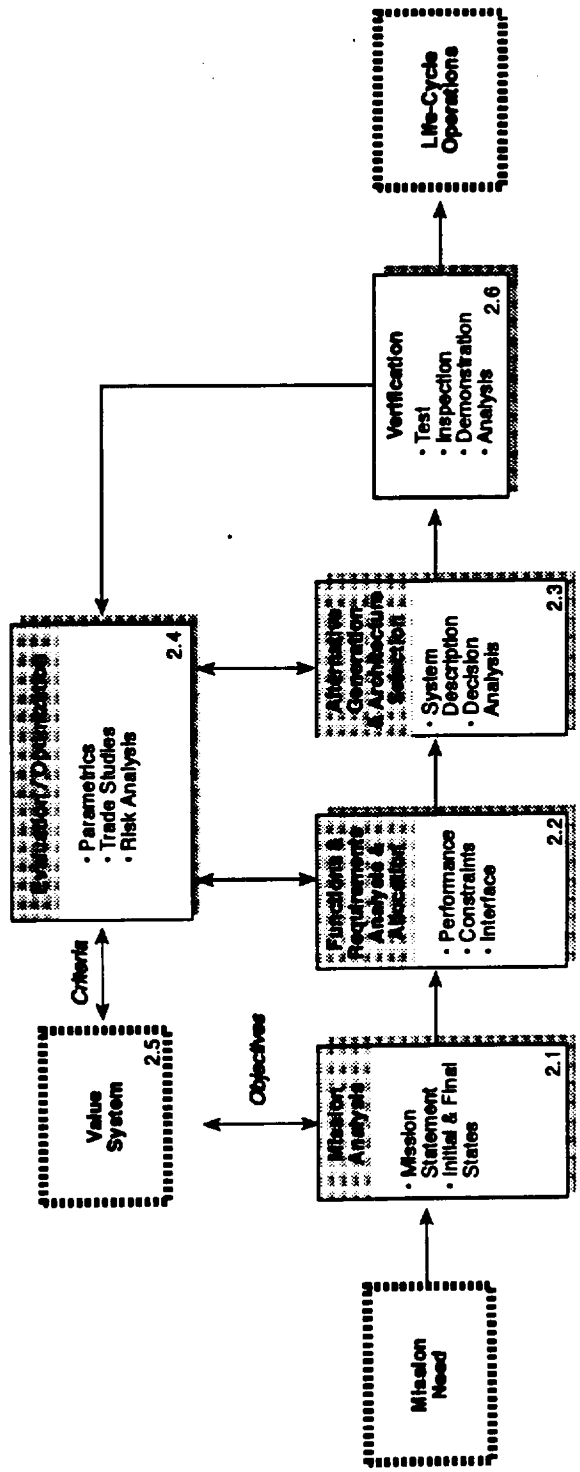
7.0 ATTACHMENTS

Attachment A The TWRS Engineering Process
Attachment B Relation Between DM, AGA, and RM Procedures
Attachment C Steps in AGA Process
Attachment D Alternatives by Decision Criteria Matrix
Attachment E Design Concept Alternatives

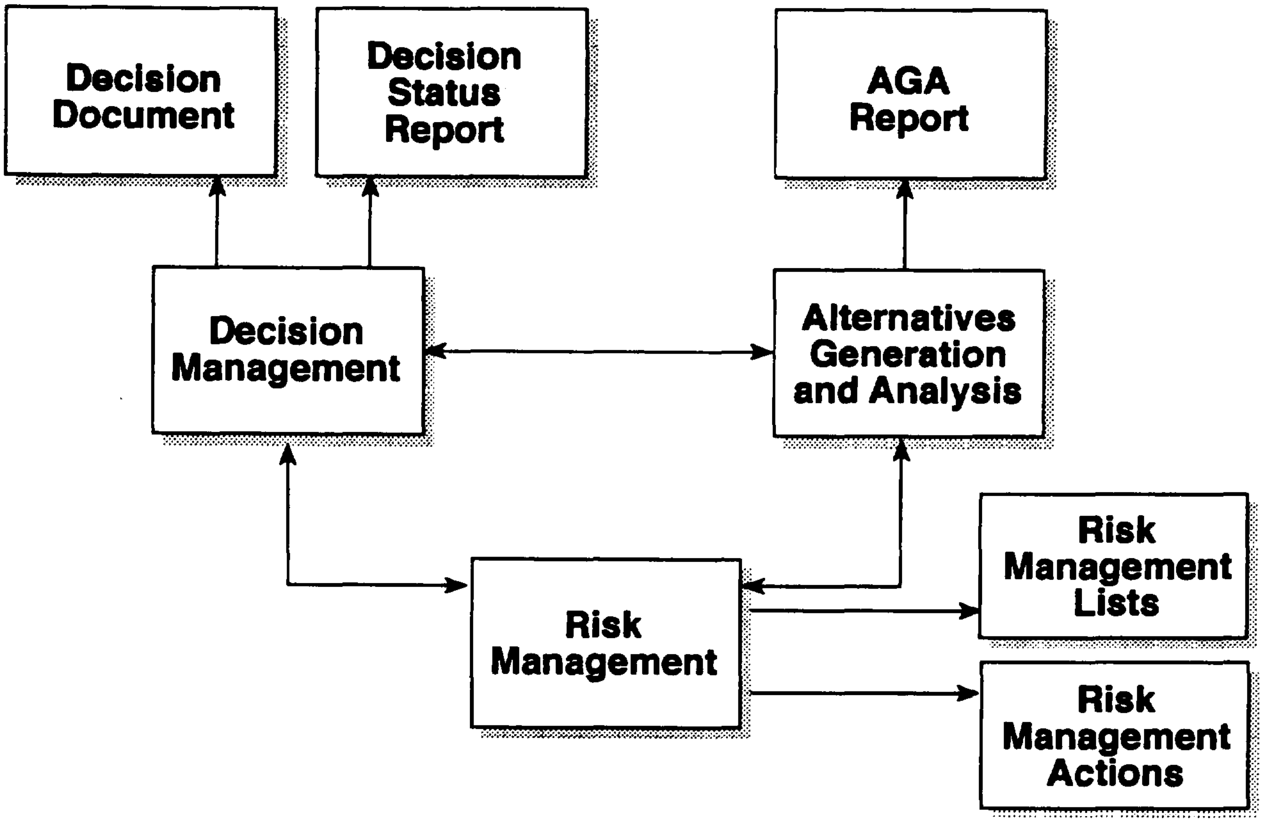
Attachment A

The TWRS Engineering Process



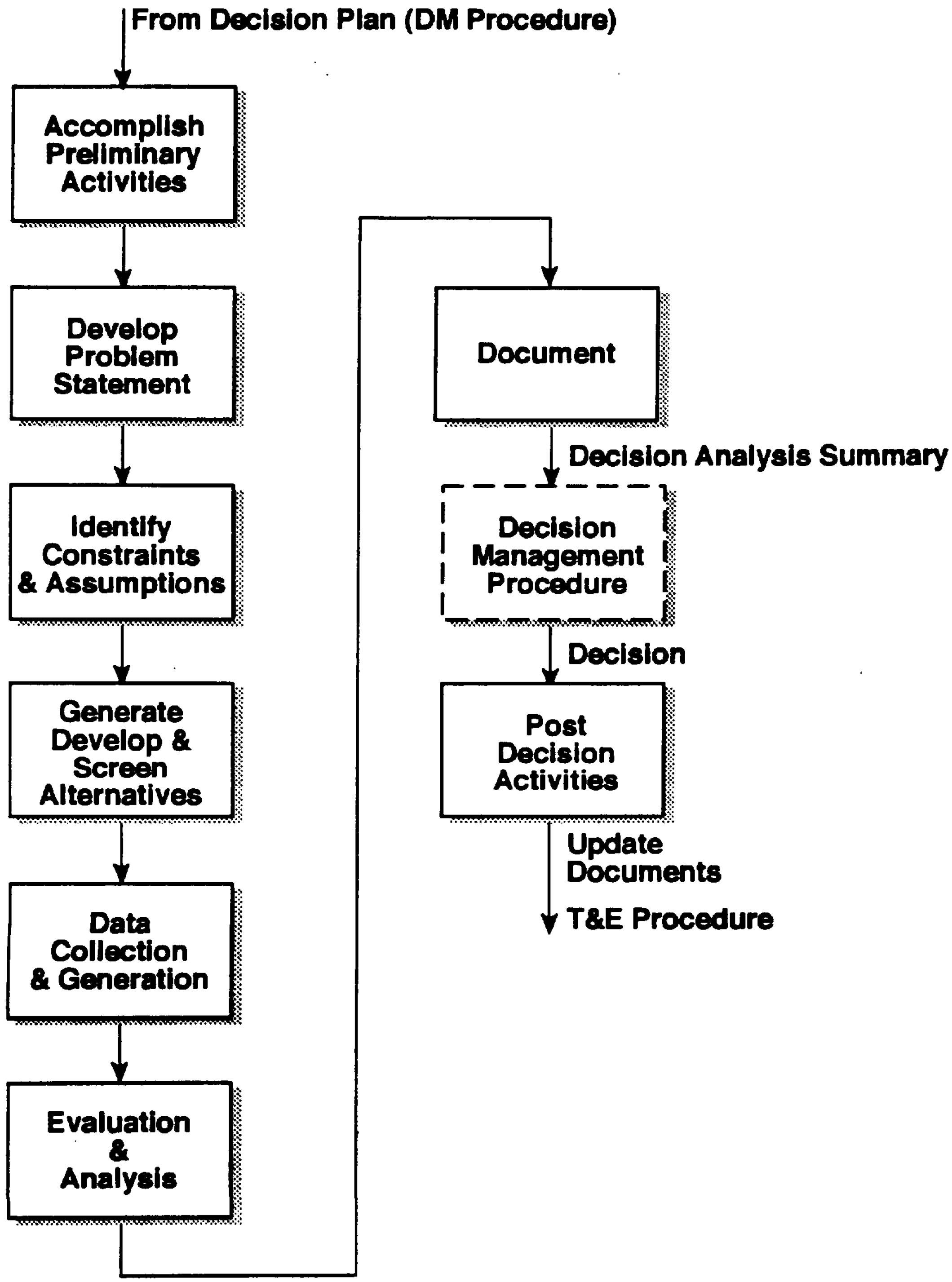
Attachment B

Relation Between DM, AGA, and RM Procedures



Attachment C

Steps in AGA Process



Attachment D

Alternatives by Decision Criteria Matrix (Example)

Alternatives by Criteria/Performance Measure Matrix for the SSB Case (One Tank Farm, Illustration Only)

Performance Measure/Decision Criteria	Alternatives										
	1	2	3	4	5	6	7	8	9	10	11
	No Action	Surface Barrier	Trade. Sluicing	Robotics Sluicing	Mech. Retrieval	Close Chemical	Box Chemical	V-shaped Chemical	V-shaped Cryogenic	Desiccant	Sel. Cl. Chem.
	No SSB	No SSB	No SSB	No SSB	No SSB	SSB & 3	SSB & 3	SSB & 3	SSB & 3	SSB & 3	SSB & 3
Public cumulative radiological risk[1]	32	2.5	0.19	0.14	0.45	0.10	0.10	0.10	0.10	0.10	0.15
Public cumulative toxic risk[2]	500	3	1	0.03	0.1	0.03	0.03	0.03	0.03	0.03	0.5
Worker radiological risk[3]	0.00	0.01	0.05	0.01	0.02	0.10	0.10	0.10	0.10	0.10	0.10
Worker toxic risk[4]	0.00	0.02	0.10	0.02	0.04	0.20	0.20	0.20	0.20	0.20	0.20
Percent removal of rad and haz. mats	0%	50%	99%	100%	95%	99%	99%	99%	99%	99%	99%
Delay in clean up	n.a.	0	0	1	1	2	2	2	2	2	2
Compliance[5]	Major Problem	Major Problem	Full Compl.	Full Compl.	Full Compl.	Full Compl.	Full Compl.	Full Compl.	Full Compl.	Full Compl.	Full Compl.
Public acceptance[6]	No	No	Some	Some	Some	Substantial	Substantial	Substantial	Substantial	Substantial	Substantial
Total life-cycle cost (in $ millions)	$0	$40	$187	$508	$428	$1,052	$1,096	$1,177	$1,802	$1,141	$614

[1] Expected number of cancer fatalities over ten thousand years.
[2] Hazard index over ten thousand years.
[3] Expected number of cancer fatalities during construction and operation.
[4] Expected number of cancer fatalities during construction and operation.
[5] Constructed measure (see text).
[6] Constructed measure (see text).

Attachment E

Design Concept Alternatives

PROCESS SELECTION

The chemical and/or mechanical processes required to achieve a function should be defined on the basis of literature reviews of historic precedence in either commercial industry, the nuclear industry (worldwide) or past practice at the Hanford Site. Process selection, done correctly, provides a simple, cost effective, and reliable scheme that requires minimal development for the application. The basis for selection of a process must be documented.

DESCRIPTION OF PROCESS

To further define each alternative architecture, the chemical and/or mechanical processes are sub-divided into the major unit operations. The unit operations identified should collectively perform necessary functions. The basis for selecting unit operations must be documented. These unit operations serve as the building blocks for the process flow diagram and as the basis for selecting the major equipment items to accomplish functions. Block diagrams can be used to communicate the unit operations as a precursor to a fully defined process flow diagram.

FLOWSHEET MODELING

As the individual unit operations are fully defined, they can be modeled to establish mass and heat transfer requirements and to verify that the process meets functions and requirements (e.g., capacity, performance). The unit operations and mass flows should be depicted on a process flow diagram (Attachment E-1). Depending on the problem, energy balances may or may not be required. In general, piping and instrument diagrams are not required for alternatives comparison.

EQUIPMENT LIST

Once mass flows and energy balances are understood at the unit operations level, individual equipment items can be selected and sized to accommodate the process requirements for flow, corrosion and temperature, and the mechanical requirements for loads, stress and performance (as specified by the F&R, TRS, DRD, etc.). These equipment parameters can be summarized on an equipment list. An example is shown in Attachment E-2. In general, equipment data sheets (an individual drawing showing the features of each equipment item) are not required.

EQUIPMENT LAYOUT

After equipment is sized it can be logically arranged in a facility. At this stage of design, the equipment is arranged to do the following:

1. Minimize piping runs.

2. Collocate equipment with common maintenance and operation requirements (e.g., remote or contact).

3. Verify that hydraulic considerations do not increase building size or increase the amount of equipment needed for the process.

Hydraulic diagrams can be used to address concerns over gravity draining or drain back for certain applications. These diagrams simply show equipment and connecting pipes in section with an accurate vertical scale.

FACILITY LAYOUT

When the core of the facility equipment layout interfaces are understood the supporting functions that make an operational facility can be added to depict plans and sections of the architectural and structural building. A list of the these Generic Facility Functions is attached as an example in Attachment E-3. An example of typical facility plans and sections are included in Attachments E-4 and E-5, respectively.

SITE SELECTION AND INFRASTRUCTURE

Selecting a site implies a number of cost impacts for utility tie-ins (electrical, telecommunications, raw water, sanitary/potable water, sewer, steam, and natural gas), railroad service, paved roadways, fences, lay-down areas, etc. These items are best depicted on a site plan of the area(s) affected. An example of a typical site plan is included in Attachment E-6.

UTILITIES AND SUPPORT

The utilities and support functions should be identified for estimating. Attachment E-7 contains an example listing of the utilities and support requirements for a typical facility. The following issues are to be resolved at this stage.

1. Should the functions be shared with other facilities or functions?

2. Which functions should be consolidated in one location?

3. Can the function be housed internal to the facility or in an annex?

4. Is there a distance constraint on functions located outside the facility?

For estimating purposes, applying the above logic defines the additional facility requirements associated with the utility and support functions.

OPERATIONAL STAFFING

Operational staffing is estimated by building up the operations and support day and shift coverage to staff all aspects of the facility. These staff-loading allocations also define the office and personnel support facilities. An example staffing estimate is attached as Attachment E-8.

LIFE-CYCLE COST ESTIMATES

Life-cycle costs consist of the following elements:

1. Project capital cost (including engineering, construction management, project management, contingency, and escalation)

2. Other project costs (development)

3. Operating costs (staff, maintenance, consumables, chemicals, utilities).

These costs can be further broken down into Expense or Capital costs as depicted in Attachment E-9. Attachment E-9 also provides an example of how elements of a design concept serve as a basis for the life-cycle cost figures (e.g., chemical and utility costs can be extracted from the flowsheet and mass balance). These costs are spread over the years in which they are incurred and results can be escalated and discounted as required for comparison of alternatives. In addition, funding profiles that graphically depict cost as a function of time are generated for use in comparing alternatives.

SAFETY ASSESSMENT

Depending on the degree to which the alternatives are developed, the approach to performing safety assessments may take one of two forms: absolute comparisons or relative comparisons. Well-developed concepts may be analyzed for conclusions related to: (1) the ability to meet WHC criteria, (2) cost of safety class equipment and seismically qualified structures, (3) operability and availability implications of Technical Specification Requirements, and (4) cost, operability and availability implications of design philosophy (e.g., remote versus contact maintenance) derived from worker safety considerations.

When design alternatives are not well developed, relative comparisons may be possible. Relative comparisons among alternatives may be based on hazards identification and qualitative assessments of design implications of hazard prevention and mitigation. Design issues that may present difficulties for regulatory approval also may be identified.

The result of the safety assessment should be a determination that one alternative is preferable over another on the basis of the following:

- Consequence and frequency of accidents affecting public safety.
- Consequence and frequency of accidents affecting workers.
- Consequence and frequency of accidents causing property damage and mission disruption.
- Ease of accident prevention and mitigation.
- Nature and prevalence of industrial hazards and occupational radiation dose.
- Technical uncertainty in demonstrating safety (e.g., high regulatory risk).

If one alternative is not significantly preferable over others on these bases, safety is not a discriminator among design alternatives.

ENVIRONMENTAL ASSESSMENT

The environmental (regulatory) impacts of a system can be assessed by evaluating the following factors:

- Hazardous material usage.
- Secondary waste generation.
- Effluent treatment systems.
- Permitting requirements.

The extent that these factors impact cost and schedule considerations is dependent on such factors as: inventory of radioactive and nonradioactive hazardous materials, the number and volume of secondary waste streams, the extent of treatment systems required to meet effluent limitations, and the complexity of required permitting documentation. The environmental requirements checklist in Attachment E-10 provides an indication of potentially required environmental documentation.

ATTACHMENTS

Attachment E-1 Process Flow Diagram Example
Attachment E-2 Equipment List Example
Attachment E-3 Generic Facility Functions
Attachment E-4 Facility Plan Example
Attachment E-5 Facility Section Example
Attachment E-6 Site Plan Example
Attachment E-7 Utilities and Support Example
Attachment E-8 Staffing Estimate Example
Attachment E-9 Life-Cycle Cost
Attachment E-10 Environmental Requirements Checklist

Attachment E-1

Process Flow Diagram Example

[This figure is available in hard copy only. Copies can be obtained from Carol Clark 373-9183.]

Attachment E-2

Equipment List Example

Equipment Description	Equipment Designation	Capacity	Material of Construction	Dimensions	Comment
LLW EVAPORATOR FEED TANK	TK-400	133 m^3	316L SS	5.5 m ID X 5.5 m H	REMOVED FROM SERVICE FOLLOWING CONVERSION
PUMP	P-401	379 LPM, 345 kPa	316L SS	MOUNTED ON TK-400	REMOVED FROM SERVICE FOLLOWING CONVERSION.
LLW Feed Evaporator	EV-402	36.9 GJ/hr	HASTELLOY C-22	3 m W X 9.8 m L X 11.6 m H	REMOVED FROM SERVICE FOLLOWING CONVERSION.
CONDENSER	EC-403	33.8 GJ/hr	316L SS	1.8 m OD X 5.5 m L	REMOVED FROM SERVICE FOLLOWING CONVERSION.
LLW Melter Feed Adjustment Tank	TK-404A	35.5 m^3	HASTELLOY C-22	3.7 m ID X 5.8 m H	Reused "AS IS" following conversion.
Pump	P-405A	379 LPM, 345 kPa	316L SS	MOUNTED ON TK-404A	Reused "AS IS" following conversion.
LLW Melter Feed Tank	TK-406	35.5 m^3	HASTELLOY C-22	3.7 m ID X 5.8 m H	Reused "AS IS" following conversion.
Pump	P-407A	379 LPM, 690 kPa	316L SS	MOUNTED ON TK-406	Reused "AS IS" following conversion.
Pump	P-407B	379 LPM, 690 kPa	316L SS	MOUNTED ON TK-406	Reused "AS IS" following conversion.
HEAD BIN	B-408	5.5 m^3	304L SS	1.4 m ID X 3.7 m T/T	Reused "AS IS" following conversion.
ROTARY STAR FEEDER	M-409	20 cm X 0.37 kW	304L SS	0.6 m X 0.7 m X 0.8	Reused "AS IS" following conversion.

Attachment E-3

Generic Facility Functions

PROCESS	Hot Cells - Canyon - Manipulator - Glove Box Generator Canyon Remote Laydown
PROCESS SUPPORT	Control Room Instrument Gallery Laboratory Sample Gallery Chemical Make-up (AMU) Hot Pipe Trench Closed Loop Corridor (Air, Water, Steam) External Chemical Storage Operational Clean Supply Storage
UTILITIES	Compressor Room Electrical Switchgear Room Emergency Generator Primary/Secondary Steam Bottle Station
HVAC	HVAC Filter Room Zone 1 HVAC Fan Room HVAC Filter Room Zone 2 & 3 Remote Filter Testing/Monitoring Gallery Remote Filter Maintenance Air Tunnel Stack Effluent Monitoring Shack
MAINTENANCE	Failed Equipment Maintenance Shop Hot Shop Crane Maintenance Manipulator Repair
ARCHITECTURAL	Loading Dock Elevators Stairwells Egress/Ingress Office Space Dispatcher Office Supervisor Office Simulator Training Control Room Lunch Room Change Rooms Toilets Air Locks Storage Gallery Rail Truck Access External Roadways

Attachment E-4

Facility Plan Example

[This figure is available in hard copy only. Copies can be obtained from Carol Clark 373-9183.]

Attachment E-5

Facility Section Example

[This figure is available in hard copy only. Copies can be obtained from Carol Clark 373-9183.]

Attachment E-6

Site Plan Example

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Attachment E-7

Utilities and Support Example (2 Sheets)

Function Description	Location	Shared vs Dedicated	Grouped	Internal	Annex	Close External	No Distance Constraint	Potential to use an Existing Facility
Sample Analysis	Analytical Facility	Dedicated	X			X		
Oxygen System	BHA	Shared					X	X
Collect and Handle Non-Radioactive Liquid Waste System	Bulk Cold Chem Bldg/MUB	Shared	X			X		
Cold Chemical Supply System	Bulk Cold Chem Bldg	Shared	X			X		
Cold Chemical Vent System	Bulk Cold Chem Bldg	Dedicated*	X			X		
Cooling Tower Water System	Cooling Tower	Shared					X	X
Telecommunications System	Emerg Response Ctr	Shared	X			X		
Emergency Power System	Emerg Generator Bldg	Dedicated				X		
Major Equip Assembly	Fabrication/Assembly Shop	Shared	X				X	X
Spare Parts Fabrication	Fabrication/Assembly Shop	Shared	X				X	X
Utility Steam System	Mech Utilities Bldg	Shared	X			X		
Compressed Air System	Mech Utilities Bldg/ User Facility	Shared	X		X (Breathing Air Bottles)		X (Plant and Instrument Air)	X (Plant and Instrument Air)
Demineralized Water System	Mech Utilities Bldg	Shared	X				X	X
HVAC Chilled Water System	Mech Utilities Bldg	Shared	X			X		
Treatment Complex Management and Support System	Oper Support Bldg	Shared					X	X
Regulated TWRS Treatment Complex Entry System	Regulated TWRS Complex Entry Bldg	Shared	X			X		
Employee Support System	Regulated TWRS Complex Entry Bldg/various support facilities	Dedicated	X			X		
Process Facility Oper Control System	Regulated TWRS Complex Entry Bldg/Emerg Response Ctr	Dedicated	X			X		
Normal AC Power System	Switchgear Bldg	Dedicated				X		
Sanitary Sewer System	Treatment Complex Site	Shared				X		
Sanitary Water System	TWRS Complex Site	Shared	X			X		
Raw Water System	TWRS Complex Site	Shared	X			X		
Collect and Handle Solid Waste System	User Facility	Dedicated		X				
Collect and Handle Potentially Radioactive Liquid Waste System	User Facility	Dedicated		X				

Attachment E-7 (cont'd)

Utilities and Support Example
(2 Sheets)

Function Description	Location	Shared vs Dedicated	Grouped	Internal	Annex	Close External	No Distance Constraint	Potential to use an Existing Facility
Waste Condensate Collection System	User Facility Annex	Dedicated			X			
Cold Chemical Feed System	User Facility	Dedicated		X				
Process Facility Vent System	User Facility	Dedicated		X				
Process Steam and Condensate System	User Facility	Dedicated		X				
Process Cooling Water System	User Facility	Dedicated	X	X				
Melter Cooling Water System	User Facility	Dedicated	X	X				
Process Chilled Water System	User Facility	Dedicated	X	X				
Uninterruptible Power Supply System	User Facility	Dedicated		X				
Regulated Facility Entry System	User Facility	Dedicated			X			
Personnel Protection System	User Facility	Dedicated		X				
Maintenance & Repair System (MSM & other)	User Facility	Dedicated		X				
Supply Air Treatment System	User Facility (Proc Bldg Roof)	Dedicated	X		X			
Exhaust Air Treatment System	User Facility (Fan/Filter Annex & Proc Bldg Roof)	Dedicated	X (Zone II & III Systems)		X			
[illegible]acuum System	User Facility	Dedicated		X				
Shipping and Receiving System	Warehouse	Shared	X				X	X
Warehousing and Storage System	Warehouse	Shared	X				X	X
Storage and Service Yard	Warehouse	Shared	X				X	X
Process Water System	Water Pumphouse	Shared	X				X	X
TWRS Treatment Complex Site Fire Water System	Water Pumphouse/ TWRS Complex Site	Shared	X			X (Underground Piping)	X (Pumps & Stor Tank)	X (Pumps & Stor Tank)
Process Facility Fire Water System	Water Pumphouse TWRS Complex Site	Dedicated	X			X (Underground Piping)	X (Pumps & Stor Tank)	X (Pumps & Stor Tank)

Attachment E-8
Staffing Estimate Example (Sheet 1 of 5)

Staffing for TWRS Treatment Complex

POSITION	SHIFT STAFFING																					Total
	Day Shift			A Shift			B Shift			C Shift			D Shift			Training Shift			Sub Total			
	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	
Building Support																						
PLANT MANAGEMENT																						
Plant Manager	1																		1	0	0	1
Administrative Assistant	1																		1	0	0	1
Technical/Budget Analysts	2																		2	0	0	2
Clerical	1	2																	1	2	0	3
JOB CONTROL																						
Managers	2																		2	0	0	2
Clerical		4																	0	4	0	4
Facility Administrator	3																		3	0	0	3
Job Control Specialists	4																		4	0	0	4
Material Specialists	2																		2	0	0	2
Schedulers	10																		10	0	0	10
Planners	10																		10	0	0	10
Crane Planners	2																		2	0	0	2
PLANT ENGINEERING																						
Managers	1																		1	0	0	1
Clerical		2																	0	2	0	2
Designers/Drafters		2																	0	2	0	2
Plant Engineers	14																		14	0	0	14
ANALYTICAL LABORATORY																						
Managers/Supervisors	1			1			1			1			1			1			6	0	0	6
Clerical		2																	0	2	0	2
Chemists	3			3			3			3			3			3			18	0	0	18
Chemical Technicians			4			11			11			11			11			11	0	0	59	59
STANDARDS LABORATORY																						
Managers	1																		1	0	0	1
Clerical		1																	0	1	0	1
Chemists	2																		2	0	0	2
Chemical Technicians			2																0	0	2	2
RADIATION PROTECTION																						
Managers	1																		1	0	0	1
Clerical		1																	0	1	0	1
Health Physics			18																0	0	18	18
FACILITY SERVICES																						
Managers/Supervisors	1																		1	0	0	1
Clerical		1																	0	1	0	1
Process Operators			18			2			2			2			2			2	0	0	28	28
Crane Operators			3			2			2			2			2			2	0	0	13	13
Power Operators			4			3			3			3			3			3	0	0	19	19
Driver			2																0	0	2	2
COMPUTER SUPPORT																						
Managers	1																		1	0	0	1
Clerical		1																	0	1	0	1
System Admin./Analyst	3																		3	0	0	3
DOCUMENT CONTROL																						
Managers	1																		1	0	0	1
Clerical		2																	0	2	0	2
Document Control	4																		4	0	0	4
Technical Editor	2																		2	0	0	2
PROGRAM OFFICE																						
Program Managers	1																		1	0	0	1
Clerical		1																	0	1	0	1
Program Scheduler	1																		1	0	0	1
Activity Engineer	3																		3	0	0	3
Subtotal	78	19	51	4		18	4		18	4		18	4		18	4		18	98	19	141	258

Attachment E-8 (cont'd)

Staffing Estimate Example (Sheet 2 of 5)

Staffing for TWRS Treatment Complex

POSITION	SHIFT STAFFING																					Total
	Day			A			B			C			D			Training			Sub			
	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	
Clerical		4																	0	4	0	4
Shift Engineers	3			1			1			1			1			1			7	0	0	7
Process Engineers	20																		20	0	0	20
Technicians		2																	0	2	0	2
SURVEILLANCE and TESTING																						
Manager	1																		1	0	0	1
Clerical		1																	0	1	0	1
Surveillance and Testing	10																		10	0	0	10
QUALITY ASSURANCE and CONTROL																						
Manager	1																		1	0	0	1
Clerical		1																	0	1	0	1
Quality Control Inspectors	5																		5	0	0	5
Quality Assurance Engineer	3																		3	0	0	3
SAFETY ENGINEERING																						
Managers	1																		1	0	0	1
Clerical		1																	0	1	0	1
Emergency Preparedness	1																		1	0	0	1
Radiation Engineers	5																		5	0	0	5
Nuclear Engineers	5																		5	0	0	5
Industrial Safety Engineers	2																		2	0	0	2
NUCLEAR MATERIALS ADMINISTRATION																						
Managers	1																		1	0	0	1
Clerical		2																	0	2	0	2
Specialists	3																		3	0	0	3
TRAINING																						
Managers	1																		1	0	0	1
Clerical		2																	0	2	0	2
Trainers	8																		8	0	0	8
Subtotal	73	13		1			1			1			1			1			78	13	0	91

Attachment E-8 (cont'd)

Staffing Estimate Example (Sheet 3 of 5)

Staffing for TWRS Treatment Complex

POSITION	SHIFT STAFFING: Day			A			B			C			D			Training			Sub			Total
	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	
PROCESS STAFF																						
OPERATIONS MANAGEMENT																						
Operations Manager	1																		1	0	0	1
Shift Manager	2			1			1			1			1			1			7	0	0	7
Shift Support Manager	2			2			2			2			2			2			12	0	0	12
Operations Plant Engineers	8																		8	0	0	8
Clerical		2			1			1			1			1			1		0	7	0	7
OPERATORS																						
Receipt			1			2			2			2			2			2	0	0	11	11
Cesium Ion Exchange			1			2			2			2			2			2	0	0	11	11
Effluents			1			2			2			2			2			2	0	0	11	11
Evaporators			1			2			2			2			2			2	0	0	11	11
LLW Melter			2			3			3			3			3			3	0	0	17	17
HLW Melter			2			2			2			2			2			2	0	0	12	12
Product Handling			2			2			2			2			2			2	0	0	12	12
HAZARDOUS MATERIAL CONTROL																						
Manager	1																		1	0	0	1
Clerical		2																	0	2	0	2
Technicians		3																	0	3	0	3
Engineers	8																		8	0	0	8
ENVIRONMENTAL CONTROL																						
Manager	1																		1	0	0	1
Clerical		1																	0	1	0	1
Technicians		2																	0	2	0	2
Engineers	5																		5	0	0	5
RADIATION PROTECTION																						
Managers/Supervisors	3			1			1			1			1			1			8	0	0	8
Clerical		1																	0	1	0	1
Health Physics						8			8			8			8			8	0	0	40	40
Subtotal	31	11	10	4	1	23	4	1	23	4	1	23	4	1	23	4	1	23	51	16	125	192

Attachment E-8 (cont'd)

Staffing Estimate Example (Sheet 4 of 5)

Staffing for TWRS Treatment Complex																						
	SHIFT STAFFING																					
	Day			A			B			C			D			Training			Sub			
POSITION	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	E	NE	BU	Total
MAINTENANCE																						
Manager	1																		1	0	0	1
Clerical		1																	0	1	0	1
Maintenance Engr.	3																		3	0	0	3
Training Coordinator	1																		1	0	0	1
MECHANICAL MAINTENANCE																						
Managers/Supervisors	1			1			1			1			1			1			6	0	0	6
Clerical		1																	0	1	0	1
Person in Charge	1																		1	0	0	1
Mill Wrights			6			2			2			2			2			2	0	0	16	16
Pipe Fitters			8			2			2			2			2			2	0	0	18	18
Insulators			2																0	0	2	2
Riggers			2			2			2			2			2			2	0	0	12	12
Drivers			1			2			2			2			2			2	0	0	11	11
Welders			2																0	0	2	2
Carpenters			2																0	0	2	2
Painters			2																0	0	2	2
Sign Writer			1																0	0	1	1
I and E MAINTENANCE																						
Managers/Supervisors	1																		1	0	0	1
Clerical		2																	0	2	0	2
Person in Charge	1			1			1			1			1			1			6	0	0	6
I&E Technicians			8			2			2			2			2			2	0	0	18	18
Electricians			6			2			2			2			2			2	0	0	16	16
MANIPULATOR MAINTENANCE																						
Managers/Supervisors	1																		1	0	0	1
Clerical		1																	0	1	0	1
Person in Charge	1			1			1			1			1			1			6	0	0	6
Mill Wrights			2			2			2			2			2			2	0	0	12	12
Electricians			2			2			2			2			2			2	0	0	12	12
I & E Technicians			2			2			2			2			2			2	0	0	12	12
Subtotal	11	5	46	3		18	3		18	3		18	3		18	3		18	26	5	136	167

TOTAL	190	48	110	12	1	59	12	1	59	12	1	59	12	1	59	12	1	59	250	53	402	708

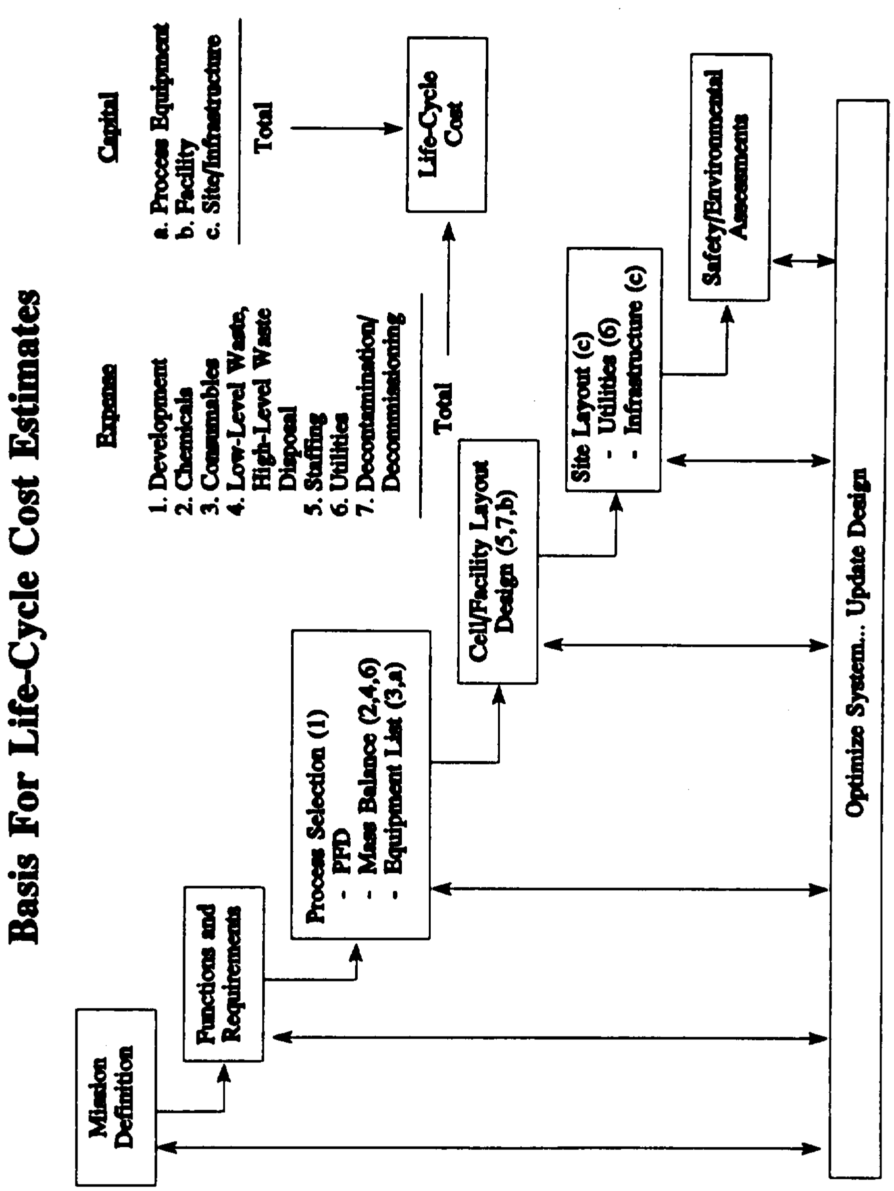
Attachment E-8 (cont'd)

Staffing Estimate Example (Sheet 5 of 5)

POSITION	LLW PLANT	HLW PLANT	PRETREAT FACILITY	COMMON AREAS	TOTAL
BUILDING SUPPORT					
Plant Management				7	7
Job Control	14	8	8	7	37
Plant Engineering	6	5	3	5	19
Analytical Laboratory	34	25	21	5	85
Standards Laboratory				6	6
Radiation Protection	6	5	4	5	20
Facility Services	23	17	14	10	64
Computer Support				5	5
Document Control				9	9
Program Office				6	6
Subtotal Building Support	83	60	50	65	258
ENGINEERING & SUPPORT					
Process & Technology	13	9	7	6	37
Surveillance & Testing	4	3	2	3	12
Quality Assurance & Control	3	2	2	3	10
Safety Engineering	5	4	3	3	15
Nuclear Materials				6	6
Training	3	2	2	4	11
Subtotal Engineering &	28	20	16	25	91
PROCESS STAFF					
Operations Management	12	9	7	7	35
Operators	29	24	31	1	85
Hazardous Material Control	5	4	3	2	14
Environmental Control	3	2	2	2	9
Radiation Protection	19	14	12	4	49
Subtotal Process Staff	68	53	55	16	192
MAINTENANCE					
Management	1	1	1	3	6
Mechanical Maintenance	28	20	17	9	74
I&E Maintenance	16	12	10	5	43
Manipulator Maintenance	25	18	1	0	44
Subtotal Maintenance	70	51	29	17	167
GRAND TOTAL	249	184	150	123	708
PERCENT OF TOTAL	0.35	0.26	0.21	0.17	
BASE CASE	9	38	NA	NA	

Attachment E-9

Life-Cycle Cost



Attachment E-10

Environmental Requirements Checklist (4 Sheets)

Environment -media	Permit, approval, or requirement	Regulation(s)	Regulatory agency	Restriction	App. (Y or N)
NEPA	NEPA Documentation	10 CFR 1021	DOE	Title II Design (Projects); Procurement	
SEPA	SEPA	WAC 197-11	State Agency	License; Permit	
CERCLA	ARARs	40 CFR 300 to 400	EPA	Construction	
Nonrad. Air Emissions	New Source Review/NOC; Source Registration	WAC 173-400-050; WAC 173-400-100; APCA Reg. 1	Ecology; APCA	Construction	
	PSD	WAC 173-400	Ecology; APCA	Construction	
	TAPs	WAC 173-460	Ecology; APCA	Construction	
Radioactive Air Emissions	NESHAPS	40 CFR 61, Subpart H	EPA	Construction	
	Radiation Protection - Air Emissions	WAC 246-247	DOH	Construction; Operation	
All Air Emissions	Air Operating Permit	WAC 173-401	Ecology; DOH; EPA	Operation	
Asbestos	NOI	APCA Reg. 1, Article 8; 40 CFR 61, Subpart M	APCA	Before Working with Asbestos	
Outdoor or Unconfined Burning	Burn Permit	WAC 173-425; APCA Reg. 1, Article 5	Hanford Fire Department	Open Burning	
Ozone Depleting Substances/ CFCs	Release Prevention; Recovery/Recycle; Certification Labeling	40 CFR 82	Ecology	Reporting; Training; Operation	

Attachment E-10 (cont'd)

Environmental Requirements Checklist (4 Sheets)

Environment -media	Permit, approval, or requirement	Regulation(s)	Regulatory agency	Restriction	App. (Y or N)
Soil Column Waste Water Disposal	SWDP	WAC 173-216	Ecology	Operation	
	Approval of Engr. Report, Plans & Specs., and O&M Manual	WAC 173-240	Ecology	Construction	
	UIC Permit/ Registration	WAC 173-218	Ecology	Operation	
Domestic Waste Water Disposal	Septic Systems <14,500 gpd Capacity Design Approval	WAC 246-272	DOH	Construction	
	Septic Systems >14,500 gpd Capacity Design Approval	WAC 173-216; WAC 173-240	Ecology	Construction	
	Pretreatment Permit	40 CFR 403; City Ordinance	City of Richland	Discharge to City Sewage Facility	
	Operator Certification	WAC 173-230	Ecology	Operation	
	Discharge Standards	WAC 173-221	Ecology	Discharge	
Surface Waste Water Disposal	NPDES Permit	40 CFR 122	EPA	Operation	
	Storm Water Discharge Under General Permit	57 FR No. 175	EPA	River Construction	
	U.S. Dept of Army Permit	33 CFR 325	USACE	River Construction	
	Section 10 Permit	33 CFR 320; 33 CFR 322	USACE	River Construction	
	Nationwide Permits	33 CFR 330	USACE	River Construction	
	Hydraulic Projects Permit	WAC 220-110	WA State Dept. of Fisheries	River Construction	

Attachment E-10 (cont'd)

Environmental Requirements Checklist (4 Sheets)

Environment -media	Permit, approval, or requirement	Regulation(s)	Regulatory agency	Restriction	App. (Y or N)
Surface Waste Water Disposal (Continued)	Shoreline Development Permit	WAC 173-14 to -20	Benton County	River/Island Construction	
	Aquatic Lands Lease	WAC 332-30	DNR	Construction	
	Hanford Reach Study Act Notification	PL 100-605	U.S. Park Service	Construction within 1/4 mi. of River	
	Water Quality Modification Permit	WAC 173-201	Ecology	River Construction	
	Certification of NPDES Permit	40 CFR 121	Ecology	Operation	
	Categorical Standards	40 CFR 405 to 471	EPA	Operation	
Drinking Water Supply	Approval of Engr. Report, Plans & Specs.	WAC 246-290	DOH	Construction	
	System ID. Number	WAC 246-290	DOH	Operation	
	Operator Certification	WAC 246-292	DOH	Operation	
Solid Waste	Solid Waste Handling Facility Permit	WAC 173-304	BFDHD	Construction	
Dangerous Waste	Dangerous Waste Permit (RCRA Part A and B)	WAC 173-303; 40 CFR 264; 40 CFR 265; 40 CFR 270	Ecology	Construction of New Facilities or Expansion of Existing Facilities	
UST	Tank Permit	WAC 173-360	Ecology	Operation	

Attachment E-10 (cont'd)

Environmental Requirements Checklist (4 Sheets)

Environment -media	Permit, approval, or requirement	Regulation(s)	Regulatory agency	Restriction	App. (Y or N)
All Media	Floodplain, Wetland Assessment	10 CFR 1022	DOE	Any Surface Disturbance	
	Cultural Resource Review	36 CFR 800	DOE	Any Surface Disturbance; Modification of Bldgs. Eligible for Listing on Historical Register	
	Excavation Permit	36 CFR 800	DOE	Any Excavation	
	Ecological Compliance Review	10 CFR 1021; 50 CFR 17; 50 CFR 402.6; DOE Order 5484.1	USFWS	Construction; Habitat Modification	
	Preoperation Monitoring of Facilities, Sites, and Operations	DOE Order 5400.1	DOE	Operation	
	Radiation Protection Standards	DOE Order 5400.5	DOE	Construction	

APCA = Air Pollution Control Authority
ARAR = Applicable or relevant and appropriate requirement
BFDHD = Benton Franklin District Health Department
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
DNR = Department of Natural Resources
DOE = U.S. Department of Energy
DOH = Washington State Department of Health
FR = Federal Register
O&M = Operation and maintenance
NEPA = National Environmental Policy Act
NESHAPS = National Emission Standards for Hazardous Air Pollutants
NOC = Notice of Construction
NOI = Notice of Intent
PL = Public Law
PSD = Prevention of Significant Deterioration
RCRA = Resource Conservation and Recovery Act of 1976
SEPA = State (of Washington) Environmental Policy Act
SWDP = State waste discharge permit
TAP = Toxic Air Pollutant
UIC = Underground injection control
USACE = U.S. Army Corps of Engineers
WAC = Washington Administrative Code

TITLE:

TECHNICAL PERFORMANCE MEASUREMENT

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to provide guidance and direction for implementing a Technical Performance Measurement (TPM) Program within the overall Systems Engineering activities for the Tank Waste Remediation System (TWRS) program. TPM is a management tool intended to assist in the evaluation of the technical performance of a mission, project, or program and to provide alerts of potential performance problems by tracking key TPMs. These measures are carefully selected such that their achieved values are strong indicators of the eventual success of the program or project. The implementation of the TPM Program has the following benefits:

- TPM provides management control via technical monitoring of system progress during the development phase.
- TPM further ensures that requirements are satisfied prior to operation.

The main objectives of a TPM Program are:

- Provide visibility of actual (achieved) versus planned performance.
- Provide early detection or prediction of problems that require management attention.
- Identify key performance measures for the system verification process.
- Provide inputs into overall program, decision, and risk management.
- Facilitate management and technical monitoring of the system's development to ensure that the final design meets operational requirements.
- Support impact assessment of proposed changes.

2.0 SCOPE

This procedure applies to all TWRS technical development activities in support of systems management. It includes guidelines for implementing a TPM Program to track performance measures for projects or subprojects within the TWRS Program, and it describes TPM reporting. The implementation of a TPM

Program is required by the *Tank Waste Remediation System Systems Engineering Management Plan* (SEMP) (WHC 1996). The graded approach contained in Appendix A of the SEMP shall be used to determine the extent and level of detail required during the application of this procedure.

The cost and schedule, though important, are not included in the TPM technical measures. However, integration of the technical performance with the cost and schedule ultimately occurs because the interactions of the three variables preclude varying one without considering the other two.

The TPM Program is implemented at various levels within the TWRS Program. The program (top) level TPM Program is established first. Lower-level TPM Programs are developed from the top-level TPM Program using the TWRS function tree.

3.0 DEFINITIONS

1. Achieved to date The value of the performance measure demonstrated by test or analysis at the time a review is conducted.

2. Availability The probability that an item will be in an operable and committable state at the start of a mission initiated at a random time. It is a function of reliability and maintainability measures.

3. Constraints Restrictions or limitations that must be met. Constraints are used to screen alternative strategies and are always nontradable by the designer (as opposed to requirements that are tradable).

4. Current Estimate The value of a technical measure predicted for the end of the development phase.

5. Demonstrated Technical Variance The difference between the planned and demonstrated value of a technical measure.

6. Demonstrated Profile A time-history plot of all performance values that have been achieved since the start of the development activities.

7. Demonstrated Value The value of a desired technical measure achieved in a particular test or engineering analysis.

8. Dependability The measure of the system operating condition at one or more points during the mission, given the system condition at the start of the mission. Dependability is a function of operating time (reliability) and downtime (maintainability).

9. Function A specific action, activity, or process that achieves or supports the achievement of an objective (e.g., an operation that a system must perform to accomplish its mission).

10. Function Tree A hierarchical (tree) structure that organizes work to be accomplished in a logical relationship. The work can be related to products or services. The structure relates work elements to each other and to the end product or service. The function tree results from the systems engineering efforts that completely define the program or project.

11. Integrated Logistic Support (ILS) A management function that provides that initial planning, funding, and controls, which help to ensure that the customer will receive a system that will not only meet performance requirements, but one that can be expeditiously and economically supported throughout its programmed life-cycle.

12. Logistic Support The composite of all considerations necessary to ensure the effective and economical support of a system throughout its programmed life-cycle. It is an integral part of all aspects of system planning, design and development, verification, production and construction, operation, and disposal.

13. Maintainability An inherent characteristic of system or product design. It pertains to ease, accuracy, safety, and economy in the performance of maintenance actions. A system should be designed such that it can be maintained without a large investment of time, cost, or other resources (e.g., personnel, materials, facilities, and test equipment) and without adversely affecting the mission of that system. Maintainability is the ability of an item to be maintained, whereas maintenance constitutes a series of actions to be taken to restore or retain an item in an effective operational state. Maintainability is a design parameter. Maintenance is a result of design.

14. Measure of Effectiveness (MOE) A set of attributes that numerically define the capabilities the system must have in a few critical areas such as reliability, maintainability, and availability.

15. Measure of Success A set of attributes that, when compared to actual results, show how well the objective in question was accomplished. The measure of success is a general statement, the MOE is more specific.

16. Performance Requirement The extent to which a mission or function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or readiness. Performance requirements are initially defined through requirements analyses, and trade studies using sponsor needs, objectives, and/or requirement statements.

17. Planned Value The anticipated value of technical measure at a given point within the development cycle.

18. Planned Profile A plot of planned value versus time. It may be desirable to indicate a range of acceptable values versus time. When this range is shown, it is known as a tolerance band.

19. Predicted Technical Variance The difference between the specification requirement and the current estimate of the technical measure.

20. Producibility A measure of the relative ease and economy of producing a system or a product. The characteristics of design must be such that an item can be produced easily and economically, using conventional and flexible manufacturing methods and processes without sacrificing function, performance, effectiveness, or quality.

21. Program An organized set of activities directed toward a common purpose. Programs are typically made up of technology-based activities, projects, and supporting operations.

22. Project A unique major effort within a program that has firmly scheduled beginning, intermediate, and ending date milestones.

23. Reliability An inherent characteristic of design, defined as the probability that a system or product will perform in a satisfactory manner for a given period of time when used under specified operating conditions.

24. Requirement A specification of how well the system needs to perform a function. The extent to which a function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or safety. Requirements include performance requirements, constraints, and interface requirements.

25. Risk A measure of the uncertainty of attaining a goal, objective, or requirement pertaining to technical performance, cost, and schedule. Risk level is categorized by the probability of occurrence and the consequences of occurrence. Risk is assessed for program, product, and process aspects of the system. This includes the adverse consequences of process variability. The sources of risk include technical (e.g., feasibility, operability, producibility, testability, and systems effectiveness); cost (e.g., estimates, goals); schedule (e.g., technology/material availability, technical achievements, milestones); and programmatic (e.g., resources, contractual).

26. System A combination of related functions or equipment integrated into a single mission.

27. System Effectiveness A performance characteristic expressed in terms of one or more Figures of Merits (FOM). These FOM represent the extent to which the system is able to perform the intended function.

28. Technical Milestone A point where a TPM evaluation is reported.

29. Technical Measures A selected subset of the system's performance measures tracked in TPM. Critical technical parameters (products and processes) relate to critical system characteristics and are identified from risk analyses and contract specifications. Examples of technical parameters include: (a) specification requirements, (b) metrics associated with technical objectives and other key decision metrics used to guide and control progressive development, and parameters identified in the sponsor requirements documentation.

30. Technical Performance Measurement (TPM) A management tool defined as the design assessment that estimates, through engineering analysis and tests, the values of the essential (critical) performance measures of the current design function tree. It forecasts the values to be achieved through the planned technical program effort, measures the difference between the achieved values of those allocated to a certain function tree element by the systems engineering process, and establishes the impact of these differences on system effectiveness.

4.0 RESPONSIBILITIES

The Manager TWRS Technical Integration is responsibile for the TWRS TPM Program. The responsibility of establishing and implementing a TPM Program within a project may be assigned by the project manager to an appropriate managing or performing organization, whichever is applicable. The responsible organization will accomplish the following tasks:

1. Develop a TPM assessment plan.

2. Identify the performance measures to be tracked in coordination with the customer and the higher level TWRS organization.

3. Establish the TPM planned (forecast) profiles.

4. Coordinate with the organization(s) Test Support Group (TSG) responsible for the test and evaluation (T&E) efforts.

5. Track, forecast, and assess performance measures (achieved versus planned).

6. Prepare performance status reports.

7. Conduct technical review meetings.

In tracking and forecasting the performance measures, the responsible organization can delegate the tasks of engineering analysis to an appropriate performing engineering organization.

5.0 PROCEDURE

5.1 Technical Performance Measurement Process

TPM is an iterative approach that follows a forecast-measure-assess process (see Attachment B). Initially, the system performance is predicted in terms of selected performance measures, over the projected development time using the available information. This is the "forecast" portion of the approach. This initial forecast is termed the "planned profile" for each of the performance measures selected. The forecast is updated during the system development to reflect changes in requirements, design, technology, etc., and to verify that the requirements are met.

The "measure" part of the TPM Program is accomplished in conjunction with the system T&E efforts. In this subprocess, each performance measure is subjected to the appropriate verification method. During the early stages of the development, analysis may be the only method for performance verification. As the development progresses, subscale testing, computer simulation techniques, and ultimately, full-scale proof and operational tests become viable options to verify the performance with higher fidelity.

Finally, after performance measures have been achieved by any of the verification methods, comparisons with initial planned profiles and/or updated forecasts provide proof of how well the system performs. These comparisons represent the "assess" portion of the TPM process. The results of this assessment are fed back to the forecast subprocess for another iteration until the system has met the operational requirements. As the development progresses, and the maturity of the program/project increases, the accuracy of the TPM performance assessment increases. The TPM process identifies the performance measures from previously determined systems performance requirements. The performance measures are quantified (MOEs). These MOEs ultimately become the test criteria during the verification (T&E) process. Using the threshold values of the MOEs during the T&E process ensures that the system's performance requirements are met and guarantees that the developing system will meet these requirements when it becomes operational.

While the TPM offers insight into the evolving capability of the system to accomplish the intended mission, it also provides valuable signals as to potential technical risks. It is, therefore, a major factor in the risk management process. Performance measures that either are not met or become marginal must be evaluated for technical risk in order to take appropriate risk mitigation actions, if needed.

TPM is implemented as a management tool within the TWRS systems engineering activities. It takes input from Evaluation and Optimization and provides output to Verification (Attachment A).

The TPM implementation procedure consists of the following steps:

1. Develop TPM assessment plan.

2. Establish the TPM hierarchy tree.

3. Develop Master Measurements List (MML).

4. Establish the TPM planned profiles.

5. Monitor system performance through tracking, forecasting, and assessment.

6. Prepare TPM charts.

7. Prepare TPM summary status reports.

8. Conduct TPM assessment reviews.

The above steps are not necessarily sequential because two or more steps may be performed concurrently. Furthermore, they may be repeated or updated when appropriate.

The process (see Attachment B) starts with the development of an assessment plan outlining various aspects of the TPM activities. The assessment plan is followed by establishing the TPM hierarchy tree from the TWRS architecture tree with inputs from the cost, schedule, and hardware requirements. A MML containing the key performance measures, is then developed. This list is developed from the existing requirements and is the central repository for system performance. It contains the key (critical) performance measures (system characteristics) whose values are indicative of the mission success. Next, the planned profiles are constructed using the program schedule to identify milestones to be used for forecasting, tracking, and assessment of these measures. These planned profiles may undergo revisions as the system development progresses. System summation models are developed to forecast, track, and assess the selected performance measures. The next step in the process is to record the TPM results in a suitable format (graphical or tabular) comparing the achieved and the planned values. Then, a performance status report is developed to summarize the system effectiveness and performance assessment. This report is presented in periodic technical reviews. The frequency of these review meetings should be consistent with the scheduled events of the project under consideration. The purpose of these technical reviews is to assess the progress of technical performance of the mission/system under consideration. Meanwhile, the interim results of the TPM Program are continually fed into the risk management system, T&E activities, and system integration processes for evaluation and corrective actions. The process described above continues until the system's development has met the operational requirements and the risk to mission success has been reduced to an acceptable level. These elements are described in detail in the following section.

The TPM process is dynamic, due to continuous revision throughout the development phase of the project/program. Process updates may be driven by the results of the TPM process as a whole or any part thereof. For example, if future work shows that new measures are critical to the success of the mission, these measures will be added accordingly. Further, if the performance assessment proves that a certain requirement cannot feasibly, economically, or technically be met, then the requirement itself may be subject to change.

5.1.1 Develop Technical Performance Measurement Assessment Plan

The responsible organization will start the development of an assessment plan early in the program life-cycle. The assessment plan will outline the performance measure selection process and identify the measures that have been selected. The assessment plan should be updated as additional performance measures are identified. For the identified measures, the assessment plan should forecast the values to be attained through the development activities and the methods to be used for forecasting, tracking, and assessment. For each scheduled assessment, the plan should coordinate with concurrent test efforts. Initially, the assessment plan takes input from project documentation and historical background. As the development progresses, it is updated through interaction with the system T&E process (Attachment B). A typical assessment plan contains the following information:

- A summary of the plan for demonstration of system technical performance.
- Lists of all critical hardware items, their TWRS architecture tree numbers, specification number, the key measures for each item, the specifications that completely identify these key measures, and their quantitative requirements.
- Lists of milestones related to performance achievement for the system and each subsystem.
- Lists of available verification documents.
- Technical reviews and reporting plan.

5.1.2 Establish the Technical Performance Measurement Hierarchy Tree

The TPM hierarchy tree is developed from the TWRS architecture tree from the system level down to various subsystems and component levels. The TPM hierarchy tree defines the build-up of system measures from selected elements of the TWRS architecture tree. The linkage between the TWRS architecture tree and the TPM hierarchy tree is the key to the TPMs use as an effective management tool. Developing the TPM tree from the TWRS architecture tree ensures traceability of progress on technical performance to cost and schedule aspects of the work effort. This allows program management to associate technical tolerance limits with schedule and budgetary constraints.

Attachment C is a hypothetical illustration of a TPM hierarchy tree derived from a program architecture tree.

Although the elements of the TWRS function tree are principally applicable to the TPM hierarchy tree, in some cases, items may contribute differently to the selected TPM measures. For example, some hardware items may not significantly contribute to the TPM measures while others may contribute to two or more measures. Therefore, the TPM hierarchy tree may not directly correspond to the project function tree in content or level of detail. For example, it may be necessary to expand certain parts of the function tree in some areas of a given project to facilitate the forecasting, tracking, and assessment in that area. In addition to the function tree, the TPM hierarchy tree also considers inputs from cost and schedule, and hardware requirements allocation. Attachment C shows how the total system performance requirements are allocated from the top to the bottom of the hierarchy. Operational availability and total system maintenance burden are identified as upper-level mission measures. Allocations are made from these to the subsystem measures for reliability, maintainability, etc., for each supporting subsystem element. Further allocation for each subsystem element is made at the component measures levels for each overlying element. Upon completion of identification of the system's requirements and their conversion into MOEs, they are placed into the MML to serve as test criteria during the T&E efforts.

5.1.3 Develop Master Measurements List

The MML is the backbone of the TPM process. This list contains all the performance measures selected on a given program/project. It is the central repository for the systems engineering elements and provides traceability for test criteria (MOEs) with their sponsoring requirements. The list takes its main inputs from the system requirements and specifications developed during the functions and analysis step and identified in the resource allocations database. Measures selected must be meaningful and quantitative. The MML follows the TPM hierarchy and is tailored according to specific project needs.

5.1.4 Establish Technical Performance Measurement Planned Profiles

The TPM planned profiles are graphical plots of the anticipated performance of a system over the development time. They depict time-phased goals of the measured values for an element of the TPM hierarchy tree. These goals are the anticipated development achievements for the element that are used to monitor progress to ensure contract objectives are met. On each graph, the abscissa shows the calendar time expressed in terms of project/program major events (milestones) and the ordinate indicates the value of the performance measure being tracked. The planned profiles are initially predictions made at the start of the development activities. The system test planning provides the initial input to the planned profiles. Attachment D, an example of a typical planned profile, shows that a program schedule comprised of milestones and goals affects the planned profiles because milestone/goal represents a calendar time increments. These predictions can be made from analysis, available test results, and historical data. As the development of the system progresses, the planned profiles can be revised to reflect changes in design, requirements, growth planning, and other relevant information. Attachment E shows an example of a planned profile for a Technology Development Effort.

5.1.5 Monitor System Performance Through Forecasting, Tracking, and Assessment

The system summation models are the tools that the TPM team uses to forecast, track, and assess performance throughout the development of the system. Initially, these tools may be limited to simple prediction methods and historical database. For a first-of-kind activity, no historical data exists, and the TPM team may have to rely on simple estimation methodology alone. As the system development progresses, more information becomes available as data are collected from the same project under consideration. In addition, the advancement of technology, hardware, and software is a major factor in facilitating the development of future tools. The level of detail and the degree of complexity of the system summation models increase as the maturity of the system development increases. System summation models are the summary-level reports that management uses to identify deviations from the planned profile. They are used with current estimates/measurements of the MOEs to provide a total system performance estimate at each reporting period. The typical summation models include growth plans showing progress in system development in achieving specific reliability and maintainability values for facilities and equipment. These plans normally include the measure's developmental progress tracked on a time axis showing milestones, former, present, and future values of the measure, and specific fixes that have facilitated the measure's growth. Management can use the information to determine such things as, deviation form planned values, progress-to-date, probability of achieving the goals or modifications to performance, cost, or schedule necessary to facilitate associated program objectives.

The system summation models are greatly affected by the interaction with the system testing. The progress/goals are achieved and demonstrated through establishing milestones, measured values, etc. These are assured through the T&E process. The interface with the performance, forecasting, and tracking system, or the results of such, are used as inputs to summary reports. These results are used to effect future developmental fixes, milestones, and testing. Typical system summation models include, but are not limited to, the following approaches:

- Engineering analysis
- Math models
- Computer simulations
- Subscale testing
- Procedures for growth planning.

The performance of the overall system is characterized by a number of key measures that are compiled in the MML. The forecasting, tracking, and assessment is a subprocess of the TPM that uses the systems summation models to evaluate the system performance at major milestones. As the development phase progresses, information is exchanged between this subprocess and the T&E process of the systems engineering activities. Feedback is usually reflected in updating the system summation model and the assessment plan. Feedback impacts measures, configuration, specifications, milestones, etc., which in turn cause modifications to the design baseline. Any proposed changes to the performance, schedule, and cost is assessed and seen in the system summation models.

5.1.6 Prepare Technical Performance Measurement Charts

At each evaluation point, the achieved-to-date performance is plotted/tabulated against the predicted forecast for each measure. A typical graphical TPM chart may include, but is not limited to, the following:

- Title (performance measure being tracked)
- TPM Number
- TWRS function tree (system architecture) number
- Date
- Major program/project events (milestones)
- Planned profile (initial, updated, or both)
- System requirement for the measure being considered (baseline and/or updated)
- Achieved to date (demonstrated performance)
- Method/approach used for demonstration
- Current estimate (value of performance predicted for end of development)
- Desired performance at end of development (goal)
- Demonstrated variance (difference between achieved and planned)
- Tolerance band (allowed deviation from planned profiles).

The TPM chart should be tailored to the specific needs of the project/system being evaluated. Attachment D is an example of TPM plot including some of the above information. The TPM charts and records of achieved profiles are prepared, compiled, and maintained by the TPM responsible organization. These records form the database needed for system effectiveness and summary reports, and are used as management tools at technical reviews.

5.1.7 Prepare Technical Performance Measurement Summary Status Reports

System effectiveness is characterized by a number of FOMs or MOE. These FOM or MOE represent the extent to which the system is able to perform the intended mission. They are developed using the System Effectiveness Planning and Analysis Procedure, Cost Effectiveness Planning and Analysis Procedure, and the Logistic Support Planning and Analysis Procedure, as appropriate. The FOM or MOE vary considerably depending on the type of system and mission requirements. Examples of these measures may include reliability, availability, dependability, etc. They are an integral part of growth planning. Throughout the duration of the development phase, these measures usually evolve with the system, and hence, they become test criteria during the T&E process.

The records of achieved profiles are used to construct the summary status report. The summary status report is prepared by the TPM responsible organization. This report summarizes the key findings of the TPM activities. This element of the TPM Program provides inputs directly into risk management and decision management (DM). It is presented for management review at scheduled project events. These summary reports are the mechanisms that management uses to track the overall program progress and system effectiveness. They are the management indicator if there is a problem that may impact cost, schedule, or design. Attachment F is an example of a summary status report.

5.1.8 Conduct Technical Performance Measurement Assessment Reviews

Periodic reviews between the customer and contractor(s) and between the TPM teams and management are conducted to determine whether the plan should be altered as uncertainties are disclosed, eliminated, or reduced. These reviews are planned early as part of the TPM assessment plan. They are usually held quarterly. They may be scheduled to coincide with design reviews and other program milestones (see Section 5.2.4.1). These reviews are the main vehicle to exchange the results of the TPM with organizations responsible for the system verification and testing, risk management, and DM.

5.2 Implementation Guidelines

Additional guidance on the implementation of the TPM Program is provided in the following areas:

1. Selection of TPM measures.

2. Developing planned profiles.

3. Monitoring system performance through forecasting, tracking, and assessing the TPM measures.

5.2.1 Selection of Technical Performance Measurement Measures

TPM measures, system characteristics, can be classified into one of the following categories:

1. Contractual and/or regulatory requirements.
2. Customer-selected measures.
3. Experience-related measures.

In addition, measures also can be related to:

1. Operations
2. Producibility
3. Configuration
4. Integrated Logistics.

Examples of TPM measures may include, but are not limited to: sampling system reliability, maintainability, availability, number of stabilized tanks, sampling rate, etc.

In developing a cost-effective TPM Program, only a few key performance measures should be selected at the top level. The total number of detailed measures to be tracked to support these top-level measures may be significant. The lower-level measures are identified through the requirements allocation process. These measures represent allocation of system-level requirements to lower levels within the system hierarchy and should be available in the systems engineering documentation.

In the absence of historical database for first-of-a-kind system, the selection of performance measures that are indicative of mission success may not be obvious. In this case, measures could be selected using the following guidelines:

1. Most significant qualifiers or determinant of the total system product or function.

2. Measures whose values can be rapidly derived from results of analyses or test.

3. Measures whose time-phased values and tolerance bands are predictable during development.

Further, the key measures should be selected on the basis of overall technical importance, technical risk assessment, parametric sensitivity in the engineering models, and interface relationship.

The selection of the TPM involves the following tasks:

- Review performance specifications and systems engineering documents that detail critical performance elements.

- Develop a framework for the TPM tree from the TWRS function tree.

- Select TPMs using the full scope of the systems engineering process. A comprehensive set of key measures is selected for the system according to the above criteria.

Each TPM Program should establish the requirement for a controlled MML. Whenever there are several TPMs to be implemented within a project, the responsible organization should assign a number to each TPM for documentation and filing purposes.

5.2.2 Developing Planned Profiles

A planned profile must be established for each selected performance measure. As one of the initial steps of a TPM Program, appropriate profiles are prepared using historical data, test planning, contract requirements, and other available information. The planned profile may be constant, increasing, or decreasing as a function of time, based upon technical maturity, experience, and historical background.

Planned profiles should be viewed as dynamic, particularly where systems engineering/engineering development is still in progress. Where trade studies indicate that cost or time to achieve a planned requirement is excessive, the requirement could be relaxed and new profiles established. Meanwhile, other measures may also require adjustment. Planned profiles usually undergo continuous revisions as the system progresses until the development activities have been completed and the system performance has met the operational requirements.

The utility of all TPM assessment and forecasting methods is enhanced by establishing a tolerance band for each planned profile. Attachment D illustrates the tolerance band for a TPM as it would be indicated on a TPM chart. The boundaries of the tolerance band reflect the known limitations of the estimating technique being used and past experience. They define the region within which it is reasonable to expect that the specification requirement will be achieved within cost and schedule constraints. Use of both upper and lower bounds on each measure allows management to detect under-achievement and over-achievement trends.

The TPM planned profile is based on the system analyst's "current estimate" (Attachment D) of the critical technical measure at TPM tracking completion and the actual value of the technical measure or the "achievement to date." The system analyst uses parametric analysis techniques to make the "current estimate." This parametric analysis should consider the program or project funding profile, the technology base, and schedule constraints. Based on the uncertainties inherent in the parametric analysis performed, tolerance bands can be generated for the technical measure's profile. The performance measurement profile also can display a threshold value for the critical measure based on the minimum requirements or objectives associated with the measure. Further, the performance measurement profile will call out the technical milestones for which the TPM will be evaluated.

5.2.3 Monitoring System Performance

Performance monitoring is accomplished through forecasting, tracking, and assessing the TPM selected measures. The methods used for evaluating the technical performance are: testing, inspection, demonstration, comparison, and analysis. The level of detail of each specific method is dependent on the scope or phase of the project, available resources, and desired output. For example, during early stages of the development, analysis may be the only approach for assessing the proposed system, which is mainly a paper design. However, there is still a range of possibilities in terms of the method/depth of analysis.

The choice of the method for a particular project/program is dependent on the type of the TPM identified, maturity of program, historical data, etc. Each method is associated with a specific cost profile, as well as development time, and accordingly provides a certain level of confidence. Program needs must be weighed against related costs and schedule impact when the tracking and forecasting methods are selected.

During the pre-concept and concept phase, achievement to date is tracked at each assessment stage (milestone), for each selected measure, and at each specified level of the TWRS function tree. These point estimates, based on either analysis or test, are used to forecast/predict the expected value at the end of the concept phase.

If any demonstrated or forecasted value falls outside the planned tolerance band, corrective action plans must be prepared by the responsible organization/contractor. Each deviation should be analyzed to determine the cause and to assess the impact on higher-level measures, interface requirements, and system and cost effectiveness. The Programmatic Risk Information Management System (PRIMS) also is updated. Alternative recovery plans are developed showing fully-explored cost, schedule, and technical performance implications. On the favorable end of the scale, when performance exceeds requirements, opportunities for reallocation of requirements and resources are available.

5.2.4 Technical Performance Measurement Reporting

A major portion of the TPM activities involves documenting and reporting the TPM status. A system shall be developed to provide current TPM status on demand. The results of the TPM tracking and forecasting should be displayed in the form (graphical or tabular, Attachments D through F) that shows a comparison of achieved value versus planned and current estimate for each measure at a certain desired point in time (milestone). Formal reports, which include all TPMs for a project or specific subproject (effort), are prepared for reviews and to respond to management requests.

5.2.4.1 Report Timing and Frequency. The reporting delivery requirements of the system performance should be correlated with the assessment points (milestones) defined in the planning profiles. Typical candidates for correlated program milestones and frequency of the performance assessment include, but are not limited to:

- System Requirements Review (SRR)
- Technical Requirements Review (TRR)
- Design Requirements Review (DRR)
- Detailed Design Review (DDR)
- As-Built Design Review (ADR)
- Hardware Validation Tests
- Performance Tests
- Environmental Tests
- Reliability Tests
- Computer Software Tests.

In addition, periodic technical reviews are conducted to assess the interim performance of the system under consideration. The purpose of these technical reviews is to determine whether the planned technical activities should be altered as uncertainties are disclosed, eliminated, or reduced. These reviews are planned as part of the systems engineering management effort, not a reaction to technical problems that suddenly occur. They are used to seek opportunities to reduce or redirect program effort to effect economies in budget and time, as well as to increase or redirect program effort to overcome weaknesses that may develop in the planned program.

TPM assessment update events for corresponding elements of the TWRS function tree may be scheduled to coincide with configuration item design reviews, system-level reviews, and periodic technical reviews.

5.2.4.2 Report Format. A formal TPM report is a compilation of individual TPM assessments. Each TPM report (chart) contains a comparison of achieved versus planned values, design analysis status, variance analysis, and supporting information (Attachments D through F).

The TPM report includes the planned value, demonstrated value, demonstrated variance for the design at the time of the assessment, current specification requirement, and the predicted variance for the end product. Determination of the current estimate is based on the demonstrated value and changes to the measure value that can be attained within the remaining schedule and cost baseline. The performance comparison can be in graphical or tabular form.

The TPM summary report may also include a status of the design configuration, discussion of design and engineering investigations (e.g., experiments and tests performed), analysis that supports the demonstrated value, and a discussion of technical effort supporting the predicted profile leading to current estimate. The exact report format should be tailored to specific program needs.

6.0 REFERENCES

Orsag, F., 1996a, *TWRS Systems Engineering Manual*, "Test and Evaluation," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

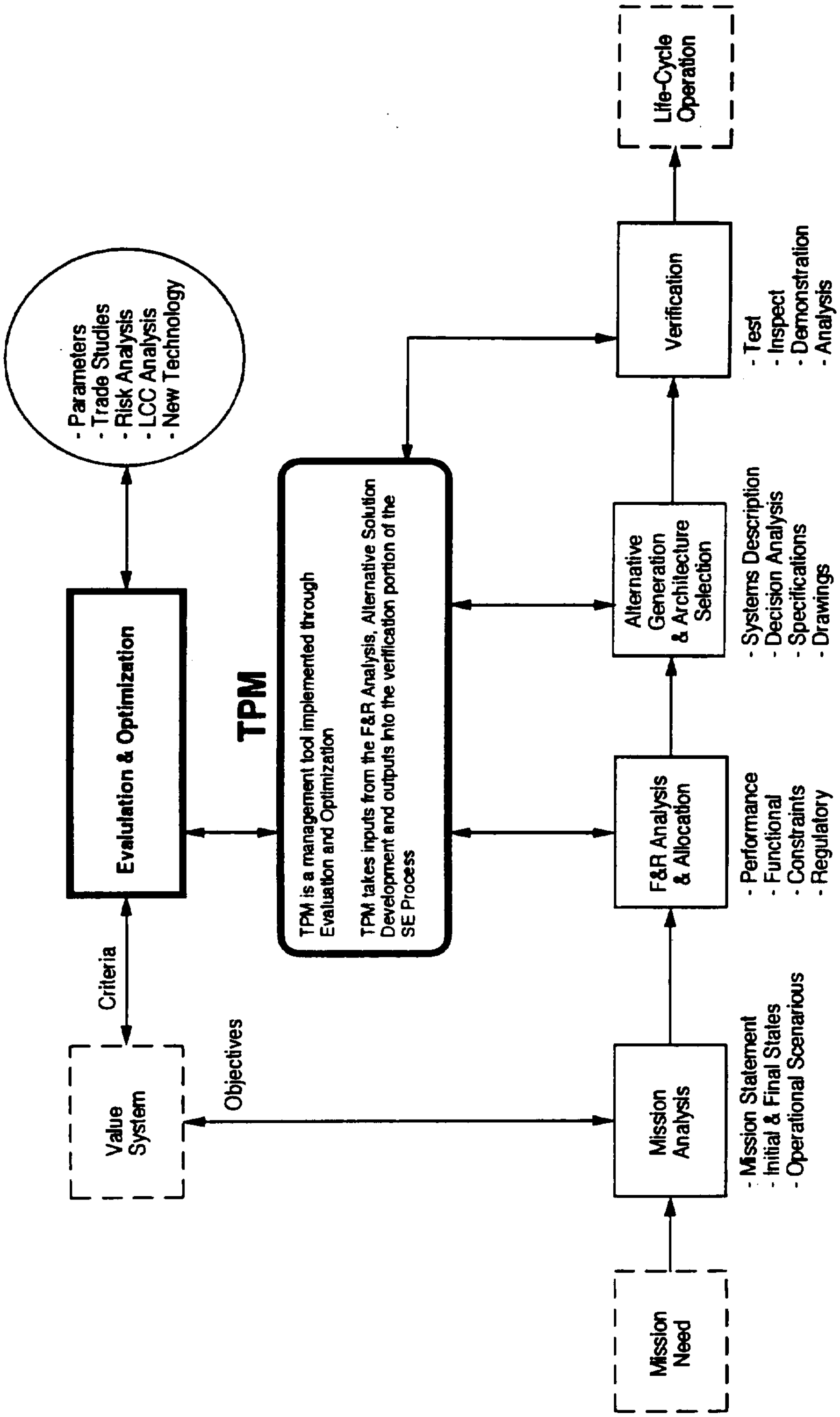
WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A Systems Engineering Process
Attachment B TPM Flow
Attachment C TPM Hierarchy Tree
Attachment D Typical Planned Profile
Attachment E Planned Profile for Technology Development Program
Attachment F Summary Status Report
Attachment G Technical Achievement Matrix
Attachment H Alternative Technical Performance Assessment Methodology

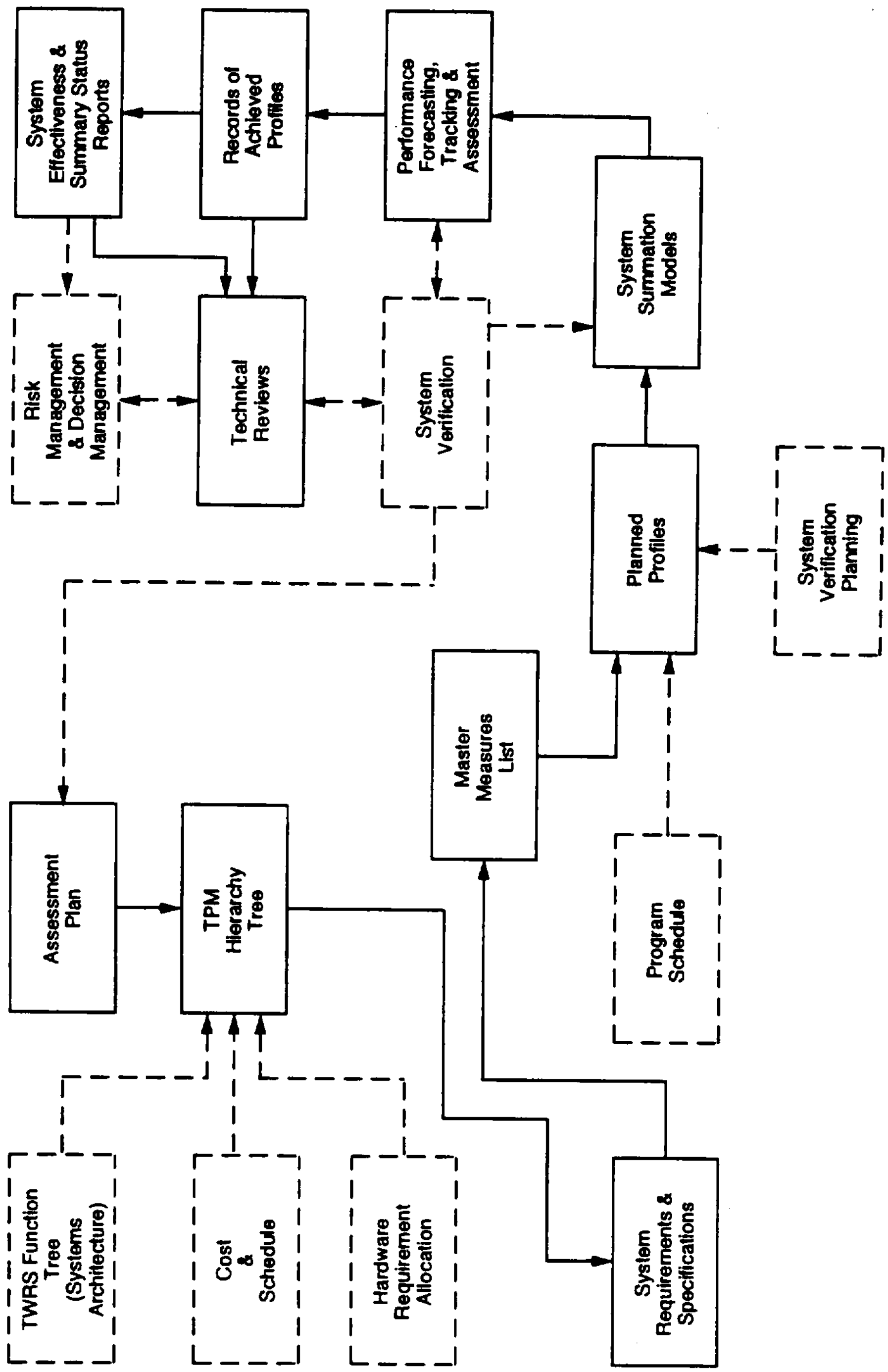
Attachment A

Systems Engineering Process



Attachment B

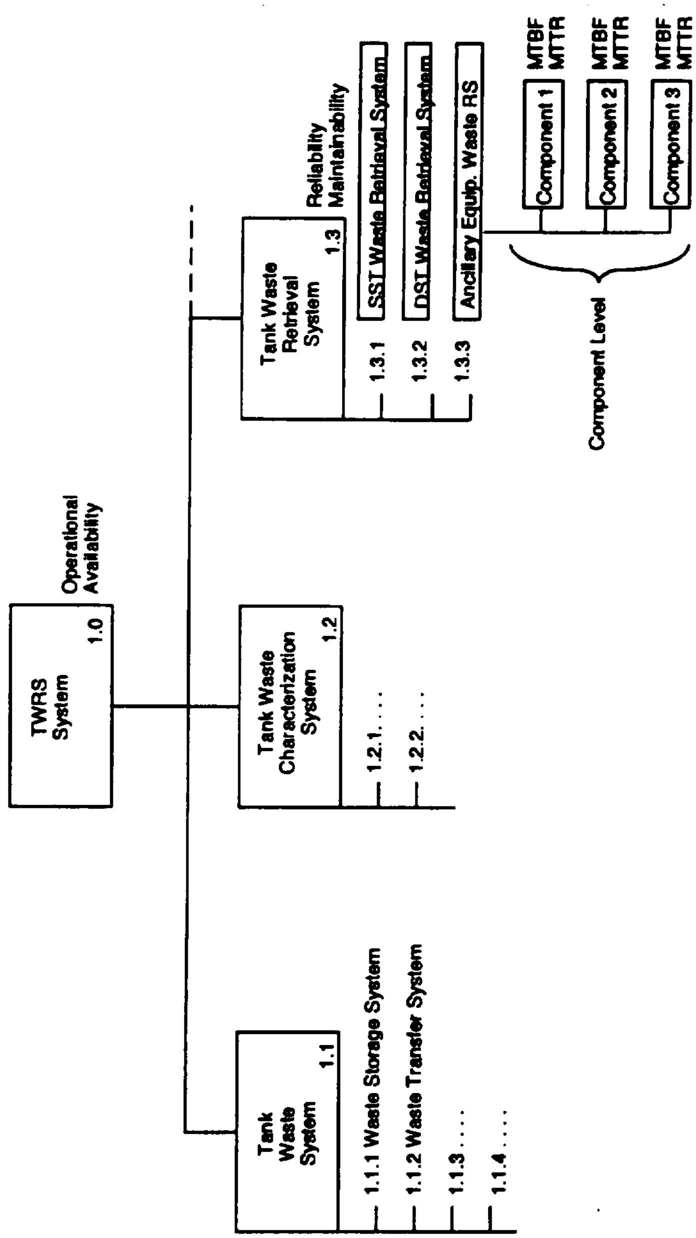
TPM Flow



NOTE: Blocks shown in dashed lines are not part of the TPM Process.

Attachment C

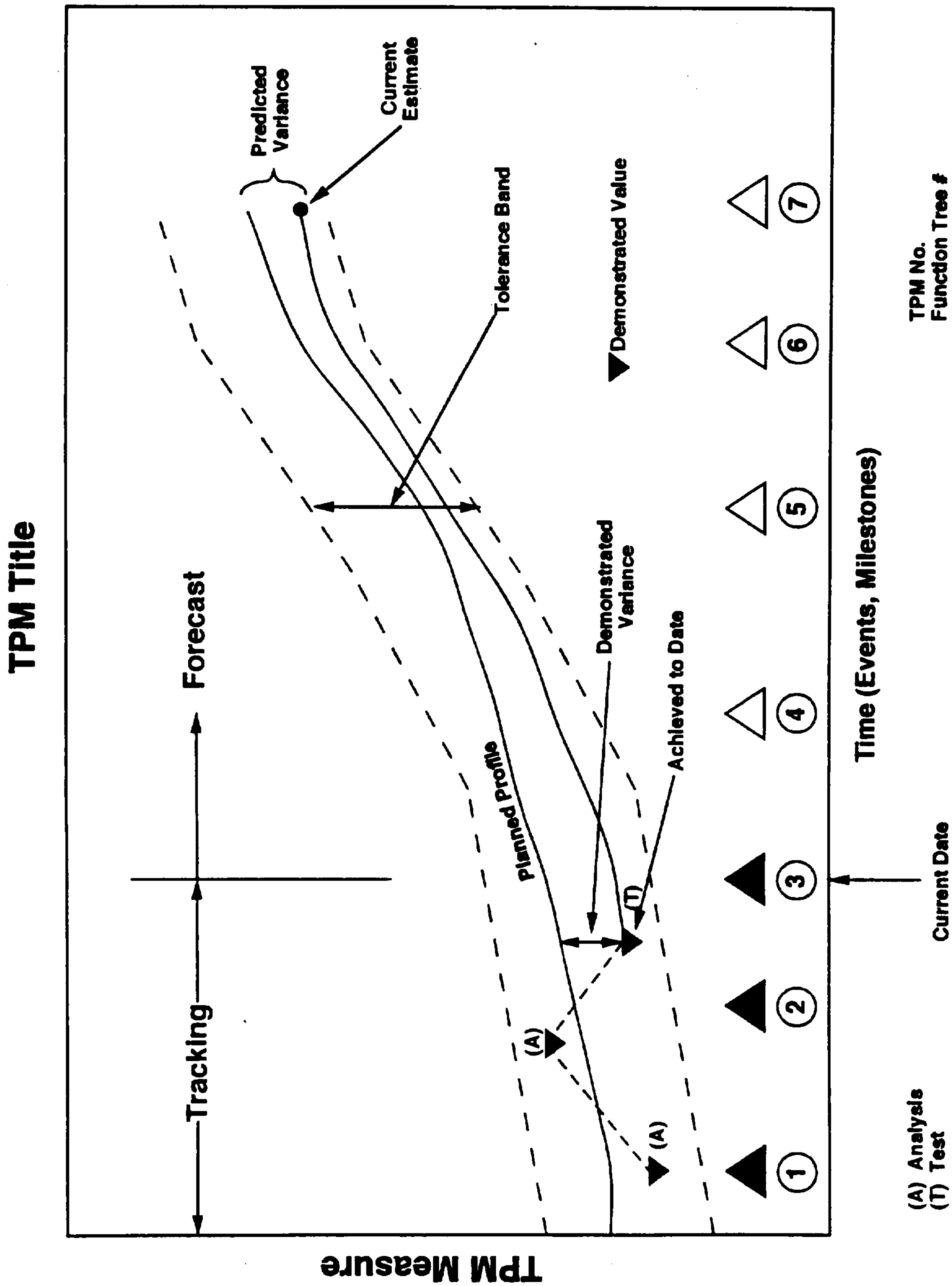
TPM Hierarchy Tree



Example of TPM Tree Development using TWRS Architecture Tree. The figure illustrates the tree for a single measure, (e.g. Operational Availability). The component Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) are contributors to the system level Operational Availability. Not all subsystem measures are conveyed to the subsystem or component levels. Multi-measure tree is possible also. Examples from actual TWRS TPMs will be included herein when available.

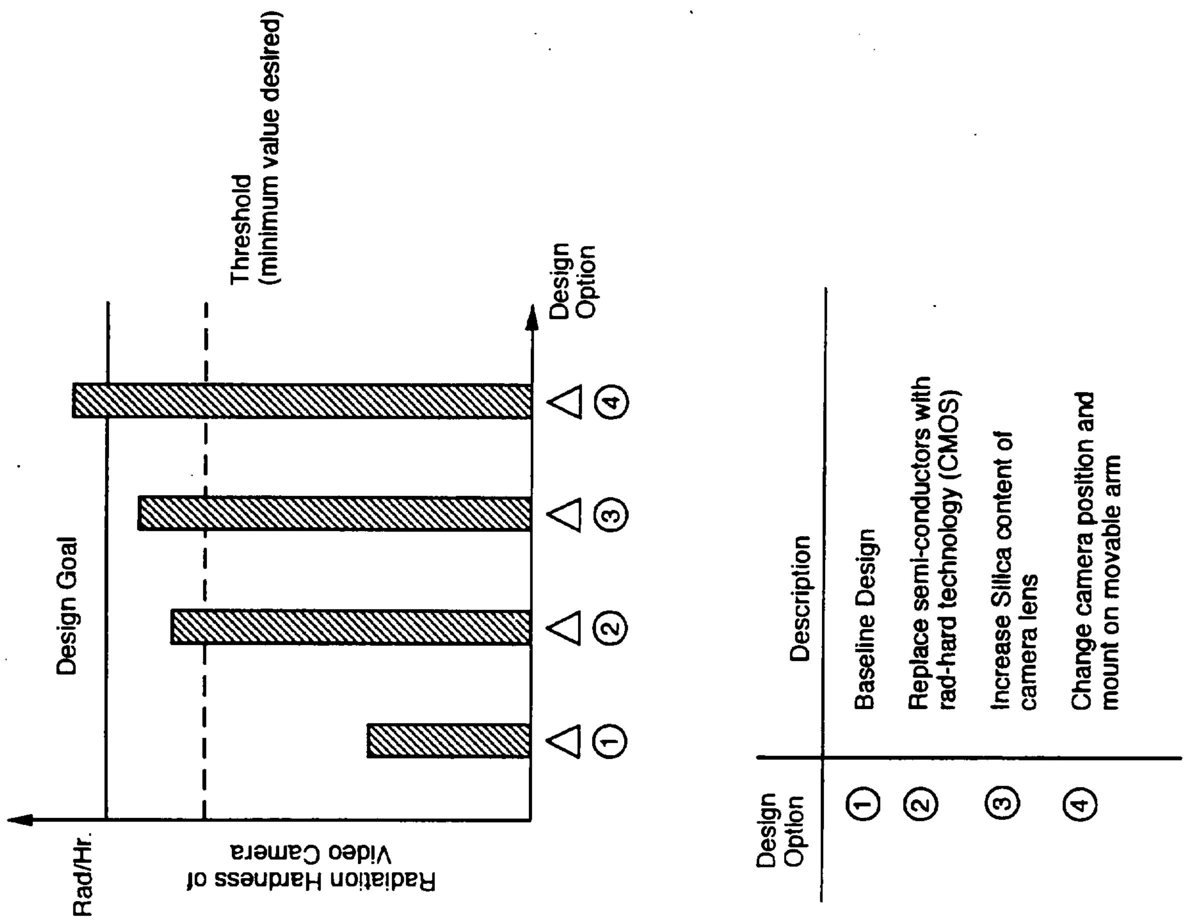
Attachment D

Typical Planned Profile



Attachment E

Planned Profile for Technology Development Program



Attachment F

Summary Status Report

SYSTEM EFFECTIVENESS AND SUMMARY PERFORMANCE STATUS REPORT									
RESPONSIBLE ACTIVITY			DATE						
IDENTIFICATION	CHARACTERISTICS	REQUIREMENTS		STATUS			VARIANCE		
WORK ITA ELEMENTS	PRIMARY PERFORMANCE CHARACTERISTICS OR PERFORMANCE PARAMETER	ESSENTIAL FOC/LR REQUIREMENT	a. SPECIFICATION REQUIREMENTS	b. STATUS BASED ON PREDICTION	c. STATUS BASED ON TEST RESULTS	d. STATUS BASED ON OPERATIONAL USE	a b	a c	a d

NOTES:

Attachment G

Technical Achievement Matrix

ITEM DESCRIPTION Transmitter - 5243

TEST HARDWARE →	Bread-Board	Trial Model	Prototype #1		Prototype #2		**END OBJECTIVE**
DESIGN FACTORS / TECHNICAL ACHIEVEMENT EVENTS	1	2	3	4	5	7	
A Power Required	800KW	605KW					600 + 5 KW
B							
C							
D							
E							
F							
G							
H							
I							
J							
K							

Attachment H

Alternative Technical Performance Assessment Methodology

An alternative method for management planning and control of technical performance is use of a Technical Achievement Matrix. After the requirements and technical objectives have been developed for the project, the project manager must plan the progress of the project toward them in order to subsequently control technical performance. As is typical in good planning, interim achievements must be identified and ordered so that as the program progresses, actual achievement can be measured against planned achievement. Furthermore, to be realistic and usable, the plan should be expressed in terms of how the engineers intend to do the job.

The engineer first attempts to demonstrate the feasibility of his basic concepts as quickly as possible under the simplest of conditions. He next tries to achieve more and more of the engineering requirements while retaining basic product performance requirements. In general, his modus operandi is to successively achieve an increasing combination of the requirements imposed. It is convenient to express the plan for this kind of technical progress in a tabular or matrix form. This is done in Attachment G in what is called a Technical Achievement Matrix. The row headings are a listing of the various design factors. The column headings represent the major technical achievement events that the engineer has planned. In the last column, the final design objective for each factor is listed. The heavy-stepped line is used to represent the engineer's plan of interim technical achievements.

For instance, the engineer's first aim was to build a breadboard with the required performance. Thus, the heavy line indicates that at the first technical achievement event, it was expected that three engineering performance requirements would be attained. His second step was to build a model that would meet the capacity and size requirements, as well as the performance requirements. Thus, it is indicated at the second technical achievement event that all five of these requirements will have been met. This is continued until at the sixth technical achievement event the engineer has a design, represented by a piece of hardware, that meets all of the engineering requirements. The technical performance plan for the component is thus evolved in terms of the engineer's view of his work.

Flexibility in the construction of these matrices permits them to be tailored to the particular problem at hand. In any particular case, the Technical Achievement Matrix would be a function of what had to be performed and the way in which the engineer, subject to the constraints of his design requirements, intended to go about reaching his objectives (engineering requirements). Also, it is not to be inferred that the engineer thinks about only those specifications above the heavy line. He should be concerned with all the requirements all the time. However, he does not try to meet them all at once, and the matrix is expressing his plan of gradual achievement. The engineer does not necessarily plan to achieve the final objective for each design factor for each piece of test hardware to be built. However, it is important that he set down in advance what he does expect to achieve for each successive technical achievement event. For one design factor, it is relatively easy to predict what can be achieved far in advance with each piece of test hardware. For another design factor, it may not be technically feasible to predict what can be achieved with future test hardware until the results of current testing have been completed. Under these conditions, the design engineer could use a "rolling wave approach" in predicting technical achievement for future technical achievement. Under this approach, the engineer would be required, as a minimum, to commit himself to at least one planned technical achievement for each design factor in advance at all times.

In Attachment G, the coordinate boxes are divided diagonally to make provision for showing planned technical achievements in the upper left half of each box and actual achievement in the lower right-hand box. The last column is divided horizontally for planned and predicted. Thus, it can be seen that the engineer does not expect to achieve the one design required until the second model is built, and that he doesn't expect to make the design factor until the first prototype is built. This is the way that many developments are conducted and the Technical Achievement Matrix must reflect it.

In the particular example presented, the engineer planned and certainly was able to get into testing quickly. To an extent he was using components that were within the state-of-the-art, and therefore, able to assemble them and start testing his concepts on an achievement event that occurred early in the program so that the manager did not face the problem of a long wait before getting his first reports on actual data. Such early testing will be the case in many kinds of projects. This condition exists in many projects, but where it doesn't, some different kind of technical achievement events have to be generated before the first planned testing takes place. The character of these events should be a function of the particular program and the planned situation. However, they would probably be design reviews or events related to design reviews. Thus, when testing does not take place early in the project, the design review should be programmed into the matrix as an alternative method of measuring and reporting technical performance.

Another important consideration when developing plans for the development of a particular product component is functional relationships with the other product components. These relationships normally would be identified during engineering analysis and must be incorporated into the plans for technical development.

Test Plans. The technical achievement events used in these examples have been events that represented the end of testing at various points in the project. The reason for this is that the test offers an objective and quantitative measure of progress toward final objectives that is hard to obtain otherwise.

Because there are different conditions under which a test can be performed, and because to some extent a desired result can be "squeezed" out, some standard must exist on how the test will be conducted. Where appropriate, there also must be a provision for reporting the uncertainty in the test results. In any case, there must be a test plan that is conformed to in the measuring and reporting of progress at the key events. These detailed test plans can be developed using Gantt charts, milestone charts, or PERT networks. These techniques frequently can be used as a basis for planning and controlling the various testing activities leading to a technical achievement event on the Technical Achievement Matrix. The T&E Procedure (Orsag 1996f) contains additional guidance on Testing, Test Plans, and Test Reporting.

Integration of Technical Activities. The construction of detailed "hardware development" networks is greatly facilitated once the Technical Achievement Matrix for the various end items on a hardware breakdown structure has been developed. Key technical achievement events, as specified by a project manager, on the matrix may become events in PERT networks. To construct the network these events are connected with appropriate intervening events and activities. The numbered events in a schematic representation should correspond to the technical achievement events on the Technical Achievement Matrix, which have been designated as key milestones for measurement of technical progress by management.

These detailed networks, whether constructed separately for each item, or jointly for a number of end items, must be properly integrated within the scope of the entire development. Subsequent development of activity time estimates, calculation of the critical path, slack analysis, etc. is described by various references on PERT.

It has been implied that a Technical Achievement Matrix be prepared for each item on the hardware breakdown structure down to the level representing the smallest components with which an engineering supervisor is directly concerned. Thus, during the early portion of the development when components have not yet been integrated, the system would be concerned with information from the lowest level matrices. As these lowest level items come together and form the next higher assembly, the information for the planning and control of that level is found on a matrix specifically for that end item at that level, and so on as the project goes up to higher and higher equipment levels. Thus, the Technical Achievement Matrix is always at the working level.

Most of the products a project manager will be dealing with will involve several models. That is, more than one of the items in question will be built during the project. The work on the different models will overlap considerably. Thus, at most times during the project, there is more than one working level. In this case, what information is of primary concern to management: information on the first model's subsystem performance because it more closely approaches system (missile) performance or information on progress in the lower-level hardware because it is further into the project and incorporates new results? The fact is that both kinds of information are probably very important to management because they generally want more than one dimension to their planning and control.

The project manager and intermediate levels of managers are interested in how each piece of hardware is progressing toward the end objectives. That is, they are interested in a total project view of the technical progress of each of the pieces of hardware. This was directly the basis for the development of the Technical Achievement Matrix. The managers are also interested in monitoring the progress of the individual models toward their goals, which are called out in the higher-level Technical Achievement Matrices. Thus, in these long projects, management should want to know not only how much technical progress has been made toward the end objective for each hardware end item, but also, at any time, what the technical progress is on each model to be built has been.

The planning by model does not involve the generation of any information that has not already been included in the Technical Achievement Matrix or the detailed PERT networks. The matrices involve ordering information by model number rather than by hardware end item. Similarly, with the detailed PERT networks it involves calling out those milestones that represent accomplishment in the development of each model. It is in this manner that special information can be generated about each model without developing any new information.

This same kind of reasoning can be applied to the development of other dimensions of planning and control. Assume that management wishes to have a separate look at reliability. Many of the technical achievement events in the Technical Achievement Matrix refer to the attainment of reliability specifications. To develop a reliability plan, one would simply have to sift these reliability achievements from the various matrices and order them in some meaningful report.

A project manager should be apprised of technical problems as soon as possible if they are of sufficient magnitude to warrant his attention. Normally, the project manager will know that certain design factor end objectives will be critical and will need to be watched very closely. Using his judgment, the project manager should prepare a list designated to be key design factors, about which he will be interested in receiving up-to-the-minute information. For these key design factors the reports described below may be used by the project manager on a selected basis.

The engineer's technical plan, the Technical Achievement Matrix, can be used as a local reporting device for himself and his immediate supervisors. When a technical achievement event is completed, he notes the results and records it on the matrix.

In order to see whether or not there is a serious problem, predictions by the engineer can be utilized (the system is predictive). Each time a Technical Achievement Event is completed, the engineer not only records his results for that event but, where possible, what end result he will obtain for all of his design factors. These predictions would be placed in the lower half of the boxes in the last column.

TITLE: TEST AND EVALUATION	Approved by J. D. Thomson, Manager TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to provide a methodology for:

1. Defining potential test scenarios
2. Performing the steps necessary for the test planning analysis
3. Conducting tests and preparing test documentation for the approved test scenarios.

The primary objective of the TWRS Test and Evaluation (T&E) Program is to ensure that Tank Waste Remediation System (TWRS) meets its requirements and that areas of noncompliance are noted as early as possible to identify alternative approaches with a minimum impact on project resources. Implementation of this procedure will provide management oversight for the entire TWRS T&E Program and will help minimize risks to the program.

2.0 SCOPE

This procedure applies to all test activities associated with TWRS. It correlates to the U.S. Department of Energy (DOE), Richland Operations Office (RL) Systems Engineering Standard (Draft) in that the Test Support Group (TSG) resides at the program office level and the Test Working Groups (TWG) are at the project level. The TWRS T&E Program does not utilize the program element level; therefore, those functions and responsibilities are absorbed by the program and project levels. A hierarchical chart (Attachment A) depicts the TWRS T&E organizational structure and the sphere of influence of this procedure. When Independent Verification and Validation (IV&V) is required, the scope of the IV&V effort should be defined in the contract or project enabling documents, which includes a contractual statement to ensure the independence of the activity.

3.0 DEFINITIONS

1. <u>Test Scenario</u> A characteristic or aspect of system architecture critical to overall successful system performance of mission. The following are examples of possible test scenarios: (1) if throughput of the piping system is critical to maintaining tank waste flow volume to a privatization contractor, a test scenario may be necessary to test the waste transfer system in advance to demonstrate that the system can meet the need, and (2) a test scenario may be needed to verify that a technology exists that is capable of removing 99.95% of tank waste.

4.0 RESPONSIBILITIES

4.1 Test Support Group

The TSG has the overall responsibility for the TWRS T&E Program. Members direct the development of the TWRS T&E Program from definition of test scenarios through test conduct, documentation, and termination. They select the review group to assess requirements, constraints, and architectures of TWRS, from both the system and subsystem levels, to develop potential test scenarios, and, with DOE, determine if an IV&V Program is required. They further appoint a Test Director for each approved test scenario, and with the Test Director, appoint the members of the TWG for approved test scenarios. The TSG is the review and approving authority for test plans, test procedures, and final reports prepared and submitted by the TWG, and act as the coordination conduit for passing information and getting approvals from the TWRS Program Office and other functional managers, as required. Within the TSG, there will be a chairperson and secretary to schedule the meetings (held approximately every six weeks). The TSG will develop detailed test schedules, integrate the individual test schedules into the TWRS master schedule, develop and maintain detailed cost estimates for each approved test scenario, identify and coordinate all external test interfaces, and make technical recommendations to the TWRS Program Office on the most efficient test approach. All TWRS test-related issues and activities are the responsibility of the TSG.

4.1.1 Chairperson - Test Support Group

The chairperson reports to the Director of Engineering and is responsible for scheduling and conducting TSG meetings, ensuring the membership is cognizant of the TWRS T&E Program plans and direction, and briefing the TWRS Program Office and other functional managers on TWRS T&E activities and status. He further assigns action items, reviews and approves action item development strategies and closure actions, develops TWRS test schedule changes, and prepares TWRS test cost estimates.

4.1.2 Secretary - Test Support Group

The secretary of the group records, coordinates, and distributes meeting minutes, distributes meeting notices, secures additional technical expertise as requested by the chairperson, tracks action items, distributes material submitted to the TSG for review and approval, and acts as the chairperson in his absence.

4.1.3 Members - Test Support Group

TSG members are selected by the TWRS Director of Engineering and technical and functional managers, and have the responsibility of providing technical and managerial direction for the TWRS T&E Program. They review and recommend action on the TWGs test plans, test procedures, and final reports, recommend test activities for consideration by the TWGs, and respond to action items as assigned by the chairperson.

4.2 Test Director

A Test Director, appointed by the chairperson of the TSG for each approved test scenario, has the overall responsibility for all activities required for the successful completion of the test scenario. He is responsible for the preparation and delivery of the test plan, test procedures, and the final report, including the test log, anomaly reports, and the test procedure used in the Run-for-Record (see Section 5.4.4). The Test Director conducts the test planning analysis, test and data analysis, and briefs the TSG at regular intervals, on test planning status (see Attachment D for briefing outline), test conduct, or test documentation.

4.3 Test Working Group

TWG members are appointed by the TSG, and become the test team for an approved test scenario. They are directed by the Test Director, and prepare the test plan, test procedures, and the final report. They conduct test planning analysis, collect and analyze test data, run test procedures during the test conduct, annotate the test log, initial test procedures during the Run-for-Record test, develop the detailed test schedule, and prepare and update cost estimates. The TWG identifies and procures test support equipment (TSE), develop the success criteria for each requirement, and operate equipment during the test conduct. From the start of test conduct through the delivery of final test report and the final briefing to the TSG, members of the TWG have the primary task of supporting the test activities and the functions of the TWG.

4.4 Quality Assurance Support to the TWG

Quality Assurance (QA) personnel will be required to support the TWG during the Run-for-Record testing, to provide an independent verification that each test step was performed as defined in the test procedures. These personnel will provide a QA stamp/initials for each test procedure step.

5.0 PROCEDURE

5.1 Procedure Overview

The T&E Program is implemented in five time-phased stages. In the first stage, Advanced Planning, potential test scenarios are identified and analyzed. These scenarios are presented to the TWRS Director of Engineering for approval. In stage two, Conceptual, Test Directors and TWGs are appointed for each approved test scenario, and detailed test planning is completed. The resulting test plan is reviewed and approved by the TSG. The third stage, Execution, begins with the Test Readiness Review for each approved test scenario, and includes conducting the tests. Stage four, Reporting, consists of Final Test Report completion, and includes analysis of data collected in stage three. The Final Test Report is presented to and approved by the TSG. The final stage, Termination, completes the duties and responsibilities of the Test Director and the TWG for their test scenario.

5.1.1 Test & Evaluation

T&E is the gathering of data under specified conditions, to determine the worth, quality of performance, and degree of effectiveness of the TWRS System (or system elements). The primary goal of testing is to ensure the system architecture is capable of performing its mission within its operational environment. Evaluation is an iterative process that begins during the T&E Conceptual stage and extends through the Execution and Reporting stages.

The T&E Process Flow Diagram shown in Attachment B is a sequential representation of the significant test activities occurring during an approved test scenario. Box numbers refer to T&E Procedure paragraph numbers.

5.1.2 Verification & Validation

Verification is the process of ensuring established requirements are being met by the TWRS System (or system elements). Validation establishes the credibility of the test process. Validation is extremely important during model testing and simulations where the generated data must establish the credibility of the method used for verification of the model selected to represent the operational environment.

5.1.3 Development Test and Evaluation

Development test and evaluation (DT&E) is used to verify TWRS requirements and processes during system developmental stages, prior to operational milestones. It emphasizes testing at the subsystem level to verify innovative technologies, design solutions, and intricate process flows. DT&E supports early technical baseline development, requirements verification, technology verification, risk mitigation, and verification of technical performance measurement (TPM) parameters. Data collected during the DT&E phase may not be representative of the operational environment and should be treated accordingly. It should be collected during this phase to measure system or subsystem availability, which is the time the system is available for testing divided by the total time. The total time is not necessarily 24 hours per day; it may be the summation of all time scheduled for the test conduct. The DT&E phase is concluded when the full system test has begun.

5.1.4 Operational Test & Evaluation

Like DT&E, the primary goal of operational test and evaluation (OT&E) is the verification of the TWRS requirements. However, OT&E is usually performed within the actual operational environment, or as close to the operational environment as practical. OT&E is conducted to determine the *integrated* system's performance within its intended operational environment, and its ability to perform its mission, satisfy technical performance requirements, and operate within specified constraints and boundary conditions. Data should be collected to assess system or subsystem availability as described in Section 5.1.3.

5.1.5 Technical Performance Measurements

TPM parameters are used to determine the level of design maturity, identify key areas for possible test scenarios, and to provide inputs for decision and risk management. These parameters are selected from requirements critical to accomplishing mission objectives, protecting the environment, ensuring public and worker safety, and are key indicators of technical progress. The TSG will analyze the TPMs to determine which parameters should be verified as part of the T&E Program, and to direct the TWGs on the appropriate TPM parameters to be used in their specific test planning analyses. The *Technical Performance Measurement Procedure* (Orsag 1996d) contains additional information on selection and use of TPM parameters.

5.2 Advanced Planning

Advanced planning begins with the selection of the test scenarios necessary to ensure a complete TWRS T&E Program. Scenarios will generally be selected based on the subjective opinion of engineers, scientists, and systems managers with specific knowledge of TWRS, its processes, and the potential subsystem architectures. Individuals selected to participate in test scenario selection may be TSG members asked by the group to review trade studies, processes, and architectures, or they may be selected from the non-TSG technical community by the TSG to fill a specific need. The TSG will select review teams to identify potential test scenarios as additional architectures become available for review and analysis until the entire TWRS architecture has been reviewed and all potential test scenarios identified.

5.2.1 Test Scenario Selection

The test scenario selection process provides a technical basis for identifying potential test scenarios that would be conducted throughout the conceptual, preliminary design, detailed design, and construction life-cycle phases of TWRS. The process provides a cost effective T&E Program tailored to TWRS needs, that verifies technical requirements prior to full-scale operation, and reduces risks to accomplishing TWRS Program objectives. Results of the subgroup review will be provided to the TSG, following the briefing outline in Attachment D. In addition, the briefing should include a listing of review group members and their areas of expertise.

Test scenarios are selected based on the following parameters:

1. High-Risk Areas
2. Single-Point Failure Node
3. Requirements Verification
4. Architectures and/or Processes.

These parameters are not in rank order, and none is more important or relevant than any other.

5.2.1.1 High-Risk Areas. Test program implementation requires the identification of high-risk areas within the system, that require verification prior to proceeding with the design solution and/or process development. These high-risk areas are identified, by use of the *Risk Management Procedure* (Orsag 1996c). High-risk areas are characterized by a high level of difficulty/complexity in verifying requirements, the presence of innovative or complicated design solutions and/or processes, and/or by the presence of single-point failure nodes (see Section 5.2.1.2). Members of the TSG, working with the Risk Management Group, will evaluate the system architecture to select those risk areas matching these selection criteria. They will use the results of *Alternative Generation and Analysis Procedure* and *Decision Management Procedure* (Orsag 1996a, 1996b) as a source of data for this review and analysis.

5.2.1.2 Single-Point Failure Nodes. A single-point failure node results when a single component failure at the node will cause the entire system to discontinue operations. Careful analysis of the Concept of Operations and the system architecture will provide insight into these nodes. Once identified, a potential test scenario can be formulated and identified to the TSG for further processing.

5.2.1.3 Requirements Verification. Requirements verification is based on the assumption that all requirements have been validated by the process described in the *Functions and Requirements (F&R) Procedure* (Orsag 1996d). Success of an end item may be at risk when its requirements are complicated, technically challenging, or push the state-of-the-art, either by the nature of the requirement or by the resulting system architecture. Such requirements offer the potential for identifying and developing test scenarios to verify the ability of the end item to meet these requirements. As stated in the *Functions and Requirements Analysis and Allocation Procedure* (Orsag 1996d), all requirements must be verifiable, or they should be dropped from consideration.

5.2.1.4 Architectures and/or Processes. System architectures providing state-of-the-art solutions may have little or no supporting test information. While these innovative solutions may be required to meet system requirements, or may have cost and schedule advantages, they should be carefully analyzed as potential test scenarios. Absence of a test history is not sufficient justification for rejecting a design solution, completion of a test scenario to verify the end item may be sufficient to justify design solution acceptance.

Complex processes required to maintain system throughput are also potential test scenarios. These processes may generate single-point failure nodes, require innovative design solutions, or prove difficult for verifying the allocated requirements, which are valid reasons for testing the process prior to certifying the architecture operationally ready.

The TSG, identifies potential test scenarios to verify the selected subsystems prior to full-scale operations. Other verification methods (see Section 5.2.2) should also be considered by reviewers.

5.2.2 Other Verification Methods

As the multi-disciplined aspects of the TWRS are being reviewed for potential test scenarios, other evaluation methods should be considered for those areas that require validation without the expense of a high profile test scenario. These methods include:

1. Analysis
2. Demonstration
3. Inspection
4. Simulation.

5.2.2.1 Analysis. There are two types of analyses performed in a comprehensive T&E Program: (1) analysis of the data collected as a result of the testing verification, and (2) analysis performed independently of other verification methods. This paragraph addresses the latter. Analysis is a series of steps in assessing performance, requirements, or deficiencies. It is the process of accumulating results and conclusions to provide proof that a requirement has been met. Analysis shall be based on compilation and interpretation of information resulting from inspections, trade studies, demonstrations, and/or other analyses. An example of the use of this method might be the verification of a mass flow rate of the final design for a segment of the systems architecture.

5.2.2.2 Demonstration. This is the verification of a requirement by operating the unit under test, in a manner and environment consistent with its operational use. No special test equipment or instrumentation is used for a demonstration. An example of this verification method is the operation of commercial off-the-shelf equipment that will become part of the final TWRS architecture.

5.2.2.3 Inspection. Inspection is an investigative process to confirm the satisfaction of a requirement, without the use of special laboratory appliances, devices, supplies, or services. Inspection is usually nondestructive and may include visual, auditory, olfactory, and tactile investigation. Simple physical manipulation, measurement, and gauging also may be included. An example would be the receiving inspection of components procured as part of a TWRS subsystem.

5.2.2.4 Simulation. Simulation is the determination of system, subsystem, or process performance by observing the functioning of another analogous system or process. An example would be a computer simulation (using uniquely designed software) of an industrial process.

As review groups complete verification tasks, the review group leader briefs findings and recommendations to the TSG (see Attachment D for a briefing outline). The TSG may review and accept the information without modification, accept it with modification, or request the review group continue the analysis process, developing additional data as required by the TSG. When the TSG is satisfied, a recommendation is developed and carried by the chairperson to the TWRS Director of Engineering for management approval. A detailed description of this process is provided in the TWRS T&E Plan.

5.3 Conceptual

5.3.1 Test Director

The conceptual stage is the initiation of test planning required for each approved test scenario or group of scenarios. A Test Director is selected by the TSG from the TSG or from the technical/management community, for each approved test scenario. The Test Director is responsible for all activities beginning with test planning and progressing through test conduct, reporting, and documentation. Selection as Test Director confers membership into the TSG, for those not already in the group. It is important that all Test Directors attend the TSG meetings to understand lessons learned by other Test Directors, become familiar with unique test support equipment identified in other test planning efforts, understand test related procurement strategies, identify interfaces (both functional and physical) with other tests, as well as other functions areas and activities, and to resolve resource and schedule conflicts.

5.3.2 Test Working Groups

A TWG, chaired by the Test Director, is formed for each approved test scenario. The TWG may be assigned a single test scenario or multiple, similar scenarios grouped together, depending on the degree of difficulty, time required to plan and execute the test, and/or degree of importance to the final architecture selection. TWG membership will be selected by the TSG and the Test Director from the active membership of the TSG and the TWRS technical/management communities. TWG membership does not automatically confer membership in the TSG; however, the TSG may request selected individuals from TWGs to attend TSG meetings and participate in its activities.

5.3.3 Test Planning

Planning must be pursued in a deliberate, comprehensive, and structured manner. Thorough planning helps the planner develop issues that can be measured and evaluated, so system operational effectiveness can be assessed by TWRS management.

Planning includes:

- Program/system definition
- Identification of:
  - System requirements
  - Measures of Effectiveness (MOE)
  - Critical issues
- Determination of organizational considerations, including:
  - Test resources
  - Manpower requirements
  - Program costs
  - Schedules and milestones
  - Test philosophy/approach
  - Mechanics of test plan development.

5.3.3.1 Test Scope. TWG members begin test planning by defining the scope of the test(s) to be conducted. The test scope can be narrowly defined to verify a single requirement, as in the case of a specific bench test, or it can be broad as in the case of a full-scale system test that verifies all requirements. Members of the TWG need to complete this step in the planning process to define the boundaries of the planned test and facilitate further test development.

5.3.3.2 Test Requirements. Once the test scope has been defined, the TWG will identify all requirements, processes, and architectures to be tested. This is accomplished by reviewing the *Functions and Requirement Procedure* (Orsag 1996d), design documents, as-built drawings (if any), Concept of Operations, and the latest changes to the local, state, and Federal regulations, to identify all functional requirements, proof-of-concept requirements, design requirements, and system constraints. The TWRS Concept of Operations should be carefully examined to identify functional areas that may become part of the test plan. A functional activity, once identified for testing, will be analyzed in the same fashion as a functional requirement.

5.3.3.3 Test Planning Analysis. Test planning analysis follows the requirements identification. During test planning analysis, TWG members examine each requirement and develop the test environment and success criteria for verifying the requirement. Requirements may be verified using a single success criterion or may require the development of multiple success criteria for full verification. Some requirements may require multiple variations of the operational environment for complete verification, while other requirements may need both multiple success criteria and multiple operational environments for complete verification.

Each requirement should be entered onto a Test Planning Analysis Form (see Attachment C), assigned a number and title, have the related success criteria identified, and include reference(s) to provide traceability to the requirement's origin. Although each form can accommodate multiple requirements, limiting one requirement per form makes planning activities flow more easily. These forms provide the basis for the written test plan that must be approved by the TSG.

5.3.3.4 Measures of Effectiveness. A MOE is a quantative or qualitative measure of system or subsystem performance or characteristics, which indicates the degree to which it performs a task or meets an objective under specified conditions. They should be based on the system's operational requirements, without regard to anticipated test constraints. This enables the TWG to define all test outcomes that must be measured to completely evaluate the system. A specific test event is identified for each MOE to define the data to be gathered.

The primary function of the MOE is to generate the test outcome and indicate how the system is to be evaluated. For quantative MOEs, a data element is defined that incorporates information to be obtained during each attempt at measuring the desired characteristic. For subjective MOEs, it may be helpful to define a number of data elements that the TWG should consider in judging adequacy of system operations.

5.3.3.5 Success Criteria. A MOE will be developed to measure system or subsystem performance or characteristics, as each requirement, group of requirements, process, and/or architecture is identified for testing. Success criteria or expected results are then defined for each requirement and for each MOE, realizing that several requirements may be satisfied by a single expected result. Conversely, one requirement may require several expected results for full assessment. The expected result is used to determine the success of the test.

5.3.3.6 Test Support Equipment. As the TWG members are developing success criteria and test environments, special attention should be given to the identification of TSE required for test conduct. TSE is identified as any device required to measure, display, log, and/or record test parameters needed to verify requirements, and includes common equipment and facilities (e.g., voltmeters, 110v 60 hz power, concrete pads, etc), special equipment and facilities (e.g., spectrum analyzers, dual trace scopes, high-speed cameras, 220v 400 hz low-ripple voltage, etc.), and unique equipment (e.g., special software developed to capture high data rate parameters, etc.). All TSE required for each requirement verification should be listed on the Test Planning Analysis Form (see Attachment C).

5.3.3.7 Resources. Human resources must be considered during test planning. Special data gathering skills or training not found in the TWG may be required. The Test Director must make such arrangements, through the TSG if necessary, for all required human resource(s) to participate in the test planning analysis, development of the test procedures, test conduct, data analysis, and test documentation phases.

5.3.3.8 Human - Machine Interface. Throughout the test planning analysis, TWG members must be aware of the Human-Machine Interfaces (HMI) of the system architecture. The HMI aspects of the operational system may become important test conditions and relegated to a position equal to that of a functional requirement. The design documents and the Concept of Operations will provide considerable guidance in this area.

5.3.3.9 Safety. Safety is the responsibility of all personnel and needs to be analyzed not only for the test conduct, but also for the final operational configuration. Certain operational requirements (e.g., temperature, mechanical systems, nuclear and chemical hazards, mass flow systems, etc.) pose severe hazards and should be addressed during the test planning analysis. All aspects of the nuclear and chemical hazards should be addressed, including (1) types and severity of the radiation and chemical hazards, (2) monitoring equipment required, (3) special clothing or breathing apparatus, (4) emergency equipment, and (5) off-normal conditions.

5.3.3.10 Test Schedule and Cost Estimate. The test schedule and related cost estimate should be developed as test planning analysis progresses. Special consideration is needed for development and procurement cycles for unique and special TSE, timely acquisition of common TSE, special human resource requirements, design and construction progress of the subsystem to be tested, development of the detailed test procedures, external interfaces with other subsystems and functions, and safety and compliance issues to be resolved prior to the start of test conduct. Individual test schedules should be integrated with the overall test schedule, as maintained by the TSG, and detailed cost estimates submitted to the TSG for review and approval.

5.3.3.11 Test Plan. The test plan is the overall management tool for the test scenario and is generated during test planning analysis activities. It defines the methodology used in test planning analysis, develops the test schedule, refines the cost estimate, identifies the required TSE, selects the TSE acquisition strategy (if needed), identifies the TSE resource requirements, determines verification methods, (analysis, demonstration, inspection and simulation), details the activities necessary to complete these functions, defines the test scope, validates the test requirements, and defines the success criteria. The Test Plan should follow WHC-IP-1026, *Engineering Practices Guidelines*, Appendix K, Figure 1, "Test Plan Content Guidelines" (WHC 1995) (MOEs should be added to this guideline). The plan will be approved by the TSG and become an appendix to the final report. The Test Director will summarize the plan in a briefing to the TSG to ensure TWRS Program objectives are met. The briefing generally should follow the outline presented in Attachment E. The document shall be designated as a supporting document (e.g., WHC-SD-TEP-XX) per WHC-CM-6-1. A TWRS document listing shall be generated and maintained to show this document relative to its predecessor, supporting analyses, and successor documents.

5.3.3.12 Test Procedures. Detailed test procedure development begins after test plan development is completed. These procedures define the installation and checkout of all the TSE, type of data to be developed and recorded, sequence test steps are to follow, detailed operation of the unit under test, stimulus and expected response, detailed safety precautions to be observed by the test team, a detailed description of any differences between the test bed and the expected operational unit, the normal operating parameters, emergency operating parameters, emergency response if required, how, when, and where to take measurements, when special resources are required, how many TWG members are required for each procedure, and unacceptable environmental conditions that would ultimately delay the test conduct (if any). Test procedures provide the roadmap for the test team to gather data for requirements verification, and should follow WHC-IP-1026, *Engineering Practice Guidelines*, Appendix K, Figure 3, "Test Procedure Content Guidelines" (WHC 19xx). TWG members develop procedures from test planning analysis, conduct the test, collect data, analyze results, and write the final report. The procedures are approved by the TSG to facilitate test discipline.

5.3.3.13 Long-Lead Procurement. Procurement of long-lead procurement items, as identified during test planning analysis for the TSE, must be initiated in sufficient time to support the test scenario schedule. Special attention should be given to the preparation and funding of purchase orders, subcontracts, and requisitions necessary to have a complete set of test equipment prior to the start of test conduct.

5.4 Execution

Implementation of the test plan can only begin when all planning and preparation is completed, all materials and equipment have been acquired, test team members (e.g., the TWG members) have been briefed, all the necessary approvals and coordinations have been completed, and the final briefing has been given to the TSG in the test readiness review.

5.4.1 Test Readiness Review

Each test scenario will have a test readiness review approximately two weeks prior to the initiation of test conduct. The review will be scheduled by the TSG chairperson. At the review, the Test Director will brief the TSG on all test planning activities from the selection of the Test Director up to and including the day of the briefing. The purpose for the briefing is to advise the TSG that all planning activities have been satisfactorily completed and that the test has a high probability of success. At the completion of the test readiness review, the TSG will authorize the test conduct to begin and inform the appropriate management levels. (See Attachment F for a Test Readiness Review Briefing Outline.)

5.4.2 Test Log

The Test Director should establish a Test Log, which is a chronological record of important events that occur throughout the test conduct. Logging should begin on the first day of the test site. Names of test team members, daily start and stop times for testing, important visitors onsite, all incidents and/or accidents, weather (if important to the test data), unscheduled repairs, and unplanned interruptions should be entered into the log. The test log should be a bound notebook with numbered pages. Entries should be dated and initialed, mistakes should be lined through, not obliterated, and all entries should be in ink. The test log will become an appendix to the final test report.

5.4.3 Dry Run

Most test scenarios will include a dry run through the test procedures prior to the Run-for-Record, which is the official, recorded test conduct. Dry runs are conducted to familiarize test members with test conditions from which critical data will be gathered, test procedures, and the operational checkout of special and unique TSE. Occasionally, multiple dry runs will be required to complete pretest preparations. Redline changes are made to the test procedures during dry runs, and procedures may be updated (e.g., incorporate the redline changes) prior to performing the Run-for-Record. While a few red lines may not justify a complete rewrite, extensive redlines may require a complete rewrite of the procedures prior to the Run-for-Record tests. Test schedules should reflect procedure update activities.

5.4.4 Run-for-Record

The Run-for-Record is the official test conduct and is performed with the expectation that the unit under test will meet all requirements. As each test step is completed, both the TWG member performing the test and participating QA representatives will annotate the test procedure. When all the steps in the procedure have been completed, the procedure becomes an appendix to the final test report. Once all Run-for-Record procedures have been completed, test conduct is considered complete, ending the execution stage of T&E.

5.4.5 Anomaly Reporting

All test anomalies should be documented by test team members as they occur, with special attention given to describing the anomaly, prevailing operational conditions, TSE in use, and the procedure step(s) being conducted when the anomaly was observed. The Test Director should review all anomalies at the end of each test shift to verify continuation of the test is justified, test conduct may otherwise be interrupted until the anomalous condition is eliminated. A resolution plan for each anomaly must be defined and executed by the TWG. Anomalies not resolved by the completion of the Run-for-Record must be immediately identified to the TSG for further action. All anomaly reports will become an appendix to the final test report.

5.4.6 Data Collection

Complete and accurate collection and preservation of data is critical to T&E. As testing progresses, generated data must be recorded, either automatically using data recorders, or manually by test team members, and preserved for analysis during the next stage. In most cases, this data will verify that success criteria established for the requirement was achieved, which is the primary objective of the test. Failure to follow the test procedures or a breach of testing discipline could negate this portion of the test, and incur additional costs for rerunning the test, as well as impacting schedules. Test discipline is critical to successful testing.

5.5 Reporting

The reporting stage includes post-test briefings, the final documentation, and analysis of data. While all of these activities are related to some degree, the quick-look briefing must be prepared and presented before the other activities are complete.

5.5.1 Data Analysis

While data analysis can begin as soon as data is collected during the execution stage, the majority of the data analysis effort is conducted during the reporting stage. It should be noted, however, that the first part of the analysis is a quick review to support the preparation of the quick-look briefing. Several TWG members should be assigned the task of reviewing data to ensure the appropriate results were obtained. Occasionally, it may be necessary to request support from technical experts who can usually be obtained through the TSG. Data analysts should make a complete set of notes to accompany each calculation, keeping in mind that this analysis may have to be recreated in the future by a staff member not associated with the TWG. Therefore, all notes should be complete and legible. The data analysis will help support the findings and recommendations of the TWG.

5.5.2 Quick-Look Briefing

As data analysis continues, remaining TWG members will concentrate on creating the quick-look briefing for the TSG (see Attachment G for a Quick-Look Briefing Outline). This briefing is usually scheduled within five working days of completion of the test conduct, and provides an overview of the test setup, test conduct operation, use of the TSE, unusual occurrences or incidents, data collection and review, and a preliminary estimate as to success or failure of the unit under test to meet its operational requirements. The Test Director will present the quick-look to the TSG on the requested date.

5.5.3 Final Test Report/Briefing

The remaining activities of this stage are the preparation and delivery of the final test report and the final briefing to the TSG. Again, the Test Director has the primary responsibility for both activities, with the support of the entire TWG membership.

The final report should be a detailed account of all the activities of the TWG, and should generally follow WHC-IP-1026, *Engineering Practice Guidelines*, Appendix K, Figure 4, "Test Report Content Guideline" (WHC 1995). It should include the concurrence signature of all the TWG members, the Test Director, and be approved by the TSG. Included in the final report are: executive summary, test scope, the complete details of the test planning analysis effort, the long-lead procurement activities, the TSE analysis and selections, the writing and approval of the test procedures, the test conduct, test anomalies and anomaly closure plans, safety infractions or violations, lesson learned, conclusions, and recommendations. Attached appendices should include the Run-for-Record test procedures, data collected during the test conduct, the test log, and a copy of all (open and closed) anomaly reports. The final report will be distributed to the members of the TSG, the TWRS Director of Engineering, the Technical Data Center, and RL (3 copies). Additionally, the final report should address the MOEs and discuss how each one was obtained or exceeded expectations. The document shall be designated a supporting document (e.g., WHC-SD-TER-XX) per WHC-CM-6-1. A TWRS document listing shall be generated and maintained to show this document relative to its predecessor, supporting analyses, and successor documents.

The preparation and presentation of the final briefing by the Test Director to the TSG is the last activity of this stage. The briefing should be a summary of the Final Test Report and generally follow the outline in Attachment H.

5.6 Termination

With the acceptance of the final report by the TSG, the TWG and Test Director duties and responsibilities have been fulfilled. TWG members can be returned to their parent organizations for other assignments. The TSG should not release any TWG members until the final report is approved and the final briefing completed.

5.7 Outputs

The following is a listing of the outputs resulting from this procedure.

- Test Scenario Selection Briefing (see Section 5.2.1)
- Test Plan (see Section 5.3.3.11)
- Test Plan Briefing (see Section 5.3.3.11)
- Test Procedures (see Section 5.3.3.12)
- Test Readiness Review Briefing (see Section 5.4.1)
- Test Log (see Section 5.4.2)
- Anomaly Reporting (see Section 5.4.5)
- Quick-Look Briefing (see Section 5.5.2)
- Final Test Report/Briefing (see Section 5.5.3).

6.0 REFERENCES

Orsag, F., 1995a, *TWRS Systems Engineering Manual*, "Alternatives Generation and Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland Washington.

Orsag, F., 1995b, *TWRS Systems Engineering Manual*, "Decision Management," WHC-IP-1231, Westinghouse Hanford Company, Richland Washington.

Orsag, F., 1995c, *TWRS Systems Engineering Manual*, "Risk Management," WHC-IP-1231, Westinghouse Hanford Company, Richland Washington.

Orsag, F., 1995d, *TWRS Systems Engineering Manual*, "Technical Performance Measurement," WHC-IP-1231, Westinghouse Hanford Company, Richland Washington.

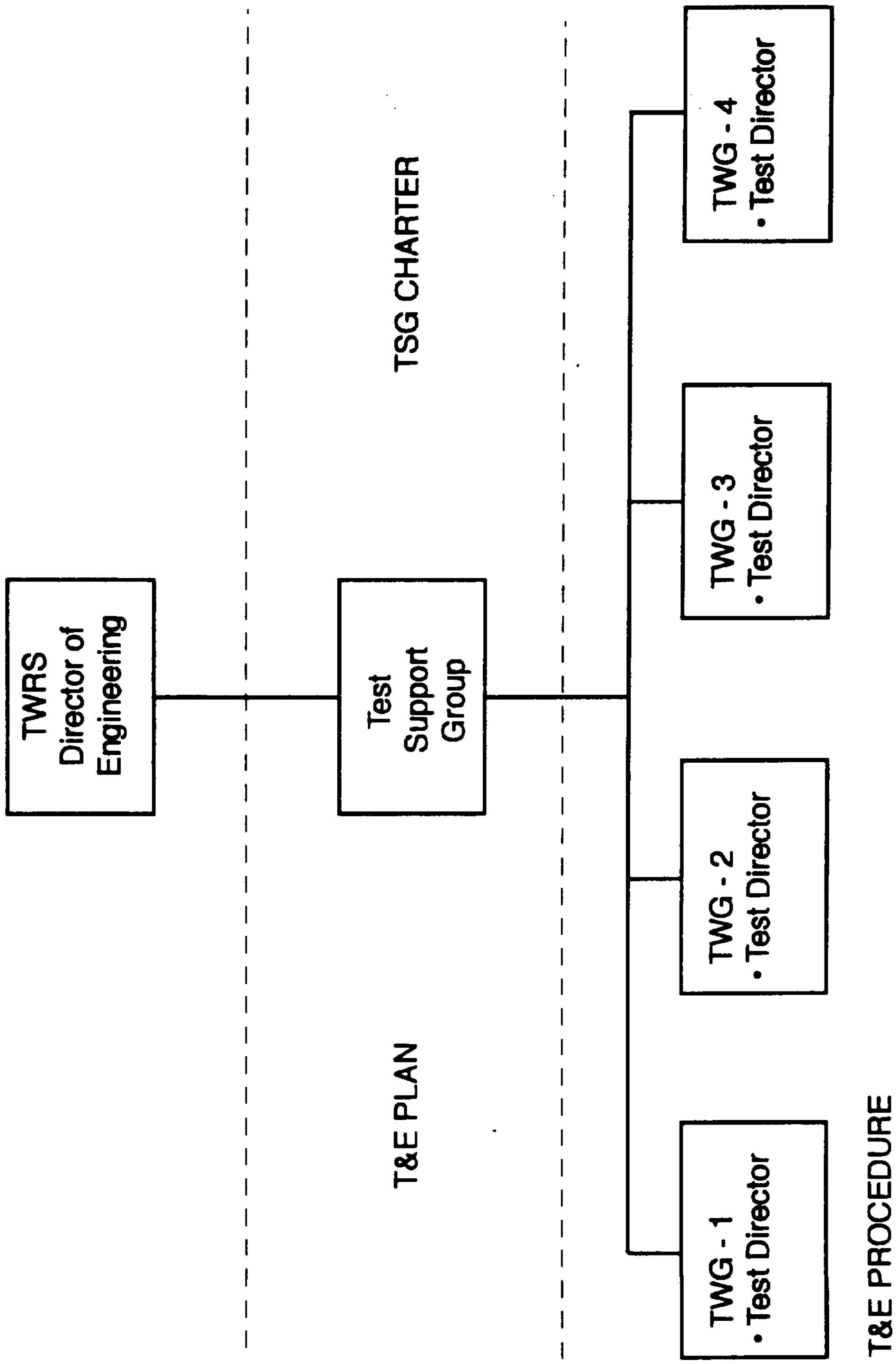
WHC, 1995, *Engineering Practice Guidelines*, Appendix K, "Test Plans, Specifications, Procedures, and Reports," Rev. 1, WHC-IP-1026, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A Test and Evaluation Structure
Attachment B Test and Evaluation Process Flow Diagram
Attachment C Test Planning Analysis Form
Attachment D Status Briefing Outline
Attachment E Test Plan Briefing
Attachment F Test Readiness Review Briefing Outline
Attachment G Quick-Look Briefing Outline
Attachment H Final Test Report Briefing Outline

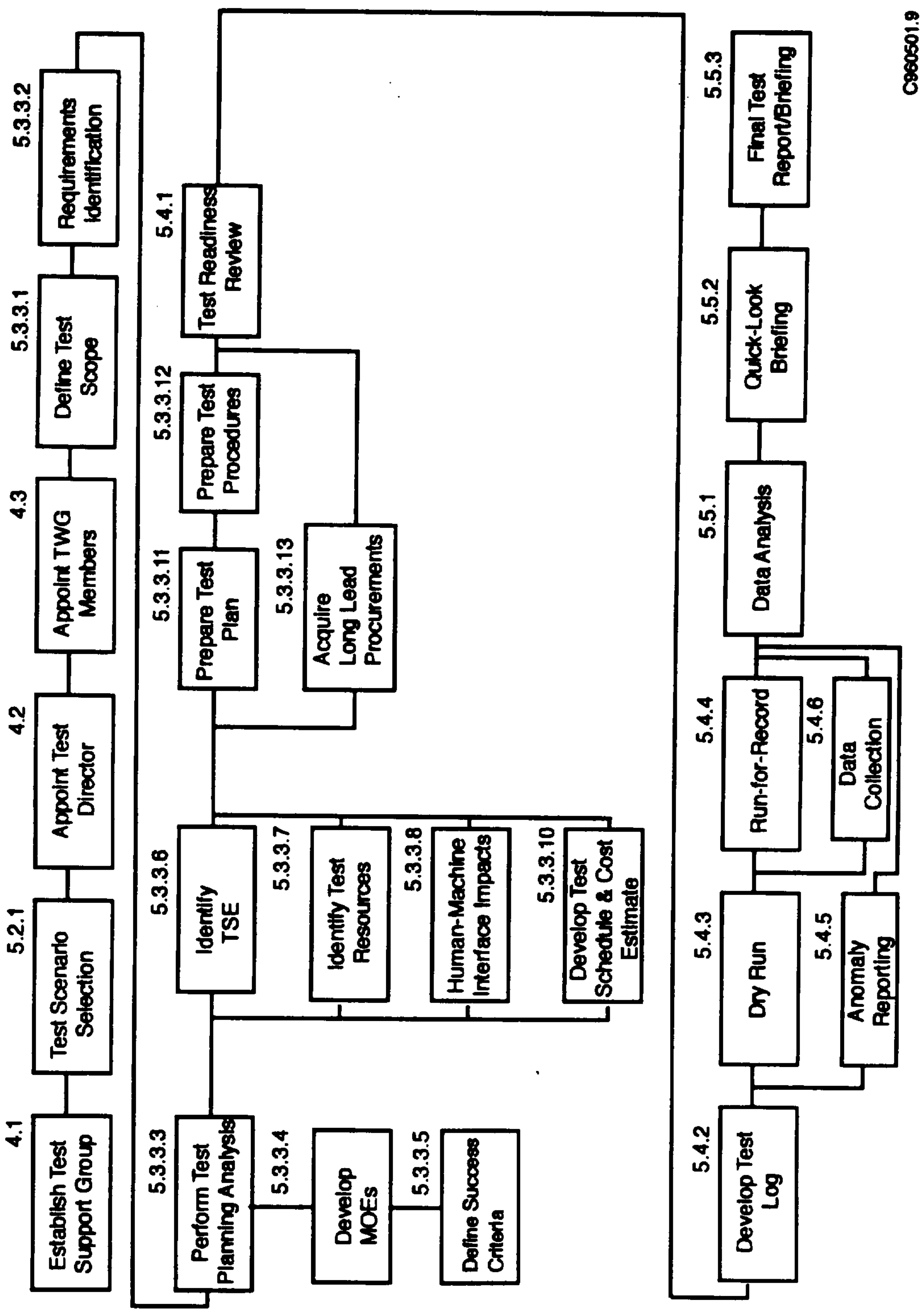
Attachment A

Test and Evaluation Structure



Attachment B

Test and Evaluation Process Flow Diagram



Attachment C

Test Planning Analysis Form

NAME & NUMBER	FUNCTION DESCRIPTION/ REQUIREMENTS	SUCCESS CRITERIA	DATA REFERENCE

Attachment D

Status Briefing Outline

I. Introduction

II. Purpose of the Briefing
Because this is a status briefing state the test scenario for which the status applies.

III. Objective of the Briefing
Describe the goals the briefing is trying to achieve.

IV. Assumption and Ground rules
During the test planning process assumptions and groundrules may have been developed for the planning, procedure development and/or the test conduct. List these assumptions and groundrules and explain the impact to the test program.

V. Technical Approach
Describe the technical approach being used for the test planning and test conduct. Include all consultants that are required and the test activities impacted.

VI. Test Schedule Compliance
Update and brief the detailed test schedule. Note all deviations from the schedule baseline and provide an explanation for each.

VII. Test Cost Estimate Compliance
Update and brief the detailed cost estimate. Note all deviations from the cost baseline and provide an explanation for each.

VIII. Open Issues
Identify all open issues associated with the test program and provide a resolution plan for each open item.

IX. Findings and Recommendations
Present the latest findings and recommendations of the TWG, if any.

X. Conclusion
Present all conclusions derived by the TWG, if any.

Attachment E

Test Plan Briefing

I. Introduction
Set the stage for a briefing on the test plan which is the culmination of the test planning analysis process.

II. Purpose of Briefing
The purpose of the briefing is to report on the completed test planning analysis activities.

III. Objective of Briefing
Provide the detailed activities of the test planning analysis process and the results of that process.

IV. Assumptions and Ground Rules
During the test planning process assumptions and groundrules may have been developed for the planning, procedure development and/or the test conduct. List these assumptions and groundrules and explain the impact to the test program.

V. Test Scope
Provide the scope of the test scenario that just completed the test planning analysis process. It should agree with the assumption in Section IV.

VI. Test Requirements Identification
Identify all test requirements, processes and architectures that are part of the test scenario and how they were derived.

VII. Test Planning Analysis
Explain how the test planning analysis process was developed, conducted and concluded.

VIII. Measures of Effectiveness (MOE)
Define the specific MOEs developed and the success criteria needed to evaluate each one.

IX. Test Support Equipment
Identify all the test support equipment that will be required to support the test procedure development, the test conduct and the documentation phase of this test scenario. Provide an acquisition plan for insuring this equipment availability when required. Identify all interfaces with other test scenarios and functional areas that utilize this equipment.

X. Test Resources
Identify all resources required to support the test procedure development, the test conduct and the final analysis and documentation preparation. Include unique skills and educational requirements. Include all unique safety and monitoring equipment. Provide an acquisition plan for ensuring the resource availability when required. Identify all interfaces with other test scenarios and functional areas that utilize these resources.

XI. Human - Machine Interface
Identify the HMI aspects of the system design that will be unique test requirements and explain the analysis process for these selections.

XII. Long Lead Procurements
Identify all items requiring early procurement to support the test development process. Identify the source of this information.

Attachment E (cont'd)

XIII. Test Schedule
Update and brief the detailed test schedule. Note all deviations from the schedule baseline and provide an explanation for each.

XIV. Safety
Describe all nuclear and chemical hazards associated with this test. Describe all safety and monitoring equipment. Describe all foreseeable scenarios that could cause safety problems. Describe recovery and mitigations actions for the possible safety problems. Describe all safety problems with a high consequence risk.

XV. Test Cost Estimate
Update and brief the detailed cost estimate. Note all deviations from the cost baseline and provide an explanation for each.

XVI. Open Issues
Identify all open issues associated with the test program and provide a resolution plan for each open items.

XVII. Conclusion
Present the conclusions developed by the TWG.

Attachment F

Test Readiness Review Briefing Outline

I. Introduction
Explain that the TWG is ready to test this particular scenario.

II. Purpose of the Briefing
To review all the test preparation leading up to this briefing.

III. Objective of the Briefing
This briefing is limited to this particular test scenario.

IV. Assumptions and Ground rules
During the test planning process assumptions and groundrules may have been developed for the planning, procedure development and/or the test conduct. List these assumptions and groundrules and explain the impact to the test program.

V. Test Plan Summary
Summarize the test plan and highlight the risk areas and critical technical areas of the test conduct.

VI. Test Procedures
Define the test procedure development process, the review and acceptance process and breakdown of each procedure. Explain how the procedures will be used during the test, who will be the test operators and who will witness each step, and how the final Run-for-Record test procedure will be maintained for inclusion in the final report. Include all safety related matters. Develop the details for performing Dry-Runs and updating the procedures prior to the Run-for-Record.

VII. Test Schedule
Update and brief the detailed cost estimate. Note all deviations from the cost baseline and provide an explanation for each.

VIII. Test Cost Estimate
Identify all open issues associated with the test program and provide a resolution plan for each open item.

IX. Open Issues
Present the latest findings and recommendations of the TWG, if any.

X. Conclusion
Are you ready to test?

Attachment G

Quick-Look Briefing Outline

I. Introduction
Be brief, this is a quick look at the test results.

II. Purpose of the Briefing
Provide current assessment of the test data.

III. Objective of the Briefing
Inform the community on the prognosis of the test conduct.

IV. Assumptions and Ground rules
During the test planning process assumptions and groundrules may have been developed for the planning, procedure development and/or the test conduct. List these assumptions and groundrules and explain the impact to the test program.

V. Test Conduct Review
Provide an overview of the test conduct and highlight the risk areas and the critical aspects of the test conduct.

VI. Data Collection and Analysis
Define the data collection and analysis process.

VII. Anomalies w/Resolution Plan
Identify all anomalies, how, when, why they occurred, the test configuration at the time, and the resolution for each.

VIII. Lessons Learned
Describe the lessons learned from this test conduct and how future test conductors could be impacted.

IX. Open Issues
Identify all open issues associated with the test program and provide a resolution plan for each open item.

X. Test Schedule
Only review the test conduct portion of the test schedule and identify all deviations.

XI. Out of Tolerance Cost Items
Highlight and explain all items that exceeded their budget.

XII. Preliminary Conclusion
Provide the expected result of the test conduct.

Attachment H

Final Test Report Briefing Outline

Introduction

- Purpose for Briefing
- Executive Summary (of T&E Results and Conclusions and Recommendations)

I. Purpose & Background

1.0 T&E Purpose
1.1 Assumptions, Ground Rules, Directives
1.2 Description of System Tested
1.3 T&E Background
1.4 Test Resources:
    1.4.1 Personnel (TRWG, Test Director; Identification & Selection Process)
    1.4.2 Equipment
    1.4.3 Locations, Facilities & Dates
1.5 T&E Plan (Final version, condensed)
1.6 Test Schedule Summary
1.7 Test Costs: Budget vs Actual

II. Test Description

2.0 Test Requirements
2.1 Test Planning Analysis Results (Method of Accomplishing T&E)
2.2 Scope, Limiting Factors & Issues

III. Test Results

3.0 Summary
3.1 Requirement
    3.1.1 Method of T&E
    3.1.2 Results & Conclusions (Conclusion supported by specific results)
    3.1.3 Recommendations

(Repeat 3.1 as 3.2, 3.3, etc for multiple requirements, as necessary)

IV. Anomaly Reporting

4.0 Introduction
4.1 Summary of Anomalies
4.2 Anomaly Description (How, when and why, and test configuration)
4.3 Anomaly Resolution Plan

Attachment H (cont'd)

V. Summary/Conclusion

5.0 General Description
5.1 Findings & Recommendations
5.2 Lessons Learned
5.3 Open Issues
5.4 Conclusion

TITLE:

RISK MANAGEMENT

Approved by:

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to provide guidance and direction for performing risk management (RM) in support of the Tank Waste Remediation System (TWRS). It has been written to encourage maximum flexibility during implementation, while still providing a consistent basis for approaching RM.

The goal of the RM Program is to reduce programmatic risk to an acceptable level through the process of risk assessment, analysis, and handling and to communicate to decision makers information about the actions being taken to ensure the success of TWRS. This procedure communicates a standard approach to RM that is applicable to all TWRS projects.

The procedure is written as a set of detailed instructions to reduce ambiguity and ensure uniformity across all TWRS programs and projects. Extensive use has been made of figures and tables to assist users in the processing and management of risk-related data and information.

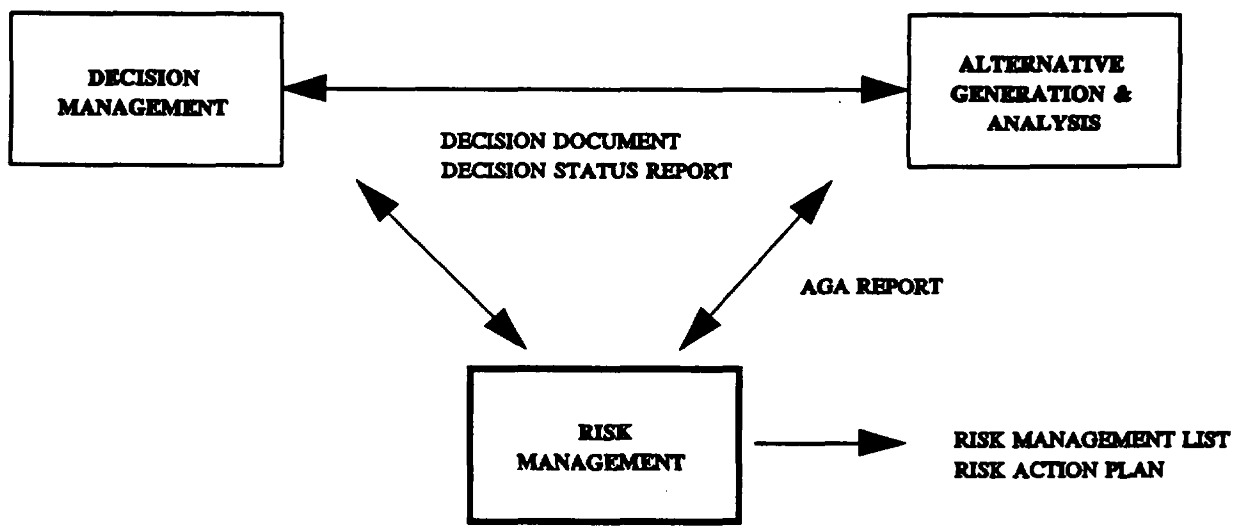
The procedure is to be used in conjunction with a number of other TWRS documents, including the *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)* (WHC 1996), *Programmatic Risk Management Plan* (WHC 1995b), the *Decision Management (DM)* (Orsag 1996b), *Alternative Generation and Analysis (AGA)* (Orsag 1996a), *Technical Performance Measurement (TPM)* (Orsag 1996f), and *Test and Evaluation (T&E)* (Orsag 1996f) Procedures.

2.0 SCOPE

This procedure applies to Westinghouse Hanford Company (WHC) management, technical staff, and support contractors assigned to the TWRS Program. Risk is defined as the combination of the probability of an unwanted event occurring and the consequences if the event does occur. RM consists of the steps taken to develop a RM Program and then to assess, analyze, and handle risk. This procedure covers programmatic risk, including cost, schedule, and technical performance. Cost risk is the risk of exceeding a planned budget. Schedule risk is the risk of not meeting planned milestones. Technical performance risk is the risk that some system characteristic will not perform as expected. Presently, Environmental Safety and Health (ES&H) risks are only included as they affect programmatic risks.

As described in the TWRS SEMP, RM and DM are systems control activities; meaning, they are two of the tools used to effectively manage risk, configuration, interfaces, decision-making, T&E, and TPM. Both interface with

AGA, one of the principal processes of systems engineering. The interactions among RM, DM, and AGA Procedures are depicted below. DM initiates the interaction by identifying the need to make a decision, normally documented in the form of a decision plan. The AGA process, performed as a trade study, evaluates the various alternatives and recommends a preferred alternative. The risks for the preferred (selected) alternative are transferred into the RM process through means of an AGA Report. The interactions among DM, AGA, and RM are continuous. As risks are managed through action plans and status updates, they should be used to indicate the need for further decisions and trade studies. In addition to the DM and AGA processes, other systems engineering processes that impact RM are TPM and T&E.



Interaction Between DM, AGA, and RM

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

This section describes the organizational responsibilities for RM.

4.1 Management

Managers at all levels are responsible for managing risks that affect their activities, and each manager is to make risk an essential management tool. Following are the RM responsibilities for TWRS managers:

- Designate a RM point-of-contact (POC) to assist the manager in the conduct of the risk program

- Review and approve risk management lists (RML) and action plans
- Prioritize risk handling actions
- Use risk as a management tool during meetings with U.S. Department of Energy (DOE), Richland Operations Office (RL)
- Make RM a tool in day-to-day decision-making.

4.2 Point-of-Contact

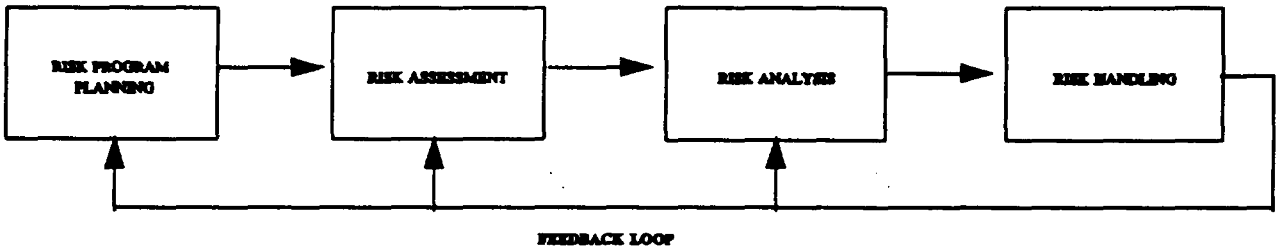
Managers are to designate a POC, who is responsible for assisting management with the implementation of the RM Program. Following are the RM responsibilities for a POC:

- Develop and maintain a RML and action plans
- Establish and maintain a risk database (currently a Microsoft Access application)
- Develop and maintain a RM plan that describes how the RM Program will be conducted.
- Prepare and distribute risk status reports
- Coordinate external risks affecting other TWRS organizations and system functions
- Represent management at RM working group meetings.

Questions pertaining to the RM procedure should be addressed to the TWRS Technical Integration organization responsible for TWRS RM.

5.0 PROCEDURE

The top-level view of the TWRS RM process is depicted below. It starts with the sequence of risk program planning and ends with risk handling, although the system is an iterative process with a feedback loop that can be re-entered anywhere along the process. Risk program planning is the front-end task, and consists of determining how risks will be assessed, analyzed, and handled. Risk assessment consists of the steps taken to identify unwanted events that may have a programmatic impact. Risk analysis consists of the steps taken to determine the likelihood of an unwanted event, the severity of its possible consequences, and whether or not the risk should be considered critical to the program or project. Risk handling consists of the steps taken to determine what actions should be taken to avoid, transfer, share, control, or assume the effects of risk, and to integrate actions with key program management documents, such as the Multi-Year Program Plan (MYPP) and the Work Breakdown Structure (WBS).

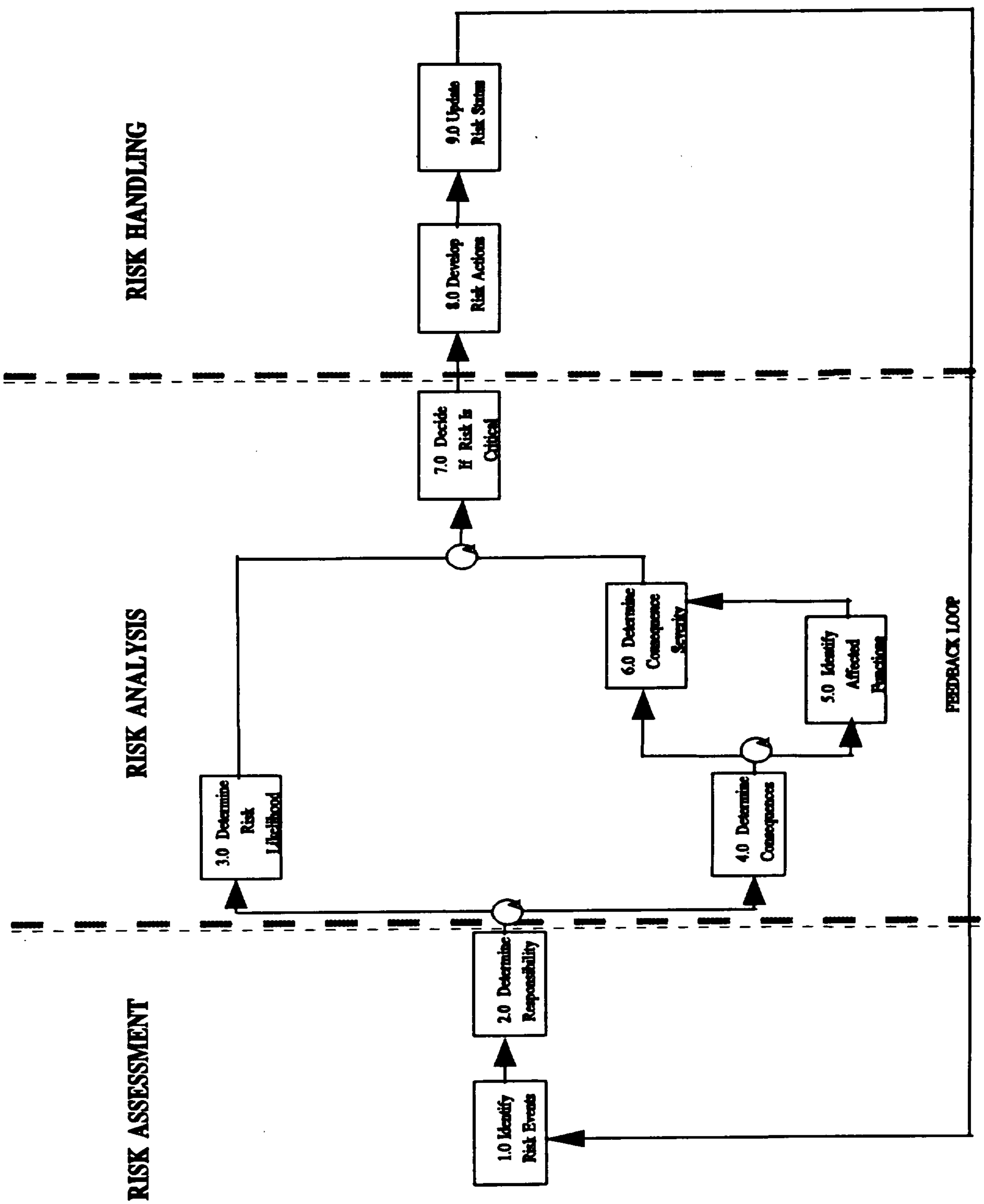


Top Level Risk Management Process

The implementation of risk assessment, analysis, and handling is depicted below as a 9-step process with Steps 1 and 2 performed during risk assessment, Steps 3 through 7 during risk analysis, and Steps 8 and 9 during risk handling. The following table contains summary descriptions of each of the 9 process steps. In the various process flow models used herein, an "A" in a circle is used to indicate that the output from one step can be used as the nput to one or more subsequent steps.

Risk Management Process Descriptions

Step	Process	Description
1.0	Identify Risk Events	From any number of sources identify what events pose a risk and generate a list of risk events.
2.0	Determine Responsibility	Identify by name the RL POC, the Responsible Manager, the Responsible Contact, and if applicable the Monitor Contact for the risk event.
3.0	Determine Risk Likelihood	Assign a rating of Low, Medium, or High based on the probability of the risk event occurring.
4.0	Determine Consequences	Prepare a list of consequences if the risk event does occur.
5.0	Identify Affected Functions	Prepare a list of system functions that are affected by the risk event and its consequences.
6.0	Determine Consequence Severity	Assign a rating of Low, Medium, or High based on how negative the effect will be if a risk event occurs.
7.0	Decide if Risk is Critical	Using the provided risk value matrix, find the qualitative rating located at the intersection between risk likelihood and consequence severity. Designate the risk as Not Critical if the risk value is less than Very High and none of the criteria apply. Designate the risk as Critical if the risk value is Very High, or if one or more of the criteria apply.
8.0	Develop Risk Actions	Prepare a list of actions that might be taken to Avoid, Transfer, Share, Control, or Assume the risk. Identify the current status of each action as Pending, Ongoing, or Complete. Prepare an action plan to ensure the completion of each action.
9.0	Update Risk Status	Periodically review the status of the risk and action plans and update all sources of information accordingly.



Risk Management Process

The steps should be performed in the sequence indicated. However, they may be tailored to fit the complexity of the project, and those that do not apply may be omitted. TWRS SEMP, Appendix A, contains a systems engineering graded approach that can be used to determine what risk products should be produced for a given level of project complexity.)

A Programmatic Risk Information Management System (PRIMS) has been developed to record and manage information. The database application has features that provide for tracking historical risk data, maintaining a RML, and recording qualitative and numerical likelihood and severity data that can be used in the analysis process. Attachment A contains a description of PRIMS and its major data tables. Attachment D contains a Glossary of the terms used in the RM Program.

5.1 Risk Program Planning

RM begins with risk program planning. Risk program planning includes developing internal procedures for how an organization will conduct risk assessment, analysis, and handling. These internal procedures are to be described in a Risk Management Plan (RMP) and distributed for compliance and coordination. A RMP should address organizational responsibilities as well as implementation procedures, products, quality control, and internal reviews and updates. Following are some of the elements that a RMP should contain:

- The purpose of the organization or project
- Organizational responsibilities
- RM team composition
- The process used to assess, analyze, and handle risks
- Products and databases (e.g., PRIMS)
- Status report formats
- Scheduled reviews and updates.

Attachment B contains an annotated outline for a suggested RMP. A RMP should be a living document and periodically reviewed for needed updates and revisions.

5.2 Risk Assessment

Risk assessment consists of the steps taken to identify all significant risk events and to assign management and technical staff responsibility, leading to risk analysis and handling. Every aspect of TWRS and its program and project elements should be examined to identify events that if they occurred could cause a programmatic disruption. The RM processes performed during risk assessment are: (1) Identify Risk Events and (2) Determine Responsibility. The objective of risk assessment is to develop a manageable set of significant risk events and to assign management and technical staff responsibility.

5.2.1 Identify Risk Events

The task of identifying risk events is a multi-step process, beginning with the identification of possible risk events and ending with a set of events that are entered into PRIMS, as shown in the process flow model below. The prime source for technical performance risk events are the trade studies performed as part of the AGA process. This model contains an inset showing how risks might enter process Step 1.3, Determine Events From Selected Architecture, through the DM and AGA interface. Details about how the interface should work may be found in the *Decision Management (DM)* and *Alternative Generation and Analysis (AGA) Procedures* (Orsag 1996b, 1996a). Other sources for technical performance risk events are the *Mission Analysis (MA)* and the *Functions and Requirements (F&R) Procedures* (Orsag 1996d, 1996c) including the issues and system functional and process flow diagrams that accompany F&R documents.

Other sources for technical performance risk events are the tracking and reporting activities performed during TPM. TPMs are system characteristics such as regulatory requirements, customer-selected constraints, or experience-related requirements. The *Technical Performance Measurement (TPM) Procedure* (Orsag 1996e) describes how technical performance measures are to be managed and used to provide input to RM and DM.

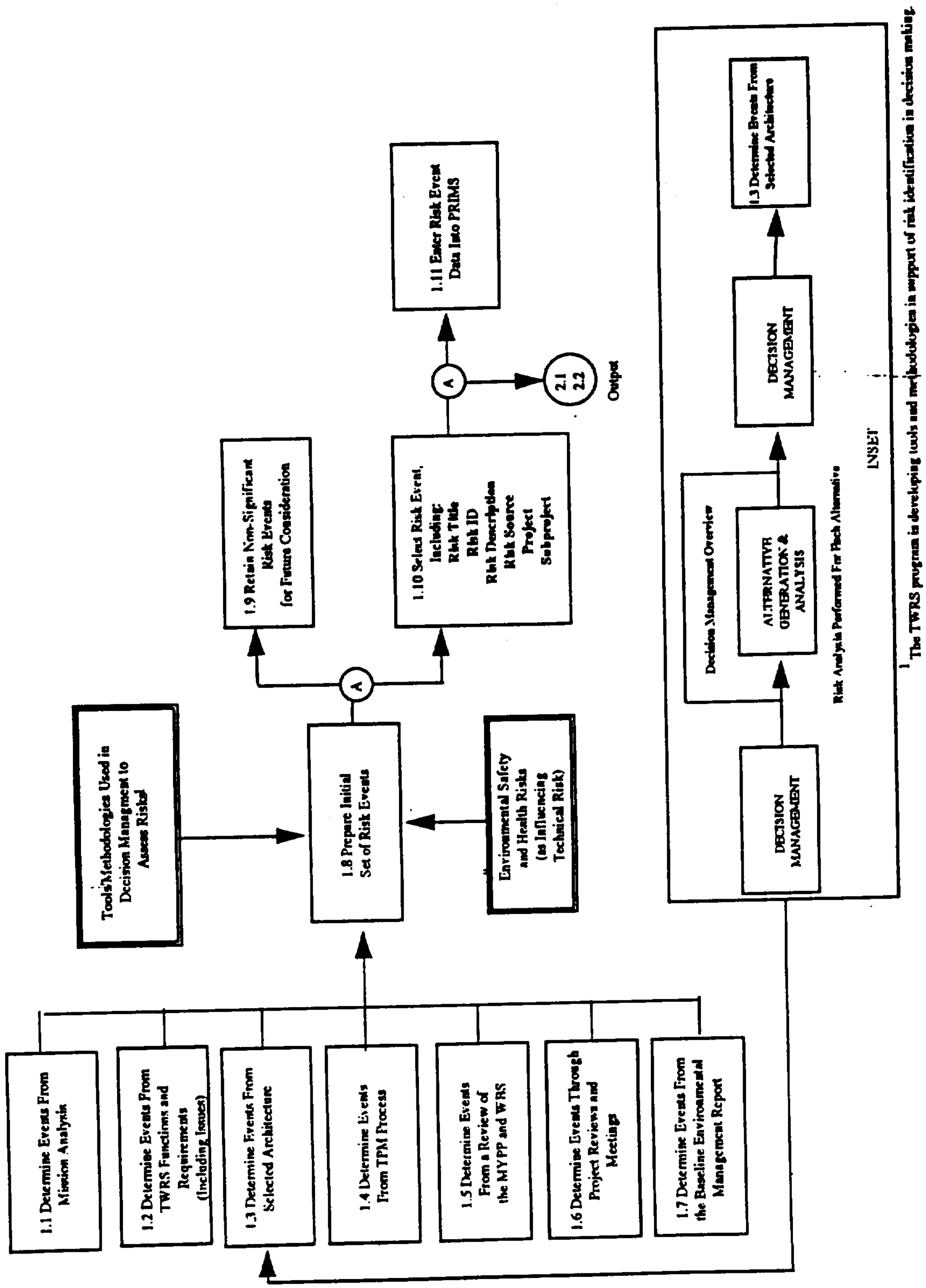
The prime source for cost and schedule risk events should be the MYPP and the WBS. Other sources for cost and schedule risk events are Data Quality Objectives (DQO), project reviews, and meetings.

During Identify Risk Events, risk events should be analyzed for significance (e.g., when they are expected to occur, frequency of occurrence, and the time window when they should be addressed). Those risk events accepted as being significant should be placed on a RML that is created when data are entered into PRIMS. Those not accepted as being significant should be placed on a separate informal list (may use a separate PRIMS database) and retained for future consideration. For significant risks, the following table contains a description of the data elements that should be entered into PRIMS. The title of a risk should be worded to describe an undesirable event or situation. Any explanation of the risk event should be placed in the risk description field. The Risk Data Sheet (RDS) number is the number that is assigned in accordance with the *Management Evaluation Matrix Training Package and Reference Material* (WHC 1995a).

Identify Risk Events Data Description

Field Name	Data Type	Description
Risk Title	Text (130)	Short title for the risk event
Risk ID	Text (50)	Unique risk event identifier
Risk Description	Memo	Description of the risk event
Risk Source	Text (120)	Source of risk event descriptive information (e.g., name, organization, document)
Project	Text (50)	Name of project responsible for the risk (e.g., Waste Characterization)
Subproject	Text (50)	If applicable, name of sub-project responsible for the risk
RDS Number	Text (255)	Risk data sheet number

Note in the process flow model below, that the output from process Step 1.10, Select Risk Event, becomes the input to PRIMS and process Step 2.1, Determine Management Responsible Persons and process Step 2.2, Determine Technical Staff Responsible Persons, in the model under Section 5.2.2. It is essential to assign management and technical staff responsibility for a particular risk event before proceeding with risk analysis and risk handling.



Identify Risk Events

5.2.2 Determine Responsibility

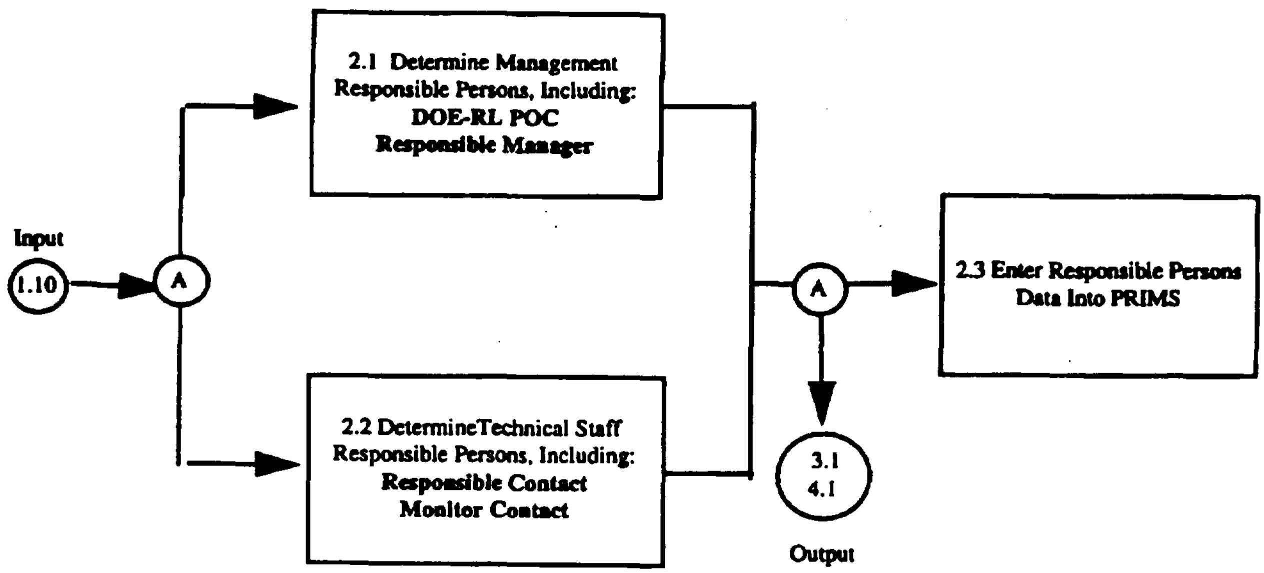
After identifying a risk event, management and staff responsibilities must be determined. As shown in the process flow model, a RL POC, Responsible Manager, as well as a Responsible Contact, must be identified for each risk. Identifying a Monitor Contact is optional, depending on the need to share risk information across organizations.

The RL POC should be a DOE person having oversight for the risk. The Responsible Manager should be the person responsible for managing the resources in the organization that will be managing the risk and handling actions. The Responsible Contact should be the person designated by management to track, coordinate, and report on the status of the risk and handling actions. The Monitor Contact may be the person from another TWRS project who needs to be kept informed of the status of the risk because it has a potential impact on their project. The following table contains a description of the data elements that should be entered into PRIMS.

Determine Responsibility Data Description

Field Name	Data Type	Description
RL POC	Text (50)	Name of RL point of contact
Responsible Manager	Text (50)	Name of program, project, or sub-project manager having most oversight for the risk
Responsible Contact	Text (50)	Name of WHC person having staff action oversight for the risk
Monitor Contact	Text (50)	Name of WHC person from another TWRS organization that is monitoring the risk because of potential impacts to their organization (e.g., the low-level waste [LLW] project may monitor risks managed by the Characterization project because the risks may impact LLW).

Note in the below model, that the output from process Step 2.1 and Step 2.2 become the input to PRIMS and process Step 3.1 and Step 4.1 in the flow models under Sections 5.3.1 and 5.3.2. The RL Contact, the Responsible Manager, and the Responsible Contact, along with other technical staff, should jointly determine the likelihood of a risk event occurring and its consequences.



Determine Responsibility

5.3 Risk Analysis

Risk analysis consists of the steps taken to determine the likelihood of an event occurring, consequence severity, risk value, and whether a risk is to be considered critical or not. The RM processes performed during risk analysis are:

- Step 3: Determine Risk Likelihood
- Step 4: Determine Consequences
- Step 5: Identify Affected Functions
- Step 6: Determine Consequence Severity
- Step 7: Decide If Risk Is Critical.

The objective of risk analysis is to determine risk likelihood, consequence severity, affected system functions, and to decide whether or not a risk is critical to the success of a project.

5.3.1 Determine Risk Likelihood

Risk likelihood is the probability that an unwanted event will occur <u>if no further action is taken to prevent it from happening</u>. To standardize the ratings for risk likelihood, a quantitative rating scheme of low, medium, or high is to be used. The qualitative ratings are to be determined by first assigning a point estimate as to the probability of occurrence using a value between 0 and 1. (0 is no probability of occurrence and 1 is 100 percent probability of occurrence.) Next, a qualitative rating is to be assigned to the risk event using the following guidelines:

- **Low:** Risk likelihood is less than 25 percent (<.25).
- **Medium:** Risk likelihood is from 25 percent to 75 percent (.25 to .75).
- **High:** Risk likelihood is greater than 75 percent (>.75).

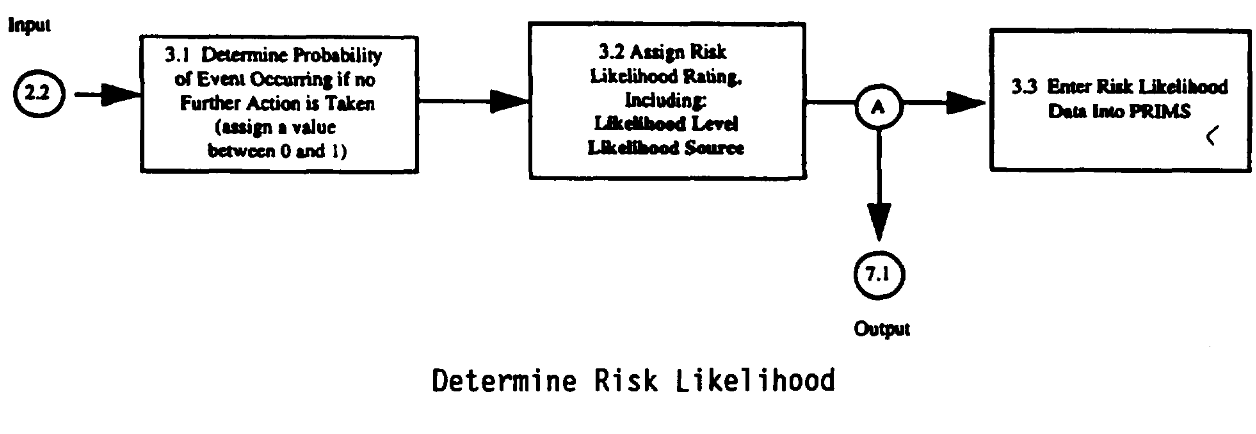
The flow model below depicts the general sequence for determining risk likelihood. In process Step 3.1, the method used to determine the probability of occurrence may be qualitative or quantitative. However, the method used should be consistently applied and specified in the project's RMP.

Likelihood level should be rated as low, medium, or high, and where or how the rating was assigned (source) and recorded. The table below contains descriptions of the data elements that should be entered into PRIMS.

Determine Risk Likelihood Data Description

Field Name	Data Type	Description
Likelihood Level	Text (7)	Level of risk likelihood (list - Low, Medium, or High)
Likelihood Source	Text (120)	Source of how likelihood was determined (e.g., name, organization, document, meeting)

Note in the flow model below, that the output from process Step 3.2, Assign Risk Likelihood Rating, becomes an input to PRIMS and process Step 7.1, Select Risk Value From Matrix, in the model under Section 5.3.5. Risk Likelihood is one of the key variables that is used to determine whether or not a risk is Critical or Not Critical.



Determine Risk Likelihood

5.3.2 Determine Consequences

Consequences are the negative effects should an unwanted risk event occur. Consequences can be determined by building possible event scenarios or by using a more formal analysis approach. As part of preparing a list of consequences, system functions impacted by a risk must be determined. Most consequences determined during this process step will be those that affect cost and schedule, and to a lesser extent technical performance. Most technical performance consequences will be determined when system functions are examined during process Step 5, Identify Affected Functions.

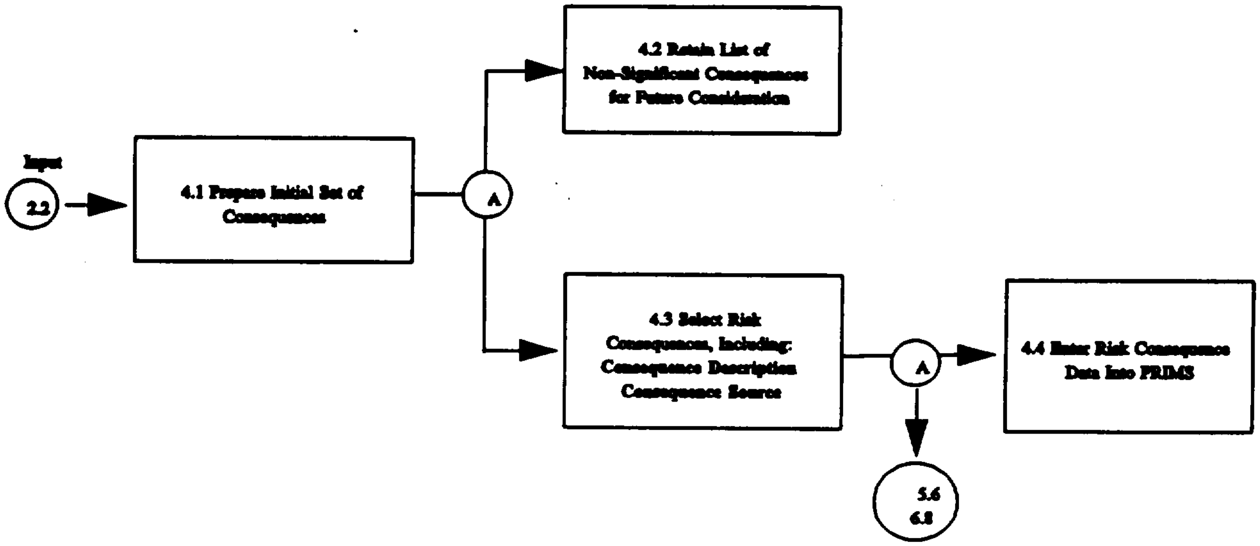
The sources used to identify risk events can also be used to identify their possible consequences. The consequences should be analyzed for their impact on the TWRS system and the project (e.g., duration, intensity, and degree of disruption). Consequences not considered significant should be placed on a separate informal list (may use a separate PRIMS database) and retained for future consideration. Those accepted as being significant should be entered into PRIMS.

The flow model below depicts the flow for determining consequences and entering the data in PRIMS. The table below contains descriptions of the data elements that should be entered into PRIMS. The consequence should be described using a memo field and the source of the consequence included.

Determine Consequences Data Description

Field Name	Data Type	Description
Consequence Description	Memo	Description of the consequence
Consequence Source	Text (120)	Source of consequence descriptive information (e.g., name, organization, document, meeting)

Note in the flow model below, that the output from process Step 4.3, Select Risk Consequences, becomes the input for PRIMS and process Step 5.6, Determine Impacted Functions, in the model under Section 5.3.3, and the output



Determine Consequences

for process Step 6.8, Determine Consequence Severity, in the model under Section 5.3.4. In most cases, a consequence will have some impact on a system function, and before Consequence Severity can be adequately determined all Affected Functions must be identified.

5.3.3 Identify Affected Functions

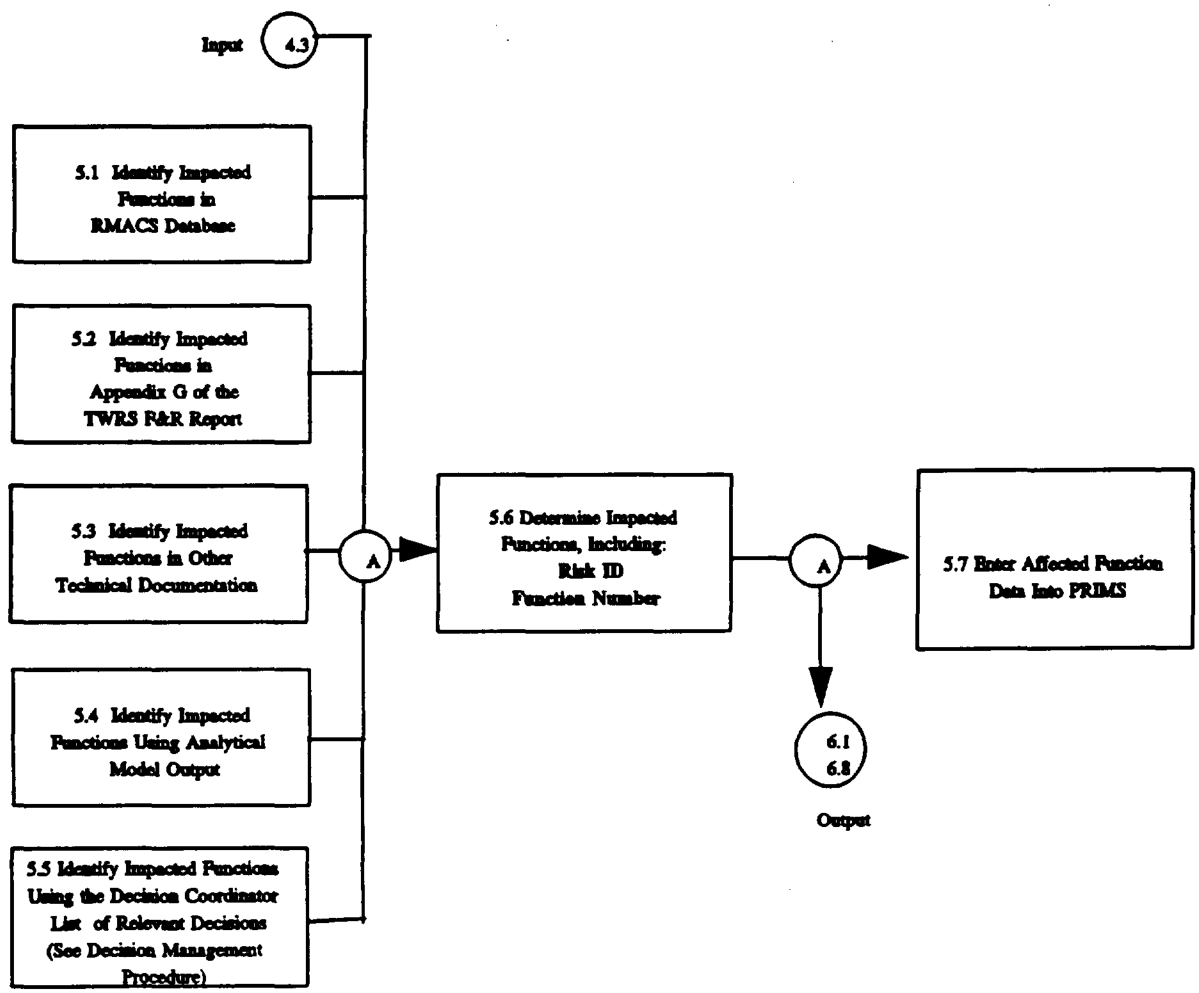
Affected functions are the TWRS functions contained in the F&R document that a risk event and its consequences may affect. The Requirements Management and Assured Compliance System (RMACS) as implemented in the Requirements Driven Development (RDD)-100 database, TWRS F&R documents, other technical documentation, and outputs from process simulation models are all sources for identifying affected functions. Identifying affected functions requires that an analysis be conducted using the output from the previous processes (i.e., the assessment and analysis performed to identify risk events, their likelihood, and possible consequences).

The model below depicts the flow for identifying affected functions and entering data into PRIMS. The table below contains descriptions of the data elements that should be entered into PRIMS. The risk identification number (ID) and function number, and the function numbers should be the same as those maintained in the RDD-100 database.

Identify Affected Functions Data Description

Field Name	Data Type	Description
Risk ID	Text (50)	Unique Identifier of Risk Event
Function Number	Text (50)	Function number as stored in RMACS

Note in the model below, that the output from process Step 5.6, Determine Impacted Functions, becomes an input to PRIMS and process Step 6.8, Determine Consequence Severity, in the model for Section 5.3.4. System functions that are affected by a risk must be known to adequately determine Consequence Severity.



Identify Affected Functions

5.3.4 Determine Consequence Severity

Consequence severity is the magnitude of the negative effect of a risk on cost, schedule, and technical performance. The sources used to identify risk events, consequences, and affected functions should also be used to determine consequence severity.

To standardize the ratings for consequence severity, a qualitative rating scheme of low, medium, or high is to be used. The qualitative ratings are to be selected using the following guidelines:

- **Low**: Has minor impact on system functions, or requires minor changes to cost and schedule goals and TPMs (e.g., minor changes within the scope of a project's own budget).

- **Medium**: Has significant impact on system functions, or requires significant changes to cost and schedule goals and TPMs (e.g., reprogram project to get funding from some other project within the program).

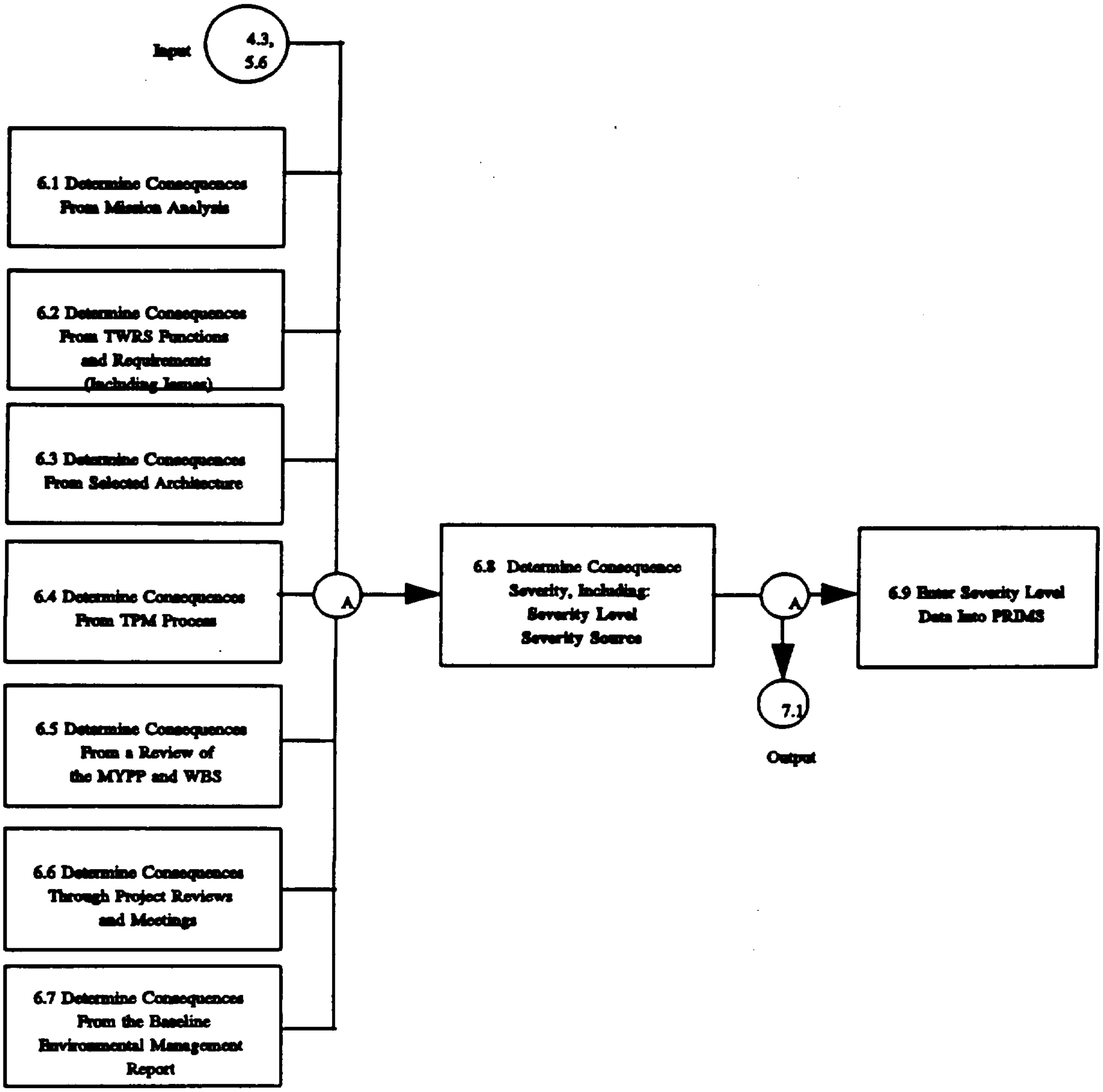
- **High**: Has critical impact on system functions, or requires critical changes to cost and schedule goals and TPMs (e.g., project goes back to DOE for additional funding).

The model below depicts the flow for determining consequence severity and entering the data into PRIMS. The table below contains descriptions of the data elements that should be entered into PRIMS. Consequence severity should be entered as either low, medium, or high. The source for how each consequence severity level was determined should also be entered.

Determine Consequence Severity Data Description

Field Name	Data Type	Description
Severity Level	Text (7)	Consequence severity level (list - Low, Medium, or High)
Severity Source	Text (120)	Source of consequence severity level (e.g., name, organization, document, meeting)

Note in the model below, that the output from process Step 6.8 becomes the input for PRIMS and process Step 7.1, Decide If Risk Is Critical Or Not Critical, in the model under Section 5.3.5. Risk Likelihood and Consequence Severity must be determined before a decision can be made as to whether or not a risk is Critical or Not Critical.



Determine Consequence Severity

5.3.5 Decide if Risk is Critical

Critical risks are the risks that require the most management and technical staff attention. The designation "Critical" is a subjective indicator of the need to intensively manage a risk based on its programmatic impact. The information used in making the decision is the intersection of risk likelihood and consequence severity within a Risk Value Matrix and a set of six subjective criteria. The decision may be made using the Risk Value Matrix alone, or it may be made in conjunction with the subjective criteria.

Risk Value is a means to rate the overall importance of risk based on the relationship between risk likelihood and consequence severity. It is a magnitude guideline and an interpretive measure of programmatic impact. To standardize the Risk Value rating process, a qualitative Risk Value Matrix, as shown below, is to be used. Risks with a risk value of Very High should be designated as Critical. Risk with a risk value of less than Very High should be designated as Not Critical. Following are the definitions of the Risk Value Matrix relationships:

- **Very Low**: Risk likelihood is low and consequence severity is low.
- **Low**: Risk likelihood is low and consequence severity is medium, or risk likelihood is medium and consequence severity is low.
- **Medium**: Risk likelihood is low and consequence severity is high, risk likelihood is medium and consequence severity is medium, or risk likelihood is high and consequence severity is low.
- **High**: Risk likelihood is medium and consequence severity is high, or risk likelihood is high and consequence severity is medium.
- **Very High**: Risk likelihood is high and consequence severity is high.

Risk Likelihood \ Consequence Severity	Low	Medium	High
Low	Very Low	Low	Medium
Medium	Low	Medium	High
High	Medium	High	Very High

Risk Value Matrix

To supplement the Risk Value Matrix, subjective criteria were developed to aid in making a decision about designating a risk as Critical or Not Critical, because Risk Value may not be the sole adequate discriminator.

Following are the six subjective criteria for determining if a risk is critical. These criteria are to be used in conjunction with the Risk Value Matrix, or separately. A risk may be designated as Critical with a risk value of less than Very High if one or more of these criteria apply:

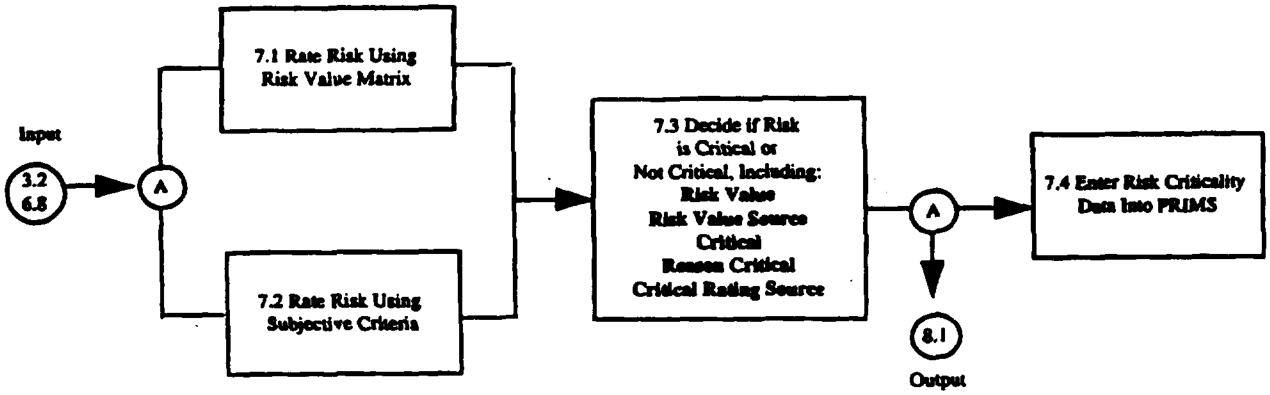
- Consequence severity is particularly serious
- Immediate action is required to preclude the risk from happening
- Avoiding the risk is a top stakeholder priority, or a top priority of TWRS or RL
- A high value performance-based initiative (PBI) is associated with the risk
- Avoiding the risk will be very difficult to successfully coordinate
- Senior management oversight is required.

The model below depicts the flow in determining risk value and entering data into PRIMS. The following table contains descriptions of the data elements that should be entered into PRIMS. Risk value should be determined using the Risk Value Matrix. Also, enter the source used to determine the risk value, including whether a tool other than the Risk Value Matrix was used. When the risk is considered critical, select the YES option, when not, select the NO option. Enter the reason for the risk being critical and provide the source used in making the determination (e.g., subjective criteria).

Decide If Risk Is Critical Data Description

Field Name	Data Type	Description
Risk Value	Text (2)	Ranking of the importance of the risk which is determined from risk likelihood and consequence severity (list - VL, L, M, H, VH) (e.g., Very Low, Low, Medium, High, Very high)
Risk Value Source	Text (120)	Source of the risk value (e.g., risk value matrix, name, organization, document, meeting)
Critical	Yes/No	Risk is critical (yes) or not critical (no)
Reason Critical	Text (250)	Reason why risk is critical
Critical Rating Source	Text (120)	Source of critical rating information (e.g., name, organization, document, meeting, RV matrix, criterion)

Note in the below model, that the output from process Step 7.3 becomes the input for PRIMS and process Step 8.1, Prepare Initial List of Risk Handling Action, in the flow model under Section 5.4.1. Whether a risk is Critical or Not Critical will influence the amount of effort that should be put in risk action planning.



Decide If Risk Is Critical

5.4 Risk Handling

Risk handling is the set of steps taken to reduce risk to an acceptable level. There is no RM if there are no provisions for handling identified risks. The RM processes performed during risk handling are: Step 8, Develop Risk Actions, and Step 9, Update Risk Status. The objective of risk handling is to develop actions that are realistic and achieve the goal of reducing risk to an acceptable level.

Risk handling requires continuous management attention. Some risk actions may address more than one risk and as such must be carefully coordinated. Actions that cross organizational boundaries will require the "buy in" from affected programs and projects. It is also possible that some risk handling actions may compound problems for other organizations, and thus present a new set of risks, and managers and technical staff must pay particular attention to this possibility.

5.4.1 Develop Risk Actions

A risk action is the technique selected to reduce risk to an acceptable level through one or more of the following: avoidance, transfer, sharing, control, or assumption.

- **Avoidance** - Action taken to completely rule out the potential for a risk and its consequences.
- **Transfer** - Action taken to entirely give a risk to another organization through contractual agreement (e.g., privatization), or arrangement.
- **Sharing** - Action taken to allocate a portion of a risk to another organization so as to reduce risk likelihood or consequences.

- **Control** - Action taken to monitor and correct conditions so that either risk likelihood or consequence severity, or both, are reduced.

- **Assumption** - Decision made to accept a risk should it occur and to take no action beforehand.

The sources used during risk assessment and analysis should also be used to develop risk actions. Actions not immediately adopted should be set aside for future consideration. Those adopted should be placed in PRIMS and used in the preparation of an action plan should one be deemed necessary. Each action should be considered from a cost-benefit perspective as described in, Potential Enhancements to Addressing Programmatic Risk in the Tank Waste Remediation System (PNNL-11068).

A risk action plan is a description of how a risk will be handled in accordance with the selected handling technique (i.e., avoid, transfer, share, control, assume). As the plan evolves it should be compared with current or proposed changes to cost, schedule, and technical performance. Cost and schedule data should be prepared for each action and compared with program elements contained in the MYPP and WBS. Where necessary, revisions should be made to the MYPP and WBS.

Attachment C contains an annotated outline for a Risk Action Plan. The plan can be 1 or 2 pages in length or more extensive, as long as it is complete and contains sufficient detail for implementation. It is not necessary to prepare a formal action plan for each risk; however, formal action plans are recommended for critical risks. More abbreviated and less formal plans are recommended for non-critical risks.

An essential aspect of risk action development is to determine the status of each action, whether Pending, Ongoing, or Complete.

- **Pending** - Action has not yet started, or a decision has not yet been made to adopt the action.

- **Ongoing** - Action started, but not is not yet complete.

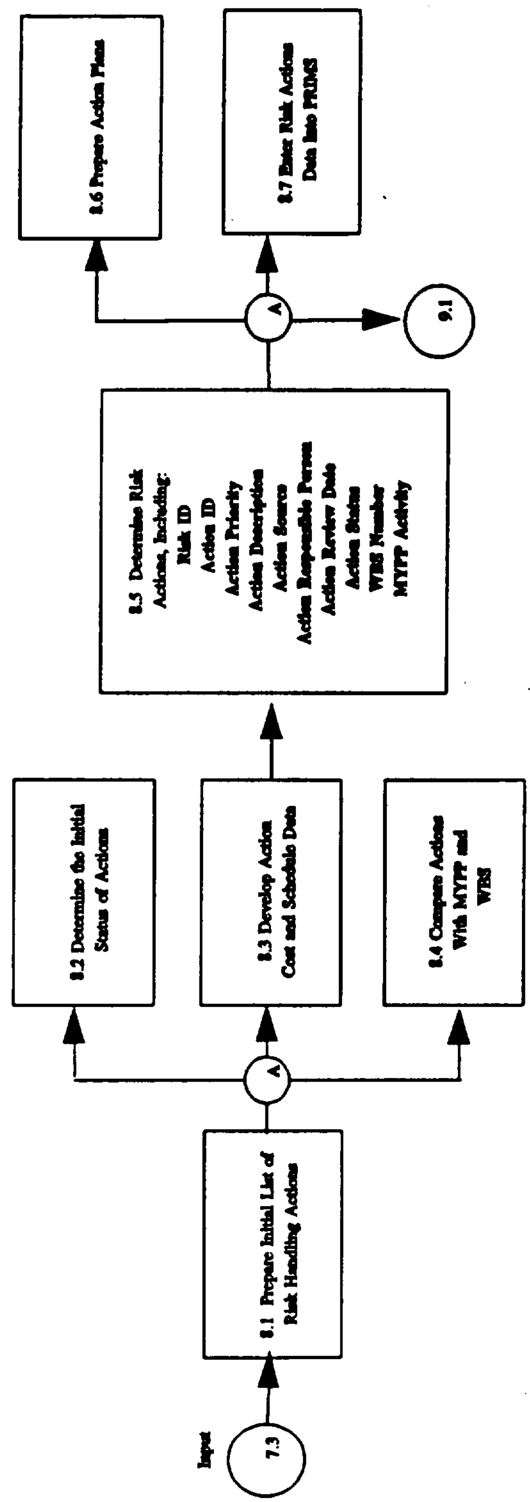
- **Complete** - Action fully implemented.

The model below depicts the flow of developing risk action and entering data into PRIMS. The following table contains descriptions of the data elements that should be entered into PRIMS. A unique number is to be assigned to each action because a risk may have more than one action. If there is more than one action, then each should be ranked in priority. Also, every action must be periodically reviewed to determine if the action is accomplishing what was intended.

Develop Risk Actions Data Description

Field Name	Data Type	Description
Risk ID	Text (50)	Identifier of associated risk (linking field)
Action ID	Text (50)	Unique action identifier
Action Priority	Integer	Ordering priority for set of actions
Action Description	Memo	Description of the action
Action Source	Text (120)	Source of action descriptive information (e.g., name, organization, document, meeting)
Action Responsible Person	Text (50)	Person responsible for taking action, or for tracking and reporting on the action
Action Review Date	Date	Next review date for action
Action Status	Text (8)	Status of an action (list - Pending, Ongoing, or Complete)
Benefit/Cost	Integer	Benefit to cost ratio estimate (values 1 to 10 -- 10 is high benefit/low cost)
Benefit/Cost Source	Text (120)	Source of benefit/cost evaluation
WBS Number	Text (120)	Number in the WBS that relates to the action
MYPP Activity	Text (255)	MYPP activity name.

Note in the model below, that the output from process Step 8.5, Determine Risk Actions, becomes the input for PRIMS and process Step 9.1, Establish Schedule For Regular Review Of RML, in the model under Section 5.4.2. When adopted as a risk action, management and technical staff should periodically review risks for status and needed changes in planned actions.



Develop Risk Actions

5.4.2 Update Risk Status

The final process step in RM is to review the status of each risk and prepare an update as depicted in the model below. Reviews should be frequently conducted to determine the overall status of each risk and risk action. The overall status of each risk should be evaluated and categorized as Green, Amber, or Red, and the results entered into PRIMS. The evaluation is a subjective assessment of how well the risk is being handled, not how serious the risk is to TWRS. Following are the definitions of each category:

- **Green** - All risk handling is expected to reduce risk to an acceptable level and is on schedule and within budget.
- **Amber** - Handling actions may fall short of reducing risk to an acceptable level and minor deviation exists between planned risk handling and schedule and budget.
- **Red** - Handling actions are expected to fall far short of reducing risk to an acceptable level and major deviation exists between risk handling and schedule and budget and management intervention is required.

Continuous feedback throughout the RM process is important. For example, risk status ratings may need to be re-determined based on the duration of the project, as well as system performance. There may also be a need to revisit any non-significant risks and consequences to see if circumstances have elevated their importance. Red status risks should be reviewed at least weekly, Amber status risks every two weeks, and Green status risks should be reviewed every month.

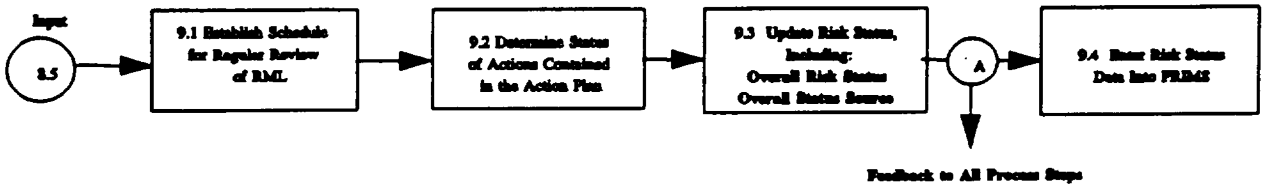
The following table contains descriptions of the data elements for risk status that should be entered into PRIMS. Review data should include the status (Green, Amber, or Red), and the source of the status update.

Update Risk Status Data Description

Field Name	Data Type	Description
Overall Status	Text (5)	Overall status of risk action (list - Green, Amber, or Red)
Overall Status Source	Text (120)	Source of overall status information (e.g., name, organization, document, meeting)

At a minimum, risk reviews should be tied to program and project milestone reviews and verification activities (e.g., T&E). Critical risks should be reviewed at least monthly. The purpose of risk reviews is to determine whether risk handling actions are on track or should be altered. The reviews should be proactive, not crisis oriented, and conducted to allow sufficient time for corrective action.

Another risk status tool is the System Effectiveness and Summary Status Report described in the TPM Procedure, which is a record of achieved performance profiles and summarizes the key findings of TPM. The status report should be used as an input to determining overall risk status and the status of risk actions.



Update Risk Status

6.0 REFERENCES

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7.0 Attachments

Attachment A Programmatic Risk Information Management System (PRIMS)
Attachment B Project Programmatic Risk Management Plan Annotated Outline
Attachment C Risk Action Plan Annotated Outline
Attachment D Glossary

Attachment A

Programmatic Risk Information Management System (PRIMS)

PRIMS was developed using Microsoft Access Version 2.0 for the database engine and Microsoft Visual Basic Version 3.0 for the Graphical User Interface (GUI). This software system provides the user with a standard windows type interface integrated with a relational database management system. Following is a general list of the capabilities of PRIMS:

- Operates on a standard personal computer platform in the Microsoft Windows environment.
- Operates through a GUI, including starting the application from an icon.
- Performs initial installation from a setup file with minimal user interaction.
- Provides standard reports output to screen or printer for viewing data in the database.
- Provides simple data entry and management screens.

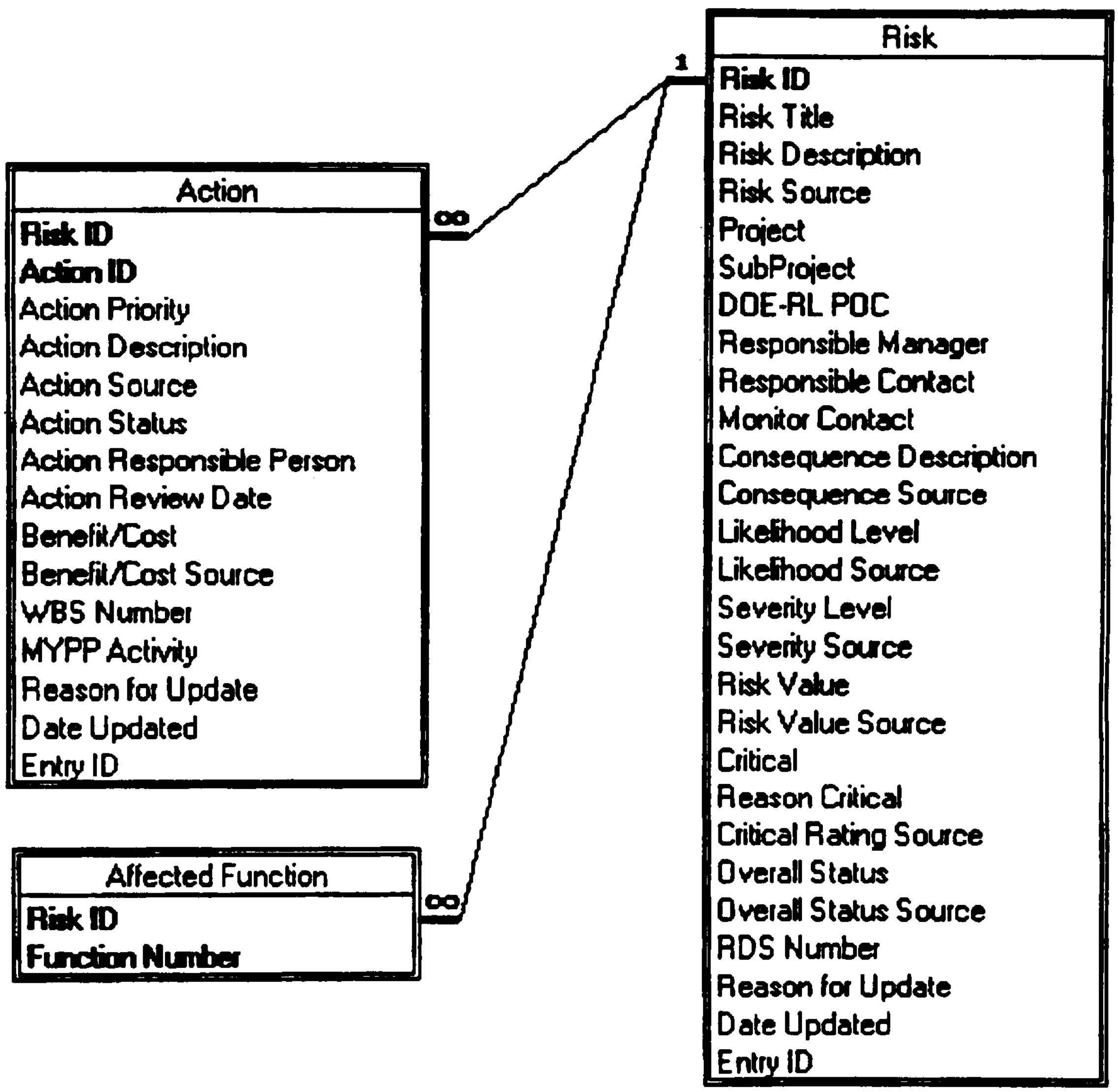
Some data integrity and configuration management features were designed into PRIMS, these being:

- The database contains three required fields that must be filled in whenever tables are updated. Specifically, when changes are made to a record, they are not saved until the nature of the update (Reason for Update), when the update was made (Date Updated), and who made the update (Entry ID) is provided.
- When a change is made in the database, the capability of moving the old record (before the update is made) to a corresponding archive table is provided. An archive table exists for each of the two main tables (Risk and Action) with similar structure. The archive tables will contain a history of all records that are archived.
- Database fields are available for recording the source of the data entered in key fields (e.g., Risk Source, Likelihood Source, and Severity Source). The source information provides a reference that can be used to verify the data entered.
- Access to updating the database is administratively controlled, so that only a limited number of authorized individuals are able to update information stored in the database.
- The record cannot be saved unless update data elements are completed. The following table contains a description of the data elements that must be completed each time a record is saved or edited in PRIMS.

Mandatory Table Entries

Field Name	Data Type	Description
Reason for Update	Memo	Purpose of update to record (required entry)
Date Update	Date	Date record update made (required entry)
Entry ID	Text (50)	Unique identifier of person making the record entry

The relationship among the three major tables in the PRIMS is depicted in this model.



Programmatic Risk Information Management System

Attachment B

Project Programmatic Risk Management Plan
Annotated Outline

The Risk Management Plan (RMP) can be 2 or 3 pages, or more extensive, as long as it is complete and contains sufficient detail for implementation. The following is a suggested format.

I. Introduction

1. **Purpose.** This section should include: *Description of the purpose of the RMP for the project or subproject. Reference the Tank Waste Remediation System (TWRS) Programmatic Risk Management Plan as defining the need for project and subproject RMPs, and as providing additional details on the internal implementation of risk management (RM).*

2. **Scope.** This section should include: *Brief description of the project or subproject to which the RMP applies.*

3. **Management Organization and Responsibilities.** This section should include: *Organizational structure, personnel assigned to RM tasks (by name or position, responsibilities of assigned personnel (by name or position), and points-of-contact for implementing the RMP.*

II. Risk Management Implementation

4. **Risk Assessment.** This section should include: *Description of how risks will be identified and control and monitoring responsibilities assigned. Include description for how risk assessment data will be entered into the Programmatic Risk Information Management System (PRIMS). (Use the RM Procedures where appropriate in the description.)*

5. **Risk Analysis.** This section should include: *Description of procedures for how risks will be rated for likelihood and severity and risk value determined. Include description for how risks will be determined to be critical or non-critical, and data entered into the PRIMS. (Use the RM Procedures where appropriate in the description.)*

6. **Risk Handling.** This section should include: *Description of procedures for how risk action strategies will be developed, action plans written, status updates prepared and distributed for coordination and decision making, and data entered into the PRIMS. (Use the RM Procedures where appropriate in the description.)*

III. Schedule. This section should include: *Description of schedule and deliverables for implementing the RMP at the project level.*

IV. Appendices (As Required)

Attachment C

Risk Action Plan Annotated Outline

The plan can be 1 or 2 pages, or more extensive, as long as it is complete and contains sufficient detail for implementation. The following is a suggested format.

I. Introduction.

1. **Risk Event Title and Number.** This section should include: *Same risk event title and number information as that contained in the Programmatic Risk Information Management System (PRIMS).*

2. **Overview.** This section should include: *Description of the scope of the plan and general description of the tasks and activities.*

3. **Applicable Documents and Definitions.** This section should include: *List of the documents, meeting notes and other items that will be used as directives or guidance in the implementation of the action plan.*

II. Risk Handling

4. **Risk Actions.** This section should include: *Same action description information as that contained in PRIMS.*

5. **Implementation Steps.** This section should include: *Description of the methods that will be used to implement a particular action, including any qualitative or quantitative measures and standards that must be met.*

6. **Management Organization and Responsibilities.** This section should include: *Organizational structure, personnel assigned to tasks (by name or position), responsibilities of assigned personnel (by name or position), points of contact for implementing the action plan.*

7. **Management and Control.** This section should include: *Where information about the status of an action is to be stored in PRIMS and maintained under configuration control. Include the management control procedures that will be used to ensure compliance with the planned actions.*

8. **Reviews and Status Updates.** This section should include: *Description of the process which will be used to integrate and coordinate the action plan, including dissemination of the action requirements to subprojects and other organizations and the coordination of reviews and status reporting.*

III. Schedule. This section should include: *Description of schedule and deliverables for implementing the Risk Action Plan.*

IV. Appendices (As Required)

Attachment D

GLOSSARY

Action Description

The "Actions Description" field should contain a set of actions which, if implemented, would reasonably be expected to reduce the stated risk to an acceptable level. These actions do not have to ensure that the risk will be eliminated if it would not be practical to do so. Development of the set of actions should be derived from an examination of all practical ways to reduce the risk level such as:

- *Risk Avoidance* - avoiding a particular risk by selecting an alternative project strategy.
- *Risk Transfer* - shifting a risk to another entity outside the responsibility of the program, such as through a contractual agreement (e.g., Privatization).
- *Risk Sharing* - allocating a risk among multiple parties.
- *Risk Control* - reducing a risk by decreasing the likelihood of its occurrence or reducing the severity of its consequences.
- *Risk Assumption* - accepting a risk and its consequences.

The set of actions does not have to include all possible options as long as the proposed set is adequate. Multiple actions can be identified, each with a separate responsible person. However, only one person should be responsible for each specific action. Actions that are an expected part of normal business should not be included ("Do your job well" is always implied). If the desired level of risk reduction cannot be achieved at the project level, specific actions to address the problem at a higher level should be included or the issue should be referred to another organizational element that can provide additional risk reduction.

Action Identification Number (ID)

The "Action ID" field is the unique identifier of a particular action for a particular risk. This field in coordination with the "Risk ID" provides the key to locating any action in the database. The format for the "Action ID" should be the letter "A" followed by a sequence number. For example, the Action IDs for a risk having three handling actions would be A1, A2, and A3.

Action Priority

The "Action Priority" is a sequence number that is used to prioritize the order in which actions are to be undertaken. When actions are printed, they will be identified in the order in which they were prioritized.

Action Responsible Person

The "Action Responsible Person" is the person responsible for implementing and reporting on the action. The entry should show the last name (more if confusion could result) of the individual directly responsible/accountable for accomplishment of the action. When two names are shown, it should only be because both parties have direct responsibility to their managers for the action. If more than one name within one of the two organizations is required, the Action subset should be revised to require only a single name. The named person(s) should have the authority to accomplish the specific action.

Action Review Date

The "Action Review Date" can be any date that will ensure timely consideration of the action subset prior to a known event/milestone or with a frequency appropriate to the level of concern (Overall Status) for this risk. For Critical risks this can be expected to range from no later than a month for Green risks to weekly for Red risks.

Action Source

The "Action Source" is a description of the source of action information, such as the name of a person, organization, or document.

Action Status

The "Action Status" indicates whether the action subset has been implemented or completed. The status should be selected from the following list: pending, ongoing, complete, unfunded. "Pending" should only be used for a recommended action subset that has not yet been directed or, if directed, has not yet begun. "Unfunded" is a pending action that has not yet been funded. "Ongoing" should be used only when activity to complete the action is actually underway. "Complete" should be used only when the desired or anticipated affect has been achieved and no further action is anticipated. "Complete" entries should be removed as soon as that information has been communicated adequately, usually by publication of at least one later version of the Risk Management List (RML).

Benefit/Cost

The "Benefit/Cost" field provides an estimate of the benefit to cost ratio of pursuing a particular action. The values entered should be in the range from 1 to 10, where 1 indicates a low benefit/high cost action and 10 is high benefit/low cost action.

Benefit/Cost Source

The "Benefit/Cost Source" is a description of the source of Benefit/Cost information, such as the name of a person, organization, or document.

Consequence Description

"Consequence Description" should be a listing, in general order of importance, of consequences that will or might occur should the risk situation develop. Uncertainty about their occurrence should be reflected in the wording. Each of these statements should have an apparent direct cause/effect relationship with the stated risk (event/situation).

Consequence Source

The "Consequence Source" is a description of the source of consequence information, such as the name of a person, organization, or document.

Critical

The "Critical" field indicates whether or not a risk is critical (yes/no). Critical risks are all those risks that require intensive management or regular visibility with senior management. They focus on that subset of risks that are the most significant or urgent. Some of the lower-level or more detailed risks may be combined into broader, higher-level issues that are appropriate for senior management.

As a guide, risks might be considered critical if any of the following conditions exist:

- Risk Value is Very High.
- Consequences are particularly serious.
- Immediate action is required.
- Issue has high visibility/interest from stakeholders or the Federal Government.
- Required actions are difficult to coordinate.
- Senior management decision is required.

"Critical" determination should generally be based on the criteria above, but any factor that makes Management attention an imperative can be applied. Generally, risks for which no serious consequence exists, there is a negligible likelihood of occurrence, or where action/attention is not warranted in the near term would not be considered critical.

Critical Rating Source

The "Critical Rating Source" is a description of the source of the critical rating information, such as the name of a person, organization, or document.

Date Updated

The "Date Updated" field records the date of the most current update to the database. This information is required whenever a change is made to either the Risk or Action tables. The date information is used for tracking the "history" of a risk and for archiving purposes.

U.S. Department of Energy, Richland Operations Office (DOE-RL) Point of Contact (POC)

The "DOE-RL POC" is the U.S. Department of Energy (DOE) person having oversight for the project/program that is responsible for the risk. The entry should show the last name (more if confusion could result) of the individual directly responsible/accountable for overseeing a particular project or program. When two names are shown, it should only be because both parties have direct responsibility to their managers for the risk. If more than one name within one of the two organizations is required, the risk should be revised to require only a single name.

Entry Identification Number (ID)

The "Entry ID" field contains the unique identifier of any person making updates to the database. This information is required whenever a change is made to either the Risk or Action tables. The identification information is used for tracking the "history" of a risk and for archiving purposes.

Function Number

The "Function Number" field identifies the Tank Waste Remediation System (TWRS) function contained in the F&R which a risk may affect. The function number should match the number maintained in the RDD-100 database. In some cases, there may be more than one function number related to a particular risk. Refer to RDD-100 documentation for further information on format.

Likelihood Level

The "Likelihood Level" indicates the likelihood that a particular risk will occur. Likelihood should be rated as Low, Medium, or High. The qualitative ratings are to be determined by first assigning a point estimate as to the probability of occurrence using a value between 0 and 1 (0 is no probability of occurrence and 1 is 100 percent probability of occurrence). Next, a qualitative rating is to be assigned to the risk event using the following guidelines:

- *Low:* Risk likelihood is less than 25 percent (<.25).
- *Medium:* Risk likelihood is from 25 percent to 75 percent (.25 to .75).
- *High:* Risk likelihood is greater than 75 percent (>.75).

Likelihood Source

The "Likelihood Source" is a description of the source of likelihood information, such as the name of a person, organization, or document.

Monitor Contact

The "Monitor Contact" is the Westinghouse Hanford Company (WHC) person from another TWRS organization who is monitoring a risk because of potential impacts to his/her organization. For example, the LLW Project may monitor risks managed by the Characterization Project because the risks may impact LLW. The entry should show the last name (more if confusion could result) of the individuals directly responsible/accountable for monitoring the risk of concern. When more than one name is shown, it should be only because all parties have direct responsibility to their managers for monitoring the risk.

Multi-Year Program Plan (MYPP) Activity

The "MYPP Activity" field contains the MYPP activity that is related to a particular action. The format of this field should correspond to standard MYPP terminology.

Overall Status

The "Overall Status" should reflect the level of concern that the Responsible Contact has for the current state of this risk. This subjective value must consider the seriousness of the risk as well as the expected outcome of anticipated and ongoing actions. The overall risk status, classified as red, amber, or green, links directly to the handling actions and indirectly to the risk value. The overall status reflects all actions at all levels of management that are related to the risk.

- *Red* indicates that it is not being handled adequately or that even if all that can be done has been completed, this risk still presents a major threat to the project. It would typically be used if some significant action remains to be taken or that identified actions are not expected to produce the desired result.

- *Amber* indicates uncertainty or instability in the situation or some marginal inadequacy in the planned actions.

- *Green* indicates that the risk is being handled adequately according to the Responsible Contact.

Overall Status Source

The "Overall Status Source" is a description of the source of status information, such as the name of a person, organization, or document.

Project

The "Project" field indicates the project directly responsible for handling the risk. A list of projects (e.g., characterization, retrieval, immobilize High-Level Waste [HLW], immobilize Low-Level Waste [LLW], upgrade tank farms, cross-site transfer, ...) is provided.

Reason Critical

The "Reason Critical" field provides supporting information for why a risk is critical. Whenever possible, a specific reason should be provided. If a risk is no longer deemed critical, this field should be updated to reflect the current status. Refer to the "Critical" definition for further guidance on determining if a risk is critical.

Reason for Update

The "Reason for Update" field contains the purpose for making updates to the database. This information is required whenever a change is made to either the Risk or Action tables and is used for tracking the "history" of a risk and for archiving purposes.

Responsible Contact

The "Responsible Contact" is the WHC person designated by management to oversee and report on the status of the risk and handling actions to ensure actions are being completed. The entry should show the last name (more if confusion could result) of the individuals directly responsible/accountable for tracking the action status.

Responsible Manager

The "Responsible Manager" is the WHC manager responsible for the resources (funding and people) in an organization that will be managing the risk and handling actions. The entry should show the last name (more if confusion could result) of the individual having the direct authority to allocate resources and assign responsibilities for managing the risk.

Risk Description

The "Risk Description" should be a concise statement of a single risk or aggregate risk, of primary concern to the managers and staff maintaining this list. The statement should ideally use verbs such as may, might or could, to express the uncertainty that characterizes all risk. Aggregated risks should include closely related issues that are within a single area of responsibility and result from the same root cause(s). The degree of aggregation is difficult to define because it is derived from the level of management involved, management styles, number of risks to be considered and other similar factors. Some trial and error in achieving a comfortable degree of aggregation should be expected and may change over time. The description should be no longer than required to be reasonably clear (that is, to be understandable by competent members of the intended audience).

Risk Identification Number (ID)

The "Risk ID" is the unique identifier of a particular risk. The format for this ID for each project is shown below. The "001" in the Risk ID column is a sequence number place holder that should be filled with the appropriate sequence number (i.e., 001...999).

Characterization	CHA-001
High-Level Waste	HLW-001
Low-Level Waste	LLW-001
Retrieval	RET-001
TWRS Engineering	ENG-001
Storage and Disposal	S&D-001
Tank Farm Transitions	TFT-001
Management Systems	MGS-001

Risk Source

The "Risk Source" is a description of the source of risk information, such as the name of a person, organization, or document.

Risk Title

The "Risk Title" is a short descriptive title that summarizes the main focus of the risk statement. This information is used to quickly screen through a list of risks. An example might be "Insufficient Funding" or "Feed Specifications."

Risk Value

The "Risk Value" is a rating of the overall magnitude of a risk. This measure specifically does not consider expected effects of proposed or on-going risk handling actions. It is a magnitude guideline and should be used as an interpretive measure of programmatic impact. The relationship is expressed as a qualitative rating, and to standardize the ratings, a rating scheme of Very Low, Low, Medium, High, or Very High is to be used. It generally expresses the product of the likelihood and the consequence, as in the following matrix. The matrix is a guide only.

		Consequence Severity		
		Low	Medium	High
Risk Likelihood	Low	Very Low	Low	Medium
	Medium	Low	Medium	High
	High	Medium	High	Very High

Risk Value Source

The "Risk Value Source" is a description of the source of risk value information, such as the name of a person, organization, or document.

Severity Level

The "Severity Level" reflects the magnitude of the consequence of a risk on cost, schedule, and technical performance. To standardize the ratings for consequence severity a qualitative rating scheme of Low, Medium, or High is to be used. The qualitative ratings are to be selected using the following guidelines:

- *Low:* Has minor impact on system functions, or requires minor changes to cost and schedule goals and technical performance measures (e.g., minor changes within the scope of a project's own budget).

- ***Medium:*** Has significant impact on system functions, or requires significant changes to cost and schedule goals and technical performance measures (e.g., reprogram project to get funding from some other project within the program)

- *High:* Has critical impact on system functions, or requires critical changes to cost and schedule goals and technical performance measures (e.g., project goes back to DOE for additional funding)

Severity Source

The "Consequence Severity Source" is a description of the source of severity information, such as the name of a person, organization, or document.

SubProject

The "SubProject" field indicates the sub-project directly responsible for monitoring and handling the risk. This field may be left blank if it is not applicable to a particular risk.

Work Breakdown Structure (WBS) Number

The "WBS Number" indicates the WBS number that corresponds to a particular action. This field may be left blank if it is not applicable to a particular action.

TITLE:

DECISION MANAGEMENT

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

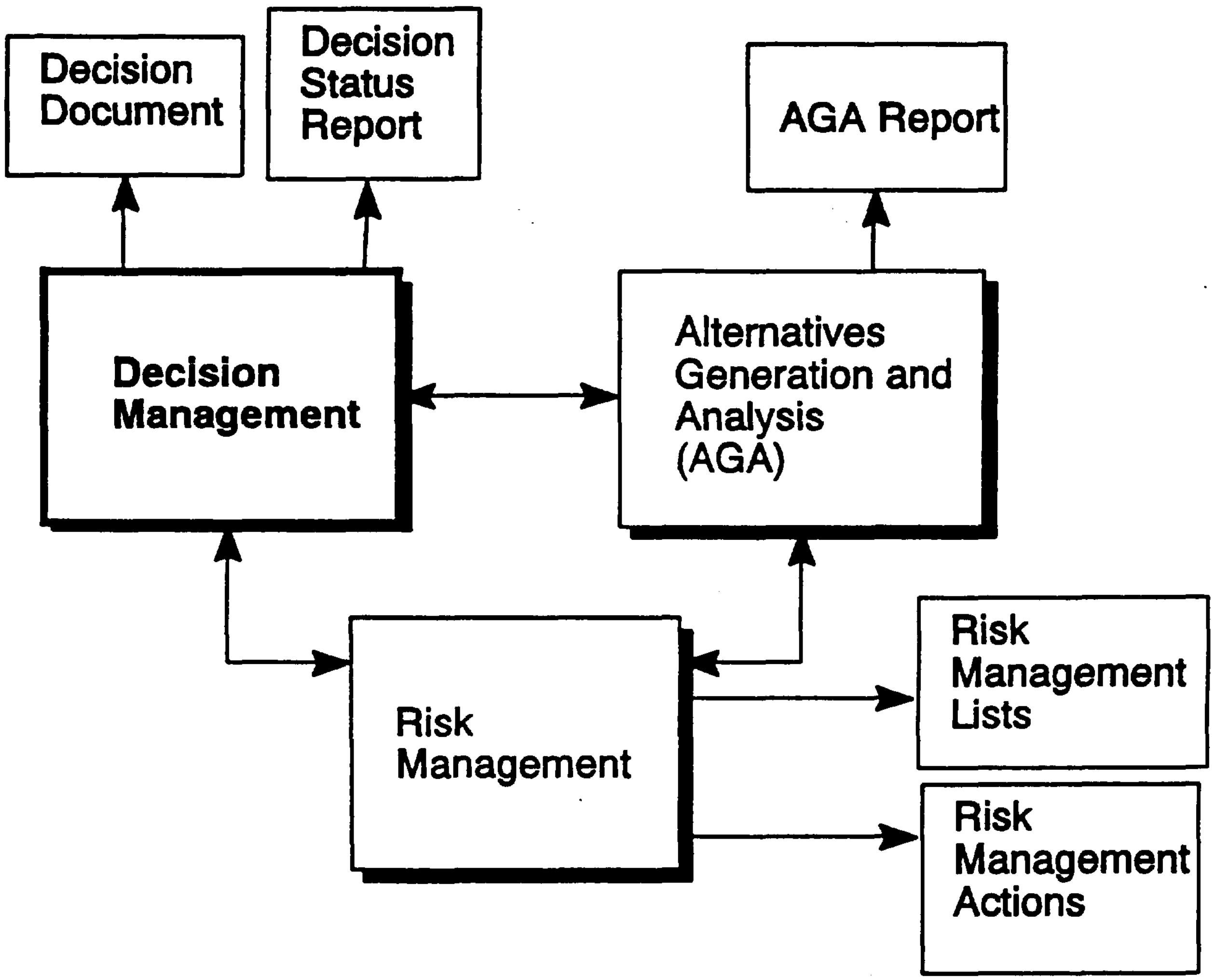
The purpose of this procedure is to provide guidance and direction for planning, managing, and making decisions. Decision management (DM) involves planning, documenting, observing, and initiating actions that promote good decision-making.

Using the DM process will:

- Produce timely and well-developed decisions
- Provide decision traceability back to system requirements
- Provide a means of tracking and monitoring decision-making progress
- Provide historical trail for implemented decisions.

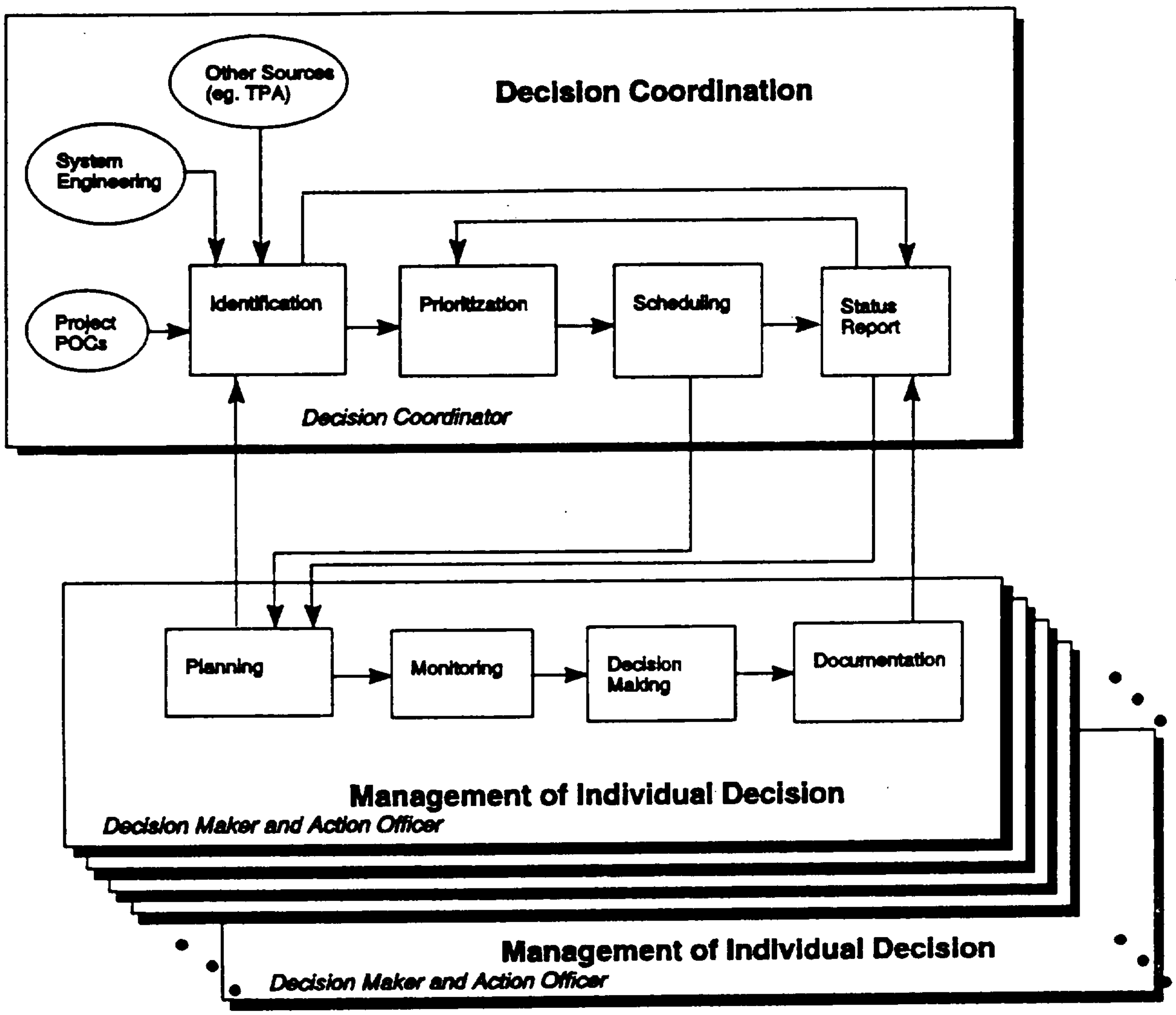
2.0 SCOPE

This procedure applies to specific architecture decisions. However, it has been written to be applicable to any DM situation. This procedure is to be used in conjunction with the *Alternatives Generation and Analysis (AGA) Procedure* (Orsag 1996a) and the *Risk Management (RM) Procedure* (Orsag 1996b) as shown in the figure below. The degree of formal implementation and documentation of the procedure will vary with the level and complexity of the decision being made. For high level Tank Waste Remediation System (TWRS) architecture decisions, the documentation is expected to be formal and complete. As decisions progress to lower levels (generally more technically detailed), the decision maker (see Section 4.1) will determine the degree to which documentation will be required to support the decision.



Relationship Between DM, AGA, and RM Procedures

There are two distinct aspects of DM: (1) decision coordination (programmatic planning and scheduling), and (2) managing individual decisions (as shown in the figure below). Decision coordination refers to maintaining a proactive influence on the overall set of decisions needing to be made. This influence includes identifying a comprehensive set of decisions needing to be made, understanding the interactions between decisions, scheduling the sequence, and strategy for addressing each decision, and tracking the progress of individual decision within the context of the overall set.



Decision Management Process

Planning and managing individual decisions refers to the processes and mechanisms needed to provide a timely and informed resolution to each individual decision. Technical decision analysis is performed for each individual decision. This DM Procedure addresses both decision coordination and individual decision aspects of DM.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Westinghouse Hanford Company (WHC) is responsible for developing appropriate practices for the conduct of DM at the Hanford Site. Programs and projects with special needs and/or conditions may modify these procedures as needed to prepare a graded approach to DM. When modified from the description in this document, the procedures shall be approved by the decision maker prior to implementation.

The following sections describe the roles and responsibilities of the individual involved in DM. The guiding principles behind these responsibilities are:

- Technical staff develop the detailed technical understanding needed to make selections between alternatives
- Technical staff deliver this technical understanding to the decision maker
- Decision makers consider both technical and non-technical information to form the basis selecting an alternative.

There are four distinct roles involved in DM.

- <u>Decision maker</u>. Approves decision plans, decides on the decision review process, and declares the formal outcome of the decision-making process.
- <u>Action Officer</u>. Prepares relevant decision documentation and monitors the decision-making process to ensure timely progress.
- <u>Support board</u>. Supports the decision maker by providing additional review of decision related information and by bringing additional technical expertise into the consideration of technical options.
- <u>Coordinator</u>. Prepares and maintains the comprehensive list of decisions, the decision schedule, and Decision Status Report.

4.1 Decision Maker

The decision maker is primarily responsible for considering all of the relevant information that has been developed in support of the decision-making action and for declaring a preferred selection from among the alternatives for a specific decision. (It is acknowledged that any one alternative may be constructed from combinations of several other alternatives.) The decision maker must be an individual with the authority to make the decision via direct declaration of a preferred alternative and to commit the organization to the consequences and obligations of the decision. In addition to this primary role, the decision maker also provides endorsement of the decision plan (see Section 5.1). With this endorsement, the decision maker declares that if the supporting information is developed according to that plan, he/she will be able to make an informed and timely commitment to one of the analyzed alternatives. By endorsing the decision plan, the decision maker declares the identified decision criteria, time frame, and supporting information complete and sufficient to allow decision-making to proceed. Furthermore, the decision maker acknowledges the identified interactions with other decisions such that obligations are made to inform other decision makers of the outcome of the decision action. The decision maker may choose to convene a decision support board, and to use this board as a part of the DM process (see Section 4.3).

The WHC decision maker is responsible for identifying the selected alternative. For some decisions, the formal selection of the alternative will require concurrence from an equivalent level (equivalent to the WHC decision maker) within the U.S. Department of Energy (DOE). Criteria for identifying the proper level of WHC decision maker (and corresponding DOE concurrence when applicable) are provided in Attachment A.

4.2 Decision Action Officer

The Decision Action Officer is responsible for preparing decision plans, obtaining concurrence for those plans from the identified decision maker, initiating the decision analysis process, monitoring the decision analysis progress, announcing and documenting any adjustments required of the initial decision plans, preparing the decision analysis information for consideration by the decision maker, and documenting the formal decision outcome declaration. The Decision Action Officer is also responsible for coordinating the development of required information with other Decision Action Officers to minimize duplications in effort and variations in information assumptions. The Decision Action Officer is responsible for ensuring the information used in making the decision is preserved, such that later review of the decision-making process can be facilitated. The Decision Action Officer may designate technical staff to carry out these actions, but responsibility for providing resources and for ensuring the completion of the Decision Action Officer obligations remain with the Decision Action Officer. For some decisions, such as those made on strictly engineering bases, the Decision Action Officer and the decision maker may be the same individual.

4.3 Decision Support Board

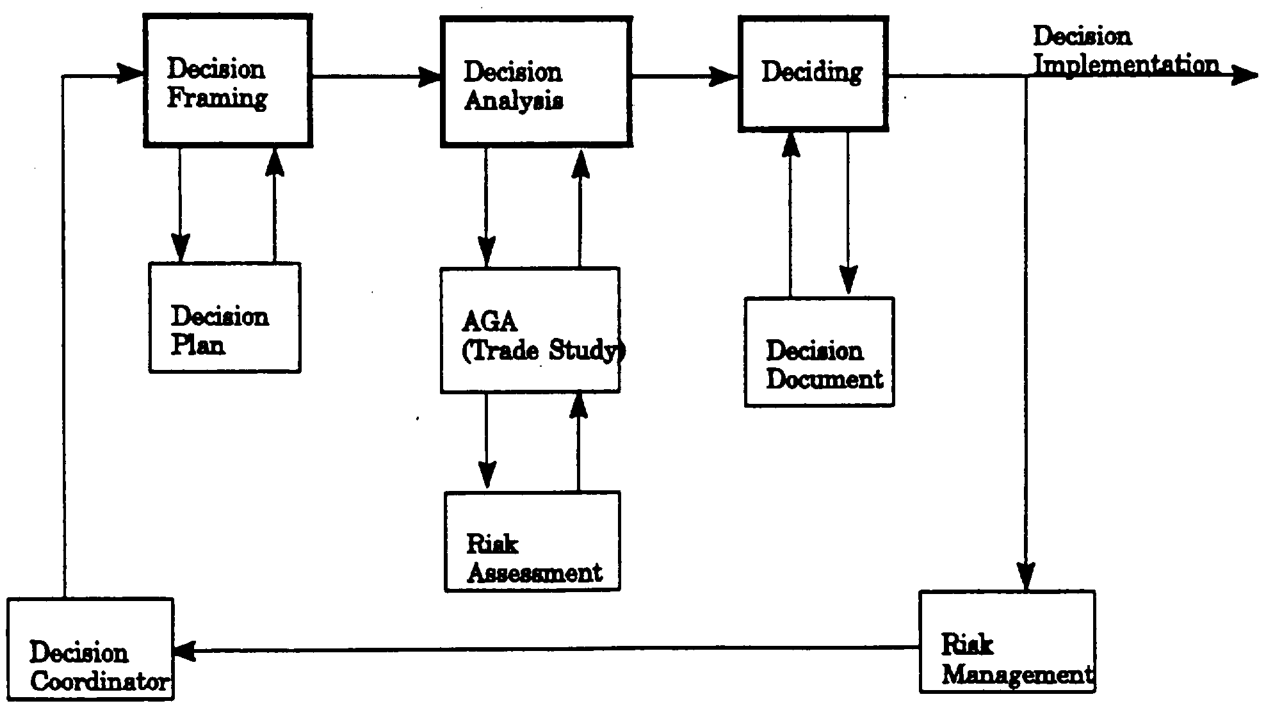
The Decision Support Board, if convened by the decision maker, shall be responsible for reviewing all relevant information and for recommending a preferred alternative. The Decision Support Board may request the Action Officer to provide additional information and detail when such information will assist in resolving differences between competing alternatives. The Decision Support Board may also make recommendations to the decision maker regarding the inclusion of additional alternatives or reframing of the decision being considered. In either case, it remains the responsibility of the decision maker to empower these modifications (through the Action Officer).

4.4 Decision Coordinator

The Decision Coordinator is NOT involved with the management of individual decisions. Instead, the Decision Coordinator provides planning and scheduling for programmatic consideration of decision interactions. The Decision Coordinator develops and maintains a comprehensive list of decisions needing to be made, examines this list for inconsistencies between identified decisions, facilitates the resolution of decisions conflicts (primarily circular logic), prepares a coordinated schedule for making decisions, and prepares and maintains an annual Decision Status Report. The intent and objectives of this report are described in Section 5.0 and a suggested format is provided in Section 6.4.

5.0 PROCEDURE

DM refers to the process of planning and managing the making of decisions. Traditionally, decision analysis techniques have been used to provide a technical and methodical approach to decision-making. A good overview of the technical process of decision-making can be found in the *TWRS Decision Guide* (PNL 1995). The elements of good decision-making, as described in the Decision Guide, are incorporated into these procedures for good DM. The DM Procedure being described here is tightly coupled to the AGA and RM processes. It is through the combination of these three procedures (DM, AGA, and RM) that the overall objectives of good decision-making are met. The figure below provides a graphical description of the interaction between the management of individual decisions, AGA, and RM. In addition to these procedures, additional guidance for considering programmatic risks in decision-making can be found in *Potential Enhancements to Addressing Programmatic Risk in TWRS* (PNNL 1996)



Management of Individual Decisions

Management of individual decisions consists of several individual, but possibly iterative, steps. These steps are intended to provide for developing, implementing, tracking, and making individual decisions. Each proposed decision needs to follow these steps to ensure both a timely and integrated DM process for an overall system. Sections 5.1 through 5.3 describe these steps for managing individual decisions.

Decision coordination is a separate activity from managing individual decisions and it requires the identification of a comprehensive set of decisions, recognition of the interactions and dependencies between these decisions, scheduling decisions according to importance and influence, and monitoring the progress/status of this set of decisions. Section 5.7 describes the processes involved in managing the complex set of decisions for the TWRS Program.

5.1 Decision Framing

The first step in the decision management process is the identificaiton of a problem for which a decision must be made. Decision framing is the process of analyzing the problem and clearly identifying and formulating the decision to be made. Framing results in the identification of a specific statement of the problem, identification of the decision criteria, and the development of preliminary notions of acceptable alternatives. Decision framing consists of two essential substeps; planning and preparation. The Decision Action Officer is responsible for implementing both the decision planning and preparation substeps.

The primary document associated with the framing activity is the decision plan.

5.1.1 Decision Planning

Decision planning involves describing the specific needs and intentions of an impending decision action. Planning consists of:

- Examining the problem and ensuring that a clear and concise statement of the issue has been developed
- Identification of a decision maker
- Identification of an Action Officer
- Determining the decision-making strategy
- Identifying methods and techniques to be used in making the decision
- Possible identification of initial alternatives
- Consideration of assumptions and constraints
- Identification of possible sources of information.

When selecting a decision-making strategy, the decision maker has two alternatives; (1) the decision maker may review the technical information provided by the AGA and directly select one of the analyzed alternatives, or (2) the decision maker may convene a decision board that considers the technical information and provides a recommended alternative. In this second case, the decision maker is still obligated to make the decision by accepting or rejecting the board's recommendation.

5.1.2 Decision Preparation

Decision preparation refers to preparing guidance information for the AGA activity (see the *Alternatives Generation and Analysis (AGA) Procedure* [Orsag 1996a]). This preparation might include describing the information and format necessary for making an informed decision. The steps involved with decision preparation should include activities such as:

- Refinement of the problem to be decided (if needed)
- Identification of any open decision issues
- Describing candidate/example decision alternatives
- Identifying appropriate units for converting decision criteria into performance measures
- Identifying analysis techniques to be used to develop acceptable, accurate, and representative technical information.

5.2 Decision Analysis

Decision analysis is the process of developing an understanding of the alternative outcomes to a decision. It is in the analysis process where all alternatives considered are measured against the relevant decision criteria. Criteria and constraints for the conduct of the decision analysis are provided by the decision-planning process. Technical guidance for the implementation of decision analysis is found in the *Alternatives Generation and Analysis (AGA) Procedure* (Orsag 1996a). During the analysis phase, DM is concerned with monitoring the progress of the analysis to ensure timely completion of the decision-making process. At the conclusion of the decision analysis effort, the Action Officer is responsible for providing a summary of the information and insight gained in the analysis to the decision maker.

5.2.1 Decision Monitoring

Decision monitoring is an ongoing activity, performed by the Action Officer, and involves maintaining an awareness of the progress of the decision analysis process. Decision monitoring involves:

- Maintaining an awareness of any sensitive or impactful events that may influence the completion of the decision-making process

- Anticipate risks associated with each event such that the Decision Action Officer can influence both the schedule and implications of the outcome of these events

- Maintain an awareness of alternative sources of information and analyses that may be used as contingency information in the event intended information sources become unavailable

- Maintain an awareness of decision schedule commitments and provide a proactive effort in meeting these commitments

- Maintain an awareness of the technology and expertise being used to develop decision supporting information such that assurances can be made that the information is of sufficient content and quality.

5.2.2 Decision Analysis Summarization

The technical information provided by the AGA often includes details that are necessary to support understanding, but are not directly useful in alternative selection. The purpose of decision analysis summarization is to format the information from the AGA so that it facilitates consideration by the decision maker. The Action Officer is responsible for summarizing the technical information. When possible, it is preferred that the executive summary of the Decision Analysis Report (from the *Alternatives Generation and Analysis (AGA) Procedure* [Orsag 1996a]) be used for this summarization. The Action Officer must determine whether the executive summary meets the decision makers needs. If not, a separate summarization will be required. The Decision Analysis Summary should present:

- General description of the problem

- General description of the analysis method used

- Each of the alternatives considered

- The results of the evaluations across all relevant decision measures

- A list of alternatives considered, but that did not receive detailed evaluation because of preliminary screening

- A tabular report of the analysis results showing the performance of each alternative on each of the decision criteria

- A narrative discussion of any apparent strengths and weaknesses for each alternative.

5.3 Deciding

The final outcome of the DM process is the selection of an alternative and the implementation of the decision. Each decision has an assigned decision maker. For many decisions, two decision makers will be needed, one representing WHC and the other representing DOE, Richland Operations Office (RL).

5.3.1 Decision Review/Declaration

The decision review/declaration step is used to consider all of the input from the decision analysis and to use this information to make a decision. The decision maker may wish to use a decision support board to broaden the consideration of decision issues prior to making a preference selection. If used, the decision support board provides a recommended alternative along with a written narrative of the rationale for the selection. The Decision Action Officer shall be responsible for recording the proceedings and results of the decision support board. On occasion, the preferred alternative may be a combination of individually evaluated alternatives. The decision maker uses the decision analysis process to determine the alternative, or combination of alternatives (synthesis), that best fits the objectives and constraints of the decision.

Once the decision maker has reviewed the decision analysis summary and has made a decision, the decision shall be communicated to the Decision Action Officer for formal documentation.

5.3.2 Decision Documentation/Closeout

The Decision Action Officer shall prepare a written account of the decision outcome. This document shall clearly identify the alternatives considered and indicate the alternative that was selected as the preferred alternative. The decision documentation shall be reviewed and signed by the decision maker to form a completed formal decision document. The documentation will:

- Describe the problem
- Describe the decision criteria used in making the decision
- Identify the decision maker and Decision Action Officer
- Document assumptions and events (based on the events described in the decision plan time table) that lead to the final decision resolution.

Once the decision document has been completed, the Decision Action Officer shall fulfill the final obligation of the decision plan by notifying the Action Officers for other impacted decisions. These required notifications should be clearly identified in the decision plan. Furthermore, any risks inherent in having selected a preferred alternative shall be passed on to individuals responsible for relevant risk management. The *Risk Management Procedure* (Orsag 1996b) should be consulted to assist in identifying RM responsibilities. Finally, the Decision Action Officer shall forward the decision document to the decision coordinator for inclusion in subsequent updates of the Decision Status Report.

5.4 Decision Coordination

Decision coordination is used to promote the logical resolution of program decisions. Decision coordination provides a framework and mechanism for demonstrating the order in which decisions need to be made. Decision coordination involves:

- Identifying a comprehensive set of decisions
- Examining the interdependencies between those decisions
- Determining which decisions need to be addressed first
- Making estimates of the time needed to complete decision actions
- Developing a schedule for addressing the decisions according to their apparent logical order and estimated time requirements
- Updating the Program Decision Status Report.

5.5 Deliverables

Four documents are generated in the DM Process. Three of these documents (Decision Plan, Decision Analysis Summary, and Decision Document) are produced in support of the management of individual decisions and responsibility for their preparation lies with the Decision Action Officer. The fourth document (Decision Status Report) results from the coordination of the overall complex set of TWRS decisions and is the responsibility of the decision coordinator. The purpose of these documents and suggested formats for the documents are presented in the attachments.

6.0 REFERENCES

Orsag, F., 1996a, *TWRS Systems Engineering Manual*, "Alternative Generation and Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996b, *TWRS Systems Engineering Manual*, "Risk Management," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

PNL, 1995, *TWRS Decision Guide*, Pacific Northwest Laboratory, Richland, Washington.

PNNL, 1996, *Potential Enhancements to Addressing Programmatic Risk in TWRS*, PNNL-11068, Pacific Northwest National Laboratory, Richland, Washington.

7.0 Attachments

Attachment A Decision Plan
Attachment B Decision Analysis Summary
Attachment C Decision Document
Attachment D Decision Maker Selection Criteria
Attachment E Decision Status Report

Attachment A

Decision Plan

1.0 STATEMENT OF THE PROBLEM

The problem statement is a concise set of words that describes the decision to be made and its associated problem(s). It clearly identifies the issue to be made by the decision action. The decision frame consists of the initial alternatives, values, information, and logic used in the analysis of a decision. Defining the appropriate frame for the decision is one of the most important steps in the entire DM process because how the decision is framed either allows or eliminates certain classes of solutions. The problem statement is often formulated as a question; for example, "What type of subsurface barrier should be adopted?" This example problem statement presumes some type of barrier is required. Assumptions that are inherent in a problem statement need to be explicitly identified as part of the overall decision frame.

2.0 DECISION CLASS

The decision class identifies the level at which a decision needs to be made. Attachment D provides guidance on determining the decision class.

3.0 RESPONSIBILITIES

3.1 Decision Maker

The decision maker must be an individual with the authority to make the decision via direct declaration of preferred alternative.

3.2 Decision Action Officer

The Decision Action Officer must be an individual with direct control over staff resources such that they are in a position to set the goals and priorities needed to implement the decision plans as scheduled. It is expected that they will designate technical staff to carry out the responsibilities of the Action Officer that are described in this procedure.

3.3 Decision Support Board (if applicable)

When used, the decision support board should consist of persons with knowledge (technical and/or non-technical) needed to appreciate any significant implications in the information contained in the decision analysis summary. For example, significant implications can cover all areas of programmatic and environmental safety and health (ES&H) risks.

4.0 DECISION STRATEGY

The decision strategy describes how the resolution of a decision is intended to proceed. The strategy needs to describe the intended use of the decision board and how the decision maker intends to integrate information developed in the analysis into a selection of preferred alternative. For example, if a parameter weighting system is to be used, the strategy section should describe the parameter weights and make some statement about how those weights were determined. If a weighting system is not used, the strategy should describe how alternatives will be examined for dominance and preference. In addition, the strategy section should explain in what form the result of the decision analysis should be presented. For example, the decision strategy should indicate whether results should be presented as a best option recommendation, as a best two or three alternatives (where the decision maker makes the final selection), or as a neutral evaluation of all alternatives considered.

5.0 DECISION CRITERIA

Decision criteria consists of information used to distinguish preference among each of the alternatives considered. The criteria must take into account those issues that are driving the initial need for the decision. For example, if the decision to be made is "Which high-level waste stabilization technology should be used?", then the decision criteria should include consideration of the objectives of waste stabilization. Other criteria (beyond those that directly relate to waste stabilization) may also be included (such as cost, schedule, etc.). These additional considerations are particularly important when they relate to impacts this decision may have on other decisions.

6.0 REQUIRED INFORMATION

Information that is required for resolution of a decision needs to be directly linked to proposed decision criteria. Information that does not provide direct insight into identified decision criteria should be avoided. For example, information describing end land uses may not have much of an impact on a decision regarding waste packaging for offsite storage. If no impact on the selection can be seen, the information should not be identified as required information. However, if the schedule for providing some target end land use requires a packaging be available within a particular time frame, then the information documenting both the anticipated end use and the impact on the packaging schedule needs to be obtained.

7.0 DECISION TIME FRAME

The decision time frame identifies the events that need to occur in order to complete the decision action. In addition, the schedule needs to identify both a minimum and maximum time frame for the completion of those events.

8.0 ANTICIPATED INTERACTIONS WITH OTHER DECISIONS

Any one decision may depend on the outcome of earlier decisions, or constrain subsequent decisions in some manner. Constraint interactions need to be documented so that appropriate notifications can be made once the decision action is completed. Dependency interactions need to be documented so that the Action Officer can monitor the progress of those constraints in a timely manner.

9.0 EXTERNAL CONSTRAINTS

Some decisions will be constrained by actions/events that occur outside of the decision-making organization. For example, a proposed decision for the TWRS Program is to "Determine the Disposition of Hanford Tank Waste". While a position on this issue needs to be clearly identified, the actual selection of a preferred alternative will be constrained by the options allowed by a Hanford Final Environmental Impact Statement. The decision plan needs to document constraints such as these.

10.0 CURRENT PLANNING BASIS/ASSUMPTIONS

The TWRS Program has adopted a strategy of identifying a planning basis for each impending decision. This planning basis is intended to provide interim information while a preferred alternative is being selected. To facilitate this concept of advanced planning, the planning basis for each decision needs to be documented along with the other information describing the pending decision. If the decision action selected is not consistent with the planning basis, it becomes essential that the Decision Action Officers for all affected decisions be notified of the change in planning basis.

The decision maker may also make assumptions such as the performance characteristics of a process or the circumstances under which the outcome of the decision will be implemented. These assumptions constrain the applicability of any subsequent analysis and decision-making. Such necessary assumptions need to be made during the planning process and documented as part of the decision plan.

Attachment B

Decision Analysis Summary

Many of the sections of the decision analysis summary are taken from the initial decision plans. They are included in the Decision Analysis Summary so that the document can stand alone and be used as the basis for decision deliberations. Care must be taken to ensure information is consistent among all decision documentation.

1.0 STATEMENT OF THE PROBLEM

Same as in the decision plan.

2.0 DECISION ISSUES

Documenting decision issues is a continuation and refinement of the decision framing activity. Open issues are identified for clarification and/or study. Uncertain boundary limits are resolved and dependencies on other decisions are addressed. Key assumptions and the basis for making those assumptions are documented. Important definitions used in the framing the decision are considered decision issues and should be documented as part of this section.

3.0 DESCRIPTION OF ALTERNATIVES CONSIDERED

Each alternative to be considered should be sufficiently described to clearly indicate how that alternative meets the needs of the decision action.

4.0 DECISION CRITERIA

Same as in the decision plan.

5.0 ALTERNATIVES EVALUATIONS

This section describes how each alternative was evaluated across all of the decision criteria. It is often convenient to display this information as an alternatives matrix. One axis of the matrix represents one of the considered alternatives. The other axis represents decision criteria. Each cell within the table then represents how that specific alternative was evaluated with regard to a particular decision criterion.

In addition to the alternatives matrix, this section should provide a discussion of any dominant and subordinate alternatives. Furthermore, this section should briefly describe any alternatives that were dropped from detailed evaluations because of early screening of criteria. The description should contain all assumptions and evaluations used in the early screening.

Attachment C

Decision Document

1.0 STATEMENT OF THE PROBLEM

Same as in the decision plan.

2.0 DATE OF SELECTION

This is the date the formal decision document is signed by the decision maker.

3.0 DECISION MAKER

Same as in the decision plan. In addition to identifying the decision maker, the decision document must contain an appropriate signature block for the decision maker to use in formalizing the decision and a block for obtaining DOE concurrence (when applicable).

4.0 DECISION ACTION OFFICER

Same as in the decision plan.

5.0 ALTERNATIVE SELECTED

This section should contain a brief but concise description of the selected alternative. The description needs to be sufficiently detailed to distinguish it from any similar, but not selected, alternatives.

6.0 DECISION CRITERIA

This is a brief listing of the criteria used to distinguish among alternatives. Reference can be made to the decision analysis summary for a detailed description of each criterion.

7.0 ASSUMPTIONS

List only key assumptions that are based on outside constraints or other related decisions.

8.0 ALTERNATIVES REJECTED

This section consists of a simple list of rejected alternatives considered but rejected. Reference to the decision report can be used to explain why each alternative was rejected.

Attachment D

Decision Maker Selection Criteria

The following criteria should be used to assist in determining the relevant decision makers. Five decision levels are identified within the TWRS Program. Each level requires a different level of responsible decision maker. The level of decision can be shifted upward to a higher level decision maker, if that higher level decision maker determines the issues and impacts of the impending decision warrant such a shift. Delegation of decisions to a lower level of decision maker does not relieve the original decision maker of their ultimate decision responsibility.

Criteria for Determining Responsible Decision Makers

Decision Level	Criteria	WHC Decision Maker	Parallel DOE Concurrence
Class I	• 4.2.X functions and above • Significant complex-wide program or cost impacts • Sitewide program or cost impacts	WHC President	DOE RL Manager
Class II	• 4.2.X functions and above • Overall impacts to TWRS Program or TWRS budget • Impacts to other onsite programs	Level 1 Manager	TWRS Program Manager
Class III	• 4.2.X.X functions • Cost or program impacts to only 1 TWRS program element	Level 2 Manager	Division Director
Class IV	• 4.2.X.X.X functions • Cost or program impacts to only 1 TWRS program element	Level 3 Manager	Program Manager
Class V	• 4.2.X.X.X.X functions • Impacts to single organizations work scope only • Impacts technical task budgets	Level 4 Manager	N/A

Attachment E

Decision Status Report

1.0 INTRODUCTION

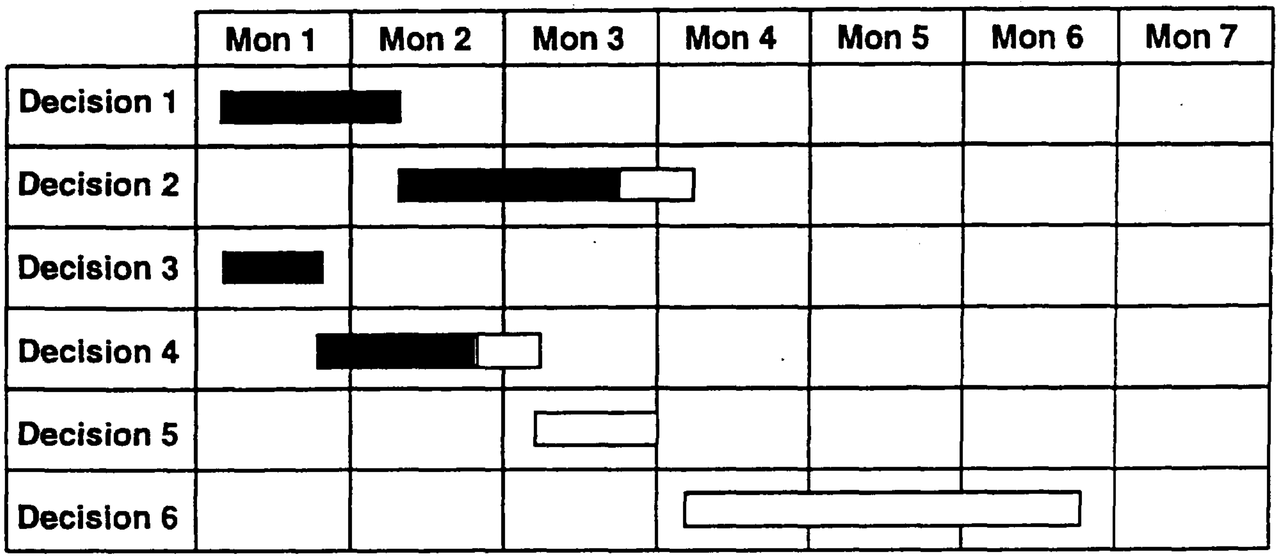
The introduction should provide the reader an understanding of the intent and organization of the report. Also, the introduction should provide the background needed to understand how decisions are identified and validated as needing made, how conflicts are identified and resolved, and how this information is translated into a decision schedule. Finally, the introduction should address the issue of annual updates versus periodic notification of significant progress or change in status.

2.0 DECISION DESCRIPTIONS

This section contains a comprehensive set of required decisions. The purpose of the descriptive information is to provide the insight needed to understand decision scheduling implications and constraints. As decisions are completed, their descriptions should be removed from this sections and the corresponding decision documents should be added to Section 4.0 of the status report. The descriptions should address issues such as the need for the decision and the dependencies and influences on other decisions. Also, estimates for any schedule and timing constraints should be included.

3.0 DECISION SCHEDULE

The decision schedule is an ordered list of decisions needing resolution. The schedule identifies the order in which decisions need to be made, provides a graphical display of decision progress, and where possible shows the time frame in which decision-making is required. The figure below provides and example of a decision schedule. The schedule shows completed decisions (Decisions 1 and 3), decisions in progress (Decisions 2 and 4), and pending decisions (Decisions 5 and 6). This portion of the status report will be update as necessary to reflect ongoing changes in the decision schedule and status.



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Sample Decision Schedule

4.0 DECISION DOCUMENTS

This sections contains a compendium of completed decision documents (see Sections 5.1 and 6.3). Additionally, notification of completed decisions may be made informally at the time the decision document is completed.

5.0 ATTACHMENT

Attachment E-1 Relationship Between Decision Management, Alternative Generation and Analysis, and Risk Management Procedures

Attachment E-1

Relationship Between Decision Management, Alternative Generation and Analysis, and Risk Management Procedures

This attachment contains a description of the mechanisms of decision coordination. The purpose of this attachment is to provide information regarding how to participate in the process of identifying and validating the development of the comprehensive list of decisions.

TITLE:

INTERFACE CONTROL

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to establish requirements and responsibilities for interface control and to describe the interface control process in the Tank Waste Remediation System (TWRS) Program. Interface control is required by the *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)* (WHC 1996). The purpose of interface control is to document and manage agreements of shared responsibility for: (1) transfer of energy, data, or materials, and (2) common physical elements between facilities, subsystems, or parts within a system. Agreements of shared responsibility for transfer of energy, data, or material typically involve internal and external organizational interfaces, which are developed through negotiation and documented in a Memorandum of Agreement (MOA) or an Interface Agreement (IA). Agreements of shared responsibility for common physical elements (i.e., physical interfaces) between facilities, subsystems, or parts are documented as Interface Control Documents (ICD).

The end objective of interface control is to ensure that structures, systems, components, and organizations fit and function together. Interface control is particularly important when system or component design is accomplished concurrently by different organizations, often in different locations. Interface control facilitates communication and understanding of technical requirements across boundaries.

The systems engineering process transforms a mission into well-defined functions, requirements, architectural concepts, and finally, the physical systems that carry out the mission. As an integral part of the systems engineering process, interface control accomplishes its objective by:

1. Identifying interfaces and responsible parties to participate in interface development at the earliest stages of a program or project.

2. Identifying interface type and functional and physical characteristics.

3. Identifying the functional and physical requirements and constraints of an interface.

4. Employing a rigorous, disciplined approach for developing and approving interfaces.

2.0 SCOPE

This procedure applies to development of new systems to accomplish the TWRS mission. It also applies to existing systems, including those being modified to meet mission requirements and those that continue in use without modification. Interface control begins with identification of external interfaces during mission analysis and continues throughout the engineering life-cycle of the system. External interfaces include TWRS Program interfaces with other site organizations or functions, the U.S Department of Energy (DOE), Richland Operations Office (RL) and its contractors, and other DOE complex-wide organizations. Interface control includes documentation and development of interfaces and approval of interface documentation. Effective development of interfaces requires coordination with other systems engineering processes such as functional analysis, requirements allocation, and project definition. The graded approach contained in Appendix A of the SEMP shall be used to determine the extent and level of detail required during the application of this procedure.

3.0 DEFINITIONS

1. Interface A functional or physical system boundary between two or more organizations, subsystems, or end items, across which energy, data, or materials pass.

4.0 RESPONSIBILITIES

Mission analysis (MA) and functions and requirements (F&R) analysis teams are responsible to prepare documentation for interfaces identified during MA and F&R analysis activities. These teams are responsible for submitting scope sheets and ICDs to the appropriate level TWRS Interface Control Working Group (ICWG) for review and approval per this procedure and the ICWG Charter (Attachment A). TWRS Technical Integration is responsible for integrating the TWRS Program technical baseline. The TWRS ICWG is chartered to provide this technical baseline integration at the program level and has responsibilities as detailed in the ICWG Charter. The TWRS ICWG ensures development of external interface scope sheets and ICDs, ensuring that interface development is consistent with technical baseline development efforts. TWRS Project Managers are responsible to understand and define their organizational interfaces and to document those interfaces (MOAs/IAs) necessary internal to their project.

5.0 PROCEDURE

5.1 Process Overview

Interface documentation takes different forms depending on the stage of development and on the type of interface. The three forms of interface documentation used are: (1) scope sheet, (2) MOA/IA and, (3) ICD. All initial functional interfaces captured on scope sheets are, as system development progresses, categorized as either physical, program, or project interfaces and are described in ICDs, or as organizational interfaces, and described in MOAs/IAs. Interfaces are communicated using one of numerous graphical techniques like N-squared diagrams or Functional Flow Block Diagrams (see *Functions and Requirements (F&R) Procedure* [Orsag 1996b]).

Scope sheets are used to capture all interfaces in early stages of system development beginning with MA. Because architectures have not yet been fully developed and only functional relationships are known, scope sheets will typically describe interfaces in functional terms.

Physical interfaces between structures, systems or components, or between programs or projects are documented as ICDs. An ICD describes the physical interface between two architectures that will be controlled by a system specification. The ICD controls the development of both sides of the physical interface and becomes a single repository for interface requirements. The system specifications take requirements from the ICD, and the design process details a system that meets those interface requirements.

ICD development and coordination are accomplished through the activities of the ICWG. During interface development, issues may be recognized as needing resolution. Interface issue resolution for internal TWRS interfaces is the responsibility of the ICWG. If an issue connected with an internal TWRS interface cannot be resolved in this manner, the issue and supporting documentation will be subjected to the TWRS Decision Management (DM) process, specifically the Decision Coordinator. An open issue will be resolved via the DM process and will be closed when the ICWG receives the Decision Document indicating resolution. Interfaces between TWRS and external entities require negotiation between the TWRS ICWG and a parallel group representing the external entity. If an issue cannot be resolved in this manner the issue and supporting documentation will be subjected to the Hanford Site interface control group for resolution.

TWRS manages internal and external organizational interfaces. Internal TWRS organizational interfaces may be defined and communicated through organization charts based on workscope or in MOAs/IAs as needed. TWRS interfaces with external activities and organizations are developed through negotiation and documented in MOAs/IAs as necessary. General guidelines for developing an MOA/IA are provided in Attachment D.

5.2 Prepare Scope Sheets

Scope sheets are prepared for the system external interfaces generated by the MA effort. If there is no MA, known program and project interfaces should be documented on scope sheets. For a project that was started prior to program generation of a Design Requirements Document, scope sheets are prepared for project interfaces identified in the project MA (see *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)*, Table 2-2 [WHC 1996]). A suggested format for scope sheets is in Attachment B. The scope sheet content may vary depending on the detail of functional analysis involved. As a minimum, the scope sheet should be assigned a control number, include the interface name and the scope, and should identify the organizations responsible for the interface and any issues relating to the interface. Scope sheets are designated supporting documents per WHC-CM-6-1 (*Standard Engineering Practices*), EP 1.12, and WHC-IP-1026, (*Engineering Practice Guidelines*). They are signed by the participants with cost, schedule, and technical responsibilities for their respective programs or projects, and are submitted to the ICWG for review. By signing, they acknowledge that issues, definitions, and responsibilities identified in the scope sheet are sufficient and complete for the current level of design maturity.

5.2.1 Approval of Scope Sheets

Scope sheets are approved by the ICWG in accordance with the ICWG Charter. The approvers of a scope sheet acknowledge their responsibility for further development of the interface. Therefore, it is expected that negotiation between applicable programs/projects will be conducted to reach agreement on the definition of responsibilities, requirements, and open issues. Any change to the technical baseline as a result of these negotiations must be approved per WHC-CM-6-1, *Standard Engineering Practices* EP-2.2, "Engineering Change Control Requirements."

5.3 Categorize Interfaces

After initially describing interfaces on scope sheets, and as system development continues, interfaces are categorized as one of the following: (1) physical interface (includes program-to-program and project-to-project), (2) TWRS-to-site organizational interface and, (3) TWRS-to-external organizational interface. Physical interfaces will be described in ICDs as system development continues; and organizational interfaces will be documented as MOAs.

5.4 Prepare Interface Control Document

As system development progresses and architectures are selected, ICDs are prepared to describe the physical interfaces between structures, systems, and components, and the requirements and constraints on them in more detail. ICDs should be prepared by personnel knowledgeable in the technical aspects of the systems that share the interface. Once the requirements have been completely allocated per the F&R procedure the design implementation of the interfaces can procede. The specific design solutions between systems and facilities involving the mechanical, electrical, and timing aspects of material/energy transfer are developed as the interface evolves. As more detailed ICDs are developed they become attachments to higher level ICDs. For a given scope sheet, there may be more than one associated ICD; for example, one dealing with the mechanical interface, one with the electrical, etc. ICDs may be drawings or narrative documents, or a combination of the two. A recommended ICD format is contained in Attachment C. Drawings that are part of the ICD shall be prepared in accordance with WHC-CM-6-3, *Drafting Standards Manual*, and EP-1.3, "Engineering Drawing Requirements", WHC-CM-6-1, *Standard Engineering Practices*. Interface drawings should not be used for construction, fabrication, or maintenance. ICDs are designated supporting documents per WHC-CM-6-1 (*Standard Engineering Practices*), EP 1.12, and WHC-IP-1026, (*Engineering Practice Guidelines*). They are signed by the participants with cost, schedule, and technical responsibilities for their respective programs or projects, and are submitted to the ICWG for review. By signing, they acknowledge that the interface scope of definition, and requirements/constraints identified in the ICD are sufficient and complete for the current level of design maturity.

5.4.1 Approval of ICDs

ICDs are signed as required per Section 5.4 and submitted to the ICWG for review and approval. ICDs are forwarded to the TWRS Decision Coordinator as necessary for issue resolution per Paragraph 5.1 above. After issue resolution and ICD approval by the ICWG, ICDs are released as supporting documents.

5.5 Prepare Memorandum of Agreement

Organizational interfaces are documented in MOAs/IAs using guidance provided in Attachment D. The MOA/IA should contain as a minimum, system requirements, the involved organizations, and their points-of-contact, and documentation sufficient to fully understand the interface. Issues connected with the interfaces are documented in the MOA as needing resolution.

5.5.1 Approval of MOAs

MOAs/IAs are approved per the guidance in Attachment D and WHC authorization and approval practices.

6.0 REFERENCES

Orsag, F., 1996a, *TWRS Systems Engineering Manual*, "Decision Management," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996b, *TWRS Systems Engineering Manual*, "Functions and Requirements Allocation and Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

WHC, *Drafting Standards Manual*, WHC-CM-6-3, Westinghouse Hanford Company, Richland, Washington.

WHC, *Standard Engineering Practices*, WHC-CM-6-1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995, *Engineering Practice Guidelines*, "Successful Systems Engineering for Engineers and Managers," WHC-IP-1026, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A Interface Control Working Group Charter
Attachment B Scope Sheet Format
Attachment C Interface Control Document Format
Attachment D Memorandum of Agreement General Guidelines

Attachment A

Interface Control Working Group Charter

1.0 INTRODUCTION

The *Tank Waste Remediation System (TWRS) Systems Engineering Management Plan* (SEMP) (WHC 1996) directs the TWRS Program to implement technical interface control, and to establish Interface Control Working Groups (ICWGs) to "maintain cognizance and control of TWRS functional and physical system interfaces." The mission of the ICWG does not end with the completion of project development. Interface control, throughout the life-cycle of the system, is essential to ensure that changes to system interfaces are reviewed and approved to support the TWRS configuration management program.

1.1 Purpose

This charter establishes the TWRS program level Interface Control Working Group and provides a top-level framework for project level ICWG organizations. It's specific purposes are to:

1. Define the ICWG roles and responsibilities.
2. Identify program ICWG membership.
3. Identify approval requirements for ICD release and revisions.

1.2 Scope

This charter describes the establishment and operating process of the TWRS Program ICWG. The scope includes all technical interface development activities for all baselines identified and developed by the TWRS Systems Engineering effort.

TWRS project level ICWG organizations will follow the interface control procedures and processes described here. Particulars of project level ICWG membership and operations are not within the scope of this charter. However, this information can be used as guidance.

2.0 INTERFACE CONTROL WORKING GROUP OBJECTIVES

The purpose of the TWRS ICWG is to establish an interface structure for the TWRS program consistent with the systems engineering process. The ICWG will review all proposed program level interfaces and interfaces between projects for technical adequacy.

The TWRS ICWG will review and approve scope sheets and ICDs in coordination with development of the TWRS Technical Requirements Baseline (TRB). The ICWG will further oversee the development of scope sheets and ICDs based on the development of lower-level interfaces via the functional decomposition process.

ICWG approval of a scope sheet or ICD does not constitute authority to implement interface changes. The ICWG will make technical recommendations to the TWRS Change Control Board (CCB) or other cognizant configuration management organizations for implementation of all program level scope sheets, ICDs, and revisions. Revisions to scope sheets and ICDs will be approved per the change control procedure in WHC-CM-6-1, EP 2.2.

Coordination between interface development and control, and systems engineering processes such as functional decomposition, requirements allocation, and project definition is essential. The ICWG will ensure that scope sheets and ICDs development track with the corresponding baseline development efforts and documents. The ICWG will also ensure that scope sheets and ICDs provided to projects meet all requirements for initiating the development of project-level scope sheets and ICDs.

The TWRS ICWG will report directly to the Director and Chief Engineer, TWRS Engineering. The ICWG will coordinate with Hanford Site interface control efforts to ensure integration of TWRS external interfaces with onsite and offsite DOE activities.

3.0 ORGANIZATIONAL ROLES AND RESPONSIBILITIES

3.1 U.S. Department of Energy (DOE), Richland Operations Office (RL)

The RL Manager of Office of Tank Waste Remediation System will assign a representative to participate in TWRS ICWG proceedings as a non-voting member.

3.2. Hanford Management and Operations Contractor

3.2.1 Hanford Site Systems Engineering

Hanford Site Systems Engineering will provide a voting member to the TWRS ICWG who is responsible to ensure external interface issues and applicable documents are coordinated, addressed, and satisfied. The site representative provides a site-level view of interface issues and concerns.

3.2.2 Tank Waste Remediation System

3.2.2.1 TWRS Design Authority

3.2.2.1.1 Chairperson

The Manager of TWRS Design Authority will act as or assign a designated voting member as chairperson of the ICWG.

3.2.2.1.2 Interface Control Administrator

This is a non-voting position within the ICWG. The Interface Control Administrator (ICA) will provide administrative support to the ICWG. The ICA will also provide tracking of the scope sheets and ICDs.

3.2.2.2 TWRS Disposal Program

The TWRS Disposal Program Office will provide one voting member who will ensure program participation in the interface control process, including handling of scope sheets and ICDs and participation in ICWG meetings. Individual Program Offices will review, discuss, and defend interface changes for systems under their cognizance.

3.2.2.3 TWRS Technical Integration

TWRS Technical Integration (TI) will provide one voting member to the ICWG to function as co-chairperson. Responsibilities of the Co-Chairperson are to assume Chairperson responsibilities when required, and ensure satisfactory operation of the ICWG. Other responsibilities include ensuring thorough technical review of all applicable scope sheets and ICDs.

3.2.2.3.1 Systems Engineer

A TWRS Systems Engineering representative will be a permanent voting member of the ICWG. His responsibilities are to support the chairperson for all interface control activities under the chairperson's cognizance. He will also ensure that systems engineering principles are properly applied to the interactions of the ICWG.

3.2.2.4 TWRS Tank Farm Transition Projects

TWRS Tank Farm Transition Projects (TFTP) will provide one voting member to the ICWG who is responsible for ensuring operational considerations for interfaces and applicable documents are addressed and satisfied. The TFTP representative will ensure participation by cognizant operations department personnel when required.

3.2.2.5 TWRS Characterization Project

TWRS Characterization Project (CP) will provide one voting member to the ICWG who is responsible for insuring CP considerations for interfaces and applicable documents are addressed and satisfied. The CP representative will ensure participation by cognizant CP personnel when required.

3.2.2.6 TWRS Technical Representative

A senior-level TWRS Technical Representative will be a permanent voting member of the ICWG. This individual must have a breadth of knowledge in the TWRS technical baseline and will ensure interfaces are defined consistent with the technical baseline.

4.0 ICWG MEMBERSHIP

The ICWG members (primary and authorized alternates) will be identified and formally documented, and such documentation will remain on file with the ICWG chairperson or a designated alternate. The members will attend ICWG meetings and address, discuss, and answer any questions that arise during each meeting. They may delegate their authority as they deem necessary. Additional members may be assigned as the board members find necessary to disposition scope sheets and ICDs and related change proposals.

5.0 MEMBERSHIP RESPONSIBILITIES

5.1 ICWG Chairperson

The chairperson is responsible for all aspects of the interface control process within TWRS. In particular, the chairperson will:

1. Preside over ICWG meetings.

2. Ensure the necessary resources are available to adequately review and disposition proposed changes.

3. Obtain scope sheet and ICD agreements and signatures and resolve discrepancies for:

    - Scope sheet and ICD need, preparation, and revision
    - Scope sheet and ICD requirements application

4. Assign an individual to the position of Interface Control Administrator.

5.2 Interface Control Administrator

The Interface Control Administrator (ICA) is responsible for supporting the ICWG chairperson and members by facilitating the interface control process. The responsibilities include:

1. Ensure the timely routing of scope sheets and ICDs for review.

2. Schedule ICWG meetings.

3. Prepare and issue ICWG meeting agendas.

4. Assemble the scope sheet and ICD packages (initial or changes) and send them to each member of the ICWG for consideration.

5. Attend the ICWG meetings, maintain attendance records, write and issue meeting minutes.

6. Track information pertinent to scope sheet and ICD status and content.

7. Coordinate with WHC Configuration Management.

8. Maintain a central file for copies of scope sheets and ICDs and related change requests and ECNs.

5.3 ICWG Members

ICWG members will attend meetings or provide a knowledgeable alternate. Their duties include:

1. Review and evaluate proposed scope sheets and ICDs and related changes for technical accuracy and programmatic impacts to cost, schedule, and technical baselines.

2. Recommend final disposition of scope sheets and ICDs.

3. Coordinate additional reviews internal to their area of responsibility.

4. Identify approval requirements for release of and revisions to scope sheets and ICDs.

6.0 ICD APPROVALS

The ICWG shall approve all new functional or programmatic level scope sheets and ICDs prior to release and all revisions to existing interface documents which required Change Control Board action as well as all new interface documents or revisions to existing ones which impact key Westinghouse Hanford Company (WHC), RL, headquarters (HQ) or Tri-Party Agreement (TPA) milestones whether or not Change Control Board action is required. Approvals for all other new interface documents or changes to existing ones may be delegated by the ICWG to project level ICWGs or technical staff members as they determine to be appropriate.

7.0 EXTERNAL INTERFACE AGREEMENTS

Where appropriate, the ICWG should enter into agreements with programs, projects, or facilities external to TWRS to establish the procedure for coordinating the review and approval of changes to an interface that may impact TWRS activities. Such agreements will be in concert and cooperation with the Hanford Site interface control efforts.

8.0 RECORDS

Records should be maintained in accordance with WHC-CM-1, Company Policies and Charters. Records disposition is defined below:

Name (Filing Unit Title or Description)	Record Type	Retention Period	Disposal Authority*	Cutoff and Retirement Instructions
Records of establishment, organization, membership, policy	R	Destroy 2 years after ICWG disbands.	GRS 16	Retain while ICWG is active; then, send to permanent records storage facility.
Documentation of key decision points	R	Destroy 2 years after ICWG disbands.	GRS 16	See above.
Agenda, minutes, final reports, records of accomplishments, others	R	Destroy after 3 years or when no longer needed.	GRS 16	See above.

*R - record material; GRS - General Records Schedule

9.0 REFERENCES

WHC, 1995, WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.
EP-1.3, "Engineering Drawing Requirements"
EP-1.6, "Engineering Data Transmittal Requirements"
EP-1.7, "Engineering Document Approval and Release Requirements"
EP-1.12, "Supporting Document Requirements"
EP-2.2, "Engineering Document Change Control Requirements"

WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Attachment B

Scope Sheet Format

Interface Number:	A control number assigned by the ICWG for tracking and identification purpose.
Interface Title:	Must match interface title in F&R database.
Participants:	Identifies the functions affected by the interface and other information from the F&R database as necessary to adequately describe scope of interface. Includes: 1. Graphical representations of the interface as appropriate (e.g., N-squared diagrams). 2. Interface characteristics 3. Functional requirements and constraints.
Issues:	Describes interface issues (if any) and analyses required to resolve the issues.
Approvals:	

Attachment C

Interface Control Document Format

1.0 Introduction/Scope

2.0 Applicable Documents

3.0 Requirements

- 3.1 Functional Description
- 3.2 Interface Requirements
  - 3.2.1 Software Requirements
  - 3.2.2 Hardware Requirements
- 3.3 Environmental Requirements
- 3.4 Quality Assurance Requirements

4.0 Appendices

Attachment D

Memorandum of Agreement General Guidelines

The purpose of this guideline is to provide concise, consistent and useful Memorandum of Agreement (MOA) and Interface Agreements (IA). The following sections have been developed using previously prepared MOAs/IAs and lessons learned from their implementation. Each MOA/IA should apply a graded approach as to its content, but should, at a minimum, consider the following topics. This guideline does not prescribe the order of the topics but only the content.

System Requirements - Establish the high-level requirements or need for the MOA/IA. Address why the action is being taken and the system level DOE/WHC requirement being met by the action (e.g., Pathforward, 4.7 Deactivation, etc.).

<u>Participating Organization(s)</u>. The MOA/IA should identify the organizations, companies, or agencies involved or directed by the MOA/IA.

<u>Point-of-Contact</u>. Each MOA/IA should identify the Point-of-Contact group within an organization which will coordinate the interfaces and information exchanges.

<u>Quality Assurance</u>. An overall quality assurance (QA) approach should be considered for the effort. If a formal QA Plan has not been implemented for the actions described in the MOA/IA, then specific acknowledgement of QA-related topics should be addressed for each of the areas discussed in the MOA/IA.

<u>Responsibilities</u>. The MOA/IA should identify both internal and external interfaces to the level of detail necessary to complete the transaction. This includes responsibilities for material, funding, documentation, personnel, equipment, etc. Some items to consider include the following:

> <u>Documentation</u>. Describe the type of engineering/legal documentation required to complete the transaction. Include which organization(s) will prepare, review, maintain (configuration management), fund, and approve the documentation. Also specify the timing and logistics of the documentation transfer.
>
> <u>Data</u>. Describe the type and pedigree of the data required for the task (e.g. characterization reports, packaging, and spent nuclear fuel (SNF) data, etc.). Specify which party(s) is required to prepare, approve, and disposition the required data and prescribe the quality requirements. Also specify at what point the information is to be provided.
>
> <u>Turnover/Custody</u>. Address both the programmatic and physical custody of the material. Include definition of responsibilities as applicable to safeguards and security. Also describe the timing and logistics of

material, documentation, and data transmission to the receiving/sending organization and the method of transport if not provided by the SNF Project.

Funding/Financial Obligations. Assign funding or financial responsibility for all scopes of work within the tasks. Also briefly discuss how change control will be implemented and if there are known uncertainties, who has financial responsibility.

Personnel. Describe which organization's personnel will perform tasks within the activity. Include operators, HPTs, and other required personnel. Also include which organization(s) will prepare/provide/approve the work procedures and/or instructions to complete the action(s).

Equipment. Describe the interface equipment required to complete the transaction (e.g., storage or transporting casks, if not provided by the SNF Project, etc.). Also describe which organization will approve the use of the equipment, provide the equipment, purchase the equipment (which includes procurement plans and controls), operate the equipment, and maintain the equipment until the completion of the activity.

Surveillances. Describe the surveillances that will be performed throughout the activity. If the MOA/IA is written prior to this information being available, the MOA/IA should establish what document/mechanism will be used to define these requirements.

External Interface Requirements. Identify other external requirements, MOA/IAs, and agreements that are necessary to complete the transaction.

Changes. Address how changes to the agreement will be submitted and approved.

Signatory Level. Describe the signature level required to approve the MOA/IA. This may include approval of the MOA/IA at the DOE-RL level and may include other higher level WHC signatures than the organizations involved in the MOA/IA.

Dispute Resolution. Uncertainties and omissions in the MOA/IA could lead to disputes which result in delays that potentially affect other downstream activities in the SNF Project. It is, therefore, critical to have the ability to settle disputes in a timely manner. Dispute resolution should consist of upper-level management stakeholders that have the authority to resolve the dispute and provide the direction/assistance required to satisfy the resolution.

TITLE:

LIFE-CYCLE COST

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this procedure is to provide guidance for conducting a life-cycle cost (LCC) analysis and for preparing a LCC analysis report. It is utilized per the *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)* (WHC 1996) in support of alternatives evaluation and cost management and is applied in accordance with the graded approach in *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)* (WHC 1996), Appendix A.

2.0 SCOPE

This procedure applies to the evaluation of alternatives and decision-making within the Tank Waste Remediation System (TWRS) over the complete life-cycle of the system including final disposal. LCC analysis is done to support alternatives evaluation (AGA process), life-cycle decision-making and management. Throughout TWRS system development and acquisition, systems operation and maintenance, and finally, system disposal, many decisions will be made that will have life-cycle implications. Below are some possible applications of LCC analysis:

- Alternative system design configurations
- Alternative procurement source selection for a given item or system
- Alternative system operations concepts
- Alternative system maintenance concepts
- Alternative logistic support plans
- Alternative D&D scenarios.

LCC analysis can significantly improve decision-making if utilized to support such alternatives evaluation work. LCC analysis should be employed when determining total costs for major projects. Decisions regarding systems development, made during early conceptual stages, have potentially great impacts on the system LCCs. As illustrated in Attachment A, 60 to 70 percent of the projected LCC of a system is committed during early conceptual design, even though actual project expenditures are minimal at that point. Attachment B illustrates that most of system LCC is in the Construction and Operation and Support areas. System alternative selection, in the early preconceptual stage has a major impact on the cost of later phases. Using LCC analysis ensures costs connected with all life-cycle phases of the system are understood and factored into decisions.

3.0 DEFINITIONS

1. Alternatives Candidate technical design strategies or approaches that potentially satisfy the functions and requirements.

2. Analogy Estimating An estimating technique that can be used when the new item has functions, physical, and performance characteristics similar to an existing item. Costs on the similar item can be gathered and modified appropriately to account for any difference in configuration. This technique can be used to calibrate a parametrically derived estimate, but is more easily performed for components than systems.

3. Bottom-up Estimating Bottom-up estimating is performed one of two ways. One method requires each organization and group involved in the development and production of a system to estimate their costs. Each organization or group may use separate cost bases such as manpower forecasts, experience, and cost estimating texts. The results are totalled and combined with overhead, general, administrative expense, and contract fees to arrive at an estimate for the system cost. The second method uses a work statement and a set of drawings with specifications to "take off" material quantities required to construct the system. From these quantities, direct labor, equipment, and overhead costs are derived and added. While bottom-up estimates are accurate and supportable, they are also labor intensive and time consuming.

4. Common Cost Basis The cost estimate re-expressed in terms that take into account the time value of money. This is especially important when comparing alternatives that have life cycles lasting many years.

5. Conceptual Design Cost Estimate This cost estimate is based on all the detailed requirements in the Functions and Requirements (F&R) Database, such as the design parameters, applicable codes, specifications, and standards. Quality assurance (QA) requirements, space requirements, Conceptual requirements, methods of performance, operations interfaces, and safety requirements are some that should be considered.

6. Contingency An amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties. The amount of the contingency will depend on the status of design, procurement, and construction and the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost.

7. Cost Baseline A budget that has been developed from the cost estimate resulting from the designation of a configuration baseline. The cost baseline is referred to as a baseline, because it is integrated with the technical and schedule baselines and subject to formal change control.

8. Cost Breakdown Structure (CBS) The CBS is a breakdown of cost in functional terms. All costs are broken out to the level required for the necessary estimating.

9. Cost Estimate A documented statement of costs estimated to be incurred to complete the project. Cost estimates provide a baseline against which cost comparisons are made during the life of a project.

10. Cost Model A model that facilitates the LCC evaluation process. The model may be a simple series of relationships or a complex set of computer subroutines, depending on the phase of the system life-cycle and the nature/scope of the program/project.

11. Cost Profile The system cost, in dollars, for each year in the life-cycle of the system.

12. Cost Target The target cost that has been established for the system or part of the system.

13. Direct Cost Any cost that can be specifically identified with a particular project or activity, including salaries, travel, equipment, and supplies directly benefiting the project or activity.

14. Discounting This is a method of expressing future cash flows (positive or negative) in terms of equivalent present values. This allows alternatives with different time/cost profiles to be compared directly.

15. Escalation A time-related change in the cost of labor and materials required to produce a given unit of work output.

16. Feasibility Studies Cost Estimate This cost estimate is based on the project's purpose, general design criteria, significant features and components, proposed methods of accomplishment, proposed construction schedule, conceptual requirements, and any other pertinent cost experiences.

17. Figure Of Merit (FOM) Ratios of system parameters that can be used in the comparison of alternatives.

18. Fixed Cost The part of the cost that does not change with the number of units produced or volume (e.g. building rent, property tax).

19. Indirect Cost A cost incurred by an organization for common or joint objectives that cannot be identified specifically with a particular project or activity.

20. Life-Cycle Cost (LCC) The sum total of the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the conceptual, production and construction, operation and support, and disposal of a major system over its anticipated useful life span. Where system or project planning anticipates use of existing sites or facilities, restoration and refurbishment costs should be included.

21. Net Present Worth/Value (NPV) The value/worth of an alternative re-expressed in present values, calculated using discounting.

22. Parametric Cost Estimate A type of cost estimate that involves developing and utilizing estimates of relationships between historical costs and system physical and/or performance characteristics. The historical costs used in the estimate reflect the impact of system growth, engineering changes, project stretch-outs, and any other cost, schedule, or performance difficulties encountered in comparable projects. This method of estimating, in addition to providing the primary basis for conceptual system project planning, also provides an early test of the reasonableness of later project estimates. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance. The analysis produces cost equations or cost estimating relationships that can be used individually or grouped into more complex models. This method is the basis of many cost estimating models available as software and can be performed very quickly for simple systems.

23. Project Management Cost Estimate This cost estimate is based on costs encountered from the functions of project management, management of procurement, QA, health and safety, and safeguards and security associated with a specific project.

24. Sensitivity Analysis A technique for determining how sensitive the cost estimate is to inaccuracies in estimation. The estimate is recalculated with changes to a specific variable(s) to see how much the overall estimate changes. The increased availability of sophisticated inexpensive computers has made this generally practicable.

25. Work Breakdown Structure (WBS) A hierarchial (tree) structure that organizes in a logical relationship work to be accomplished. The work can be related to producing products or services. The structure relates work elements to each other and to the end product or service. The WBS results from the systems engineering efforts that completely define the program or project.

4.0 RESPONSIBILITIES

The TWRS engineering organization (responsible for the development and analysis of alternatives) should do the following:

- Obtain, from the customer and the project/program office, the definition and scope of the alternatives for the LCC analysis.
- Assemble and support the LCC analysis team.
- Ensure the input documentation, tools, and materials for the LCC analysis are available.
- Conduct the technical review of LCC cost analysis.
- Ensure proper reviews and approvals of the LCC analysis reports.
- Ensure that the LCC analysis report is made available for tracking of actual costs, as historical information, and for any other purposes.

The responsibilities of the LCC analysis team are to:

- Select, in coordination with the responsible organization, the method of LCC analysis most appropriate in a given situation.
- Perform the LCC analysis.
- Write the LCC report.
- Address and resolve review comments before approval and release of the LCC analysis report and revisions.

5.0 PROCEDURE

The LCC for a system is the summation of all the costs associated with that system, from its initiation to its disposal. This LCC can be used in the comparison of different system alternatives and/or as information for cost management. LCC analysis can be used in the evaluation of whole systems/projects or for parts of the system/project, e.g. in the evaluation of make or buy options. LCC analysis is applicable to acquisition and construction projects.

LCC analysis is used whenever system costs are calculated, especially when decisions are to be made between alternatives. The SEMP graded approach requires LCC analysis to be carried out for SE levels 1, 2, and 3, (the SEMP does not require full documentation for level 3).

The LCC analysis, being part of the overall systems engineering process, is iterative in nature and, therefore, will be continually updated or revised as often as needed during the life-cycle of the system. The process starts with establishing a baseline LCC (initial LCC estimate) followed by subsequent revisions. The level of detail and complexity of each revision reflects the nature/scope of the update such as the degree of design changes or the amount of data that become available. The overall LCC analysis process is described in this section. The format for the LCC report is provided in Attachment E.

During the concept phase of a project the LCC analysis may be used to determine target cost FOM. If a design-to-cost approach is to be used on the project then the LCC becomes one of the design parameters. At this early stage of the project much of the estimating will be done using parametric methods. Parametric cost estimating is often based on "rules of thumb," which relate cost drivers and system parameters.

As the design evolves alternatives are considered. The LCC analyses are performed for each alternative with the objective of ensuring that alternatives are compatible with the established cost targets and determining which is the preferred alternative from a cost-effectiveness standpoint. As more complete design information becomes available the cost estimates can be developed by comparing the characteristics of the new system with similar systems where historical cost data are recorded. This is called analogous cost estimating. Finally, as the system design configuration becomes firm, design data (drawings, specifications, parts lists, etc.) are produced that enable detailed engineering and manufacturing estimates to be done.

Limitations of LCC analyses include:

- Estimating early in the life of a project when the degree of accuracy has a broad range

- The high cost of performing the LCC analysis may not be appropriate for all projects

- A high sensitivity to changing requirements

There are many factors that can affect the accuracy/reliability of an LCC analysis, such as;

- Omission of data
- Misinterpretation of data
- Wrong or misused estimating techniques
- Failure to assess uncertainty
- Estimating the wrong items
- Incorrect or inconsistent escalation data.

The completion of the LCC analysis requires certain specific steps be followed in a progressive, as well as iterative, manner. The analysis process is shown diagrammatically in Attachment C. The preliminary action is to establish the purpose and scope of the analysis and to assemble the required inputs. As shown in the diagram the next steps are to develop the cost breakdown structure and then develop a model of the estimate. As shown there will be an interaction with the cost analyst during this step. Once the estimate is complete then the results need to be analyzed and compared before the report can be produced.

5.1 Preliminary Actions

The responsible organization will accomplish the following preliminary actions prior to starting the LCC analysis:

a. Define the purpose and scope of the LCC analysis and determine where the LCC information will be used, e.g., cost monitoring, historical LCC database, decision management, Engineering Change Notices (ECNs), Multi-Year Program Plan (MYPP); and establish how the information will be made available.

b. Assign the LCC analysis task to a performing organization, and assemble the LCC team.

c. Obtain and maintain the required resources.

d. Gather supporting documentation and references.

The organization responsible for performing the LCC analysis will identify the analysis team and provide the required resources to support the analysis. The size and composition of the LCC analysis team, the duration of the activities and the resources required depend on the level of complexity of the project to be analyzed. The LCC analysis team will include personnel with broad technology, management and systems engineering experience in the disciplines required to perform the analysis. Cost Analysts and other specialist expertise will be available to the team as required.

The supporting information usually includes;

- Figures of Merit (FOM) and cost targets
- F&R analysis results
- Decision Document
- Previous LCC analysis report (for second or subsequent iterations)
- Cost Data
- Breakdown data (Work Breakdown Structure)
- Discount/Escalation rates/policy
- Mission Analysis
- Baseline System Description
- Risk Management Lists

When the LCCs for alternatives are to be compared, the Systems Engineer must ensure that the same cost data (labor rates, escalation policy, discount rates, etc.) and assumptions are used for each alternative. Possible sources of cost data are the Multi-Year Program Plan (MYPP) and the site contractor (for labor rates and construction costs). When a LCC analysis is complete the results should be made available to all TWRS projects.

The approach taken for the LCC analysis depends upon the status of the project and the purpose of the analysis. Where the purpose is to evaluate alternatives for only a part of the system/project then if the rest of the system is unaffected the analysis need only address that part of the system.

The choice of computer programs (if any) and models to support the analysis should be determined before it begins.

5.2 Develop Cost Breakdown Structure

The cost breakdown structure (CBS) is defined as a breakdown of cost in functional terms. The CBS is a mechanism to help ensure that all cost elements for a system are identified and included in the cost estimate. All future costs associated with activities throughout all phases of the system life cycle must be included, and costs must be broken out to the depth required to provide the necessary visibility relative to different elements of the system and/or different program activities. The work breakdown structure developed for the system may serve as an outline for the LCC analysis.

The cost categories in the CBS must be clearly defined so that there is no confusion about what each category/element is. There should be a coding system for the CBS which helps the Systems Engineer in the examination of particular areas (e.g. engineering design costs) or types of cost (e.g. producer costs, supplier costs). It is important to be able to identify the capital costs and the operating costs.

Estimated or actual costs of the four phases (Pre-Concept and Concept, Construction, Operation, Shutdown) are required. Although a system may be in the Concept phase, the cost associated with construction, operation and shutdown must be projected to complete the LCC analysis. Phase costs may be generated by different groups within an organization.

As the life-cycle of the system progresses the LCC will be reviewed and updated. In the early stages of the concept phase, target figures of merit (e.g. cost vs performance, reliability vs maintainability, etc.) are established to which the system should be designed. As the system moves into the preliminary design phase, alternatives will be generated and their LCCs calculated to provide information for the management selection decision. (Note the LCC information is just one of the pieces of information needed to support management selection decisions.) As the system goes through detailed design the cost estimates become more detailed and accurate and this is reflected in the LCC.

During the Pre-Concept and Concept phase of a system, the LCC effort focuses on identifying cost drivers, evaluating relative LCC differences among alternatives, identifying resource needs, and starting to develop estimates supporting the conceptual design report. During the early Concept phase, the analysis process emphasizes development of a LCC estimate for each alternative. During the later part of the Concept phase, the LCC baseline cost estimate previously established must be refined including converting resource needs to costs.

During the construction, operation and shutdown the analysis process tracks the actual costs against the projections from previous estimates as input for any required design modification(s). LCC analyses associated with modifications to the existing design would be treated as part of the SE process implemented for the modification. Different groups within an organization may perform the estimating and tracking functions.

The remainder of this section gives an initial breakdown of the cost areas associated with each phase. (For an example of a detailed Cost Breakdown structure see Blanchard & Fabrycky 1990).

5.2.1 Pre-Concept and Concept Phase

This phase includes the general areas of investigation for which both projected and actual costs are obtained. The following list includes some of the major cost categories for the pre-concept and concept phase, these are broken out further until the level is reached where an estimate can be done.

- Program planning - Mission Analysis, feasibility studies, project management
- Requirements Definition - Functions and Requirements Document, Technical Requirements Specifications, Design Requirements Documents
- Program research - applied research, research facilities
- Design/technical baseline development - SE, and specialty discipline support (e.g., Environmental Regulatory Integration) conceptual through final design, design support, review
- Engineering Design - preliminary and detailed
- Documentation - Startup and Operations, Preliminary safety Analysis Report
- Software
- Test and evaluation - planning, testing facilities, models and/or prototypes, test and evaluation, data/reports
- Management.

5.2.2 Construction Phase

Although this is referred to as the Construction phase it could be acquisition rather than construction for some projects. For this phase, projected and actual costs are obtained, depending upon the status of the project. Although the following list appears to be detailed, significantly more cost breakdown is required.

- Production/construction/acquisition management
- Industrial engineering and operations analysis - plant, manufacturing and methods engineering, production control, sustaining engineering

- Manufacturing - facility, tooling/test equipment, fabrication, material, sub assembly/assembly, inspection, packing, shipping, inventory warehouses
- Construction - mobilization/demobilization, preconstruction requirements, construction maintenance facilities, training, inventory warehouses
- Initial logistics support
- Safety analysis - Final Safety Analysis Report, Technical Safety Requirements
- Pre-operative, acceptance testing
- Changes and modifications - As-built drawings and documents.

5.2.3 Operation Phase

This is the phase in a systems life-cycle where a large proportion of the cost is determined. Care must be taken to ensure that all cost factors are identified and estimated accurately. This is a basic list of the cost categories for this phase which needs further decomposition for each system.

- Life-cycle management
- Operations - operations, facilities, personnel, energy/utilities/fuel, surveillance, and other testing
- Distribution - transportation, handling, warehousing
- Maintenance - customer service, production control, field maintenance, factory maintenance, test and support facilities, maintenance facilities
- Spares and material support - spare parts, storage and handling, inventory management
- Operator and maintenance training - operator training, maintenance training, training facilities, data
- Technical data
- Procedures maintenance
- Management.

5.2.4 Shutdown Phase

This is the final phase in the life of a system, but can be the source of considerable costs. This is a basic list of categories that needs to be expanded for each system.

- Disposal of non-repairable or non-salvageable elements
- Material recycling
- Retirement - personnel, support equipment, transportation, and handling facilities
- Documentation
- Management.

5.3 Develop Model

After the development of the cost breakdown structure, a model should be developed to use in the LCC evaluation effort. The cost model can be a limited set of relationships, simple computer routines, or an extensive computer program. The model should be developed based on the scope and purpose of the LCC analysis.

Life-cycle costing is a sum of the various cost categories or activities indicated by the CBS. The model is used to evaluate a system in terms of total LCC, as well as the cost of individual activities. A model can be developed for each individual activity, as needed, and then the cost associated with the individual activities can be combined in a LCC summary model. The cost for an individual activity can be analyzed or used, as necessary. The individual models can be different for each of the activities. For example, maintenance costs may be analyzed based on operations and maintenance concepts, failure rates, and mean time-to-repair factors, while engineering design costs can be estimated based on a set of engineering cost projections.

5.4 Develop the Estimate

In developing cost data for a LCC analysis, the cost analyst should initially investigate all possible data sources (data banks, initial system planning data, supplier documentation, reliability and maintainability predictions, logistic support analyses, test data, field data, etc.) to determine what data is available for direct application. If the required data is not available the cost analyst selects the most applicable estimating method.

Where there is income, e.g. from the sale of an asset during the Shutdown Phase, it is included in the estimate.

5.4.1 Cost Analysis Methodology

This is included as information to assist the Systems Engineer in understanding the task. The cost estimating will usually be performed by a Cost Engineer using the appropriate Cost Engineering procedures.

There are many costing methods available (Blanchard & Fabrycky 1990). Common techniques used to perform LCC analyses are:

- Parametric analysis
- Analogy
- Bottom-up
- Other (trend analysis, expert opinions, etc.).

The choice of a specific costing technique is not limited to the above. At each iteration of LCC analysis, more than one cost estimating technique may be used and the method will be matched with design maturity.

The trend analysis technique involves derivation of a contractor efficiency index by comparing originally projected contract costs against actual costs on work performed to date. The index is used to adjust the cost estimate of all remaining work, and cannot therefore be used at the beginning of the system.

Expert opinion estimating may be used when other techniques or data are not available. Several specialists are consulted interactively until a consensus cost estimate is established.

All LCC analyses should include contingency. Contingency represents the risks associated with cost, schedule, and technical issues. Contingency funds are to cover <u>only</u> the presented work scope. The rationale or process details used to determine the contingency shall be documented.

5.4.2 Common Cost Basis

A cost profile (Attachment D) is developed to analyze and compare different alternatives. Using CBS, activities are identified and related to a specific cost category, appropriate cost factors are used to project the costs into the future as shown in (a). The costs are summarized by major cost categories as in (b) and a system cost profile (c) is developed. The cost profile represents an estimate of future budget requirements. Figure (d) shows the graphical comparison of three alternatives that need to be compared on a economic analysis basis to determine the lowest total LCC.

In order to be able to compare alternatives with different cost profiles, all the costs need to be reduced to a common basis. In LCC analysis, both escalation and discount rates must be considered. The usual method for doing this is the net present worth method. In this method, costs are estimated in current dollars, escalated to the time when they would be spent, and then corrected to a present worth using a discount rate. Attachment F contains an example LCC analysis which uses discounting and escalation. Care must be taken when using both escalation and discounting since "nominal discount" rates include escalation, (nominal discount rate = real discount rate + inflation rate).

Escalation is especially important for systems with a long life-cycle and where the estimate is part of the cost baseline. Inflation can be one cause of escalation (or cost growth) other possible reasons include :

- Engineering changes occurring throughout design and development
- System supplier or availability changes
- Production and/or construction changes
- Support or industry capability changes
- Initial inaccuracies in estimates
- Customer needs, or governing regulations changes.

Discounting is done to take account of the time value of money, i.e. a dollar today is worth more than a dollar in a year's time. Discounting is important when comparing alternatives which have different cost profiles, e.g., one may have a high concept cost and a low operating cost and the alternative could have a lower concept cost but higher Shutdown cost. Figure (d) of Attachment D shows examples of different profiles where discounting was imperative to determine the true lowest LCC. By discounting the costs for both alternatives the costs can be compared on a common basis. When comparing the results of a LCC analysis to the previous results care must be taken to ensure that the same cost basis is used for both iterations of the LCC analysis.

5.5 Evaluate the Analysis Results

The LCC is an input to Management for decision making and/or cost management. The Systems Engineer performing the LCC analysis must evaluate the results to ensure that the information is accurate enough for its purpose.

The Systems Engineer should review the validity of the stated assumptions, adequacy of input data, inclusions and exclusions. Any areas of risk or uncertainty need to be identified and a sensitivity analysis done to determine the effects of variations in those areas have on the LCC. The Systems Engineer should identify the high cost contributors (those which contribute more than 10% of the total cost) and determine the cause-and-effect relationships and input cost factors that directly impact these costs.

When the LCCs for alternatives are being compared the Systems Engineer compares the cost profiles to determine at what points in time which alternative is the preferred one (cumulative cost profiles can be useful for this). When there is a cross-over point between alternatives towards the end of the life-cycle the analyst must ensure that the accuracy of the estimate is adequate to support a decision, if not this must be stated in the report. The Systems Engineer compares the alternatives against the target figures of merit for the project, e.g. there maybe a trade-off between reliability and LCC.

If this is the second (or subsequent) iteration of the LCC analysis the results should be compared with the earlier version. The reasons for any differences should be established and any need for corrective action identified. This comparison serves to help validate the new analysis and can help make future similar estimates more accurate.

5.6 Life-Cycle Cost Analysis Documentation

The LCC analysis reports document the outcome of the LCC analyses. Attachment E gives the recommended layout for the contents of a LCC analysis report. Supporting figures or data tables, definitions, and references may be included as appendices to the main report. Each general phase (Pre-Concept and Concept, Construction, Operation and Shutdown) of the life-cycle must be addressed in the corresponding LCC analysis report for the system being analyzed.

Section 2, the summary, may be used separately from the rest of the report a management information document so care must be taken to include all information required for decision support.

These reports are part of the cost baseline and support the technical baselines. The LCC analysis report will be revised with each iteration of the analysis.

The LCC Analysis report shall be designated as a supporting document per WHC-CM-6-1. A TWRS document listing shall be generated and maintained to show this document relative to its predecessors, supporting and successor documents.

6.0 REFERENCES

Blanchard, B.S. and Fabrycky, W.J., 1990, "Systems Engineering and Analysis," Second Edition, Prentice Hall, Englewood Cliffs, New Jersey.

Blanchard, B.S., 1991, "System Engineering Management," John Wiley & Sons, Inc.

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DOE Order 430.1, Life Cycle Asset Management, U.S. Department of Energy, Washington, D.C.

DOE Cost Estimating Guide, Volume 6 Cost Guide, November 1994, revision 0. FM-50

NISTIR 4481, 1991, The NIST "Building Life-Cycle Cost" (BLCC) Program, Version 3, (Sponsored by The Federal Energy Management Program, DOE).

WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

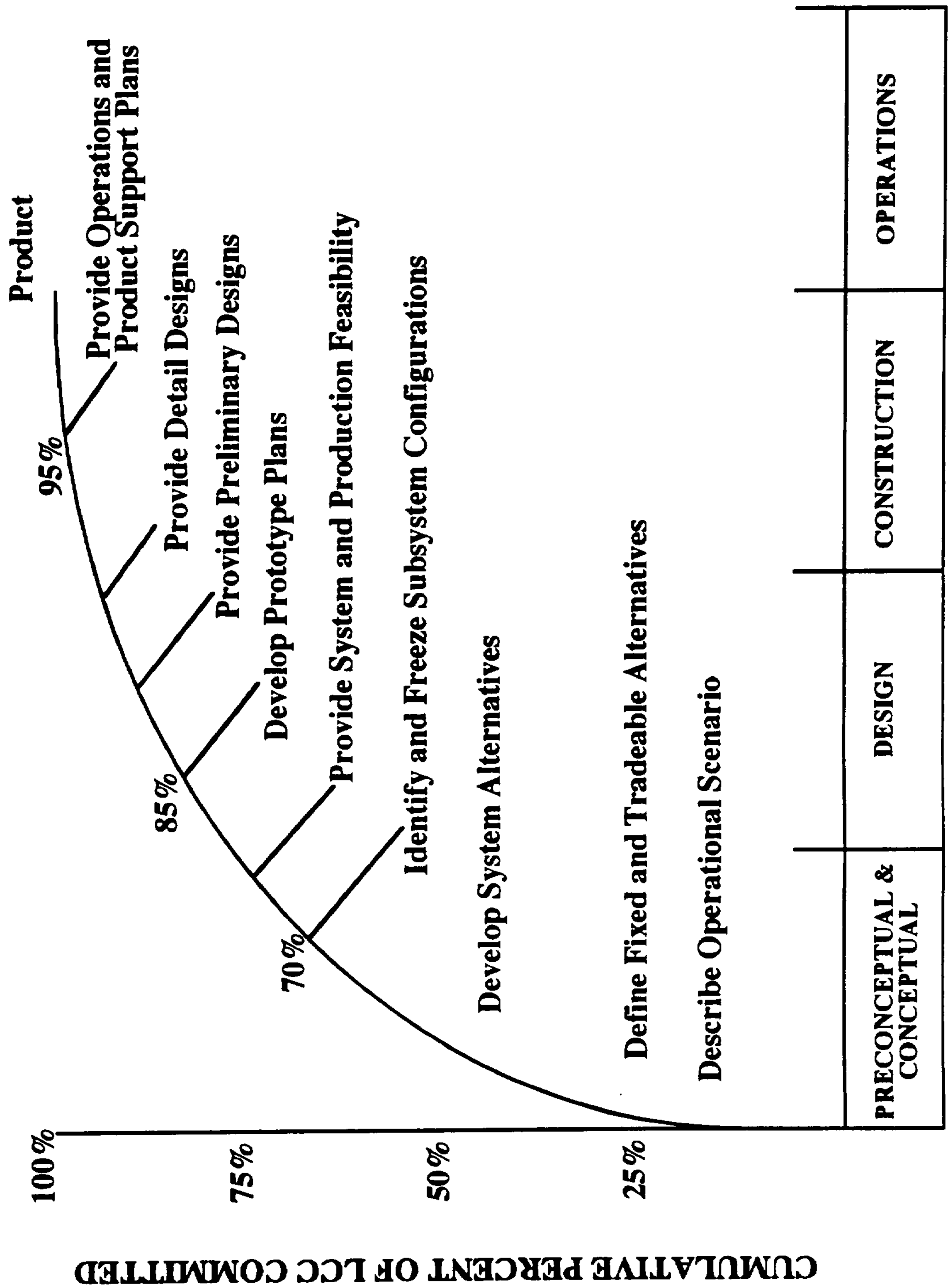
WHC-CM-6-1, Standard Engineering Practice
EP-1.1, Rev. 6, "Engineering Document Identification Requirements."
EP-1.12, Rev. 8, "Supporting Documents Requirements."

7.0 ATTACHMENTS

Attachment A Actions Affecting Life-Cycle Costs
Attachment B Life-Cycle Cost Profile for System Acquisition
Attachment C Life-Cycle Cost Process
Attachment D Development of Cost Profiles
Attachment E Example of Life-Cycle Cost Analysis Report Table of Contents
Attachment F Life-Cycle Cost Example
Attachment G Life-Cycle Cost Analysis Background

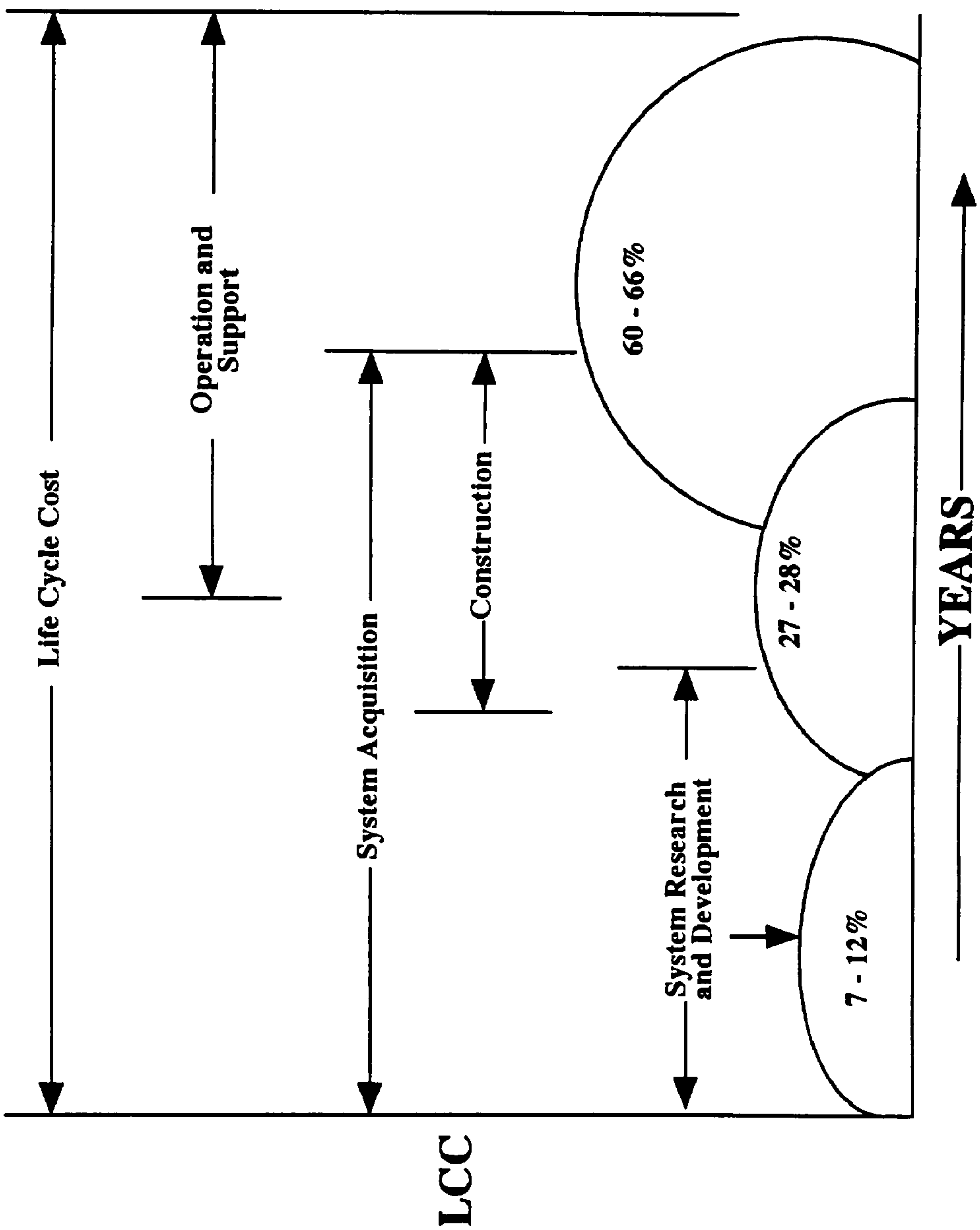
Attachment A

Actions Affecting Life-Cycle Costs
(From DOE Cost Estimating Guide)



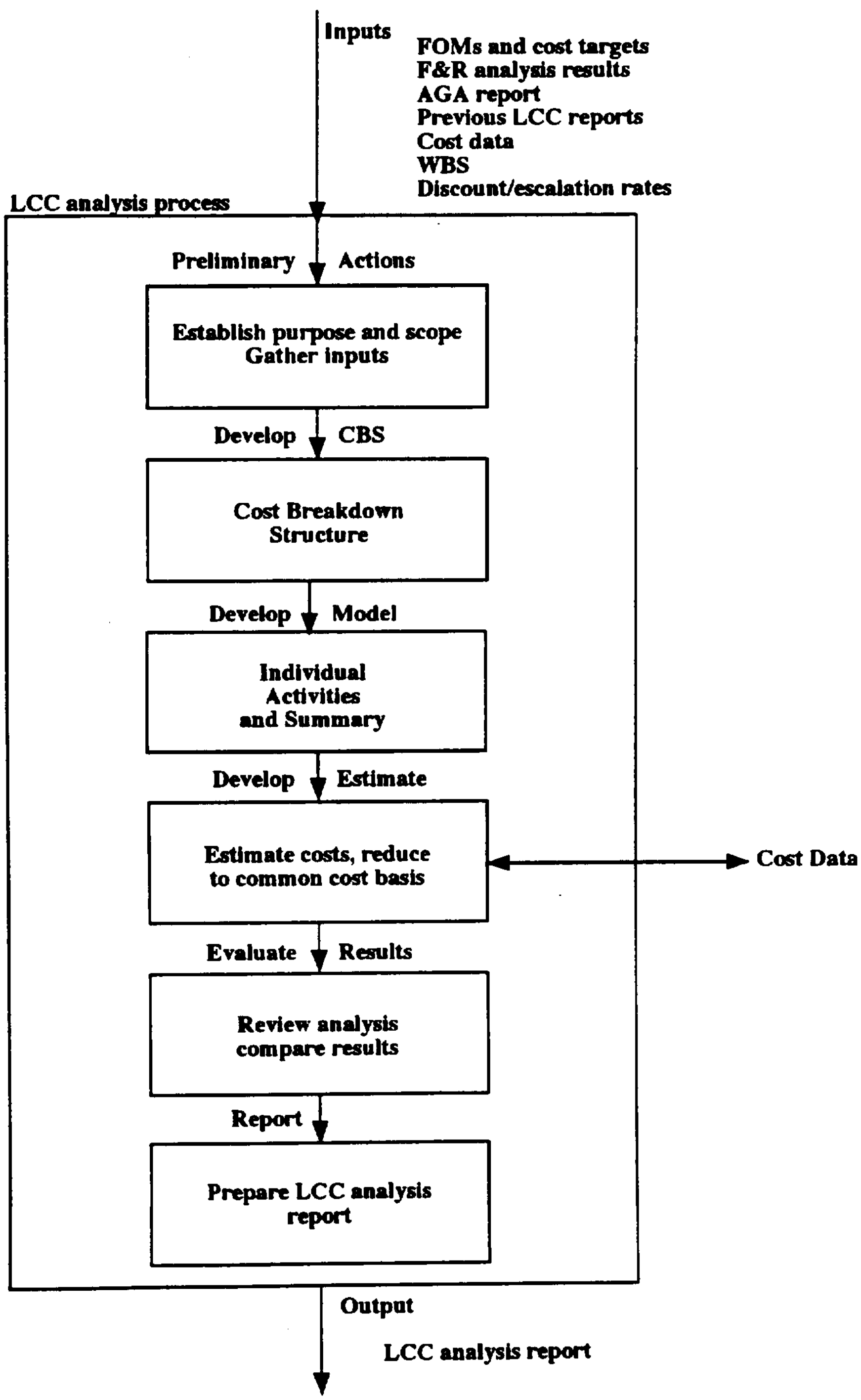
Attachment B

Life-Cycle Cost Profile for System Acquisition
(From DOE Cost Estimating Guide)



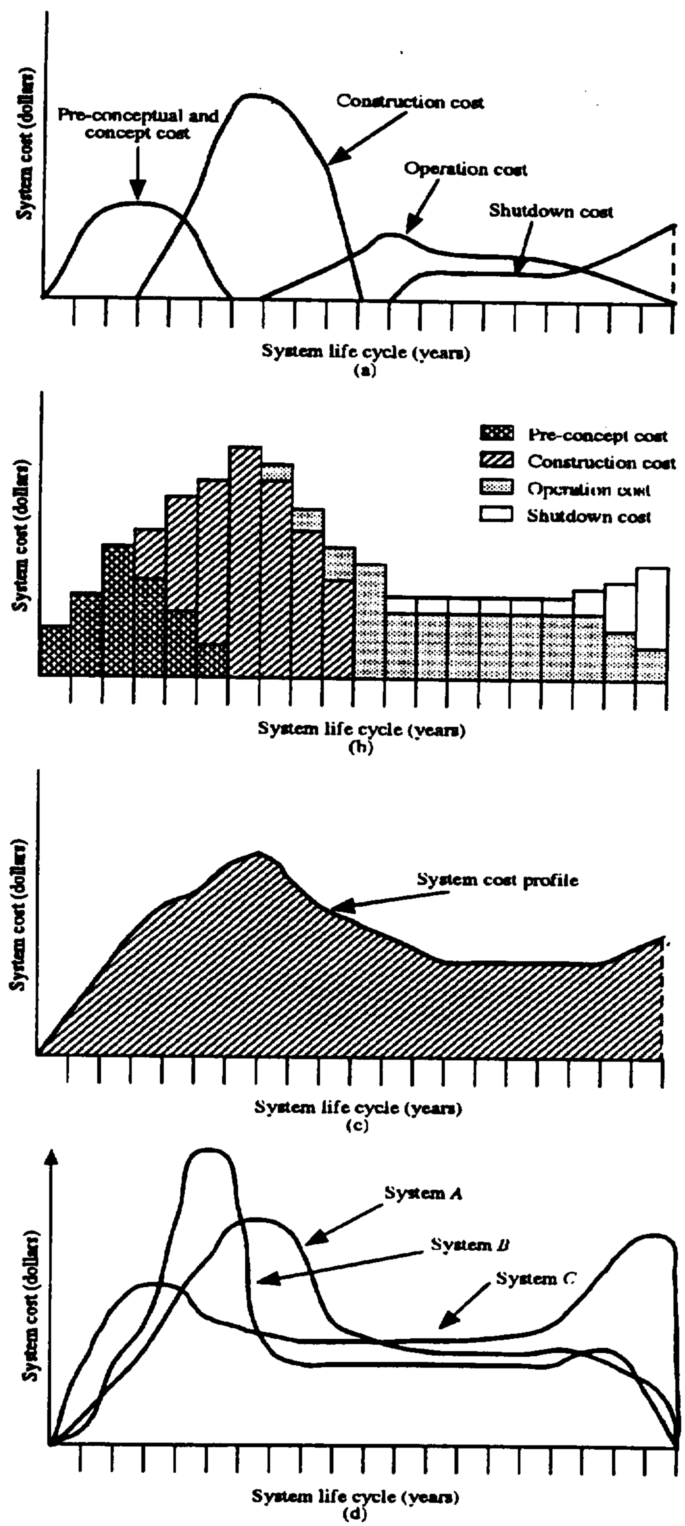
Attachment C

Life-Cycle Cost Process



Attachment D

Development of Cost Profiles



Attachment E

Example Life-Cycle Cost Analysis Report Table of Contents

The following is the suggested outline for a Life-Cycle Cost Analysis Report. An abstract briefly describing the content of the report may be included.

1.0 INTRODUCTION
- 1.1 Purpose
- 1.2 Scope
- 1.3 Background

2.0 SUMMARY OF ANALYSIS
This section needs to contain a summary of all the information pertinent to management decision support.
- 2.1 For each alternative
  - Basic assumptions
  - Cost Profile
  - Figures of merit
  - High cost contributors
  - Areas of risk or uncertainty
  - Sensitivity
- 2.2 Comparison
  A matrix/table can be used to document the alternatives.
  For alternatives highlight the differences, with reasons.
  For prior LCC analysis highlight the differences with explanations and if appropriate any need for corrective action.

3.0 LIFE-CYCLE COST ANALYSIS
- 3.1 Inputs and Sources of information, with version numbers (note this may just be references to other reports)
- 3.2 LCC Approach
  - 3.2.1 Methodology
  - 3.2.2 Inflation, Discounting, Contingency, Assumptions
- 3.3 System Costs for Each Phase for each alternative (This includes the data and source(s) of data, estimating method as applied to data, and the results of the estimating procedure.)
  - 3.3.1 Pre-Concept and Concept
  - 3.3.2 Construction
  - 3.3.3 Operation
  - 3.3.4 Shutdown

4.0 REFERENCES

TABLES
FIGURES
APPENDICES (as needed)

Attachment F

Life Cycle Cost Example

This example (see page 21) is taken from the Cost Estimating Guide, Volume 6, November 1994.

G. Example LCC Analysis

The purchase of an automobile is given as a short simplified example of LCC analysis.

1. **Definition of Scope:**

   Buyer wants to purchase an automobile

   Buyer has sufficient funds to purchase an automobile up to $25,000

   Definitive features are miles per gallon, estimated salvage value, costs of licenses and inspections, insurance, and estimated maintenance costs.

2. **Assumptions:**

   All money is spent at the end of a year for a given year

   Buyer will trade the car in after four years

   All models use the same grade of gasoline at $1.25 per gallon

   The user drives 22,000 miles per year

   Discount rate is 10 percent

   Prices escalate 4 percent per year

   Insurance costs escalate 3 percent per year

   Salvage value is in dollars at the time of salvage.

3. **Data collected:**

   CAR A: Purchase price of the car is $17,000, fuel usage is 24 miles per gallon, recommended maintenance is every 5,000 miles or 3 months, the average maintenance cost is estimated to be $250, and salvage value is $8,000.

   CAR B: Purchase price of the car is $24,000, fuel usage is 26 miles per gallon, buyer would receive a dealer's special service package which would give him free maintenance and service for the four years with unlimited mileage, and the salvage is $14,000.

CAR C: Purchase price of this used auto is $13,000, fuel usage is 15 miles per gallon, recommended maintenance is every 10,000 miles or 6 months and initial cost of $800 is estimated to remedy some problems, the average maintenance cost is estimated to be $350, and the salvage value is $5,000.

CAR D: Purchase price of the car is $11,000, fuel usage is 18 miles per gallon, recommended maintenance is every 7,500 miles or 5 months and the average maintenance cost is estimated to be $125.00. The salvage value is $4,500. Installation cost of natural gas system is $3,200.

The following can be summarized:

	CAR A	CAR B	CAR C	CAR D
Purchase price	$17,000	$24,000	$13,000	$11,000*
Salvage value	($8,000)	($14,000)	($5,000)	($4,500)
Miles/Gallon	24	26	15	18
Miles Btwn Tune ups	5,000	5,000	10,000	7,500
Insurance/Year	$950	$1,350	$800	$700

SOLUTION:

Initial cost	$17,000	$24,000	$13,000	$14,200
Salvage	($6,010)	($10,518)	($3,757)	($3,381)
Total Annual Costs (4 Yrs)	$11,595	$8,805	$12,243	$8,489
TOTAL	$22,585	$22,287	$21,486	$19,308

* Plus $3,200 initial cost of system.

From this LCC analysis, Car D is the most economical for the buyer. From this simplified LCC analysis its benefits and purpose can be recognized.

SUPPORTING CALCULATIONS FOR ANNUAL COSTS:

For converting the future values to Present Worth, a Uniform Capital Recovery (UCR) factor will be applied. Using 10 percent rates the UCR for the years 2, 3, and 4 are as follows:

UCR Year 2 (one year of capital recovery) $$\frac{1}{(1 + .1)^1} = .9091$$

UCR Year 3 (two years of capital recovery) $$\frac{1}{(1 + .1)^2} = .8264$$

UCR Year 4 (three years of capital recovery) $$\frac{1}{(1 + .1)^3} = .7513$$

FUEL

CAR A: 22,000 miles/24 miles per gallon = 917 gallons x $1.25/gallon = $1,146 for year one

	Action Costs		Present Worth
$1,146 for year one		x 1	= $1,146
$1,146 x 1.04	= $1,192 for year two	x .9091	= $1,084
$1,192 x 1.04	= $1,240 for year three	x .8264	= $1,025
$1,240 x 1.04	= $1,290 for year four	x .7513	= $969
Total - Car A:	$4,868		$4,224

CAR B: 22,000 miles/26 miles per gallon = 846 gallons x $1.25/gallon = $1,058

	Actual Cost		Present Worth
$1,058 for year one	= $1,058 for year one	x 1	= $1,058
$1,058 x 1.04	= $1,100 for year two	x .9091	= $1,000
$1,100 x 1.04	= $1,144 for year three	x .8264	= $945
$1,144 x 1.04	= $1,190 for year four	x .7513	= $894
Total - Car B:	$4,492		$3,897

CAR C: 22,000 miles/15 miles per gallon = 1,467 gallons x $1,25/gallon = $1,834

	Actual Cost		Present Worth
$1,834 for year one	= $1,834 for year one	x 1	= $1,834
$1,834 x 1.04	= $1,907 for year two	x .9091	= $1,734
$1,907 x 1.04	= $1,983 for year three	x .8264	= $1,63[illegible]
$1,983 x 1.04	= $2,062 for year four	x .7513	= $1,549
Total - Car C:	$7,786		$6,756

CAR D: 22,000 miles/18 miles per gallon = 1,222 gallons x $0.79/gallon = $965

	Actual Cost		Present Worth
$965 for year one	= $ 965 for year one	x 1	= $ 965
$965 x 1.04	= $1,004 for year two	x .9091	= $ 913
$965 x 1.04	= $1,044 for year three	x .8264	= $ 863
$964 x 1.04	= $1,086 for year four	x .7513	= $ 816
Total - Car D:	$4,099		$3,557

MAINTENANCE

22,000 miles per year x 4 years = 88,000 miles

CAR A: 88,000 miles/5,000 miles per maintenance = 17.6 (use 17 maintenance visits since the last one will be at the end of ownership).

This equates to 4.25 maintenance visits per year.

	Actual Cost		Present Worth
$1,063 for year one	= $1,063 for year one		
$4.25 x $250	= $1,106 for year two	x 1	= $1,063
$1,106 x 1.04	= $1,150 for year three	x .9091	= $1,00[illegible]
$1,150 x 1.04	= $1,196 for year four	x .8264	= $ 950
		x .7513	= $ 899
Total - Car A:	$4,515		$3,917

CAR B:

$0

CAR C: 88,000 miles/10,000 miles per maintenance = 8.8 (use 8 maintenance visits since the last one will be at the end of ownership).

This equates to 2 maintenance visits per year of ownership.

	Actual Cost		Present Worth
$350/maint. x 2	= $ 700 for year one	x 1	= $ 700
$700 x 1.04	= $ 728 for year two	x .9091	= $ 662
$728 x 1.04	= $ 757 for year three	x .8264	= $ 626
$757 x 1.04	= $ 787 for year four	x .7513	= $ 591
Total - Car C:	$2,972		$2,579

CAR D: 88,000 miles/7,500 miles per maintenance = 11.7 (use 11 maintenance visits since the last one will be at the end of ownership).

This equates to 2.75 maintenance visits per year.

	Actual Cost		Present Worth
$125/maint. x 2.75	= $ 344 for year one	x 1	= $ 344
$344 x 1.04	= $ 358 for year two	x .9091	= $ 325
$358 x 1.04	= $ 372 for year three	x .8264	= $ 307
$372 x 1.04	= $ 387 for year four	x .7513	= $ 291
Total - Car D:	$1,461		$1,267

INSURANCE

CAR A:

	Actual Cost		Present Worth
$ 950 for year one		x 1	= $ 950
$ 950 x 1.03	= $ 979 for year two	x .9091	= $ 890
$ 979 x 1.03	= $1,008 for year three	x .8264	= $ 833
$1,008 x 1.03	= $1,039 for year four	x .7513	= $ 781
Total - Car A:	$3,976		$3,454

CAR B:

	Actual Cost		Present Worth
$1,350 for year one		x 1	= $1,350
$1,350 x 1.03	= $1,391 for year two	x .9091	= $1,265
$1,391 x 1.03	= $1,433 for year three	x .8264	= $1,184
$1,433 x 1.03	= $1,476 for year four	x .7513	= $1,109
Total Ins. - Car B:	$5,650		$4,908

CAR C:

	Actual Cost		Present Worth
$ 800 for year one		x 1	= $ 800
$ 800 x 1.03	= $ 824 for year two	x .9091	= $ 749
$ 824 x 1.03	= $ 849 for year three	x .8264	= $ 702
$ 849 x 1.03	= $ 874 for year four	x .7513	= $ 657
Total - Car C:	$3,347		$2,908

CAR D:

	Actual Cost		Present Worth
$ 700 for year one		x 1	= $ 700
$ 700 x 1.03	= $ 721 for year two	x .9091	= $ 655
$ 721 x 1.03	= $ 743 for year three	x .8264	= $ 614
$ 743 x 1.03	= $ 765 for year four	x .7513	= $ 575
Total - Car D:	$2,929		$2,544

SALVAGE

	Actual Cost		Present Worth
CAR A	$ 8,000	x .7513	= $ 6,010
CAR B	$14,000	x .7513	= $10,518
CAR C	$ 5,000	x .7513	= $ 3,757
CAR D	$ 4,500	x .7513	= $ 3,381

The purchase of an automobile was chosen as an example of a LCC estimate to present an annual and fixed cost comparison. The use of this simplified LCC analysis demonstrates the vital role LCC analysis plays in evaluating alternative courses of action.

Attachment G

Life-Cycle Cost Analysis Background

The life-cycle cost of a system is the sum of all the costs associated with a system, from research and development through production/construction, operation/maintenance to retirement and shutdown.

The life-cycle cost (LCC) for a system can be used in the evaluation of alternative systems and it can be used as a cost baseline in the management of costs.

In trade-off studies Figures Of Merit (FOM) are often used in the evaluation of alternatives. There are many different parameters that can be used, but the ultimate criterion is generally some version of cost-effectiveness, and the LCC is the source of the "cost" information.

e.g., $\text{Cost Effectiveness FOM} = \frac{\text{System Effectiveness}}{\text{LCC}}$

$\text{Availability FOM} = \frac{\text{Availability}}{\text{LCC}}$

The system effectiveness, in turn, depends upon the system availability, the system dependability, system performance, etc.. These factors also have an impact on the LCC. In general there will be trade-offs between different parameters, e.g. a maximum budget and a minimum availability, reliability and maintainability, cost and reliability, etc..

Life-cycle costing is applicable to all phases of the life-cycle of a system. Cost emphasis is created early in the life-cycle by establishing quantitative cost factors as requirements. As the life-cycle progresses, cost is employed as a major parameter in the evaluation of alternative design configurations and in the selection of a preferred approach. Subsequently cost data is generated based on the established design and operation characteristics and used in the development of life-cycle cost projections. These projections are compared to the initial requirements to determine the degree of compliance and necessity for corrective action.

The life-cycle cost for a system is often expressed as a cost profile which shows the system cost (in dollars) against the system life-cycle (in years). There are different methods that could be used in developing a cost profile. The following are the main activities that need to be carried out.

1. Identify all the activities, throughout the life-cycle, that will generate costs. The year(s) when the activity is expected to occur must be established. It is useful to allocate the activities to cost categories within a Cost Breakdown Structure (CBS). The cost categories which are capital costs need to be identified.

2. Estimate the costs for all the activities identified.

3. Convert the costs to a common cost basis. This takes into account the time value of money, inflation, changes in price levels, etc.. It is important that all the alternatives being considered used the same common cost basis.

4. Summarize the costs by major phase/cost category, e.g. Concept, Construction, Operation and Shutdown. These can then be used to develop the top level cost profile.

The result of these steps is a cost profile, and can be represented as shown in Attachment D (a). Secondly these individual phase costs can be shown in the context of the whole life-cycle as in Attachment D (b). The life-cycle cost can then be represented as a cost profile as in Attachment D (c). When dealing with two or more alternatives each will have a different cost profile, as illustrated in Attachment D (d).

The initial use of LCC analysis, for a project, is the systematic analytical process of evaluating alternative courses of action early on in a project, with the objective of choosing the most appropriate alternative. The analysis covers the entire life of the project not an arbitrary time span. Once an alternative has been selected, then the initial LCC analysis becomes the cost baseline which will be used and updated during the life cycle of the project. The baseline serves as a tool for monitoring the progress of the project; differences can be investigated and appropriate action instigated.

As the life-cycle of the system progresses the LCC will be reviewed and updated. In the early stages of the conceptual phase target figures of merit (e.g., cost vs performance, reliability vs maintainability, etc.) are established to which the system should be designed. As the system moves into the preliminary design phase alternatives will be generated and their life-cycle costs calculated to provide information for the management selection decision. (Note the LCC information is just one of the pieces of information needed to support management selection decisions.) As the system goes through detailed design the cost estimates become more detailed and accurate and this is reflected in the LCC.

LCC analysis must be performed early in a project's life or it loses its impact to make a cost effective decision on which alternative is best. Attachment A shows that, for a typical project, by the end of the Pre-Concept and Concept phase decisions influencing 75% of the cumulative LCC have been made.

Attachment B is based on a typical DOD communication system acquisition profile. It shows that for each $7-$12 that is spent on R&D, $27-$28 is spent on production and $60-$66 is spent on operational support. This type of profile is common to many projects. It highlights the need to consider the costs for the life of the system, not just the cost of construction/acquisition, when selecting an alternative, since the operating costs are the largest part of the life-cycle cost, (note that clean-up costs can also be very significant). For more information: Chapter 17, Systems Engineering and Analysis by Blanchard & Fabrycky Logistics and Engineering Management by Blanchard.

TITLE: SYSTEMS ENGINEERING MANAGEMENT PLAN DEVELOPMENT GUIDANCE	Approved by J. D. Thomson, Manager TWRS Technical Integration	
AUTHOR:		F. J. Orsag
AUTHOR ORGANIZATION:		WHC

1.0 PURPOSE

The purpose of this document is to provide guidance for use in the development of a Project Systems Engineering Management Plan (SEMP). This guidance should be used following a determination of need for a SEMP through application of the graded approach process (see Appendix A of the *Tank Waste Remediation System Systems Engineering Management Plan* [WHC 1996]).

2.0 SCOPE

This guidance document applies to SEMPs developed within the Tank Waste Remediation System (TWRS) Program. This guidance is to assist in writing a project or activity-specific SEMP sufficient to the systems engineering (SE) needs of the project and be integrated with the TWRS Program. SEMPs developed within the TWRS Program will be subordinate to, and in conformance with, the *Tank Waste Remediation System Systems Engineering Management Plan* (WHC 1996). SEMPs should only be developed to reflect any differences from the TWRS Program SEMP or other senior SEMPs. (Duplicate material may be included for clarity, but this may create configuration management problems later.)

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The Westinghouse Hanford Company (WHC) is responsible for establishing appropriate practices and procedures for the TWRS Program. The organization responsible for the project will lead the project, subproject, or engineering effort to prepare a project SEMP. The tailoring will be coordinated with the TWRS Technical Integration (TI) Organization and be authorized by the organization responsible for control of the project.

The responsible organization should accomplish the following:

(1) Obtain pertinent information from other projects, the program, and the customer (of this new project)

(2) Maintain an interface with the customer

(3) Assemble a SEMP development team

(4) Ensure all necessary documentation is available (e.g., TWRS and other project SEMP[s])

(5) Perform tailoring of SEMP contents

(6) Coordinate information exchange

(7) Perform thorough reviews

(8) Ensure the completed SEMP is signed, distributed, and maintained.

5.0 PROCEDURE

To accomplish the overall purpose of this document, the following objectives must be accomplished. The majority of the steps listed below are administrative in nature. The **bold step** below is the area of major work:

(1) Complete the graded approach process of the TWRS SEMP, Appendix A. Note: This step is normally accomplished prior to execution of this guidance document.

(2) Designate a principal author

(3) Establish, as necessary, an integrated product development team

(4) Acquire the necessary reference documentation

(5) Determine SEMP content needs based on the grading process

(6) Develop an annotated outline for the SEMP

(7) Establish a SEMP development schedule

(8) Develop First Draft and release for review

(9) Incorporate First Draft comments

(10) Complete Final Draft and procedures (as necessary)

(11) Release for final comments

(12) Incorporate final changes

(13) Release SEMP (and procedures).

5.1 Graded Approach/Tailoring Process

The project (or subproject) will have determined, through the graded approach process prior to execution of this procedure, whether or not a project or activity-specific SEMP is needed.

Using the graded approach will ensure production of a SEMP that has; (1) been determined to be necessary for this project; and (2) will be of sufficient content to fulfill the functions of an engineering management plan. The result of this step is development of the minimum documentation requirements for the project SEMP, a refined approach to SE for the project, and an understanding of the SE Procedures that will be used throughout the project.

A SEMP development budget should be completed to ensure adequate support is provided for the development process. Budget estimates can be developed with the assistance of the TI Organization.

5.2 Designate a Principal Author

One person should be designated the principal author for the SEMP. This position is normally assigned by the project senior engineer or project manager (when the senior engineer position does not exist or has not been filled). This person will be responsible for completing the SEMP development planning process, creating a development team, ensuring this procedure is followed, reviews are completed, and an adequate SEMP is ultimately signed and released for use.

The principal author should be an experienced systems engineer and may come from a separate organization. However, it is best to designate as author a member of the engineering team that will continue to be with the new project during the engineering efforts.

5.3 Establish an Integrated Product Development Team

A SEMP provides a plan for the integrated (multi-disciplinary) development of an engineered system that considers the entire life-cycle of that system. Factors such as environmental permitting, cost, logistics, maintenance concepts, and system effectiveness are critical. As such, the effectiveness of the SEMP will be enhanced by the formation of an Integrated Product Development Team (IPDT), a team of writers and reviewers with a broad base of experience. The participation of these diverse disciplines will enhance the quality of the SEMP through a more thorough discussion of how these specialties will perform their functions and lead to a more integrated engineering effort.

The core team should be minimal in size (possibly no more than two or three people) and be augmented by subject matter experts designated to write specific sections, review draft products, and assist in collecting information from the perspective of their specialties. It is common to request support from others to write specific sections. Care must be taken to ensure that these people are properly briefed on the goals, requirements, and contents of the SEMP. Further, that specific guidelines regarding section contents, delivery dates, and review schedules are established for them.

TWRS TI will provide support in the development of SEMPs and other SE products and should be consulted early in the SEMP effort.

5.4 Acquire the Reference Documentation

Several of the documents referenced in Section 6.0 can provide direction and support in developing a sound SEMP. These documents and other directive and supporting materials should be gathered and reviewed by the development team.

Documentation that defines the project's scope and purpose should be collected and reviewed. It would be beneficial for the team to review the TWRS SEMP, other TWRS Project SEMPs, and the TWRS SE Procedures. Applying the procedural steps contained within the TWRS *Mission Analysis (MA)* and *Functions and Requirements Procedures* (Orsag 1996b, 1996a) will assist in ensuring there is an adequate understanding of the task at hand.

5.5 Determine SEMP Content Needs Based on the Grading Process; Tailor the SEMP

At this point, the team should execute an informal analysis of what should be contained within the SEMP. The TWRS TI Organization should assist with this activity. A rough draft SEMP outline should be developed at this point. TWRS TI will review and comment on this draft outline to ensure it will be adequate to meet the project's engineering management and program needs.

A general course of action for this content determination should be similar to the following steps:

(1) Obtain the results of the grading process

(2) Analyze the SE process required for the project

(3) Analyze the applicability of SE Procedures to the project

(4) Review the TWRS and any other senior SEMPs for adequacy

(5) Determine estimate of modifications necessary to process, procedures, and other SEMP contents (as applicable)

(6) Create the draft outline and review results of above analyses with TWRS TI.

5.5.1 Obtain the Results of the Grading Process

As noted at the beginning of this guidance document, the grading process should have been completed. This process will assist the project in determining the level of SE that needs to be applied to that project.

5.5.2 Analyze the Systems Engineering Process Required for the Project

The basis for this informal analysis is also an element of the grading process in Appendix A of the *Tank Waste Remediation System Systems Engineering Management Plan* (WHC 1996). Once grading has been completed, the team is positioned to evaluate such additional factors as the relationship between the project and other projects and the program. Interfaces are of particular importance. Complexity of the project in terms of the number of disciplines involves, life-cycle, and outstanding risk factors assist in determining the level of rigor that needs to be applied as well. The outcome of this step should be a fairly detailed understanding of how the TWRS SE process will be applied on this project.

5.5.3 Analyze the Applicability of the Existing SE Procedures for the Project

The TWRS SE Procedures contained in the *TWRS Systems Engineering Manual*, WHC-IP-1231, (Orsag 1996c) and other related WHC Procedures should be adequate for the execution of all TWRS projects. The team needs to determine what constitutes a necessary and sufficient procedure set. There are two possibilities that should be considered:

(1) Are there any tasks or processes expected that will necessitate any additional procedure?

(2) What will constitute the necessary set of procedures for this project?

Should there be additional procedures needed, TI should be requested to support development. It is advisable to take adequate time at this point to review the procedures and determine which will be used, how, by whom, and when. This will eliminate a major element of confusion at later stages of the project.

5.5.4 Review the TWRS and Other Parent SEMPs for Adequacy

To the maximum extent possible, the TWRS SEMP should be referenced as the standard, and subordinate SEMPs should only be written as exceptions to the TWRS SEMP. Subordinate SEMPS should follow the outline of the TWRS SEMP to the maximum extent possible. Each project will need to, as a minimum, include material in a SEMP or SEMP addendum (or the project management plan) that reflects dates, project phases, documentation, and other information that varies from the TWRS SEMP.

5.5.5 Determine Estimates of Modifications Necessary to the SE Process

For the majority of a project's work in writing a SEMP or in writing the necessary supplemental material needed to make the TWRS SEMP "fit" the project (dates, phases, etc) the following suggestions apply. **The following sections of the SEMP may require the closest scrutiny:**

Section 1.4 Key Participants. This section should include the key projects, offices, and organizations with which the project must coordinate. To the maximum extent, this section should list actual organizational names. This should be updated as they change.

Section 2.0 The Integrated Baseline. This section should outline the relationship between the engineering documentation and other project documentation and the document hierarchy for the engineering documentation. The manner in which the Multi-Year Program Plan (MYPP) is derived from the baseline documentation should be discussed and coordinated with any related subject matter that might reside in the project management plan. Section 2.1.2 should include more detailed project specific information than that in the current TWRS SEMP.

Section 2.2 should depict and discuss the project phases. A project life-cycle diagram and discussion are mandatory. One of the major challenges for the TWRS Program is ensuring that each project incorporates the correct level of SE activities and that the interfaces, by project phase, can be adequately "worked." The information conveyed in the Project Life-Cycle diagram and the accompanying narrative will establish a working basis to overcome this challenge.

Beyond the graphical depiction of the project life-cycle, this section should provide project-specific information regarding the project technical documentation (Section 2.2.1) and the technical review information contained in Section 2.2.2. If internal technical review plans are not incorporated elsewhere, they should be incorporated here.

Section 3.0 should reflect changes to the Program SE processes (contained in Section 4.0 of the TWRS SEMP). For example, if the project has determined that an mission analysis will not be done, that section of the Project SEMP should contain such a comment with the rationale for this decision.

Note that the TWRS SEMP section on system and cost effectiveness is lacking in content other than "pointers" to other sources and what should be done. At the Project level and below, it is recommended that this section contain either a more specific plan for establishing system and cost effectiveness or a brief discussion to how this will be handled by the project and information of where the project plans containing details can be found.

Section 3.5 concerns test and evaluation (T&E) and is another critical element for the projects. This section should address how T&E will be implemented for the project and the integration with the Program level T&E.

Program. The Project SEMP should provide insight into the rationale for, and basics on, the content of the Project T&E Plan.

Section 4.0, Systems Management and Control, should address the project structure (e.g., the work breakdown structure [WBS] should be maintained in periodic updates of the SEMP).

Roles and responsibilities for key positions (not individuals) should be contained herein, along with the names of the current position holder. Organizational interfaces (for engineering functions) should be addressed as well as what the project management structure is and how it relates to the TWRS Program management structure and other projects (e.g., describe the roles and responsibilities of the Project Manager with respect to the TWRS Chief Engineer).

For SE implementation, integration of technical disciplines (Section 4.1.4) and a life-cycle view are two of the most critical dimensions. This section should address the technical disciplines involved to ensure this view is maintained. Note here the introduction of IPDTs (and related acronyms all leading to a team-based problem-solving approach). Each project should describe how it intends to implement this team approach. These themes are carried through the remaining sections of 4.1.

System controls (as contained within Section 4.2 of the TWRS SEMP) will almost without exception be based on, and strongly linked to, the existing TWRS Program equivalents. These include: (1) the MYPP, (2) Risk Management, and (3) Decision Management, Configuration Management, and other control mechanisms.

Section 5.0 allows for the identification, definition and, discussion of other engineering related activities not otherwise captured.

The remaining sections of the SEMP are self explanatory.

After a careful study of the proposed contents of the subject SEMP, a draft outline should be completed. The proposed content of the SEMP should be reviewed with TWRS TI.

5.6 Develop an Annotated Outline for the SEMP

Following review of the draft outline (completed above), the team should develop an annotated outline. This outline should contain a description of each section, paragraph, attachment, and appendix that will comprise the SEMP.

Sources of content, an up-to-date bibliography, and other pertinent information should be a part of the annotated outline. Sources of content can be both other documents and people.

Attachment A of this procedure contains a sample SEMP outline.

5.7 Establish a SEMP Development Schedule

Writing assignments and schedules should be made following completion and review of the annotated outline. Those who will be asked to contribute to the SEMP effort should be contacted, and the entire writing team should meet to review the SEMP writing plan. Any conflicts in available time, discrepancies in proposed content, or other challenges should be resolved at this point.

The schedule should ensure adequate time is allowed to conduct any needed research, development of a thorough understanding of the needs of the project, and allow for the review processes.

5.8 Develop First Draft and Release for Review

The principal author and others should now continue the development of the first complete draft SEMP. Any delays or difficulties in development should be immediately brought to the attention of the principal author or the project senior engineer (or project lead). It is common for authors to wait until the last minute to provide their materials. This should be guarded against by the principal author through actively keeping in contact with authors, holding weekly meetings and other necessary activities.

The principal author should review the development schedule, establish a review schedule, and ensure that those who will be reviewing the document are aware of the schedule and are prepared to participate in the reviews Acquire the support of a technical editor to ensure the document flows well when written. It is appropriate to include the technical editor from the earliest steps of the SEMP preparation process. Reviewers should include: key project personnel, TWRS TI, the DOE customer (if appropriate), and closely related projects personnel. The personnel selected should include the engineering specialties areas. A formal review comment process should be incorporated to ensure comments are adequately dispositioned. The Review Comment Record (RCR) is a good tool for receipt, tracking, and resolution of review comments.

5.9 Incorporate First Draft Comments

Following the allotted review period, the comments should be reviewed by the team for appropriateness. Comments should be divided between editorial and comments that affect content. (Editorial comments should be scrutinized in any case, as they may inadvertently affect content.)

Comments on content should be placed in a tabular listing as a minimum, the paragraph and page (of interest), the comment author, and the comment. Additionally, the responsible person to seek resolution should also be named. Upon resolution of all comments they should be incorporated into the final draft of the SEMP.

5.10 Complete Final Draft and Procedures (As Necessary)

As stated above, once all comments have been resolved they should be incorporated into the final draft SEMP. At this point, the document should be reviewed by a technical editor for continuity and flow.

5.11 Release for Final Comments

The final review release of the SEMP should be sent to a wider audience than the previous draft(s). The comment period should be limited to approximately two weeks. A review meeting should be held to discuss comments approximately one week following the end of the review period. This meeting should be preceded with a redlined copy of the SEMP and a spreadsheet of comments (updated). The meeting should be scheduled for approximately three hours (depends on number and content of comments) and have a limited number of participants.

5.12 Incorporate Final Changes

At the completion of the final review period, the review meeting(s) and resolution of any outstanding issues, the final SEMP should be written. This final writing should take no longer than one week.

5.13 Release SEMP (and Procedures)

The finalized SEMP should be forwarded, with cover letter, to the responsible person for signature and release. Any changed procedures or additional procedures should be included with the final SEMP in release.

The SEMP (and procedures as necessary) should be released electronically to a shared drive on the HLAN with a minimum number of hard copies actually being produced. The SEMP is now placed under configuration control (WHC-CM-6-1, *Standard Engineering Practices*).

6.0 REFERENCES

Blanchard, B. S., and W. J. Fabrycky, 1981, *Systems Engineering and Analysis*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

DOE, 1987, *Project Management System*, DOE Order 4700.1, U.S. Department of Energy, Washington, D.C.

DOE, 1996, *Life-Cycle Asset Management*, DOE 430.1, U.S. Department of Energy, Washington, D.C.

DOE, 1996, *Systems Engineering Criteria Document and Implementing Directive*, RLID 430.1, U.S. Department of Energy, Washington, D.C.

WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-SD-WM-SEMP-002, Westinghouse Hanford Company, Richland Washington.

Orsag, F., 1996a, *TWRS Systems Engineering Manual*, "Functions and Requirements Analysis and Allocation," WHC-IP-1231, Westinghouse Hanford Company, Richland Washington.

Orsag, F., 1996b, *TWRS Systems Engineering Manual*, "Mission Analysis," WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Orsag, F., 1996c, *TWRS Systems Engineering Manual*, WHC-IP-1231, Westinghouse Hanford Company, Richland, Washington.

Systems Engineering Management Guide, Defense Systems Management College.

WHC, 1988, *Standard Engineering Practices*, WHC-CM-6-1, Westinghouse Hanford Company, Richland Washington.

The following texts have been useful and are generally available from TWRS TI staff:

Logistics Engineering and Management, Blanchard, Prentice Hall
Systems Architecting, Rechtin, Prentice Hall
Systems Engineering, Sage, Wiley
Systems Integration, Grady, CRC Press
Systems Requirements Management, Grady, McGraw Hill

7.0 ATTACHMENTS

Attachment A SEMP Table of Contents

Attachment A

SEMP Table of Contents

Below is a sample outline for a SEMP within the TWRS Program. For more detail see the TWRS SEMP. These are the minimum set of subjects that should be addressed in the SEMP to be published under this procedure. The level of detail or manner of coverage shouldn't be derived from this statement, as reference may be made to higher level SEMPs. However, it is considered a good practice to incorporate within one document all material.

1.0 INTRODUCTION
- 1.1 SEMP SUMMARY
- 1.2 SCOPE AND APPLICABILITY
- 1.3 IMPLEMENTATION
- 1.4 KEY PARTICIPANTS

2.0 INTEGRATED BASELINE
- 2.1 INTEGRATED BASELINE DEFINITION
- 2.2 PROGRAM PHASES

3.0 SYSTEMS ENGINEERING PROCESS
- 3.1 MISSION ANALYSIS
- 3.2 FUNCTIONS AND REQUIREMENTS ANALYSIS AND ALLOCATION
- 3.3 ALTERNATIVE GENERATION AND ARCHITECTURE SELECTION
- 3.4 EVALUATION AND OPTIMIZATION
- 3.5 TEST AND EVALUATION

4.0 SYSTEM MANAGEMENT AND CONTROL
- 4.1 SYSTEMS MANAGEMENT
- 4.2 SYSTEMS CONTROL

5.0 ADDITIONAL SYSTEMS ENGINEERING RESPONSIBILITIES
- 5.1 STANDARDS AND PROCEDURES
- 5.2 OTHER PLANS AND CONTROLS
- 5.3 LONG-LEAD ITEMS
- 5.4 DEVELOPING AND APPLYING CRITICAL TECHNOLOGIES

6.0 GENERAL INFORMATION
- 6.1 NOTES
- 6.2 GLOSSARY
- 6.3 ACRONYMS AND ABBREVIATIONS
- 6.4 REFERENCES

TITLE:

TECHNICAL MEETING GUIDELINES

Approved by

J. D. Thomson, Manager
TWRS Technical Integration

AUTHOR: F. J. Orsag

AUTHOR ORGANIZATION: WHC

1.0 PURPOSE

The purpose of this guide is to provide basic information on the tools and techniques for technical meeting management. All engineering procedures require the successful completion of a variety of technical meetings, to discuss alternatives, resolve issues, reach decisions, and document findings, required actions and decisions. Development and control of a program or project requires meetings of all types. They may be major technical reviews involving many people and yielding major decisions, minor technical information exchange-type meetings involving 10 to 20 experts and managers or they may be single one-on-one meetings, which may be formal or informal. In all cases, good meeting management practices should be used to ensure effective communications and accomplish the purpose for the meeting.

This document is provided as guidance for TWRS managers in the successful execution of technical meetings and reviews. It summarizes the salient points of DOE Order 430.1, *Life Cycle Asset Management* (LCAM) (DOE 1995), the *LCAM Project Management Guide* (PMG-15) (DOE 1995), and the *Tank Waste Remediation System Systems Engineering Management Plan (SEMP)* (WHC 1996). For specific reviews, these documents should be consulted for more detailed guidance.

2.0 SCOPE

This guide applies to the technical reviews aimed at ensuring the proper development, establishment, and control of the TWRS Program Baseline, as described in the SEMP. Specific types of technical reviews are described in PMG-15, the SEMP, and in Attachment A.

While this guide provides basic information on holding successful formal review meetings, its application is not limited to technical reviews. As such, the process described can be applied to execute a wide variety of meeting types. The principles and procedures described in this guide can be systematically applied to improve the performance of all types of meetings.

2.1 Purpose for Technical Reviews and Meetings in General

Meetings are held to communicate ideas, discuss or assess problems and options, and ultimately to develop agreements or understandings. Technical reviews are performed to provide to management and the customer an opportunity to assess progress, evaluate program risk, and refocus program activities at key milestones in the life of the program. They are also necessary to determine if previously identified issues have been satisfactorily resolved, to identify other issues if they exist, and expedite the resolution of all issues.

Organizers and participants of meetings will vary based on meeting type and subject. For example, a Technical Requirements Review will be led by a Program's senior manager assisted by a meeting team, while a Design Review may be organized by individual projects, and technical information exchange and discussion meetings by participants within a Project.

Similarly, the reviewing authority for each type of meeting will vary from a U.S. Department of Energy (DOE) representative for program level reviews to a representative for the lead management contractor (maintenance and operations [M&O] or Project Hanford Management Contractor [PHMC]) for project level reviews. In many cases involving the meeting of peers to discuss technical information, there may not be a review authority required. In all cases, meeting organizers must determine who is realistically needed to accomplish the goal of the meeting.

See Attachment A for a more detailed description of the major technical review types.

2.2 A Graded Approach to Successful Meetings

Because this guide is applicable to all technical meetings, it discusses a wide range of meeting activities. However, it is recommended that a common sense "graded approach" be taken to select only the most applicable activity options tailored to the meeting needs.

For example, a major review scheduled at a major program milestone may require coordination of numerous documents and the provision of extensive resources ranging from a stenographer for taking minutes, to meals, badging, transportation, and parking. On the other hand, a single one-on-one meeting with a customer may require only the development of a table-top presentation.

The graded approach process is described in greater detail in Section 5, Recommended Meeting Processes and Practices. A planning checksheet is also included as Attachment B as a menu to facilitate selection of the appropriate options for a successful meeting.

3.0 DEFINITIONS

1. <u>Agenda</u> Meeting plan, listing topics to be discussed, and planned events and activities, in order of occurrence.

2. <u>Action Item (AI) Check Sheet</u> Tabular listing of assigned action items showing the action item title, identification number, performer(s), priority, due date and sign-off authority, and providing spaces to check off completion and sign-off. Provides an at-a-glance review of the status of assigned action items.

3. Decision Point Review Meetings held at key program milestones to review pertinent data, status, etc., to make major programmatic decisions.

4. Entrance Criteria Documented listing of materials and information, such as data and documents required to complete the meeting objectives. The meeting cannot begin unless these criteria have been met.

5. Exit Criteria Specific goals or objectives that must be met during the course of the meeting, for the meeting to be a success. These must be based on the documented purpose for the meeting, and should limit discussions to only those topics germane to the purpose.

6. Key Decision Point Major program or project milestone where decisions regarding the program/project will be made.

7. Minutes Official record of the meeting, to include all important information to provide traceability and group memory. Should include participants, assignments, decisions, issues, assigned action items, follow up commitments, agreements, and all pertinent meeting information.

8. Side Meeting Discussion held outside and away from the main meeting by a subset of the participants. Side meeting decisions, findings, and agreements should be reported in the meeting.

4.0 RESPONSIBILITIES

Chairperson: The presiding officer of the meeting, responsible for organizing, holding, documenting, and providing meeting follow-up.

Document Coordinator: Meeting team member responsible for coordinating the flow of documents and comments, between meeting participants, presenters, and the chairperson, in preparation for the meeting.

Facilitator: Trained meeting management consultant to the chairperson; used to provide planning support and interactive meeting control/enhancement services, including monitoring agenda adherence, conflict resolution intervention, and control of meeting process mechanics.

Meeting Logistics Coordinator: Meeting team member assigned the responsibility of making all physical arrangements (materials, location, facility, etc.) for the chairperson.

Meeting Team: Staff selected by or assigned to the chairperson to implement pre-meeting planning, organizing, etc.

Review Authority: Key customer or management representative with the authority to make decisions, including acceptability of the review plan and sign-off for successful completion.

Scribe: Person charged with taking and compiling the minutes and all relevant documents for the meeting.

5.0 RECOMMENDED MEETING PROCESSES AND PRACTICES

The approach described in this guide assumes a graded approach will be taken in planning meetings. This means the amount of time and resources expended in preparing and holding meetings should be proportional to the size and complexity of the project or activity under review, and the scope of the planned meeting. As stated earlier, use of this guide should therefore be tailored to user needs.

5.1 Pre-Review Planning

Meeting success requires adequate early planning. The steps described below and summarized on the *Sample Planning Work Sheet* shown in the following figure will facilitate effective planning. The sample worksheet is tailored to a major technical review, and includes the full range of actions. While its purpose is to serve as a check sheet to ensure all required actions are completed, it should be initially used as a menu to select only those actions specifically required for the meeting. By redlining unnecessary actions, the worksheet becomes tailored to the specific meeting. Sample worksheets for project level technical meetings and single one-on-one meetings are presented in the *Technical Information Exchange Meeting Planning Work Sheet* figure and the *One-on-One Meeting Planning Work Sheet* figure respectively, demonstrating the graded approach to planning meetings. Descriptions of the various actions are provided in following sections.

Preliminary Notes:

(1) Purpose for Meeting:
(2) Program/Project Activity:
(3) Meeting Type:
(4) Key Decision Point:
(5) Planned Date:
(6) Meeting Team (Name/Organization/Contact Info)
  (a) Chairperson (C):
  (b) Facilitator
  (c) Review Authority (RA):
  (d) Decision Coordinator (DEC):
  (e) Meeting Logistics Coordinator (LC):
  (f) Document Coordinator (DOC):
  (g) Scribe (S):

Planning Check Sheet

Action		Ownership	Due Date	Done (X)	Hold Point/ Comment
(1)	Identify/Confirm RA	C			
(2)	Identify/Confirm Participants	C/RA			
(3)	Appoint Staff (LC, DEC, DOC & S)	C			
(4)	Establish Meeting Date/Place	C/RA			
(5)	Begin Making Arrangements	LC			
(6)	Define Entry/Exit Criteria	C/RA			
(7)	Coordinate Entry/Exit Criteria w/ Participants	DOC			
(8)	Finalize Entry/Exit Criteria	C/RA/DOC			
(9)	Identify/Assign Presenters	C			
(10)	Draft Agenda w/ Presenter Inputs	C/RA			
(11)	Coordinate Agenda Review w/ Participants	DOC			
(12)	Finalize Agenda	C/RA			
(13)	Develop Draft Presentations	Presenters			
(14)	Compile Docs & Data w/ RCRs for Review	DOC			
(15)	Coordinate Participant Review of DOCs & Data	DOC			
(16)	Coordinate RCRs w/ Presenters	DOC			
(17)	Revise Presentation	Presenters			
(18)	Review/Approve Presentations	C/RA			
(19)	Finalize Presentations per Review Inst.	Presenters			
(20)	Compile & Distribute Meeting Packages	DOC			
(21)	Finalize Arrangements	LC			
(22)	Dry Run Presentations	C/RA/Presenters			

Sample Planning Work Sheet

Post Meeting Check Sheet					
Action		Ownership	Due Date	Done (X)	Hold Point/ Comment
(1)	Compile Minutes (incl. AI, Decisions, etc.)	S			
(2)	Review/Approve Minutes & Meeting Sign-off	RA/C			
(3)	Develop Action Item Resolution Schedule	C/RA			
(4)	Distribute Minutes, etc.	S			
(5)	Develop:				
	A) Decision Tracing Check Sheet	C			
	B) Action Item Check Sheet	C			
(6)	Track Check Sheets to Completion				
	A) Action Items	C			
	B) Decisions	C			

Sample Planning Work Sheet (cont'd)

Preliminary Notes:

(1) Purpose for Meeting: *Determine the...*
(2) Program/Project Activity: *TWRS Program/Dispose of Tank Waste Project*
(3) Meeting Type: *Technical Exchange*
(4) Key Decision Point: *N/A*
(5) Planned Date: *7/3/96*
(6) Meeting Team (Name/Organization/Contact Info)
 (a) Chairperson (C): *John Smith*
 (b) Facilitator
 (c) Review Authority (RA): *N/A*
 (d) Decision Coordinator (DEC): *N/A*
 (e) Meeting Logistics Coordinator (LC): *N/A*
 (f) Document Coordinator (DOC): *N/A*
 (g) Scribe (S): *Mary Jones*

Planning Check Sheet

Action		Ownership	Due Date	Done (X)	Hold Point/ Comment
~~(1)~~	~~Identify/Confirm RA~~	~~C~~			
(2)	Identify/Confirm Participants	C/RA J. Smith			
~~(3)~~	~~Appoint Staff (LC, DEC, DOC & S)~~	~~C~~			
(4)	Establish Meeting Date/Place	C/RA J. Smith			
(5)	Begin Making Arrangements	LC M. Jones			
(6)	Define Entry/Exit Criteria	C/RA J. Smith			
~~(7)~~	~~Coordinate Entry/Exit Criteria w/ Participants~~	~~DOC~~			
~~(8)~~	~~Finalize Entry/Exit Criteria~~	~~C/RA/DOC~~			
~~(9)~~	~~Identify/Assign Presenters~~	~~C~~			
(10)	Draft Agenda w/ Presenter Inputs	C/RA J. Smith			
(11)	Coordinate Agenda Review w/ Participants	DOC M. Jones			
(12)	Finalize Agenda	C/RA J. Smith			
~~(13)~~	~~Develop Draft Presentations~~	~~Presenters~~			
(14)	Compile Docs & Data w/ RCRs for Review	DOC M. Jones			
(15)	Coordinate Participant Review of DOCs & Data	DOC M. Jones			
~~(16)~~	~~Coordinate RCRs w/ Presenters~~	~~DOC~~			
~~(17)~~	~~Revise Presentation~~	~~Presenters~~			
~~(18)~~	~~Review/Approve Presentations~~	~~C/RA~~			
~~(19)~~	~~Finalize Presentations per Review Inst.~~	~~Presenters~~			
(20)	Compile & Distribute Meeting Packages	DOC M. Jones			
~~(21)~~	~~Finalize Arrangements~~	~~LC~~			
~~(22)~~	~~Dry Run Presentations~~	~~C/RA/Presenters~~			

Technical Information Exchange Meeting Planning Work Sheet

Post Meeting Check Sheet					
Action		**Ownership**	**Due Date**	**Done (X)**	**Hold Point/ Comment**
(1)	Compile Minutes (incl. AI, Decisions, etc.)	S M. Jones			
(2)	Review/Approve Minutes & Meeting Sign-off	RA/C J. Smith			
(3)	Develop Action Item Resolution Schedule	C/RA J. Smith			
(4)	Distribute Minutes, etc.	S M. Jones			
(5)	Develop: A) Decision Tracing Check Sheet B) Action Item Check Sheet	 C C			
(6)	Track Check Sheets to Completion A) Action Items B) Decisions	 C C			

Technical Information Exchange Meeting Planning Work Sheet (cont'd)

Preliminary Notes:

(1) Purpose for Meeting: *Propose that...*
(2) Program/Project Activity: *TWRS Program/Dispose of Tank Waste Project*
(3) Meeting Type: *One-on-One with Customer*
(4) Key Decision Point: *N/A*
(5) Planned Date: *7/4/96*
(6) Meeting Team (Name/Organization/Contact Info)
 (a) Chairperson (C): *John Smith*
 (b) Facilitator
 (c) Review Authority (RA): *N/A*
 (d) Decision Coordinator (DEC): *N/A*
 (e) Meeting Logistics Coordinator (LC): *N/A*
 (f) Document Coordinator (DOC): *N/A*
 (g) Scribe (S): *N/A*

Planning Check Sheet

Action		Ownership	Due Date	Done (X)	Hold Point/ Comment
~~(1)~~	~~Identify/Confirm RA~~	~~C~~			
~~(2)~~	~~Identify/Confirm Participants~~	~~C/RA~~			
~~(3)~~	~~Appoint Staff (LC, DEC, DOC & S)~~	~~C~~			
(4)	Establish Meeting Date/Place	C/RA J. Smith			
~~(5)~~	~~Begin Making Arrangements~~	~~LC~~			
(6)	Define Entry/Exit Criteria	C/RA J. Smith			
~~(7)~~	~~Coordinate Entry/Exit Criteria w/ Participants~~	~~DOC~~			
~~(8)~~	~~Finalize Entry/Exit Criteria~~	~~C/RA/DOC~~			
~~(9)~~	~~Identify/Assign Presenters~~	~~C~~			
(10)	Draft Agenda w/ Presenter Inputs	C/RA			
~~(11)~~	~~Coordinate Agenda Review w/ Participants~~	~~DOC~~			
~~(12)~~	~~Finalize Agenda~~	~~C/RA~~			
(13)	Develop Draft Presentations	Presenters J.Smith			
~~(14)~~	~~Compile Docs & Data w/ RCRs for Review~~	~~DOC~~			
~~(15)~~	~~Coordinate Participant Review of DOCs & Data~~	~~DOC~~			
~~(16)~~	~~Coordinate RCRs w/ Presenters~~	~~DOC~~			
(17)	Revise Presentation	Presenters J.Smith			
~~(18)~~	~~Review/Approve Presentations~~	~~C/RA~~			
(19)	Finalize Presentations per Review Inst.	Presenters J.Smith			
~~(20)~~	~~Compile & Distribute Meeting Packages~~	~~DOC~~			
~~(21)~~	~~Finalize Arrangements~~	~~LC~~			
(22)	Dry Run Presentations	C/RA/Presenters J. Smith			

One-on-One Meeting Planning Work Sheet

Post Meeting Check Sheet					
Action		Ownership	Due Date	Done (X)	Hold Point/ Comment
(1)	Compile Minutes (incl. AI, Decisions, etc.)	S J. Smith			
~~(2)~~	~~Review/Approve Minutes & Meeting Sign-off~~	~~RA/C~~			
(3)	Develop Action Item Resolution Schedule	C/RA			
(4)	Distribute Minutes, etc.	S (File Only)			
(5)	Develop: ~~A) Decision Tracing Check Sheet~~ ~~B) Action Item Check Sheet~~	 C C			
(6)	Track Check Sheets to Completion ~~A) Action Items~~ ~~B) Decisions~~	 C C			

One-on-One Meeting Planning Work Sheet (cont'd)

5.1.1 Define Purpose of Meeting

The purpose and scope of the meeting should be clearly defined to establish the boundaries of meeting discussions, and to focus planning efforts, the mind-set of the participants coming into the meeting, and the execution of the meeting. The purpose should briefly state the subject(s) to be discussed, and desired outcomes. The purpose for major technical reviews is provided in DOE Order 4700.1 and LCAM PMG-15.

5.1.2 Selecting A Chairperson and Facilitator

Ranking senior managers are recommended to serve as the chairperson for all meetings, to provide the leadership and authority necessary to facilitate effective and timely decision-making, conflict resolution, and resource utilization. Representatives of the senior manager or executive can chair a meeting, but her/his authority on the manager's behalf must be made clear by the manager. These meeting leaders should be the senior manager of the organization chartered to organize and conduct the meeting, as follows:

Meeting Type	Lead Organization
Requirements Reviews	Program Level Organization
Design Reviews	Project Level Organizations
Technical Exchanges	Program or Project Organizations, as necessary
One-on-One Meetings	N/A

Attachment A provides a more detailed explanation of the chairperson roles and responsibilities for holding major requirements and design review meetings.

It is recommended that the chairperson select a trained facilitator to help manage meeting dynamics, and to optimize meeting effectiveness. The facilitator should provide guidance in planning and agenda development and participate in the meeting. During the meeting, the facilitator can take an active role as a discussion leader, or may play a more passive role, capturing notes on flipcharts, monitoring the agenda and the groups behavior, and intervening as necessary to keep the meeting on track. In either case, facilitators provide essential meeting management expertise, allowing the chairperson to concentrate more on meeting content than meeting mechanics.

5.1.3 Identifying the Review Authority

To be effective, meetings held for decision-making should include participation by a person with the authority to make the decision. Technical exchange meetings may include the project manager and/or DOE, Richland Operations Office (RL) monitor as a review authority. In the case of major technical reviews, the review authority serves as a Co-Chairperson and represents the customer's organization. He/she reviews minutes to ensure they reflect customer inputs and to provide formal acknowledgment of accomplishments and approvals, indicating the satisfactory conclusion of the review. Review authorities for various reviews are as follow:

Meeting Type	Review Authority
Decision Point Reviews	DOE, DOE/RL
Requirements Reviews	DOE/RL
Design Reviews	Prime Contractor (M&O or PHMC)
Technical Exchange	Lowest Level Decision Authority
One-on-One Meetings	N/A

See Attachment A for a discussion of review authority requirements for specific major technical review types.

5.1.4 Entry and Exit Criteria

Specific entry and exit criteria should be developed and documented for most meetings, based on the purpose and scope of the planned meeting. These criteria define the specific input and output requirements for the meetings, as planning guides and success standards. This step further refines the focus for planning the meeting by stating measurable objectives for the meeting, and by describing the resources (data, study findings, plans, documents, etc.) required to achieve these objectives. These criteria form the basis for development of a results-oriented agenda, which limits meeting discussions to subjects within the bounds set by the purpose and scope. Criteria development should be based solely on the already defined purpose for the meeting, and should restrict meeting discussions to only those topics germane to that purpose.

For example, major technical reviews will have entry and exit criteria based on plans, trade study findings, design data, critical issues, and decisions to proceed to the next phase. See Appendix B of the TWRS SEMP for a sample list of criteria.

Smaller technical exchange meetings and/or one-on-one meetings have a more narrow scope, and are held to discuss, evaluate, and/or decide on a smaller number of technical choices or on a single item. As such, the number of criteria required will generally be less.

Major technical reviews require decision authority approval of criteria, to ensure customer concurrence with review goals. Specific criteria should be developed for each technical review, relevant to the stage of the program or project. Each project will develop its own project review criteria, in conjunction with their DOE/RL monitor, which will be approved and signed by the appropriate review authority prior to initiating the review.

Depending on the scope and magnitude of the meeting, the criteria may be subject to participant review and comment. This helps focus participation and increases buy-in.

5.1.5 Establishing the Agenda

Agendas are essential to ensure all relevant topics are covered, while keeping discussions within the bounds of the meeting's scope, and to pace the meeting. The extent of development and detail of any agenda will depend on the type and scope of the meeting. In the case of formal technical reviews, agendas should be developed by the Chairperson working with the review authority (co-Chairperson), and should be based on the criteria established for the specific review. Once the review topics are determined, the Chairperson should identify and coordinate with presenters to determine/negotiate the amount of time required per topic. The agenda should provide enough time to complete the presentation, and should also allow appropriate time for discussion and questions.

Once prepared, a draft agenda should be submitted to the participants for comment and buy-in, to further ensure all problems and conflicts are surfaced. After coordinating the comments, the final agenda can be prepared for distribution prior to the meeting. (See Section 5.1.9, Pre-Review Documents Distribution).

The agenda for lesser meetings should be tailored to the purpose and scope for those meetings.

5.1.6 Identifying the Participants

The organization charged with the meeting should ensure participation by all parties involved in the activity being discussed, as well as those who can impact or be impacted by decisions made at the meeting. This includes the customer as the reviewing authority, contractors, subcontractors and vendors, and representatives from interfacing activities, and disciplines, as appropriate. This complete involvement provides better management control, and ensures efficiency, consistency, and technical adequacy by:

- Allowing an up-front consideration of the inputs and perspectives of all contractors, related scientific and engineering disciplines and specialities, customers, and suppliers.

- Reducing the probability of mistakes, false starts, and redundancies of efforts resulting from insufficient information.

- Creating better understanding among all parties, through clear, coordinated communications.

5.1.7 Scheduling

Scheduling of meetings should accommodate the availability of:

- Participants, by:
  - Avoiding conflicts with other major events
  - Allowing ample time for preparation

- Necessary information and contract articles such as:
  - Systems Engineering data
  - Trade study results
  - Specialty analysis results
  - Risk analysis findings
  - Specifications
  - Manuals
  - Drawings
  - Reports
  - Hardware or Software
  - Mock ups.

Once again, not all meetings will require all information listed above. However, planning should consider the availability of what information is required to accomplish the meeting mission. Scheduling of technical reviews should coincide with TWRS planned key decision points.

5.1.8 Meeting Logistics: Reserving a Location and Providing Resources

The chairperson should select a staff, if necessary, to assist in planning and arranging a meeting. This can include a decision coordinator, logistics coordinator, document coordinator and/or a scribe. Major meetings may require a full staff, smaller meetings may require only one support person to perform the necessary functions to assist the Chairperson in meeting preparation. Staff requirements will be dictated by the size and scope of the meeting and the availability of resources to pay for staffing.

Meeting location will be dictated by the meeting mission. For example, technical exchange meetings held to discuss the manufacturing or testing of specific components or assemblies could best be held at a vendor facility.

Formal Technical Reviews should be conducted at the lead organization's facility. To effectively facilitate the review to a successful conclusion, the Chairperson and his/her staff should be directly in control of all planning activities. The recommended use of the lead organization's facility maximizes the Chairperson's ability to lead, by providing immediate access to all necessary physical and date resources, infrastructure, and management resources, in real time during the meeting.

The meeting facility should be reserved in time to ensure availability, and should have sufficient seating for all participants. It should also provide space for side meetings, and provide all necessary meeting aids, such as overhead projectors, flip charts, white/black boards, as dictated by the needs of the specific meeting.

The lead organization should also provide all necessary resources to facilitate a successful meeting. The member and type of resources will depend on the number of participants, duration time and location of the meeting, and the amount of funding available for the meeting, as determined by the importance of the meeting.

5.1.9 Pre-Review Documents Distribution

Pre-meeting review of the meeting materials is necessary in the case of meetings planned to review documents, findings, and data to facilitate making decisions or resolving issues. In these instances, drafts of the documents and briefing charts for the review should be collected from presenters four to six weeks before the meeting, reviewed by the Chairperson, and packaged and distributed for participant reviews and comment three to four weeks before the scheduled meeting. The pre-meeting package should also include Review Comment Record (RCR) forms, and a request that completed RCRs be returned in time to incorporate comments and questions into presentations. A deadline for RCR submittals should be included.

If practiced, this option will improve meeting performance by allowing participants to arrive prepared, and by allowing presenters to better focus their presentations. This will add to meeting effectiveness and help conserve time. (See Section 5.2.1, "Adhering to the Agenda" for more details).

5.2 Holding the Meeting

5.2.1 Adhering to the Agenda

The agenda is the most critical tool for keeping a meeting on track and on schedule. The meeting should start on time, properly adhering to the agenda will help ensure completion of the entire meeting on time. Some hints for managing the agenda are:

- Establish ground rules for meeting manners.

- Discourage the introduction of new topics, not contained in the agenda.

- Hold questions and comments until after the presentation, because many questions arising early in the discussion may be answered as the presentation proceeds. (See Section 5.2.4, "Presenting [Briefing] Documents.")

- Provide meeting participants with advanced copies of all presentation materials so they can identify and submit questions and issues in advance. If possible, collect their comments in advance of the meeting to allow presenters to work answers into their presentations. (See Section 5.1.9, "Pre-Review Documents Distribution.")

- Defer lengthy discussions requiring a side or follow-on meeting. Side meeting discussion findings should be summarized in the main meeting and included in the meeting minutes. Side meetings that are concluded after the review should have their findings published to review participants as addendums to review minutes. Follow-on meetings should be formalized as action items to allow tracking.

- Use "Save Lists" to record and track important topics requiring further action outside of the meeting.

5.2.2 Taking Minutes

Minutes are essential to all meetings, so that salient points, issues, agreements and decisions are not lost. The level of detail and processing of minutes depends on the scope, duration, subject, and importance of the meeting. In the case of major meetings and technical reviews, official minutes should be recorded as directed by the Chairperson or Co-Chairperson, to include:

- Significant questions and answers
- Action Items (including responsible party (See B.[3], "Recording, Grading, and Assigning Action Items")
- Save Lists
- Deviations
- Conclusions
- Recommended courses of action
- Side meeting conclusions (See Section 5.2.1, "Adhering to the Agenda")
- Appropriate comments
- Unaccepted recommendations (along with reason for rejection)
- Copy of all briefing charts presented.

The minutes should be reviewed and approved by the Chairperson and Co-Chairperson, and be available for participant review at the end of each days meeting.

5.2.3 Recording & Assigning Action Items

Action items should be assigned by the Chair and/or review authority Co-Chair, and described in the minutes, including:

- Action to be taken
- Names, addresses, and telephone numbers of those responsible for executing the action
- The Due Date/Priority
- Sign-off Authority.

Use of formalized action item tracking forms, (see the following figure, "Sample Action Item Form") is recommended to facilitate action item execution. A form for each action item should be started by the meeting scribe, as the action item is assigned, and included in the minutes. The form can then be further completed/updated as action item efforts proceed, and published as addendums to the minutes. Note that the suggested form ("Sample Action Item Form") provides traceability to the technical review meeting, and also provides a ready reference to key participants, review/approval authorities and a description of the action item.

5.2.4 Presenting (Briefing) Documents

5.2.4.1 Presentation Hints. Presentations should be simple, concise overviews of the subject mater, focusing primarily on key points and issues. Presenters should first present an overview presentation, and then address questions and issues identified from RCRs submitted by the participants. This approach optimizes time usage by minimizing time spent on common knowledge and/or agreed-to subjects, so that more time can be spent on subjects that need to be discussed, such as issues and unresolved questions.

Charts should be in concise, simple bullet form or top level summary tables, to present only the most salient points. Details and backup data should generally not be briefed, although it can be included in hardcopy handouts and held as backup charts.

5.2.4.2 Questions & Comments. Most questions and comments should be presented using RCR forms well in advance of the review, to allow presenters to prepare and respond (see Section 5.1.9, "Pre-Review Documents Distribution"). However, questions will arise during the course of the presentation. It is recommended that such questions be held until after the presentation to preserve presentation flow and for the sake of time management (see Section 5.2.1, "Adhering to the Agenda").

SUBJECT: ____________________ LOCATION: ______________

DATE OF MEETING:

ACTION ITEM DESCRIPTION: PRIORITY: __________ DUE DATE: __________

ORIGINATOR: ____________________ ORGANIZATION: ______________

RESPONSE ASSIGNED TO: ____________________ ORGANIZATION: ______________

FOLLOW UP
STATUS: ____________________

DATE
COMPLETED:

DOCUMENT
NO:

COORDINATORS:

TECHNICAL APPROVAL

PHONE	ORGANIZATION	SIGNATURE	DATE
PHONE	ORGANIZATION	SIGNATURE	DATE
PHONE	ORGANIZATION	SIGNATURE	DATE

CONTRACTING AGENCY	DATE	CONTRACTOR	DATE	CONTRACTS	DATE

Sample Action Item Form

It should be noted that some participants may not submit questions and comments prior to the review. Their questions can slow the proceedings to unacceptable levels. The Chairperson and Co-Chairperson should screen such questions and comments at his/her discretion, using the perceived value-added as an acceptance criteria.

5.2.5 Recording & Implementing Decisions

Decisions made during major meetings and technical reviews should be made part of the formal decision management process, as described in Section 4.2.5 of the TWRS SEMP. Decisions should be based on documented and traceable trade studies and risk assessments. If necessary, they should be processed through the TWRS Program Decision Coordinator, who serves as the central focal point for maintaining decision awareness, decision prioritization and status reporting. See TWRS SEMP Section 4.2.5 for details.

Review decisions should be documented in the minutes to include:

- Statement of Decision
- Decision Issues
- Description of Alternatives Considered
- Decision Criteria
- Alternatives Exclusions
- Identification of:
  - Decision Maker
  - Decision Coordinator
  - Action Officer
  - Support Board (if applicable)
  - Key Contributors & Experts.

5.2.6 Closing the Meeting

Meetings should be closed by reviewing all decisions and outstanding or unfinished business, after all agenda items have been completed, and/or the Chairperson and Review Authority Co-Chair have determined the meeting is finished. This includes a review of:

- Action items assigned (include the priority and due date, open dates are not acceptable)

- Decisions made

- Other unfinished business, meetings, etc.

This closure process should document and display action items and decisions in simple charts, listing the title of the action or decision, along with the name of the responsible activity leader, and due date. These summary charts should be shown to the participants, who should be offered an opportunity to ask questions, and then asked for an acknowledgment of understanding and buy-ins. This will facilitate future efforts through increased understanding and cooperation.

5.3 Post-Meeting Follow-up

5.3.1 Distributing Minutes

The minutes, including formalized lists of action items and decisions, action items forms, finalized RCR forms, and side meeting summary reports. should be distributed as soon as possible after the meeting. This will reinforce participant understanding and provide them with necessary documentation to proceed after the review. It is best to get the minutes distributed within a week (5 business days), while memories of the technical review are still fresh.

5.3.2 Action Item Management

Action items must be tracked to completion. A schedule of due dates should be compiled to accompany meeting minutes. This schedule of due dates should be placed in a suspense file, and reviewed on a scheduled basis by the Chairperson. As action items are completed, the Action Item Form (see "Sample Action Item Form") should be updated until completed. Once completed, the form and a summary of outcome of the action item should be submitted to meeting participants as an addendum to the minutes.

6.0 REFERENCES

DOD 1985, *Technical Reviews and Audits for Systems, Equipment and Computer Programs*, MIL-STD-1521b, U.S. Department of Defense, Washington, D.C.

DOE, 1987, *Project Management System*, DOE Order 4700.1, U.S. Department of Energy, Washington, D.C.

DOE, 1995a, *Life Cycle Asset Management Program Management Guides (Draft)*, U.S. Department of Energy, Washington, D.C.

DOE, 1995b, *Life-Cycle Asset Management (Draft)*, DOE Order 430.1, U.S. Department of Energy, Washington, D.C.

WHC, 1996, *Tank Waste Remediation System Systems Engineering Management Plan*, WHC-50-WM-SEMP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.0 ATTACHMENTS

Attachment A Technical Reviews: Types and Descriptions

Attachment A

TECHNICAL REVIEWS: TYPES AND DESCRIPTIONS

The following paragraphs describe the purpose, scope, organization, and reviewing authority for each review type. This section is taken from the TWRS SEMP in its entirety. For specific guidance with respect to reporting, sign-off authority, etc. see DOE Order 4700.1, DOE Order 430.1 (PMG-15) and the TWRS SEMP.

System Requirements Review (SRR) is a program level review, conducted to evaluate progress in defining Program F&R, the architectural concept to satisfy mission needs and to approve the Functional Requirements Baseline. WHC TWRS Technical Integration will organize the review with RL TWRS Office participation. DOE is the reviewing authority.

Technical Requirements Review (TRR) is a program level review of system requirements, conducted to: (1) evaluate the system requirements for adequacy and risk; (2) ensure a mutual understanding among TWRS Program and Project participants of TWRS Program system requirements, the corresponding system architecture (design concepts), and test strategies; (3) assess the SE process that produced the system requirements; and (4) approve the Technical Requirements Baseline.

TWRS Program personnel will organize and conduct the TRR, with DOE/RL participation. DOE is the reviewing authority. The TRRs will be phased, reviewing the portion of the baseline applicable to specific architecture elements with sufficient commonality to combine into one review.

Design Requirements Review (DRR) is held for each project to demonstrate readiness for proceeding to design development, conducted to: (1) verify project requirements conform with system requirements; (2) identify requirements to be refined by the project; (3) approve the project DRD, project architecture, and the Design Requirements Baseline. For each project, the responsible WHC Project organization organizes and conducts the DRR, with the RL TWRS Program Office participating in selected reviews, and the M&O as the reviewing authority. The products presented at DRR form the foundation for the Key Decision 0 review.

System Design Review (SDR) is conducted to evaluate the optimization, traceability, correlation, completeness, and risk of the allocated requirements, including the corresponding test requirements to fulfill the project technical requirements. This review encompasses the total system requirements and includes a summary review of the System Engineering management work (e.g., integrated test planning, specialty discipline studies, and Configuration Management) that produced the system definition products. Successful completion of the SDR results in the approval of the Design Configuration Baseline Phase 1. The project is responsible to identify all required participants. DOE/RL will participate in selected reviews, and the M&O is the reviewing authority. For additional information on the scope of the review including a listing of products required for a technically complex project, see DOE/RL-95-12 TWRS Systems Engineering Standard, Rev AE (Draft).

The products presented at the SDR form the foundation for the Key Decision #1 review.

Preliminary Design Review (PDR) is conducted to review each project's basic design approach, the associated risks and to approve the Design Configuration Baseline Phase 2. The review is organized by the project and includes review of: requirements development, design activities, trade studies, risk analysis, specialty engineering, test planning and conduct, interface management, risk analysis and configuration management. The project is responsible for identifying required participants. DOE/RL will participate in selected reviews. The M&O is the reviewing authority. For additional information on the scope of the review including a listing of products required for a technically complex project, see DOE/RL-95-12 TWRS Systems Engineering Standard, Rev AE (Draft). The products presented at the PDR form the foundation for the Key Decision #2 review.

Definitive Design Reviews (DDR) are held for each project to demonstrate readiness to start procurement, construction, manufacturing, and coding of projects for verification. They are conducted to: (1) verify design conformance with the design requirements; (2) approve the design specifications updates; (3) evaluate the adequacy of the detailed design; (4) assess design producibility, constructability, testability, inspectability, and risk areas; (5) assess design readiness to proceed with procurement and construction; and (6) to approve Design Configuration Baseline Phase 3.

The project will organize and conduct the DDR ensuring the participation of the appropriate WHC organizations. RL TWRS Program Office will participate in selected reviews, and the M&O is the reviewing authority. The DDR can be used for design verification purposes if it meets requirements of applicable quality assurance procedures. For additional information on the scope of the review including a listing of products required for a technically complex project, see DOE/RL-95-12 TWRS Systems Engineering Standard, Rev. AE (Draft). The products presented at the DDR form the foundation for the Key Decision #3 review.

Operational Readiness Reviews (ORR) are held following completion of facility construction to: (1) compare the as-built configuration with the design configuration; (2) assess start up; (3) allow for the orderly pre-operational testing and turnover of the facility to the WHC facility operations; and (4) to approve the As-Built Baseline.

The ORR is conducted and organized by the project and the A/E. The organizers will ensure participation by the WHC Program Office and RL TWRS Program Office. The Construction, Test, and Turnover Packages and the Operations and Maintenance Packages are presented at the ORR. The as-built system will be reviewed against the technical baseline to support the DOE review milestones and to permit facility operation approval. The M&O is the reviewing authority.

Decontamination and Decommissioning Review (D&DR). A D&DR is held to ensure the D&D activities can be performed safely and to ensure that all necessary permits properly reflect the baseline.

The responsible M&O organization will organize and conduct the D&DR and will ensure the participation of all responsible parties including the D&D organization. D&D baseline documentation and the updated operational baseline configuration are presented at the D&DR.

After successful completion of the D&DR, the D&D baseline configuration will be submitted for approval and configuration control. Approval will authorize proceeding with the D&D.

The boundary between D&D and the ERC has not been defined. After it is defined, this section will be modified to describe the review to proceed with the ERC work.

Attachment B

Meeting Logistics Options Check Sheet

Option	Needed (X)	Number Required
Seating		
Side Meeting Rooms		
Overhead Projectors		
Flip Charts/Minutes		
Video		
White/Black Boards		

See other items on Page 12 & 13

- Meeting agenda/plans to guide the meeting
  - Stenographer or scribe to accurately collect minutes, etc.
  - Applicable systems engineering, data, specifications, manuals, schedules, and design and test data (specialty & trade studies, risk and analyses, etc.)
  - Mockups, hardware, etc., as necessary
  - Review Comments Records (RCRs) for documents open for discussion.
  - Message center for incoming messages
  - Lunch
  - Coffee
  - Bathrooms
  - Special Parking
  - Security - badged escorts.

DISTRIBUTION SHEET

To	From	Page 1 of 2
Distribution	TWRS Technical Integration	Date 02/05/96
Project Title/Work Order		EDT No. 612837
Tank Waste Remediation System Systems Engineering Management Plan		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
N. G. Awadalla	H6-35	X			
D. G. Baide	R2-12	X			
P. A. Baynes	H6-33	X			
R. A. Bilskis	R2-88	X			
K. D. Boomer	H5-49	X			
R. K. Brown	H5-68	X			
J. G. Burton	S7-01	X			
K. E. Carpenter	H5-68	X			
R. D. Claghorn	H5-49	X			
J. C. Danley	H6-35	X			
C. W. Dunbar	H6-35	X			
G. L. Dunford	A2-34	X			
L. F. Ermold	S7-84	X			
H. P. Fox	R2-88	X			
G. R. Franz	A2-34	X			
J. S. Garfield	H5-49	X			
K. A. Gasper	G3-21	X			
J. E. Geary	S5-07	X			
C. J. Geier	R2-36	X			
B. C. Gneiting	H6-35	X			
M. L. Grygiel	H6-33	X			
J. W. Hagan	S7-81	X			
W. A. Hesser	K6-51	X			
J. L. Homan	H5-09	X			
J. O. Honeyman	S7-81	X			
M. E. Johnson	H5-27	X			
T. J. Kelley	S7-21	X			
A. G. King	T6-03	X			
E. J. Kosiancic	H5-61	X			
B. J. Knutson	H6-35	X			
C. N. Krohn	H6-35	X			
A. Lee	H6-33	X			
L. S. Legowick	L4-89	X			
R. E. Lerch	S7-81	X			
E. J. Lipke	S7-14	X			
G. A. Meyer	S2-48	X			
W. C. Miller	A2-34	X			
T. L. Moore	R2-76	X			
T. Morton	S8-05	X			
R. J. Murkowski	H5-03	X			
R. L. Nelson	R2-54	X			
E. G. Norman	H6-35	X			
F. J. Orsag	H6-35	X			
S. P. Otte	H6-35	X			

M. A. Payne	S7-84	X
L. G. Peck	H6-35	X
R. S. Popielarczyk	R1-30	X
R. W. Powell	G3-21	X
R. D. Raaz	R2-40	X
R. E. Raymond	S7-12	X
D. P. Reber	T4-08	X
I. E. Reep	G3-21	X
W. E. Ross	S5-07	X
W. W. Rutherford	R3-25	X
D. F. Salsman	H6-35	X
P. S. Schaus	G3-21	X
W. J. Schlauder	S7-84	X
S. E. Seeman	H5-49	X
C. E. Shipler	R1-09	X
L. E. Simmons	R2-54	X
J. P. Sloughter	R2-54	X
F. O. Strankman	R2-50	X
J. D. Thomson	H6-35	X
J. E. Truax	R2-50	X
A. M. Umek	S7-81	X
T. C. Varljen	S7-75	X
M. W. Wells	S7-80	X
J. H. Wicks	R2-50	X
C. E. Wilson	S7-40	X
R. D. Wojtasek	S7-84	X
Central Files	A3-88	X

Westinghouse Hanford Company **Internal Memo**

From: Tank Waste Remediation System
Phone: 373-5983 S7-81
Date: February 5, 1996
Subject: TWRS SYSTEMS ENGINEERING MANAGEMENT PLAN, WHC-SD-WM-SEMP-002

To: All TWRS Level II and III Managers

cc: RFB File/LB

References: 1) Internal Memo, R. F. Bacon to L. F. Ermold, et al., "Systems Engineering Application," dated July 28, 1995.

2) Internal Memo, A. M. Umek to R. F. Bacon, "Systems Engineering Action Plans," dated September 28, 1995.

The TWRS Systems Engineering Management Plan (SEMP) is released for your implementation. Your Systems Engineering Implementation Plan should be revised to reflect your plan for implementing the SEMP. Jim Thomson of Tony Umek's staff will facilitate a team to prepare an integrated plan to implement the SEMP. Each director will identify a representative to participate on this team by February 12, 1996.

As I stated in my July 28 letter, you are required to implement systems engineering to all your activities. You are accountable to ensure that you, your staff, and your suppliers adhere to the systems engineering approach as a standard procedure. This SEMP will be implemented per the implementation plan on all TWRS activities.

R. F. Bacon, Vice President and Manager
Tank Waste Remediation System

csc

FEB 06 1996
Sta. 21

ENGINEERING DATA TRANSMITTAL

1. EDT № 612837

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) TWRS Technical Integration	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: TWRS	6. Cog. Engr.: Lyle Peck	7. Purchase Order No.: N/A
8. Originator Remarks: Approval/Release		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-SEMP-002 Rev. 0		0	TWRS SEMP	NA			

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. L. G. Peck	[signature]								
1	1	Cog. Mgr. J. D. Thomson	[signature]								
		QA									
		Safety									
		Env.									

18. [signature] 2/5/96 Signature of EDT Originator / Date	19. Authorized Representative for Receiving Organization / Date	20. [signature] 2/5/96 Cognizant Manager / Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

Tank Waste Remediation System Systems Engineering Management Plan

L. G. Peck
Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 612837 UC: 2000
Org Code: 74440 Charge Code: D1M20
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Key Words: TWRS, SEMP, Functions, Requirements, Architecture, Systems Engineering

Abstract: This Systems Engineering Management Plan (SEMP) describes the Tank Waste Remediation Systems (TWRS) implementation of U.S. Department of Energy (DOE) Systems Engineering (SE) policy provided in *Tank Waste Remediation System Systems Engineering Management Policy*, DOE/RL letter, 95-RTI-107, Oct. 31, 1995. This SEMP defines the products, process, organization, and procedures used by the TWRS Program to accomplish SE objectives. This TWRS SEMP is applicable to all aspects of the TWRS Program and will be used as the basis for tailoring SE to apply necessary concepts and principles to develop and mature the processes and physical systems necessary to achieve the desired end states of the program.

Approved for Public Release

WHC-SD-WM-SEMP-002 Rev. 0

TANK WASTE REMEDIATION SYSTEM

SYSTEMS ENGINEERING MANAGEMENT PLAN

February 5, 1996

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CONTENTS

CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TERMS

ABL	As-Built Baseline
BSD	Baseline System Description
CM	Configuration Management
CMPP	Configuration Management Program Plan
CRML	Critical Risk Management List
D&D	Decontamination and Decommissioning
D&DR	Decontamination and Decommissioning Review
DCBL	Design Configuration Baseline
DDR	Definitive Design Review
DOE	U.S. Department of Energy
DRBL	Design Requirements Baseline
DRD	Design Requirements Document
DRR	Design Requirements Review
DT&E	Development Test and Evaluation
ERC	Environmental Restoration Contractor
FRAT	Functions, Requirements, Architecture, and Test
FRBL	Functional Requirements Baseline
FRD	Functions and Requirements Document
FY	Fiscal Year
HQ	U.S. Department of Energy, Headquarters
ICD	Interface Control Document
ICWG	Interface Control Working Group
IPT	Integrated Product Team
IST	Integration Support Team
ITP	Integrated Technology Plan
LCC	Life-Cycle Cost
M&O	Maintenance and Operations
MAR	Mission Analysis Report
MCR	Mission Complete Review
MYPP	Multi-Year Program Plan
OBL	Operations Baseline
OCRWM	Office of Civilian Radioactive Waste Management
ORR	Operations Readiness Review
OT&E	Operational Test and Evaluation
PDR	Preliminary Design Review
PDT	Product Development Team
PHMC	Project Hanford Management Contract
PNNL	Pacific Northwest National Laboratory
RL	U.S. Department of Energy, Richland Operations Office
RMACS	Requirements Management and Assured Compliance System
RML	Risk Management List
SDR	System Design Review

LIST OF TERMS (continued)

SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SRR	System Requirements Review
SSC	Systems, Structures, and Components
T&E	Test and Evaluation
TEP	Test and Evaluation Plan
TFA	Tank Focus Area
TPM	Technical Performance Measurement
TRBL	Technical Requirements Baseline
TRR	Technical Requirements Review
TRS	Technical Requirements Specification
TWRS	Tank Waste Remediation System
WBS	Work Breakdown Structure
WIPP	Waste Isolation Pilot Plant

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TANK WASTE REMEDIATION SYSTEM SYSTEMS ENGINEERING MANAGEMENT PLAN

1.0 INTRODUCTION

This Systems Engineering Management Plan (SEMP) describes the Tank Waste Remediation Systems (TWRS) implementation of U.S. Department of Energy (DOE) Systems Engineering (SE) policy provided in *Tank Waste Remediation System Systems Engineering Management Policy*, DOE/RL letter, 95-RTI-107, Oct. 31, 1995. This SEMP defines the products, process, organization, and procedures used by the TWRS Program to accomplish SE objectives. This TWRS SEMP is applicable to all aspects of the TWRS Program and will be used as the basis for tailoring SE to apply necessary concepts and principles to develop and mature the processes and physical systems necessary to achieve the desired end states of the program.

This SEMP is intended to be a living document that will be revised as necessary to reflect changes in SE guidance as the program evolves. DOE Headquarters has issued program management guidance, DOE Order 430.1, *Life Cycle Asset Management*, and associated guideline documents that include substantial SE guidance. DOE Order 430.1 guidance will be applicable to the TWRS Program starting with the upcoming contract implementation for the Project Hanford Management Contractor (PHMC). The TWRS SEMP will be revised to reflect DOE Order 430.1 following contract award. Until then, the SEMP will reflect DOE Order 4700.1 and DOE-RL Systems Engineering policy direction. When applicable and not in conflict with 4700.1, the SEMP is consistent with 430.1 guidelines.

1.1 SYSTEMS ENGINEERING MANAGEMENT PLAN SUMMARY

SE is the approach selected by the DOE to establish and maintain the TWRS Program baseline over the life of the program. To carry out the SE process in an orderly manner and fulfill DOE SE policy requirements, a SEMP is developed to define and describe the processes and controls to be used by the participants.

1.1.1 Systems Engineering Purpose and Benefits

SE is the application of scientific and engineering principles to; 1) transform an operational need into a system of defined performance and configuration characteristics through iterative, disciplined, and documented processes; 2) ensure all necessary related parameters are integrated to optimize a system design that meets program cost, schedule, and technical performance goals; and 3) maintain controlled definition of the system over its' life-cycle. The disciplined application of SE principles offers several benefits.

- An ordered and structured approach to systems development.
- A common understanding of program goals and expectations by all participants.
- An integrated schedule of activities and how they relate.
- Documented evidence of the current condition or status.
- Traceability of significant program characteristics and system configuration at any point in the program life-cycle.
- Control of program cost, schedule, and technical performance.
- Assurance that the system being built will accomplish the mission.

1.1.2 Systems Engineering Management Plan Structure

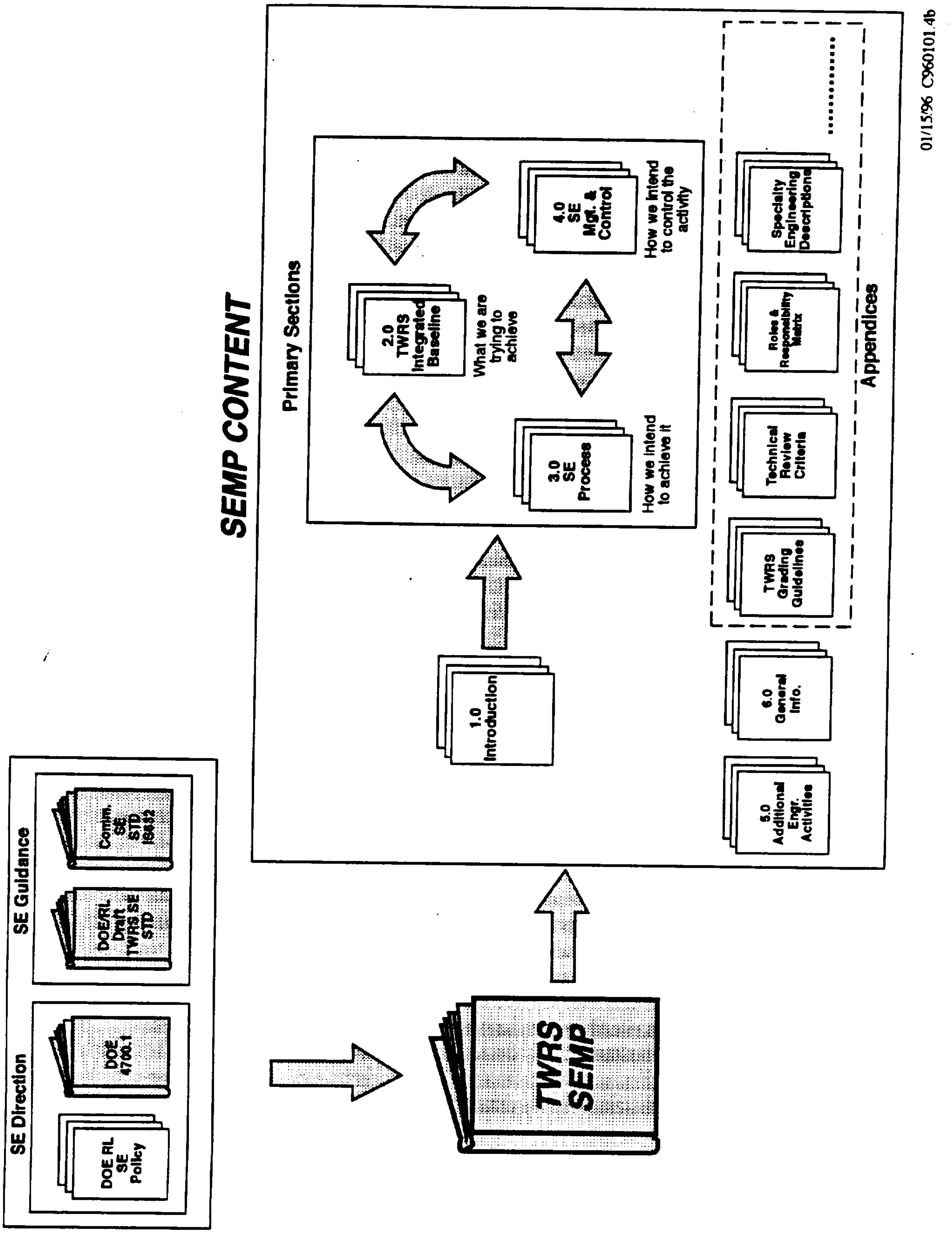
The SEMP contains seven sections (see Figure 1-1, TWRS Systems Engineering Management Plan):

1) Introduction
   - Provides a road map to the SEMP.
   - Describes the scope and applicability of the SEMP.
   - Discusses the graded approach used for implementing the SEMP across the TWRS Program and projects.
   - Summarizes the roles of the key participants.

2) Integrated Baseline -- *What we are trying to achieve*
   - Describes the relationship of the program cost, scope, schedule, and technical performance baseline.
   - Describes the phases of the TWRS Program life cycle including SE products in each phase.
   - Describes an integrated approach to identifying and establishing physical interfaces for systems and subsystems.
   - Describes the purpose for independent technical reviews.

3) SE Process -- *How we intend to achieve the integrated baseline*
   - Contains the general description of elements that constitute the SE Process.
     -- Mission Analysis
     -- Function and Requirement Analysis and Allocation
     -- Alternative Generation and Analysis
     -- Evaluation and Optimization
     -- Test and Evaluation (T&E)

Figure 1-1. TWRS Systems Engineering Management Plan.



4) Systems Management and Control -- *How we intend to control activities and products*
   - Describes the activities required to manage the SE process and related activities to ensure quality products.
   - Defines roles and responsibilities for developing SE products and activities.
   - Describes controls used to manage the activity.

5) Additional SE Responsibilities
   - Identifies applicable standards and procedures to be used.
   - Describes other plans and controls that are necessary to accomplish the tasks.
   - Describes any identified elements of the system that because of the long lead times required for their acquisition, require special early recognition and actions.
   - Describes the need for recognition and development of critical technologies that may be necessary to mitigate risks throughout the program life cycle.

6) General Information
   - Contains information related to the TWRS Program that may be helpful in performing SE tasks.
   - Provides a glossary of SE and program management terms that may be helpful in understanding concepts and principles.
   - References used to develop the SEMP.

7) Appendices
   - Contains details required to perform SE activities.

   A) The Graded Approach - Tailored application of SE is achieved through a screening process that categorizes activities by risk associated with cost, scope, and complexity. Guidelines for screening and tailored SE application is contained in this appendix.

   B) Technical Reviews - Approval to proceed through phases of the program are achieved through the review process. Descriptions of the purpose and content of each independent technical review and sample criteria for entering and exiting a technical review is included in this appendix.

   C) Roles and Responsibility Matrix - Defines responsibility for SE activities and products throughout the program life cycle.

   D) Specialty Engineering Discipline Descriptions - Defines the purpose and intent of technical disciplines that need to be integrally involved in the establishment and development of system requirements and designs.

1.2 IMPLEMENTATION

This SEMP applies to each TWRS activity (i.e., projects, subprojects) being performed under the TWRS portion of the Maintenance and Operations (M&O) contract. SE will be implemented using a graded approach to perform the necessary and sufficient SE tasks to achieve program goals. Each project will prepare an activity specific SEMP to reflect any differences from this SEMP that arise due to the application of the graded approach described below. The activity specific SEMP can be prepared in a "by exception" format using this TWRS SEMP as a model and should define how the project activities will differ from that outlined in this SEMP.

It is recognized that many of the activities of the TWRS Program are in different phases of the program life-cycle. SE tasks appropriate to the stage of the activity will be accomplished in accordance with the graded approach through mutual agreement of the M&O task leader and DOE/RL counterpart.

1.2.1 The Graded Approach

The many activities within TWRS differ greatly in type, cost, scope, and complexity. It is appropriate that the level of detail related to SE be tailored to the particular effort. This "graded approach" will allow for a screening of the proposed activity by program/project personnel and, based on consideration of key elements and present state of the activity, establish the appropriate level of SE and documentation to be generated. Agreement on the chosen SE approach must then take place between project management and the DOE customer. The graded approach will be applied to ensure that:

- The appropriate level of planning is performed,
- Necessary and sufficient documentation is created,
- Needed levels of reviews are conducted, and
- The project is integrated with the overall program.

The primary elements of the graded approach have to do with the risk/complexity of a project and the present stage of the project. The latter element recognizes the fact that within TWRS many projects have already begun. Detailed implications of the results of the grading are discussed in Appendix A. It should be noted that examples given both here and in Appendix A are meant for illustration only. Actual determination of the level of SE required should be based on careful evaluation of the project against the criteria in the following sections.

The steps to determine the level of implementation of systems engineering to a project are as follow:

1. Determine the project risk/complexity factors (high/moderate/low).

2. Select the overall SE level for the project

   - SE-1: Rigorous application of SE (high risk/complexity)
   - SE-2: Full set of SE, but tailored to project (moderate risk/complexity)
   - SE-3: Selective application of SE (low risk/complexity)
   - SE-4: Does not require SE products (management decision, virtually no risk)

3. Determine required project SE activities and products

This process description is expanded in Appendix A. Tables are provided to assist in accomplishing the above steps.

1.2.1.1 SE Levels. The result of the process described in Appendix A is the determination of the level of SE to be accomplished by a particular product, based on a determination of the risk/complexity of the project being conducted. Four grades of projects are defined, in decreasing level of risk/complexity and applicability of SE.

The first level, SE-1, requires full SE documentation. Projects within this category include, technically complex Major System Acquisitions and Major Projects involving systems, structures, and/or components (SSCs). This type of project is typical of those that follow the guidance in DOE-4700.1.

The second level, SE-2, requires the full set of SE activities and documentation, but the effort is tailored to the level of risk/complexity of the project. Projects within this category include, (a) an existing systems modification with significant complexity, and (b) modification to facilities or systems undergoing a change in status if they have been in one condition or had one purpose or function for an extended period of time, and a substantial change in condition or purpose is planned (includes facilities that have been in standdown or shutdown for several months, and are being returned to service). This type of projects would have documentation that is significantly less detailed than the SE-1 projects.

The third level, SE-3, requires selective SE documentation. Projects within this category include, an equipment/system changeout not-in-kind. In addition, many analysis and software projects may fall into this category, even though they do not involve SSCs. Software projects are required to follow software SE as defined in WHC-CM-3-10, "Software Practices."

The fourth level, SE-4, does not require SE. Projects within this category include, "changeout-in-kind," where the change is a form, fit and/or function replacement of essentially identical specification to the replaced part.

The SE levels are summarized in Table 1-1. They are described in more detail, including selection criteria and examples, in Appendix A.

Table 1-1. The Graded Approach - Summary.

SE LEVEL*	EXAMPLES
SE-1 Rigorous application of SE	- Major Systems Acquisition. - Major Projects
SE-2 Full, but tailored application of SE	- Existing systems modification with significant complexity. - Modification to facilities or systems undergoing a change in status; substantial change in condition or purpose planned.
SE-3 Selected application of SE	- Equipment/system changeout-not-in-kind. - Analysis projects. - Software projects.
SE-4 Does not require SE	- Equipment/system changeout-in-kind

* See Appendix A for descriptions and criteria

1.2.1.2 Present Stage of Project. The diagonal diagram shown in Figure 2-2 indicates that the start of a "project" is defined by a specification, called a Design Requirements Document (DRD), generated by the program. However, some TWRS projects have started prior to program generation of a DRD. In these cases, where it has been decided to continue the project, a modification to the normal SE process must be carried out. Typically this involves project generation of a project mission analysis, and an "equivalent" DRD, along with an up-front determination of the program risks assumed by this process.

Appendix A gives criteria and specific examples of how to deal with projects of different SE levels that are already within the project life-cycle prior to applying SE.

1.2.2 External Implementation

For those activities that are the responsibility of TWRS under the M&O contract but that are expected to be awarded to subcontractors for execution, the implementation of the SE process is still a requirement. Actions performed that are critical elements of SE integration (e.g., interface control and management, risk and decision management, configuration control, etc.) will be addressed to ensure that integral parts of the program produce sufficient products and documentation such that the program goals are met in an integrated and cost-effective manner. The mechanism for implementing the SE process can be significantly different than for activities performed by TWRS personnel. It is important to note that the basic principles of the graded approach as described in Appendix A remain the same, but the external agent is allowed to implement the requirements in a manner consistent with industry practices. This ensures consistency for TWRS activities and compliance with the TWRS SEMP, while allowing flexibility to outside agents to take full advantage of their existing procedures, documentation, and organization.

1.3 KEY PARTICIPANTS

The primary participants and their general responsibilities are identified in this section. Roles and responsibilities for carrying out SE tasks and activities are identified in Section 4.1.3 and Appendix C, Roles and Responsibility Matrix. Figure 1-2, Formal Organization Interfaces, shows the existing formal relationships between the major participants. Informal communication links exist between all of the participants.

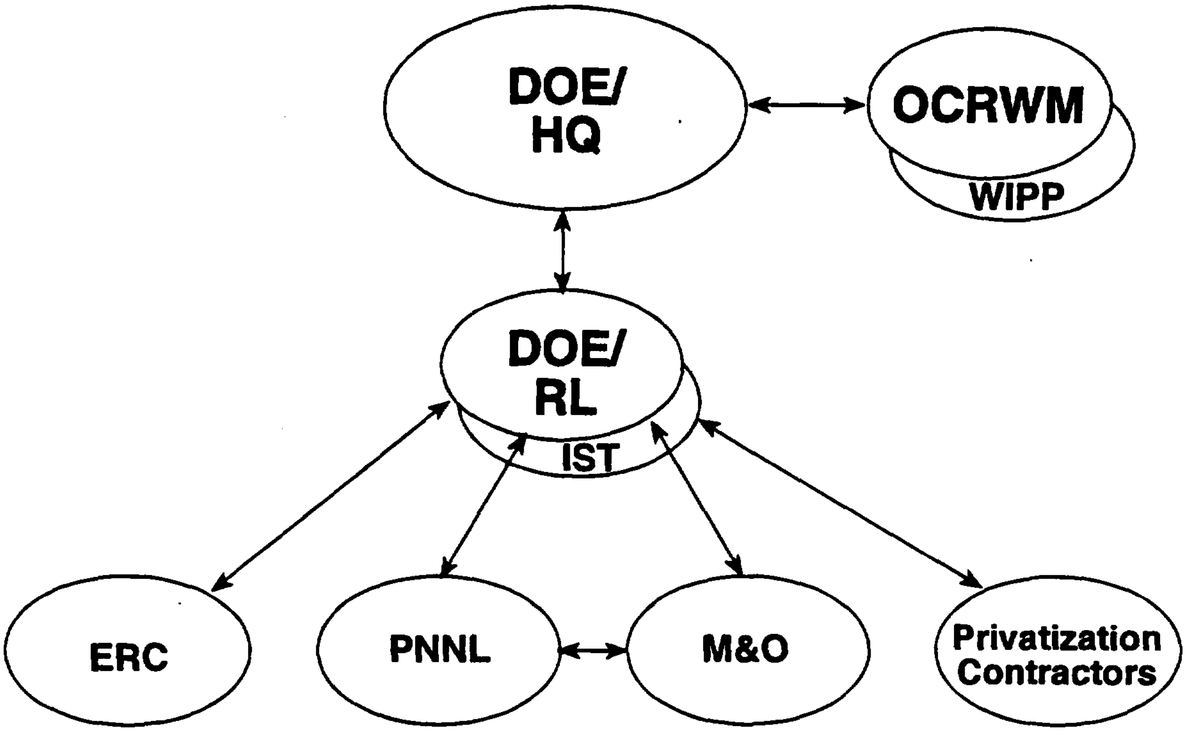
1.3.1 U.S. Department of Energy - Headquarters

The DOE/Headquarters (HQ) provides support to the DOE/Richland Operations Office (RL) TWRS Program Office for technical integration among the following:

1) The TWRS Program
2) The Waste Isolation Pilot Plant Program (WIPP)
3) The Office of Civilian Radioactive Waste Management Program (OCRWM)

The WIPP and OCRWM Programs provide the current technical interfaces for offsite disposal of transuranic and high-level radioactive wastes, respectively.

Figure 1-2. Formal Organizational Interfaces.



2/5/96 C960101.7

1.3.2 U.S. Department of Energy - Richland Operations Office

The responsibility and authority for formulating the TWRS SE program has been delegated to RL by HQ. The RL TWRS Program Office has assigned the Tank Waste, Retrieval, Treatment, and Immobilization Division as the oversight authority to monitor, assess, and ensure the adequacy of the TWRS Program SE activities. It has established TWRS SE policy for implementation by the M&O contractor. It will review and accept top-level program requirements and system descriptions as part of the SE process through established technical planning and control activities. It will identify, review, and accept project-level design requirements baselines for selected critical projects. It will also review and accept change requests to selected critical health, safety, and environmental requirements, regulatory requirements, selected performance requirements, and TWRS Program system-level interface requirements. It will ensure that TWRS Program SE goals, objectives, and priorities are clear and reflected in the products produced by the M&O contractor. RL has primary responsibility for ensuring participants, involved internally and externally with the TWRS Program, establish and maintain appropriate lines of communication. External technical communications will include: (1) technical committees, (2) government agencies, (3) national laboratories, and (4) other participants in the TWRS Program. As required, the TWRS participants will provide technical support and interact with these participants.

1.3.3 Management and Operations Contractor

As the Design Authority, the M&O contractor has primary responsibility and authority for executing the TWRS Program for DOE-RL. The execution of the TWRS Program will include implementing the SE activities outlined in this document. The M&O contractor will also identify the TWRS Program technology needs. The Westinghouse Hanford Company (WHC) vice president for TWRS has assigned the TWRS Safety and Technical Integration organization the responsibility to direct and review TWRS Program technical integration activities using SE processes and technical management techniques.

M&O contractor SE tasks will be performed in accordance with DOE Order 4700.1 and DOE/RL SE policy until initiation of the Project Hanford Management Contract currently scheduled for October 1996.

1.3.4 Project Hanford Management Contractor

The M&O contractor role will be replaced by a Project Hanford Management Contractor whose primary focus will be integrating the activities of private contractors tasked with accomplishing portions of the tank waste remediation activities. SE activities will be conducted in accordance with DOE Order 430.1 upon initiation of the PHMC contract in October 1996.

1.3.5 Technology Development Contractor

The tank waste problem spans more than the Hanford Site. Accordingly, the DOE is approaching the challenges of technology development in a multi-site methodology. The Tank Focus Area (TFA) is a multiple laboratory, multiple site technical team lead by Pacific Northwest National Laboratory and comprised of Idaho National Engineering Laboratory, Los Alamos National Laboratory, Oak ridge National Laboratory, Sandia National Laboratories, Westinghouse Savannah River, and WHC. The DOE/RL serves as the lead field office and administrator for the team.

The TFA manages, coordinates, and leverages technology development to provide integrated solutions to remediation problems that will accelerate safe and cost-effective cleanup and closure of the tanks across the DOE Complex. The technical scope covers the major functions that comprise a complete remediation system.

Initial focus of the TFA Integration Team is on technologies that can be rapidly deployed or meet near-term needs at multiple sites under multiple baselines. A major responsibility of the TFA is to ensure that DOE's tank technology budget is leveraged to the greatest benefit across the sites.

1.3.6 Integration Support Team

The Integration Support Team (IST) will assist the DOE/RL Manager of the TWRS Disposal Program in defining requirements, establishing tasks and working relationships, and managing the private contractors contracted to perform portions of the TWRS Program. The IST will provide liaison between the M&O contractor and the private contractors for information products, services, and physical interfaces that are necessary for the integrated conduct of the TWRS Program.

1.3.7 Privatization Contractors

DOE has undertaken an initiative to reduce waste remediation costs through the privatization of certain portions of the program to clean up Hanford. For the TWRS Program, privatization is being conducted in two phases. In phase I, portions of the TWRS activity related to processing tank waste are being demonstrated through proof of concept contracts with selected private contractors. These private contractors will receive sample tank waste, process the waste, and return immobilized waste product for continued storage at Hanford. Phase II expands the effort initiated in Phase I to include retrieval and immobilization of the remaining tank waste.

2.0 TWRS INTEGRATED BASELINE

The TWRS mission is to store, treat, and immobilize highly radioactive Hanford waste (current and future tank waste and the encapsulated cesium and strontium) in a safe, environmentally sound, and cost-effective manner. The mission includes retrieval, pretreatment, immobilization, interim storage and disposal, and tank closure. The TWRS Program Strategy integrates waste operations, safety issue resolution, retrieval, pretreatment, immobilization and waste disposal (Knutson 1995). In order to accomplish this strategy TWRS is using a combined program and technical management approach to develop an integrated baseline that combines the cost, schedule, and technical basis for remediating the tank waste.

2.1 TWRS INTEGRATED BASELINE DEFINITION

The TWRS Integrated Baseline is the complete set of cost, scope, schedule, and technical information used to define and manage the total program. The Integrated Baseline will evolve with increasing detail throughout the life-cycle of the system. At various points throughout the program life, a "snapshot" of the total cost, scope, schedule, and technical effort will be reviewed. After approval, this set of data is the baseline used to manage future work. The baseline will be controlled using existing Configuration Management (CM) procedures as referenced in Section 4.2.2.

2.1.1 Cost, Scope, and Schedule Baseline

The cost, scope, and schedule baseline is contained in the Multi-Year Program Plan (MYPP). The MYPP is a cost and schedule management product, and is built around the work breakdown structure (WBS). As the TWRS system architecture develops, the WBS will be re-examined for modification as part of the normal program planning. The WBS will evolve to become product based. Figure 2-1, TWRS Document Hierarchy, shows this relationship. During the transition to a product-based WBS, crosswalks between the WBS and the functions will be developed to ensure that all functions are covered and responsibility is understood.

The MYPP contains a Program Summary Schedule, that includes program and project schedules. The Program Summary schedule is an integrated schedule that defines the engineering and technical activities performed at the program and project level. When fully implemented, it will be a milestone-driven, product-based schedule that complements the modified WBS. The integrated schedule will provide management with a tool to evaluate progress against planned events and milestones. Lower-level program and project schedules are integrated into higher-level program or project schedules. Program schedules integrate the overall effort by including program requirements and architecture development, as well as technical activities for ongoing and new projects.

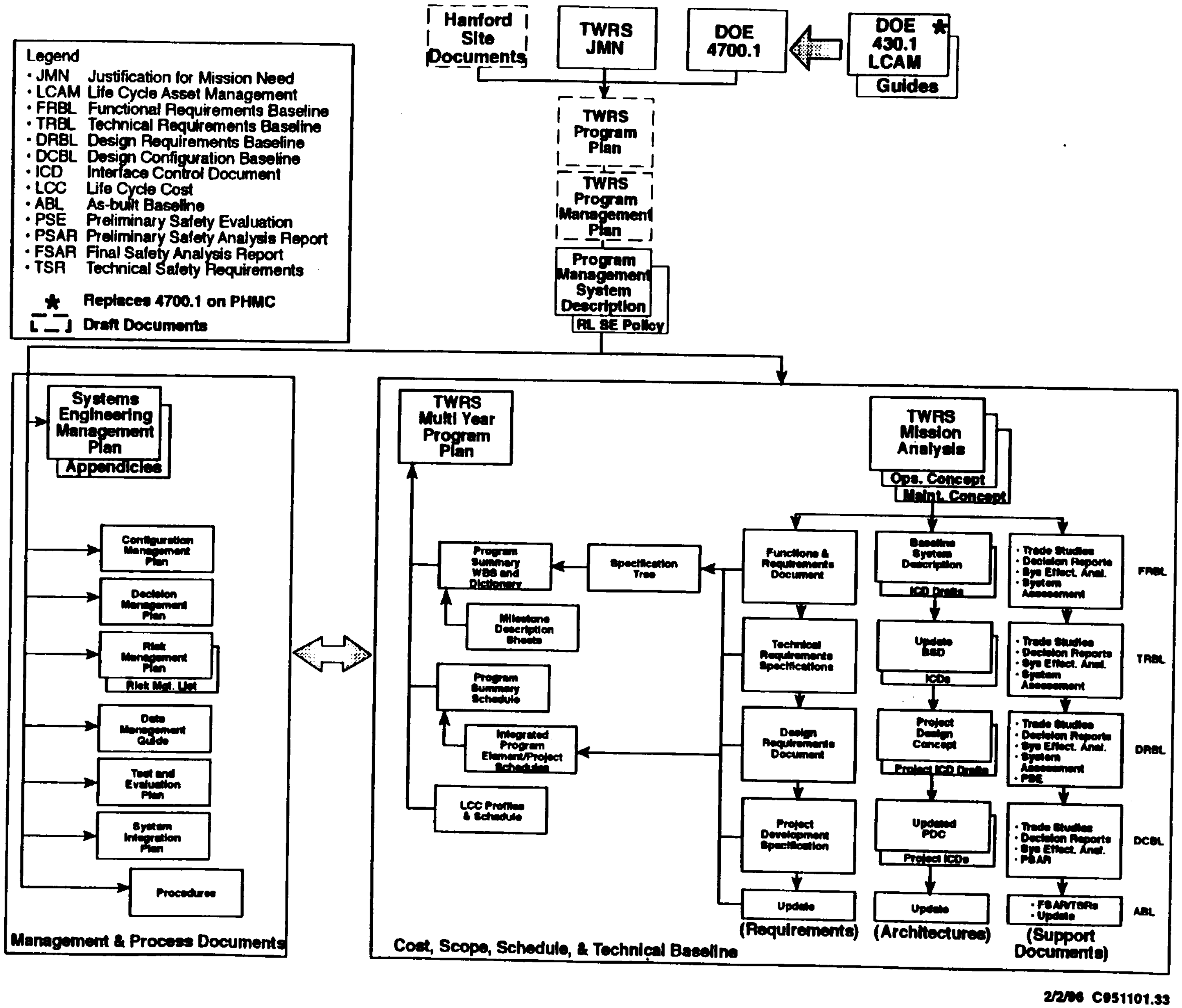


Figure 2-1. TWRS Integrated Baseline Document Hierarchy.

2.1.2 Technical Baseline

The technical baseline is the reference set of technical data. It contains all technical requirements, architectures, and interfaces generated using the SE process (see Section 3.0) to satisfy the TWRS Mission need. Technical data includes but is not limited to:

- Requirements (constraints, performance, interface, and verification requirements).
- Requirements analysis references and supporting data.
- Trade study results and supporting data.
- Authorization basis and supporting data.
- Architecture selections (hardware, software, and facilities).
- Interfaces (physical and functional).
- System Assessment Data.
- Decision Analysis and supporting data.
- Configuration control reference data requirements.

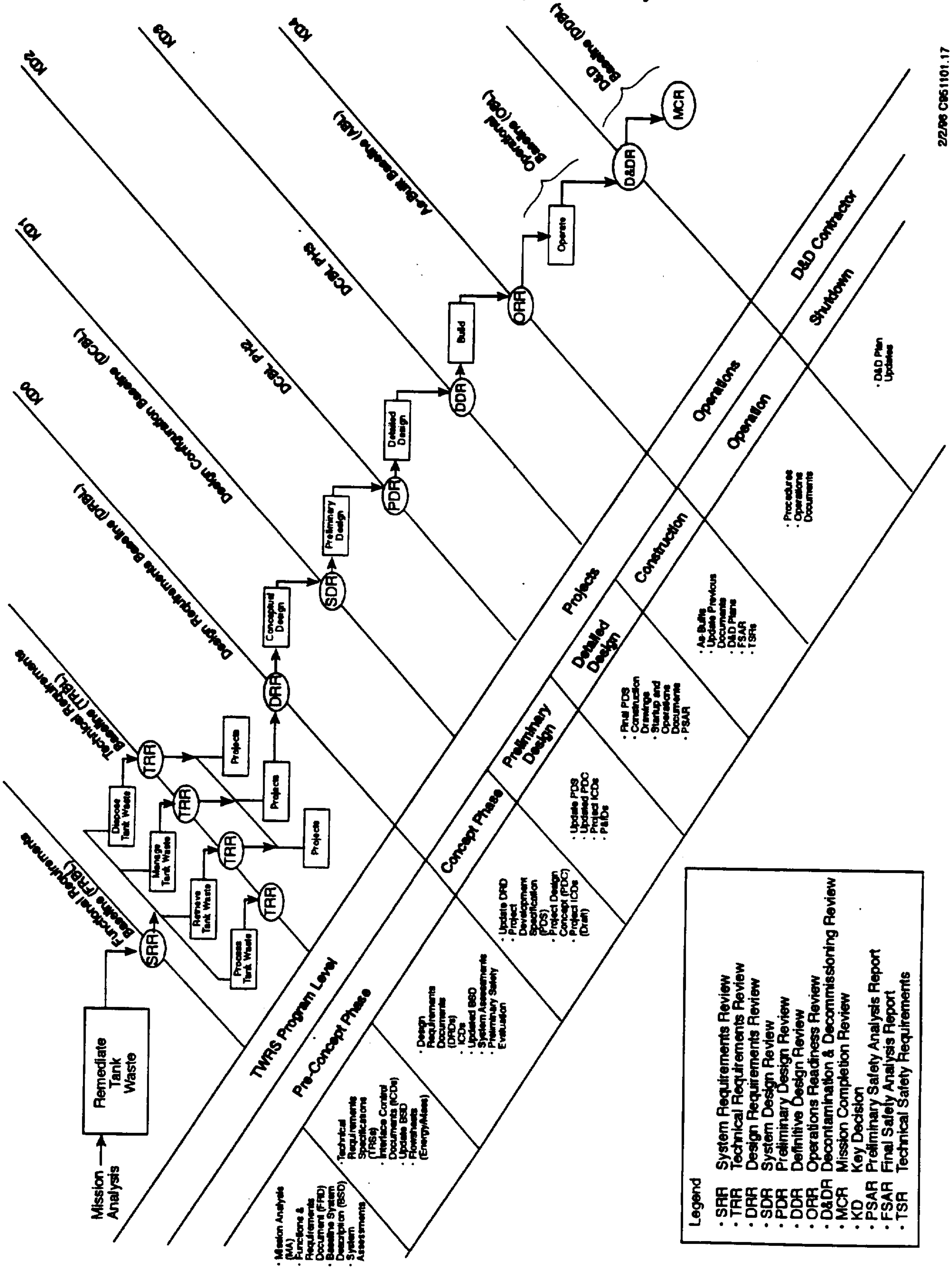
To reflect the evolution of the system description, the Technical Baseline is given different names as it matures. The baselines are: (1) Functional Requirements, (2) Technical Requirements, (3) Design Requirements, (4) Design Configuration phases 1-3, (5) As-built Configuration, (6) Operational, and (7) Decontamination and Decommissioning. Figure 2-2, TWRS Program Life Cycle, shows the evolution of the TWRS Technical Baseline, the documents defining the baseline at each phase, and the related technical baseline reviews.

2.2 PROGRAM PHASES

Program definition will be performed using a life-cycle phased approach. The phases include; preconcept, conceptual design, preliminary design, definitive design, construction, operations, and decontamination and decommissioning. The SE deliverables required to support these phases are described in Tables 2-1 and 2-2.

The TWRS Program includes existing projects, operations of the existing tank farm, support facilities and infrastructure. The existing projects are at varying stages of completion, from conceptual design to construction. These projects will establish traceability of each project mission and requirements to TWRS Program mission and requirements to ensure all program functions and requirements are fulfilled.

Figure 2-2. TWRS Program Life-Cycle.



2.2.1 Major Technical Products

The TWRS will generate products to communicate the Program's technical baseline evolution. Initial mission analysis will be described in a Mission Analysis Report. TWRS system-level requirements will be published in a Functions and Requirements document. Further definition of program-level requirements will be published in a Technical Requirements Specification (TRS), Design Requirements Documents (DRD), and Project Development Specifications using tailored Military Standard 490A formats. Architecture concepts will be published in Baseline System Descriptions (BSD) and Project Design Concepts. Formats for the TRS, DRD and BSD are contained in the Document Format Guide (Orsag et al. 1996). Previous Hanford implementation of Mil-Std-490 is described in WHC-CM-6-1 EP 1.2, *Single Use Non-Construction Specification*. Design agreements between participants will be documented using Interface Control Documents (ICD). Tables 2-1 and 2-2 provide a more detailed listing and brief explanation of each product. The document hierarchy is shown in Figure 2-1.

The TWRS is using a database tool to control and manage the information developed to define the TWRS. The database contents were published as the *Functions and Requirements Document* (FRD), WHC-SD-WM-FRD-020 Rev. 0 (Carpenter 1996). The FRD included applicable portions of constraining documents, functional interfaces, boundary diagrams, and issues as generated from the database. Future F&Rs will include architectures and test methodologies.

Table 2-1. Program Systems Engineering Technical Documents.

Program Document	Document Description
Mission Analysis Report	Documents the mission analysis results that translate mission needs and objectives from the mission or problem statement and other top-level documents into mission requirements. Includes top-level system architecture concepts, operations, and maintenance strategies.
TWRS Functions and Requirements Document (FRD)	Documents the results of the functions and requirements analysis and allocation process that transforms the mission analysis results into a set of executable functions defined by requirements including constraints, functional, interface, and performance requirements. Includes top-level functions analysis, requirements identification and assignment, architecture selections, and test methodologies.
Baseline Systems Description (BSD)	Contains summary text and illustrations for visualizing the selected architectures. References to trade study reports are included as pointers to the detailed supporting information as it develops. The BSD is used as a communication tool, for cost estimates and studies, and the next level of requirements generation. The document is updated for independent reviews and for each baseline revision to maintain baseline definition.
Interface Control Document (ICD)	Documents design agreements between projects and program or the program and the external environment.
Technical Requirements Specification (TRS)	Documents the functions and requirements analysis and allocation results in a specification format starting from the TWRS FRD document and continuing until the major program element missions are defined to a level that functions and requirements are sufficiently detailed to assign to projects. Includes functions and requirements analysis results: interface, performance, and verification requirements.
Design Requirements Documents (DRD)	Reference ICDs, functions and requirements allocated to a specific project. Describes the essential technical requirements for designing, constructing, operating, and maintaining the system. Includes the verification requirements for determining if the requirements have been met. Will be used by the project as a starting point for the design process.

Table 2-2. Project Systems Engineering Technical Documents.

Project Document	Document Description
Project Mission Analysis	Produced only when the DRD is not available to the project. Documents the mission analysis results for the project. Gives the project mission objectives and establishes a link to the Program Mission.
Project ICDs	Documents design agreements within a project and between projects.
Project Design Concept	A project-level BSD. See Table 2-1 for more information
Project Development Specification	Lower-level specification based on the Project functions and requirements analysis and traceable to the program-level requirements in the DRD. Provided as basis to perform design.
Mass/energy flow sheets	Mass and energy flowsheets describing clearly to the Architect/Engineer or design group what the process must do.
Piping and Instrumentation Diagram (P&ID)	Diagram showing piping and instrumentation schematic layouts.
Technology Development Report	Summarizes emerging or innovative technologies used in design concept. Addresses technical adequacy of the technology. Summarizes associated risk management and TEP. (Supporting document, only written if using emerging or innovative technologies.)
Project Logistics Plan	Describes the desired logistics program for supporting the project architecture. The plan addresses system availability, maintenance planning, supply support, technical data requirements, computer resources support, manpower, training support requirements, and packaging, handling, storage, and transportation requirements.
Project Reports	Reports needed by the project to fully define their project activities. Examples of project reports are Alternative Solution Reports, Trade Study Reports, or Decision Analysis Reports. These reports document project-level work related to choosing the project design solution.
System Assessment Reports	Documents the approach and results of assessing existing systems against allocated requirements to determine what modifications (if any) are required so the system complies with requirements.

2.2.2 Independent Technical Reviews

Independent technical reviews are conducted to assess the development of the integrated baseline. These reviews are conducted according to DOE Order 4700.1, *Project Management System*, and are expanded to ensure proper development, establishment, and control of the TWRS Program baseline. Reviews are used to verify conformance with system requirements at the WHC TWRS Program level and with design requirements or specifications at the WHC TWRS Project level. Technical reviews provide data for HQ and DOE/RL (Key Decisions).

There are nine baseline reviews. These reviews are the System Requirements Review, the Technical Requirements Review (TRR), the Design Requirements Review (DRR), the System Design Review (SDR), the Preliminary Design Review (PDR), the Definitive Design Review (DDR), the Operations Readiness Review (ORR), the Decontamination and Decommissioning Review (D&DR) and Mission Complete Review (MCR). Figure 2-2 shows the relationship between the reviews and the technical baseline. Additional internal reviews are conducted, as necessary for TWRS Program and Project management.

Each independent review must be successfully completed before starting the next baseline phase. For example, successful completion of the TRR is required before the Technical Requirements Baseline can be used as the input data to the Design Requirements Baseline. Reviews will only be performed after entry and exit criteria are established. Appendix B contains descriptions of the reviews and sample entry and exit criteria for TRR.

The organizers and participants of the baseline reviews will vary from review to review. For example, the SRR will be organized by WHC TWRS Program-level organization while the DDR will be organized by a Project. Program stakeholders will participate in reviews, as required, to ensure the consistency and technical adequacy of the evolving TWRS technical baseline. DOE/RL participation will depend on the baseline being approved.

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3.0 SYSTEMS ENGINEERING PROCESS

The TWRS SE process is described in the following sections and is shown in Figure 3-1. The process starts with mission analysis and continues with the TWRS SE process, which is a modification of the Functions, Requirements, Architecture, and Test (FRAT) process developed by Brian Mar (1994). The FRAT process consists of function analysis, requirements analysis and allocation, architecture selection, and test definition.

The process will be used to translate stakeholder needs into a system design and develop an optimized cost-effective solution to the identified system need. The end product of the process is documentation describing the preferred system and required performance. The process will be used throughout the life-cycle of the system. It will be used in a systematic approach that integrates the development, construction, test, operations, support, and decommissioning of the system.

The *TWRS Mission Analysis* (Knutson 1995) has been completed and functions and requirements developed to support the Privatization Request for Proposals. Subsequent work will further develop the functions, requirements, architectures, and test methodology to define necessary projects.

3.1 MISSION ANALYSIS

Mission Analysis translates the mission needs and objectives, customer desires, and other inputs, such as the value system, into mission requirements. The mission or problem to be solved must be traceable to a documented customer need. The Mission Analysis is conducted in accordance with the Mission Analysis Procedure, WHC-IP-1231 (Orsag et al. 1996) and the results are documented in a Mission Analysis Report (MAR). The information contained in the MAR will be placed under configuration control as part of the TWRS technical baseline and is the initial input for the BSD.

The MAR will contain:

1) Statement and description of the TWRS Program mission, including the description of the initial unacceptable state and a definition of the acceptable end state.

2) The scope and boundary of the TWRS Program, including a description of its interfaces to other systems both onsite and offsite.

3) Listing of imposed external constraints (fixed policy, legislation, regulations, and DOE directives) that provide the source of external requirements for subsequent requirements analysis and allocation.

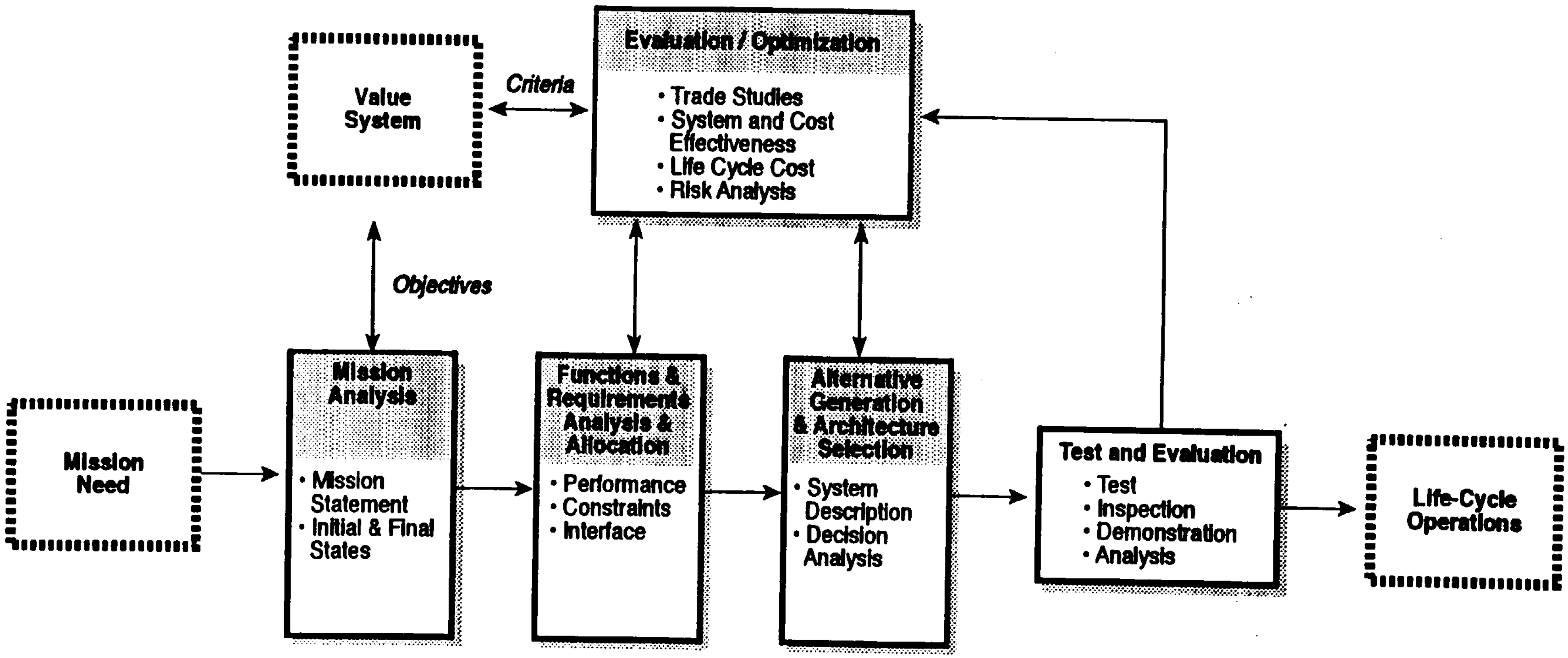

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Figure 3-1. TWRS Systems Engineering Process.

4) TWRS Program technical objectives and values that will be the basis for developing lower-level functions, requirements, and architectures.

5) The key system-level performance requirements, technical performance measures, and measures of system effectiveness to identify and measure how well the system end state must perform.

6) System-level enabling assumptions and associated risks. These assumptions will be carried into the functional analysis and identified and tracked from identification through resolution or validation of the assumption.

7) System-level T&E methodology to verify that the integrated system performs as intended and the system level requirements are fulfilled.

Mission analysis forms the basis for the next step in the SE process, which is functions and requirements analysis and allocation.

3.2 FUNCTIONS AND REQUIREMENTS ANALYSIS AND ALLOCATION

The TWRS will iterate through the functions and requirements analyses and allocation in accordance with the Functions and Requirements Analysis and Allocation procedure (Orsag et al. 1996) to transform mission analysis results into functions and requirements for accomplishing the mission. Existing architecture and initial conditions will be used as inputs to this process. Functions and requirements analyses and allocation breaks down complex systems into simpler related parts. The result is a framework of functions, constrained by applicable requirements, to satisfy the mission.

3.2.1 Functional Analysis

The TWRS performs functional analysis to decompose the mission into a hierarchy of functions that are both necessary and sufficient to satisfy the mission. The functional analysis is documented in a functional hierarchy, function flow block diagrams, and descriptions of the functions and functional interfaces. The functional analysis results, when verified and approved, will be placed under CM as part of the TWRS Program integrated baseline.

The TWRS Program functions and their associated inputs and outputs will be integrated with the Site functions. Integration means that functions will be directly traceable between the Site, the TWRS Program, and the TWRS Projects in one continuous function tree.

3.2.2 Requirements Analysis

TWRS will perform three basic requirements analysis activities: 1) requirements identification and development, 2) requirements validation, and 3) requirements allocation. The first activity identifies constraints, interface requirements, and performance requirements from the three categories are explained below. After identification and development, performance requirements are then validated by simulations, modelling, or analysis to ensure that they will satisfy the mission need. Requirements are then allocated to the applicable functions, interfaces, and architectures. Functions and the associated requirements are allocated to each architecture to prescribe how well each architecture must perform to meet the overall mission requirements, or to prescribe the characteristics of each interface.

1) Externally Imposed Constraints, include regulatory requirements that are derived from external sources such as the U.S. Congress, U.S. Environmental Protection Agency, Washington State Department of Ecology, and other regulatory agencies, DOE Orders, Secretarial Notices, and other external requirements of a mandatory nature. Where necessary, these constraints will be interpreted to derive a performance requirement that is quantifiable and verifiable.

2) Performance Requirements, are developed during the Mission Analysis and requirements analysis, or imposed on the system by the Site requirements allocation that are necessary to achieve the mission of the TWRS Program and each of the individual system elements.

3) Interface Requirements, apply to the system and may be imposed either by external sources or derived through the TWRS Mission Analysis.

The results of the requirements analysis and allocation, when approved, are incorporated into the TWRS Program technical baseline.

All information associated with functional analysis and requirements analysis will be entered into the Requirements Management and Assured Compliance System (RMACS). RMACS, the primary SE tool, will be used as the central repository for all functions, requirements, architectures, and supporting data. It will be used to generate specifications and test requirements and is used to provide top-to-bottom traceability of functions, requirements, architectures, and components. RMACS will also be used to track requirements and analyze the impact of functional and requirement changes (see Section 4.2.4).

The functions and requirements analysis and allocation process provides the starting point for alternative generation and architecture selection.

3.3 ALTERNATIVE GENERATION AND ANALYSIS

Alternative Generation and Analysis (AGA) is used to identify and analyze alternative system configurations that satisfy mission analysis and technical baseline functions and requirements, to make alternative architecture selection decisions. All reasonable alternative architectural concepts will be screened against the functions and requirements. Those that satisfy all requirements are candidates for further analysis and decision making. When existing systems are an alternative, the system will be assessed against the requirements, all deficiencies will be identified, and the resources required to modify the system will be estimated for use in evaluation and optimization activities.

The AGA Procedure (Orsag et al. 1996) describes the steps necessary to develop and analyze alternative architectures and the Decision Management Procedure (Orsag et al. 1996) outlines the steps necessary to make the architecture selection decision.

The architecture, in the form of selected engineering data, requirements, and specifications, will form the basis for the technical baseline, and then be formalized through internal and external reviews and controlled using the CM process. The architecture will start as concepts and strategies at the upper level, and mature into greater detail at lower levels. This process continues until an architectural element can be obtained as a single unit, by subcontracting, purchasing, constructing, writing unit level software, etc.

To focus the design efforts, a BSD document is produced and maintained. The BSD document provides summary text and illustrations of the architectural concepts of the TWRS Program and becomes part of the technical baseline. The BSD will mature as the architecture matures. The architecture selection and decision management activities will be captured in the RMACS to provide a traceable basis for the TWRS Program.

3.4 EVALUATION AND OPTIMIZATION

Evaluation and optimization provides the main feedback mechanism for the SE process and facilitates the development of a balanced, optimized design solution. Thus, evaluation and optimization is performed throughout the SE process. Typically, there are numerous considerations in selecting an optimum system and the evaluation and optimization process ensures that no single characteristic dominates the design. Principal methods for evaluation and optimization are described in the following sections.

3.4.1 Trade Studies

Engineering trade studies will be performed during all phases of the program and project life cycles, whenever there is a need to select from two or more options. Trade-offs are conducted among architectures, as well as the following: (1) requirements, (2) engineering designs, (3) project schedule and budget, (4) cost effectiveness, (5) technical, programmatic, environmental, safety and health risk, and (6) other significant factors. Trade studies vary in extent and cost, depending on the complexity of the project. Planning of trade studies will be initiated early in the program to minimize impact on the development of requirements documents, specifications, etc., and continue through the life of the project. Trade study planning should use a graded approach to ensure a cost-effective implementation while still providing sufficient time and resources for analyzing substantial alternatives. However, all selection between alternatives will be substantiated by some level of trade studies.

3.4.2 System and Cost Effectiveness

The basic design objective is to optimize the development of a system that will do the best job at the lowest cost. To accomplish this, all elements of the system should be addressed on an integrated basis and system analysis and trade-offs are accomplished to develop a preferred approach. The proper balance of design attributes is an important factor in analyzing a system or selecting an architecture, but the ultimate decision criteria is some form of cost effectiveness.

System Effectiveness is defined (Blanchard and Fabrycky 1981) as "the probability that a system can successfully meet an overall operational demand within a given time when operated under specified conditions" or "the ability of the system to do the job for which it was intended." System effectiveness is a term used to reflect the operational aspects and technical characteristics of a system. These include system performance, maturity of technology, availability, supportability, and dependability.

Cost effectiveness is the measure of a system in terms of mission fulfillment (system effectiveness) and total Life-Cycle Cost (LCC). Cost effectiveness includes the elements shown in Figure 3-2 and can be expressed in several different Figures-of-Merit, which relate LCC to system effectiveness, and system capacity.

System and cost effectiveness criteria, Figures-of-Merit, and related Technical Performance Measures, will be determined at the mission analysis level, and be continually updated and used as criteria during the alternative evaluation and decision making process to ensure the development of a system that operates effectively at the lowest possible LCC.

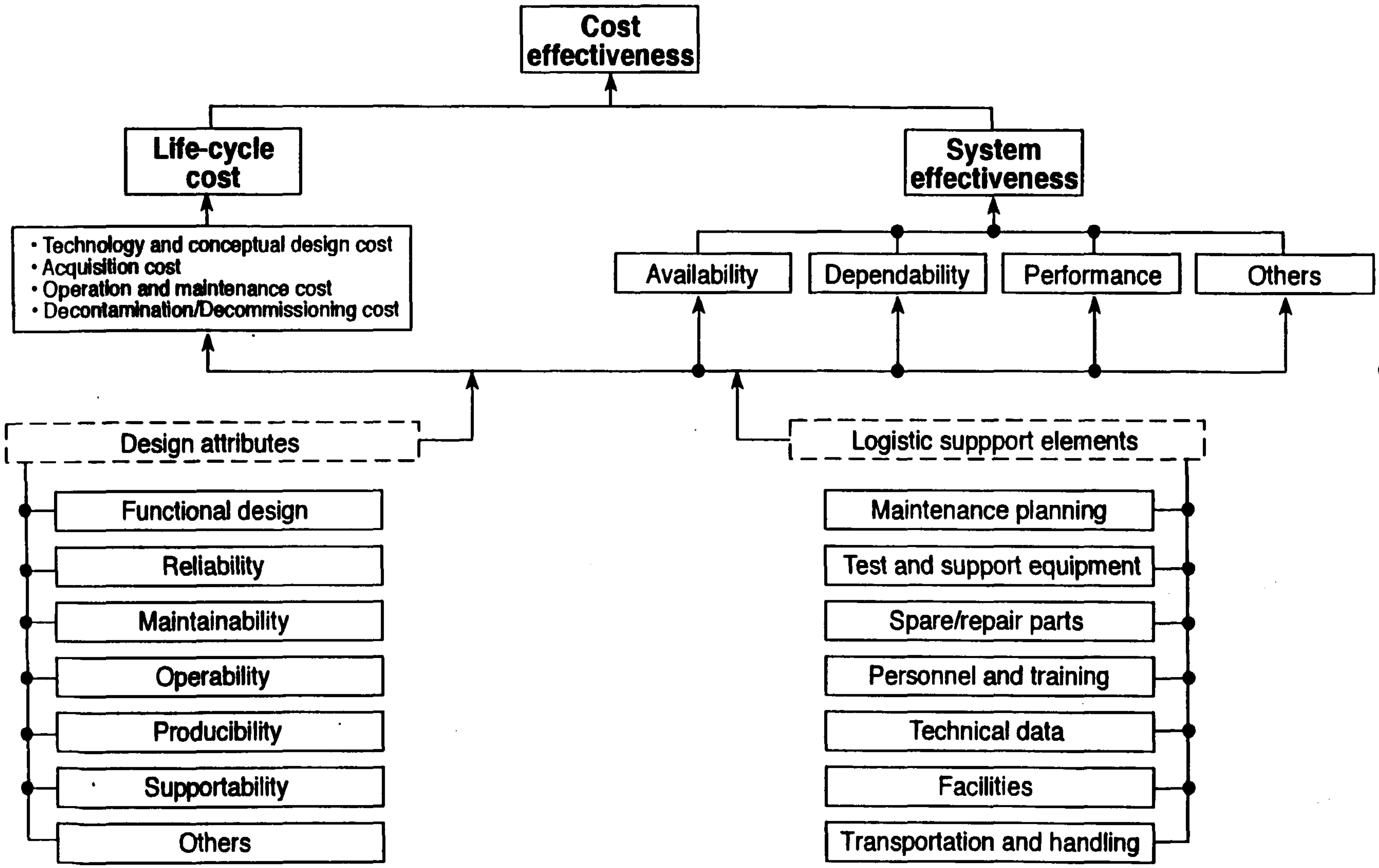

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Figure 3-2. Cost Effectiveness.

3.4.3 Life-Cycle Costs

System LCC analyses will be performed to develop the requisite cost information to support decisions on alternatives, personnel, product, process solutions, and risk assessments. LCC is the total of the direct, indirect, recurring, nonrecurring, and related costs incurred or estimated to be incurred during the anticipated life span of the system. Early design evaluations will include system trade studies that establish a desirable balance among performance, risk, reliability, supportability, schedule, cost, and other significant attributes while complying with safety, regulatory, and permitting requirements. The TWRS Program LCC analysis will be performed on a continuing basis as the program evolves and will be established specifically at each technical baseline review. The TWRS SE LCC Procedure (Orsag et al. 1996) describes the development of a LCC Program.

3.5 TEST AND EVALUATION

Test and Evaluation (T&E) is the TWRS activity that will verify that the completed system meets the customer's requirements. Performance requirements will be different for components, subsystems, and systems, but are the inputs for each level of the T&E activity. The determination of the methodology to verify that the system, and its subelements, satisfies its performance requirements is an integral step in the SE process. Section 4.2.6 explains the TWRS T&E approach.

The specific T&E method for verification will be determined as the functions, requirements, and architectures are developed to ensure that the performance requirements can be met. To be verifiable the performance requirements must be measurable, quantifiable, complete, accurate, and traceable. T&E ensures that mission objectives are satisfied because the system requirements (which were developed from the mission objectives) are used as the criteria during T&E.

The specific method to be used for requirements verification depends on various factors including cost of verification, importance of requirements, optimum system measurement point, and schedule constraints. Requirements verification methods will include one or more of the following:

1) Analysis
2) Demonstration
3) Testing
4) Inspection.

A grading system will be established to determine the extent to which the above methods should be applied to optimize usage of the verification resources and avoid expenditures where they are not warranted. For example, the most important safety and performance characteristics of the system should be extensively reviewed, analyzed, and tested to ensure satisfactory performance, while low risk, low cost elements may be verified through inspection and limited analysis.

4.0 SYSTEMS MANAGEMENT AND CONTROL

4.1 SYSTEMS MANAGEMENT

Systems management includes the TWRS organizational structure, organizational interfaces, roles and responsibilities, technical discipline integration, and systems integration activities required to develop a cost-effective system that satisfies the user's needs.

4.1.1 Program Management Structure

The TWRS Program management structure has been revised since first published in the *TWRS Program Management Plan* [1993] to focus on the projects. The revised structure has a program level Technical Integration organization and project organizations. The organizational structure is shown in Figure 4-1, TWRS Program Organization. The individual project management structures are developed based on the needs of the project and reflected in the individual Project Management Plans.

TWRS Technical Integration has been chartered to integrate the TWRS Program technical baseline, and to implement the SE process in TWRS. Technical Integration provides leadership in creating and managing the technical baseline, defining technical strategies and objectives, and implementing performance metrics to monitor progress.

4.1.2 Organizational Interfaces

TWRS will manage internal and external organizational interfaces. The internal organizational interfaces are defined and communicated using organization charts based on workscope (see Figure 4-1, TWRS Organization). For repetitive activities that call upon personnel from different organizations, a Working Group Charter will be developed.

Interactions with external activities and organizations (e.g., Privatization Contractors, IST) will be developed through negotiation and documented in Memorandums of Agreement. TWRS will identify a liaison to the external agency.

4.1.3 Roles and Responsibilities

A roles and responsibilities matrix is included as Appendix C. The matrix correlates the activities and products with the organizations, which are lead, support, review approval, and customer for those activities and products.

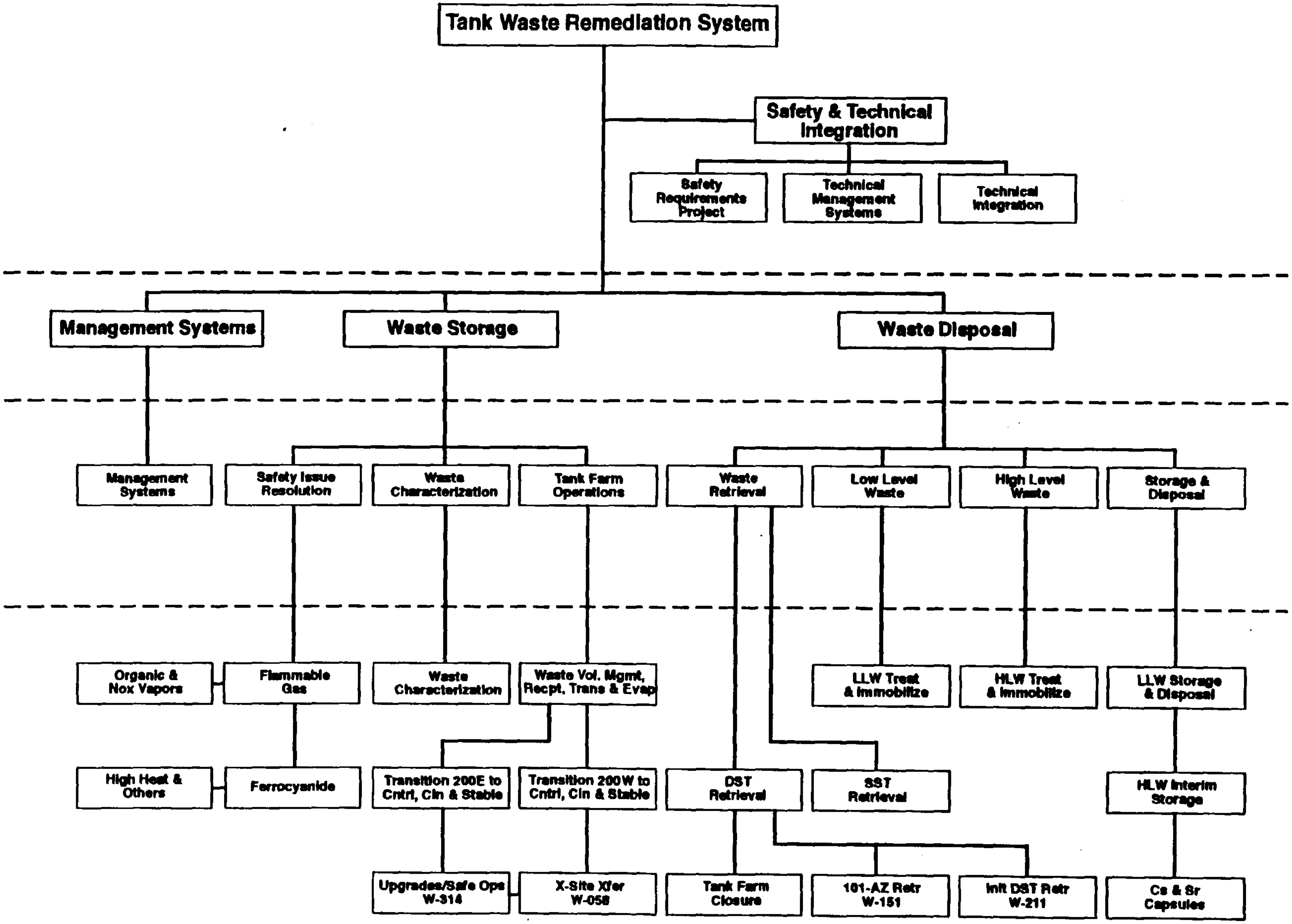

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Figure 4-1. TWRS Program Organization.

4.1.4 Technical Discipline Integration

Systems Engineers, and other personnel with responsibility for developing the technical baseline, will ensure that individuals in the regulatory, health and safety, and other specialty disciplines participate in the development of the technical baseline. These technical personnel are an integral part of the engineering development process, and will therefore participate throughout the SE process, starting with the Mission Analysis and continuing with the process of developing the lower-level functions, requirements, architectures, and T&E activities. The methodology for ensuring participation of the specialty engineers is the formation of Product Development Teams (PDT) or Integrated Product/Process Teams (IPT) to accomplish the FRAT process. The PDTs would be responsible for one of the hierarchical functions (or subfunctions) and consist of process engineers and systems engineers who form the core group. The core group would be supplemented by "specialty engineers," who participate when the specific expertise is needed.

There are many types of engineering and non-engineering specialists who's participation in baseline development is vital to ensuring a fully integrated system. The following is a list of typical specialties that will participate in the TWRS development:

- Regulatory Compliance
- Public Health and Safety
- Occupational Health and Safety
- Nuclear Specialties
- D&D
- Environmental Engineering
- Facility/Systems Commissioning and Startup
- Human Systems Integration
- Integrated Logistics Support
- Producibility and Constructability
- Reliability, Availability, and Maintainability
- Safeguards and Security
- Standardization, Materials, and Processes
- Systems Life-Cycle Cost
- Transportability
- Value Engineering
- Quality Assurance
- Operability (includes deactivation)
- Test & Evaluation
- Technology
- Other disciplines.

Appendix D includes descriptions of each of the disciplines. Personnel with specialty background or expertise should be identified by the Team Leader or other members for participation as required to ensure necessary requirements are established to impact the design process.

4.1.5 Systems Integration

System integration fulfills two functions. It provides a vehicle to focus effort and resources where required by improving understanding of the Program path forward. Integration is also the assembly of the physical pieces of the system into a whole.

4.1.5.1 Management Systems Integration. Integration is the process of unifying all of the activities performed in developing a system to increase effectiveness and efficiency . It ensures that all entities involved in system development are interacting to successfully achieve the system purpose or satisfy the customer's need. Integration starts with the SEMP which integrates the customer's needs with the WHC and TWRS management system.

Successful integration requires communication, planning, scheduling, baseline management and interface management. Effective communication and the development of a Systems Integration Plan (SIP) are the keys to successful system integration. The effective communication is facilitated by the TWRS management structure and the use of concurrent engineering in the form of PDTs. An information system that provides consistent, accurate and timely data and direct face-to-face communication in the team interaction process are important aspects of effective communication. The SIP addresses the processes and procedures to be followed in integration of TWRS with other activities. The SIP will detail the formation and use of the PDTs. It will also specifically address the need for integration of private vendor facilities and project work with WHC and government-engineered efforts.

Integrated planning consists of consistent guidance, practical procedures, appropriate tools, adequate resources and integrated reporting. The three key taskings in integration are system definition, establishment of an architecture, and verification that the proposed architecture meets system objectives. The TWRS planning process ensures that no work is performed that does not contribute to satisfying the customer's need and results in the MYPP. The TWRS SE Program Summary Schedule, an event driven schedule which is coordinated to the TWRS WBS, identifies the key events and the accomplishments that must be achieved by those events.

Baseline management, or maintaining approved, defensible and integrated baselines, is covered by existing TWRS configuration management procedures. The TWRS Integrated Baseline, covered in Chapter 2.0, integrates the plans, schedules and technical baseline into a coherent management structure. Interface management, covered in Paragraph 4.2.3, prescribes the activities necessary to manage the inter-relationships of numerous sub-systems or components. The product of systems integration is integrated plans and schedules where key milestones for system definition, design, construction, test, deployment, operation and D&D are assembled and conflicts resolved.

4.1.5.2 Physical System Integration. Physical System Integration is the process of creating an assembly from pieces of the system. It is used both top down and bottom up. TWRS will use system integration from the top down to analyze all parts of a complex system, and their interrelationships, to solve the problem and satisfy the customer's need with the best possible total solution. For TWRS this means that TWRS must be integrated with not only the site but must also be cognizant of interfaces and relationships with other DOE sites. The effects of TWRS on the interfacing components of other affected DOE sites, i.e., the repository, as well as the effects of the other sites on TWRS must be considered. The top-down integration continues with an in-depth evaluation, at each level of decomposition, of the integration of the components of TWRS to provide the best "integrated" solution. TWRS will use the FRAT process with emphasis on architecture definition and interface analysis to accomplish the complete integration activities.

Integration occurs from the bottom up when parts (components) are tested at the lowest level and the parts are then put together in a planned manner to verify the operation of the entire system. Some bottoms-up integration does not require actual testing, but may use analysis of the combinations of lower level results to verify the acceptance criteria has been satisfied. The TWRS Test and Evaluation Plan (TEP) will contain the details of this integration process.

4.1.6 Training

Training will be provided to TWRS staff so that they have the knowledge and skills necessary to understand and implement the SE Process as a way of doing business. This will include training for present and new employees. The TWRS Technical Integration group will have primary responsibility for developing the content and methods for training.

Training is a process that provides a managed training program, a training plan, training experience, and measures training effectiveness. The highest-level requirements for training and the type of training expected for management, project leaders and technical staff will be defined. A training plan will be prepared to detail specifically the content and methods of training. This will include an introduction to SE and the use of the specific SE procedures required for the conduct of TWRS work. The effectiveness of training will be measured by monitoring; 1) increase in employee skills for doing their job, and 2) the degree of improvement in the quality of the SE products.

4.2 SYSTEMS CONTROLS

The TWRS Program is implementing the systems controls described in this section, to develop the TWRS in a cost-effective manner. These methods provide the tools to effectively manage risks, configuration, interfaces, and decision making, to provide traceability of all requirements, and to manage T&E processes and technical performance measurement. Use of this structured approach provides management with cost-effective controls over the life of the project.

4.2.1 Risk Management

The TWRS Program is establishing a systematic and integrated risk management program approach to support line management at program, project, and subproject levels with evaluations of programmatic cost, schedule, and technical performance risk. The approach uses a top-down, bottom-up flow of risk data and information (see Figure 4-2, Risk Management List Organizational Structure). The primary tool for managing risk is the risk management list (RML), which identifies risks, describes their likelihood and consequences, and identifies handling actions and responsibilities. The RML may be supplemented by a Critical Risk Management List (CRML) that includes only the highest risks. In some cases, the CRML may be the only risk list presented to management, but a RML still needs to be generated.

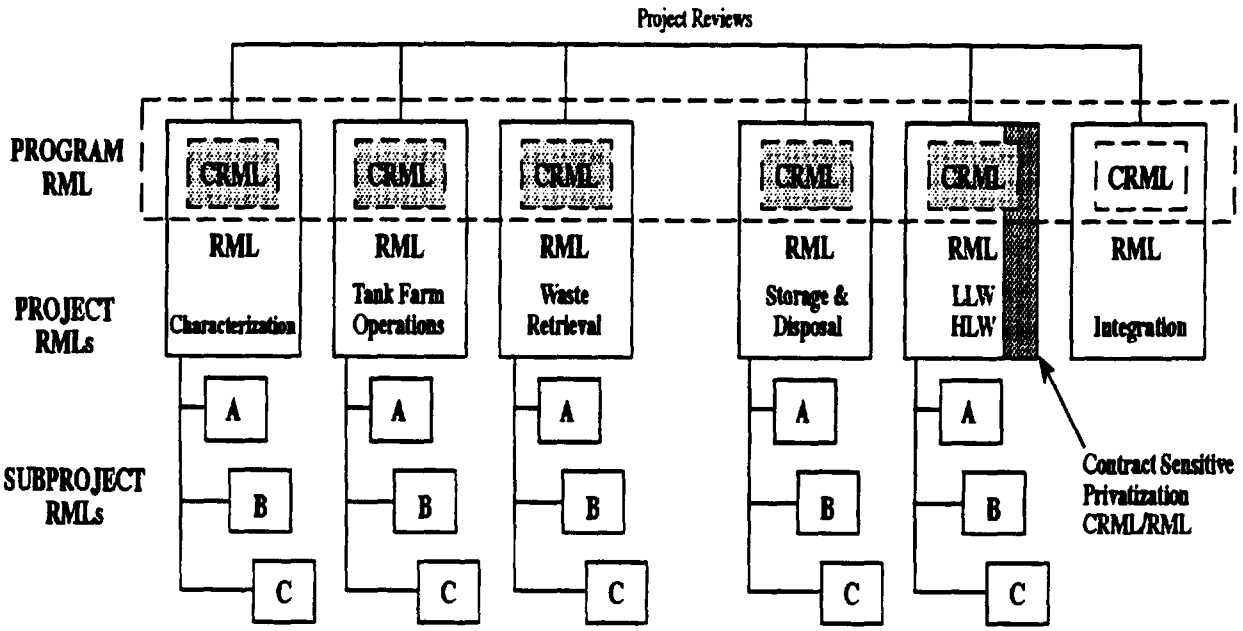


Figure 4-2. Risk Management List Organizational Structure.

There will be an overall TWRS Program-level CRML and RML. Each project is to maintain its own CRML and RML and oversee the development of applicable subproject CRMLs and RMLs. Following are the key elements of TWRS risk management program. Additional details are contained in the *TWRS Programmatic Risk Management Plan*, WHC-SD-WM-PMP-018.

- Each TWRS project will develop an RML specific to its activities and consistent with the TWRS RML.

- The TWRS Programmatic Risk Management Plan will be periodically updated to support fiscal year planning.

- An integrated risk database will be used by program, project, and subproject managers and technical staff to query, review, and distribute programmatic risk information.

- Continued improvements will be made in the process and tools for risk management including methods for identifying risks, selecting risk management actions, revision of procedures, training, and communicating lessons learned.

- Mentoring assistance will be provided to projects and subprojects to help them implement risk management.

- Projects will assign a point of contact for risk management integration.

- Programmatic risk will be used as evaluation criteria in trade-off studies.

The TWRS Risk Management Program will be managed and controlled through the performance of risk assessment (identification), risk analysis, and risk handling (see Figure 4-3, Risk Management Functions). Risk assessment involves the examination of all aspects of a project or subproject in order to identify potentially undesirable events that can detrimentally affect the program and make an initial assessment of the impact such an event could have if it occurred. Risk analysis involves the process of quantifying both the likelihood of an undesirable event and its impact should it happen. Risk handling involves the identification of handling actions, development of action plans, action implementation, and status tracking, including planning for follow-on actions in response to programmatic changes.

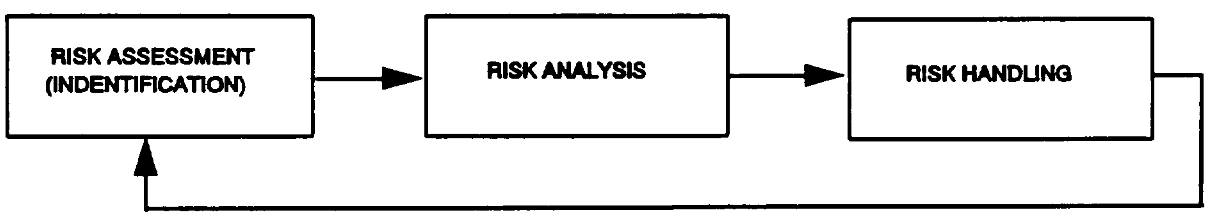
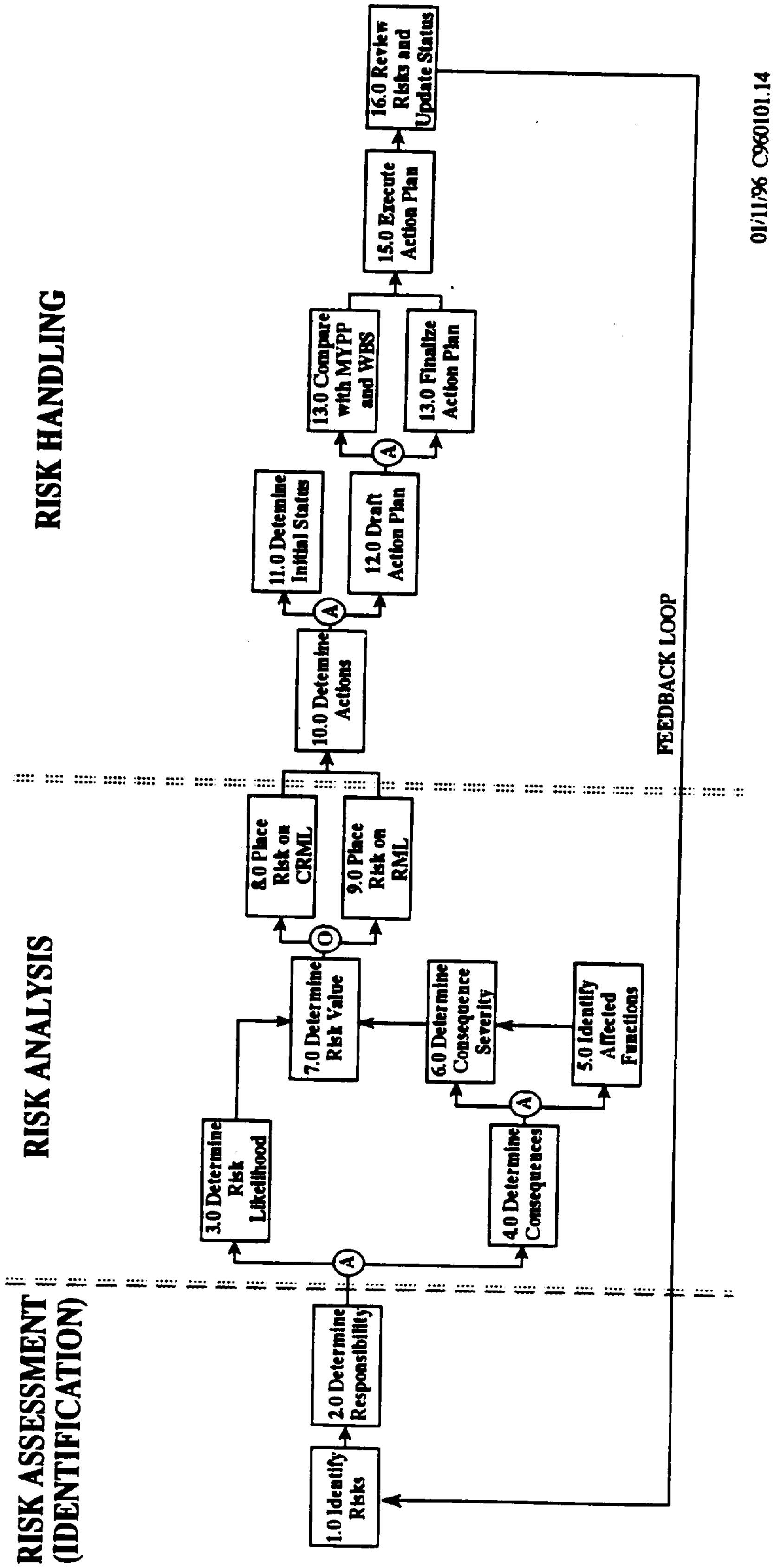


Figure 4-3. Risk Management Functions.

The TWRS Risk Management Program will be performed at all levels as functional process steps. The process steps should be iteratively performed and have feedback anywhere within the process. (See Figure 4-4, Risk Management Process.)

Figure 4-4. Risk Management Process.



Detailed instructions for performing the TWRS Risk Management Program are contained in the TWRS Risk Management Procedures (Orsag et al. 1996).

4.2.2 Configuration Management

TWRS Configuration Management (CM) will be implemented in accordance with WHC-SD-WM-CMP-013, *Tank Waste Remediation Systems Configuration Management Program Plan* and WHC-SD-GN-CM-2001, *Configuration Management Program Plan for Hanford Site Systems Engineering*. The TWRS Configuration Management Program Plan (CMPP) describes the CM Program for TWRS and defines the requirements and responsibilities for execution of the TWRS Configuration Management Program. It provides the methodology to establish, upgrade, reconstitute, and maintain consistency among the requirements, product configuration, and product information. The technical consistency afforded by the TWRS CMPP provides for the safe, economic, and environmentally sound management of the TWRS products throughout their life cycles. This is necessary to achieve the mission objectives and support the DOE Integrated Site Baseline.

The TWRS CMPP complies with WHC CM requirements and aligns with the criteria established in the DOE Standard, DOE-STD-1073-93. The TWRS CM Program implements requirements of DOE/RL-93-0106, *Tank Waste Remediation System, Program Management Policies*, DOE/RL-95-58 (E), *Hanford Site Systems Engineering Criteria Document (Draft)*, the *Hanford Strategic Plan* (October 1994); and RLPD 5000.1, *Baseline Execution and Management Process*, and complies with the requirements established in applicable DOE Orders and Directives.

4.2.3 Interface Management

The TWRS Program interface management process is comprised of identification and documentation of functional and physical interfaces, and establishing and maintaining control of interfaces. ICDs will be developed continuously throughout the TWRS Program life-cycle beginning with the early conceptual stage. ICDs are a component of the program Integrated Baseline and as such are required to be under configuration control. ICDs will be developed in accordance with the established TWRS Interface Control procedure (Orsag et al. 1996).

The TWRS Interface Control Working Group (ICWG) is tasked to manage alternative generation and architecture selection, evaluation and optimization, and verification activities between organizational elements. The ICWG is responsible for establishing and controlling TWRS interfaces. The ICWG has been set up within TWRS for the purpose of maintaining cognizance and control of TWRS functional and physical system interfaces in accordance with the TWRS ICWG Charter.

4.2.4 Requirements Traceability

The TWRS Program will provide requirement traceability throughout the system life. TWRS will use an integrated database, the RMACS to store and manage the SE data. Changes to the database will be managed using CM processes (see Section 4.2.2). The RMACS engine is RDD-100*, a relational database.

Requirement management and CM processes will provide traceability for all of the SE data. Requirement traceablity includes managing the requirement source (e.g., constraining document, function decomposition, trade study), applicable requirements analysis to interpret the source, requirement allocations to architectures, test and evaluation method, and revision and approval records. These items plus all applicable issues, enabling assumptions, and decision management references will be recorded and managed to provide a defensible "pedigree" for TWRS requirements.

RMACS contains not only the single integrated database but also supporting information management tools to allow freer access to TWRS data for use by the engineering staffs and other personnel. The primary access for the engineering community is via the Browser, which is PC-based and readily available via the Hanford Local Area Network (HLAN). Figure 4-5 shows the information infrastructure.

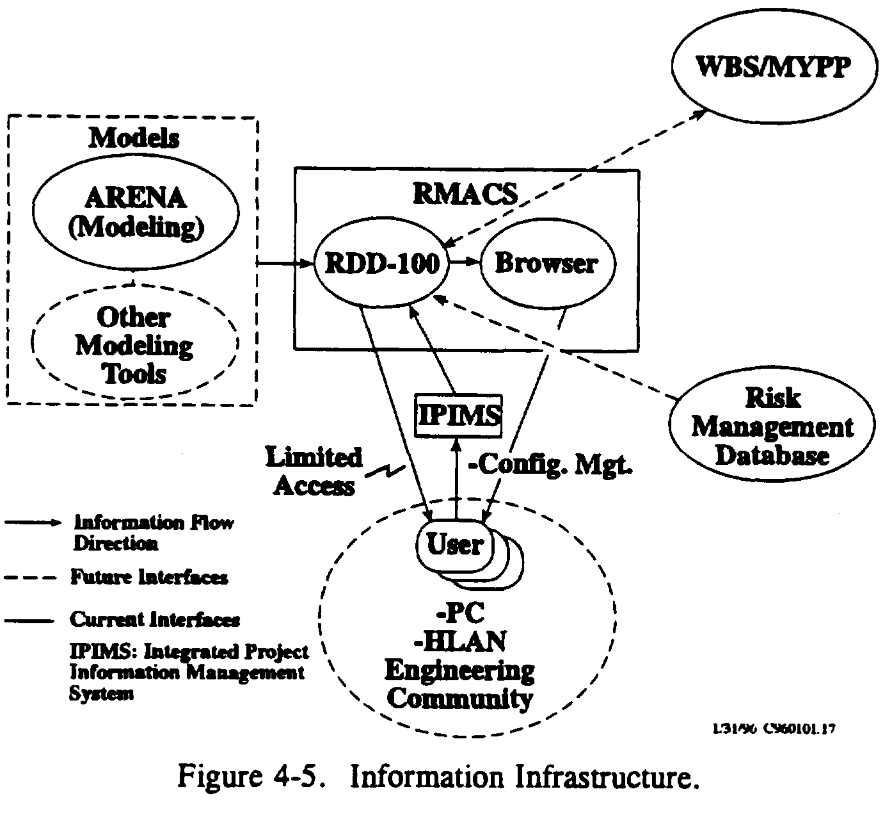


Figure 4-5. Information Infrastructure.

* RDD-100 is a trademark of Ascent Logic Corporation.

4.2.5 Decision Management

The TWRS Program uses a Decision Coordinator to function as a central point of contact for maintaining awareness of TWRS decisions and thereby providing assurance that important decisions have been identified and considered in the decision prioritization process. The Decision Coordinator produces an Annual Decision Status Report that will identify, coordinate, and track the status of all TWRS decision-making efforts. The report contains summary descriptions of each decision, a prioritized list of decisions, indications of decision progress and status, and a compendium of decision documents from completed decision actions.

Decision management provides traceability for affected decisions through utilization of a rigorous and methodical decision-making process. Decision management encompasses a slightly broader perspective than decision making. This perspective acknowledges the interdependencies of decision making in complex environments and provides for the cataloguing and coordination of multiple decision-making activities. It is the responsibility of a decision coordinator to maintain this overview awareness and to schedule decision-making activities in a manner that promotes effective decision making. Once initiated, managing a particular decision involves three basic steps (bold boxes shown in Figure 4-6): (1) decision framing, (2) decision analysis, and (3) deciding.

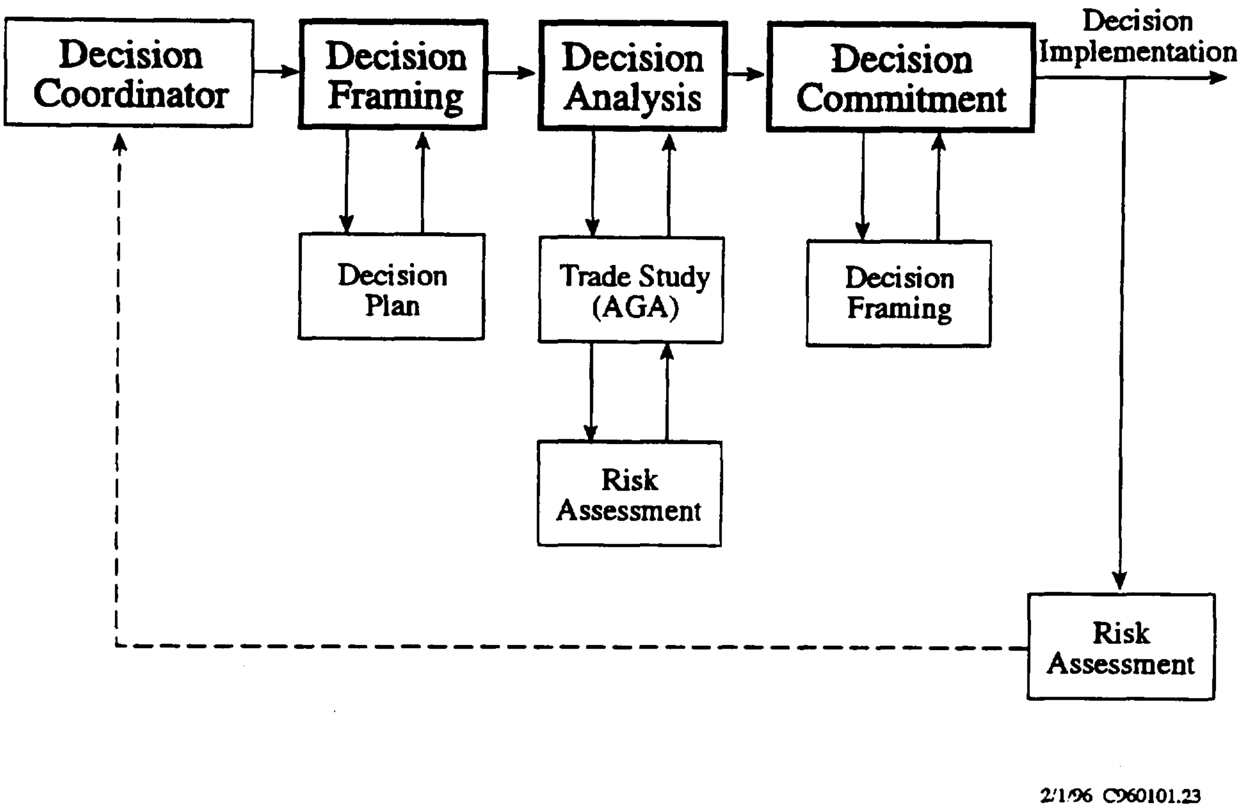


Figure 4-6. Decision Process.

Decision Framing - Decision framing is the process of analyzing the problem and clearly identifying and formulating the decision to be made. Framing results in the identification of a specific statement of decision, identification of decision criteria, and the development of preliminary notions of acceptable decision alternatives. The development of a comprehensive set of alternatives falls under the responsibility of the Alternatives Generation and Analysis (Orsag et al. 1996) and is a fundamental part of the trade study analyses. However, the framing process develops essential insight into applicable constraints that will be applied to any proposed decision alternative. The responsibility for developing the decision frame is assigned to a decision action officer. Working with the decision maker, the action officer prepares a decision plan (described in Decision Management, (Orsag et al. 1996) which documents the results of the decision-framing effort. These plans form the basis of communication between the decision maker and those technical staff that will be responsible for developing needed information as part of the decision-analysis activities.

Decision Analysis - Decision analysis is the process of developing an understanding of the alternative outcomes to a decision. It is in the analysis process where all alternatives considered are measured against the relevant decision criteria. As the technical information is developed for these alternatives, insight may be gained that leads to the creation of additional alternatives that warrant consideration in the decision. Within the TWRS program, risk is a fundamental consideration in every decision. As a result, the identification and assessment of the risks of each alternative is part of each decision analysis. Results of a decision analysis are documented in two ways. First, the specific details of the analysis are captured in a detailed decision-analysis report (see the AGA procedure for guidance). Secondly, the results of that analysis are reduced to a summary of the information needed to make the selection of a preferred alternative. This summary information is prepared, as a decision summary report (see decision management procedure for guidance), by the action officer and presented to the decision maker to facilitate consideration of the analyses in the selection of the preferred alternative.

Deciding - The final outcome of the decision-management process is the selection of an alternative and the implementation of the decision. Each decision has an assigned decision maker. For many decisions two decision makers will be needed, one representing WHC and the other representing DOE/RL. The decision is signed by the decision maker(s). This selection is further publicized by informing the decision coordinator as part of the decision implementation activities. The decision coordinator maintains a record of the outcome of all scheduled decisions.

Interface with Risk Management - Any decision made retains an element of risk. Risk enters the decision-management process at two points (see Figure 4-6): 1) as an adjunct to the trade study efforts during decision analysis and 2) as an impact to the subsequently selected decision following the decision-commitment process. This risk results from assumptions and uncontrollable events that can not be resolved prior to making the decision. TWRS has established a risk-management procedure to address and manage the impact of these risks. The action officer is responsible for communicating risk related issues to those individuals responsible for risk management, as identified in the procedure for risk management (Risk Management, (Orsag et al. 1996).

4.2.6 Test and Evaluation

The TWRS will use Test & Evaluation (T&E) to; (1) quantify technical and program risk; (2) verify design and product conformance with requirements and specifications; (3) support technology and design development; (4) provide continuing estimates of operational performance; and (5) ensure that program objectives are achieved. Verification evolves with program and project maturity and is accomplished through:

- Analysis
- Test
- Demonstration
- Inspection.

Model testing and simulation studies are conducted prior to the acquisition of prototype and operational assets. These tests and studies include subscale test models for verification of design and/or process solutions, full scale sub-systems to verify commercial product compatibility with system requirements and computerized simulations of subscale and full scale systems to assess system performance. They are conducted concurrently and sequentially with system designs and other T&E methods to support the life-cycle management of the TWRS. Resource requirements (hardware, software, personnel, facilities) will be identified as well as conducting requirements and test planning analyses to assess cost and schedule impacts which will be integrated into the TWRS cost profile and master schedule.

The T&E Program consists of both development test and evaluation (DT&E) and operational test and evaluation (OT&E). Although the primary goal for each is the same (i.e., verification of TWRS Program requirements), the specific approach and activities in each phase (development and operating) are different. DT&E emphasizes technology development (research) and design development (prototype) testing. Program and project-level activities and involvement dominate this phase. The Technology Development Contractor or the vendor is also involved if there is emerging or innovative technologies being developed. DT&E supports the following: (1) early technical baseline development, (2) requirements development and allocation, (3) technology verification, (4) prototype design performance, (5) risk mitigation, and (6) technical performance measurement. Initial DT&E efforts will be supported by analytical techniques (mathematical models and simulations) and physical testing. Testing helps to define, develop, and select performance parameters and requirements as the design evolves. DT&E culminates during the final design phase.

The intent of OT&E is to ensure that the developing system is capable of meeting its objectives, within its intended operational environment. OT&E is conducted on operational equipment and includes procurement acceptance, installation acceptance, pre-operational testing, and operational (turnover and startup) testing. In this phase, Project, Operations, Engineering, Architect/Engineer, and vendor activities predominate. OT&E will be conducted to determine the performance and suitability of the integrated TWRS Program and its elements to meet the TWRS Program mission and TPMs. Performance assessment and technical performance measurement efforts continue during OT&E to verify that test results meet specified requirements.

A WHC TWRS Test and Evaluation Plan (TEP) will be developed and implemented to guide and direct the management of TWRS T&E activities. The TWRS TEP is the basis for other T&E planning documents including TWRS Project T&E plans.

The WHC TWRS Program TEP will be prepared and will:

- Summarize the objectives, responsibilities, logic, resources, and schedules for planned T&E.
- Describe the system-level tests to be performed, test rationale, relationships to other tests in the integrated sequence, and the contribution each makes to verification of the system.
- Describe the evaluation process to be followed to ensure performance compliance and verification of the TWRS Program.
- Outline each participant's role in the T&E effort.

T&E documentation (Test Plans and Reports) will address the following information to support conformance verification; (1) test requirements, (2) acceptance criteria, (3) test scope, (4) test procedures, (5) test schedules, (6) estimated cost, (7) test data, and (8) test results. T&E plans and reports must be developed, approved, controlled, and maintained according to applicable DOE orders and procedures.

4.2.7 Technical Performance Measurement

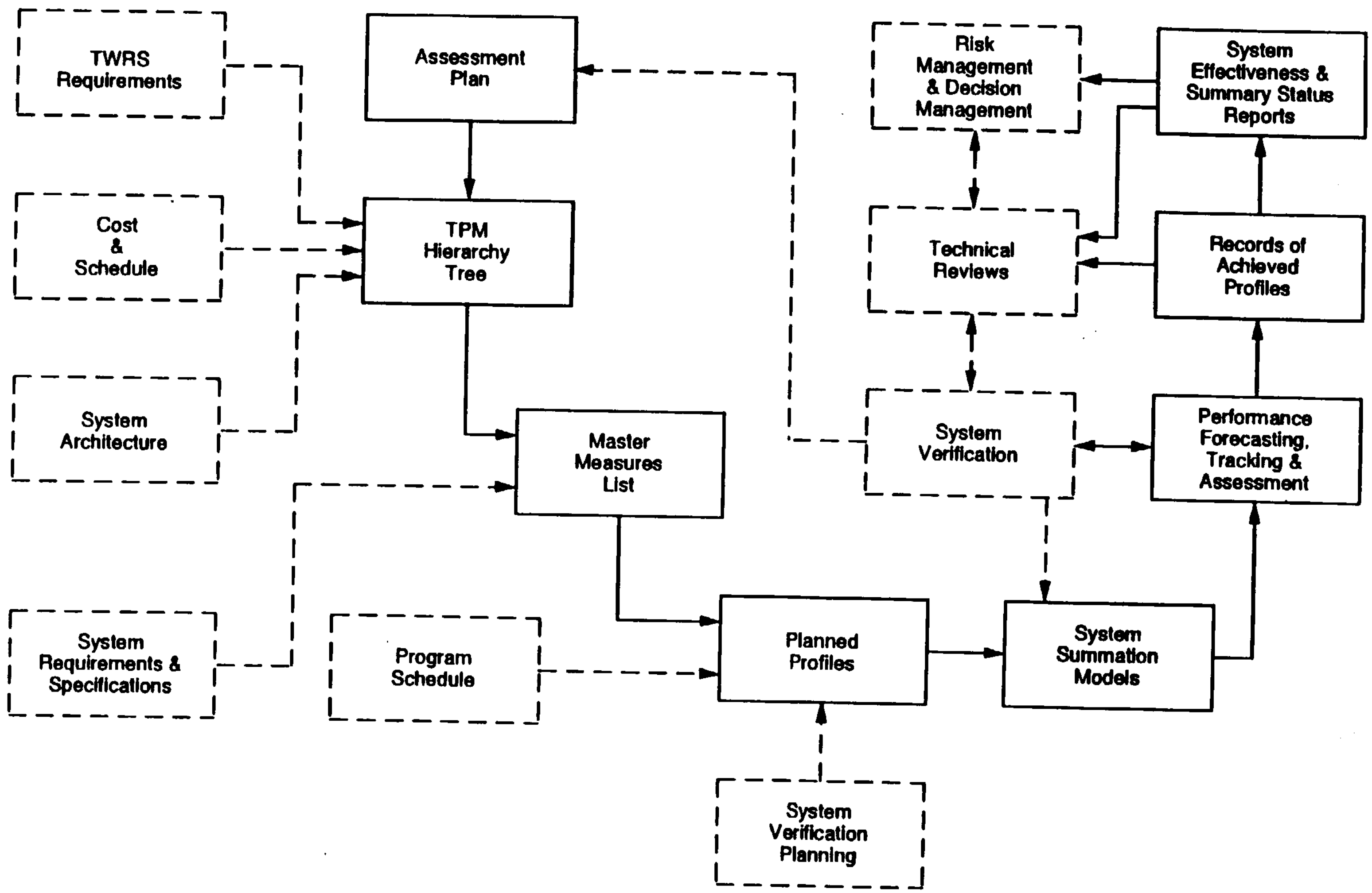
TWRS will use Technical Performance Measurement (TPM) to:

- Gain insight into the maturity of the engineering design
- Identify key parameters for the T&E Program
- Provide inputs into overall program, decision, and risk management.

These parameters are compared to predicted values or are used on a relative basis for comparison of alternatives. TPMs are tracked as a function of time once the system architecture has been selected. From that point, deviations of the actual parameters from the estimated (or design "goal") values provide management with an estimated maturity of, and the associated risk in, the TWRS Program.

TPMs will be selected from requirements that are critical to accomplishing the mission objectives, protecting the environment, or ensuring public and worker safety. The parameters selected for tracking will be key indicators and forecasters of technical success. These parameters will be analyzed to help determine what should be verified along with when and how verification should be accomplished. (See Figure 4-7, TPM Relationships.) The Technical Performance Measurement Procedure (Orsag et al. 1996) contains additional information on TPMs and expands on Figure 4-7.

WHC TWRS Technical Integration will be responsible for updating, maintaining, and tracking the TPMs. Some parameters will be tracked throughout the program. Others will be tracked only during specific program phases or to identify and resolve specific risk issues. TPMs will be input to T&E as test candidates for data collection. As the T&E program progresses, test results will be reviewed, evaluated, and compared to the parameter limits. Trend analyses will be conducted to determine performance achievements (verification) and deviations (corrective action initiation). When performance exceeds specifications, opportunities for requirement or resources reallocation will be examined.



NOTE: Blocks shown in dashed lines are not part of the TPM Process.

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Figure 4-7. Technical Performance Measurement Relationships.

5.0 ADDITIONAL SYSTEMS ENGINEERING RESPONSIBILITIES

Includes other areas not specifically included in previous sections but that are essential for DOE understanding the performing contractor's proposed SE effort.

5.1 STANDARDS AND PROCEDURES

The documents shown in Section 5.1.1 are pertinent to the development, implementation, and application of SE principles and methodology to the TWRS Program and should be used in carrying out the detailed SE tasks and activities. The documents are shown in hierarchial form to represent precedence of one documents guidance over another. Other documents that provide additional guidance for performing the tasks are shown in Section 5.1.2. These documents are provided as guidance in understanding the intent and purpose of SE principles and activities.

5.1.1 Applicable Documents

DOE Order 4700.1 Project Management System

Tank Waste Remediation System Systems Engineering Management Policy, DOE/RL letter, 95-RTI-107, Oct. 31, 1995.

Tank Waste Remediation System Program Plan, DOE/RL-92-58 Draft, March 31, 1993.

Tank Waste Remediation System Program Management Plan, DOE/RL-92-59 Draft, March 31, 1993.

Tank Waste Remediation System Program Management Policies, DOE/RL-93-0106, Nov. 30, 1994, (Note: Not yet accepted by WHC).

Tank Waste Remediation System Multi-Year Program Plan, WHC-SP-1101, 1995.

Tank Waste Remediation System Configuration Management Program Plan, WHC-SD-WM-CM-013 Draft.

Tank Waste Remediation System Risk Management Plan, WHC-SD-WM-PMP-018.

Tank Waste Remediation System Decision Management Guide.

Westinghouse Hanford Company Tank Waste Remediation System Systems Engineering Manual, WHC-IP-1231, DRAFT.

5.1.2 Guidance Documents

DOE/RL-95-12, Rev AE, Tank Waste Remediation System Systems Engineering Standard, DRAFT, April 3, 1995

DOE/RL-95-XX, Hanford Site Systems Engineering Criteria Document, Rev A, May 8, 1995

EIA/IS-632, EIA Interim Standard, Systems Engineering, December, 1994

DOE Order 430.1, Life-Cycle Asset Management and Supporting Guides, DRAFT.

IEEE P1220 Standards for Systems Engineering.

Defense Systems Management College Systems Engineering Guide, January 1990, Fort Belvoir, VA.

5.2 OTHER PLANS AND CONTROLS

This section reserved.

5.3 LONG-LEAD ITEMS

This section reserved.

5.4 DEVELOPING AND APPLYING CRITICAL TECHNOLOGIES

The decision to proceed with the Privatization, the December 1995 TWRS Technology Needs review, and other actions have resulted in the obsolescence of the TWRS Integrated Technology Plan (ITP). The role of the ITP is being replaced by the Tank Focus Area efforts (see paragraph 1.4.4) and the efforts cited below. TWRS represents the TFA User's Steering Group for Hanford.

The development of critical technologies for TWRS will be handled primarily through the TFA. However, when the requirement exists for the development and application of critical technologies that are not addressed through the TFA the following process will be used:

The Hanford Site Technical Coordinating Group has applied the following needs prioritizing criteria to establish the immediate (FY77 & FY98) technology needs:

Technology Gaps - Does the technology need address a critical gap in the existing program baseline?

Urgency - Is the technology need extremely urgent for meeting cleanup schedules or reducing existing risk?

Cost Reduction - Does the technology need have the potential for significant cost savings over the current baseline technology?

Effectiveness Improvement - Does the technology need have the potential for significant increase in effectiveness over the current baseline technology?

Safety Improvement - Does the technology need have the potential for significant improvement in worker safety over the current baseline technology?

Schedule Improvement - Does the technology need have the potential for significant improvement in cleanup schedule over the current baseline technology?

Applying these as a screening or determining basis for critical technology needs will then result is a prioritized list to be used for establishing development projects. Each technology development project will be based on a Technology Development Plan (TDP) (format to be developed). Each TDP will be tailored to include those sections appropriate for the technology development effort at hand. The plan may include; a) an overall strategy, b) a path towards proof of concept, b) a plan for conversion from concept to application, d) scale-up and e) other sections as appropriate. Additionally the plan will describe the resource requirements and technical performance measurement parameters for tracking development. If appropriate, a more comprehensive process may be required, in which case the Systems Engineering grading procedure may be executed and a more comprehensive systems approach applied.

In all cases, technology development efforts will apply established engineering and systems engineering procedures as applicable.

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6.0 GENERAL INFORMATION

6.1 NOTES

This section reserved.

6.2 GLOSSARY

Alternative Solution. A candidate technical design strategy or approach that potentially satisfies the functions and requirements.

Analysis. A series of steps in assessing performance requirements or deficiencies.

Architecture. The selected design solution from the set of alternative solutions that best satisfies the requirements, and is used for more detailed design activities.

As-built. The end-item as actually produced (constructed, fabricated, etc.), which may differ from the item's design for construction. End-item design documentation should be changed, if differences occur, to reflect the "as-built" configuration.

As-Built Design. Constitutes the design of the as-built operational system. Confirmation of As-built condition ensures that the system is constructed according to the approved drawings and that the system performance, quality of materials and workmanship meets system requirements.

Assessment. An evaluation activity to determine whether results being obtained are accomplishing desired purposes; a determination of whether a job, task, operation or end-item satisfies all applicable requirements.

Baseline. A quantitative definition of cost, schedule, and technical performance, structured using a product based Work Breakdown Structure, that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field programs, projects, tasks, or subtasks are measured, assessed, and controlled. Once established, baselines are subject to change control procedures.

Baseline Change Control Board. A formal body of representatives, designed and chartered by senior management, with responsibility for ensuring the proper definition, coordination, evaluation, and disposition of all proposed changes to program baselines within their jurisdiction, as defined in the TWRS Management Integrating Procedures or Change Control.

Baseline, Cost. A budget that has been developed from the cost estimate made at approval of the technical baseline; the majority of the budget has been time phased in accordance with the schedule. The cost baseline is integrated with the technical and schedule baselines and is subject to formal change control. It normally contains direct and indirect budget; management reserve budget; undistributed budget and higher level budgets; contingency amount; and amount for fee, as appropriate.

Baseline, Integrated. A baseline composed of and integrating the program's technical, schedule, and cost baselines. This baseline is subject to formal change control. (See **Baseline**)

Baseline, Schedule. A time-phased, product based, life cycle plan with a logical sequence of interdependent activities, milestones, and events necessary to complete a TWRS project or program. This baseline incorporates the total technical scope of work and provides a basis for analyzing performance. The schedule baseline is integrated with the cost and technical baselines and is subject to formal change control.

Baseline System Description (BSD). Document that provides an overall description of the system, in an easily understood illustration and narrative format for visualizing architecture concepts. It is used by the participants working on the TWRS Program as a communication tool, and as a point of departure for briefings, studies, and cost estimates.

Baseline, Technical. The documented functions, requirements, and configuration from which the program will acquire an operational system. Describes all or part of an Activity's functional, performance, inter-operability, interface and verification requirements necessary to demonstrate the achievement of those specified requirements.

Change Control. A documented process applying technical and management review and approval of changes to technical, schedule, and cost baselines.

Characterization. Sampling and analysis activities designed to determine the condition and present status of tank material, and to better understand the impacts of past operations on the soil and groundwater.

Closure. (Hanford Site) The process by which a hazardous waste treatment, storage, or disposal facility, which has discontinued operation, is finally dispositioned in accordance with a Washington State-approved closure plan.

Configuration. (1.) Functional or physical characteristics of a set of controls, including hardware, firmware, software, and any other items as described in technical documentation and achieved in a product. (2.) Description of the current state of a system or system element, usually in quantitative terms.

Configuration Management (CM). Part of an integrated management program that is used to control certain technical relationships among design requirements, technical documentation, and physical configurations within the TWRS Program.

Constraint. An externally imposed mandatory restriction, limitation or requirement, imposed by agencies and organizations, such as the U.S. Congress, U.S. Environmental Protection Agency, Washington State Department of Ecology, and other regulatory agencies, and DOE Orders, Secretarial Notices, and other regulatory documents. Where necessary, these constraints will be interpreted to derive performance requirements that are quantified and verifiable.

Construction. Any combination of engineering, procurement, erection, installation, assembly, or fabrication work involved in creating a new facility or altering, adding to, or rehabilitating an existing facility. It also includes the alteration and repair (including dredging, excavating and painting) of buildings, structures, or other real property.

Cost Estimate. A documented statement of costs estimated to be incurred to complete a project or activity.

CRWMS. DOE's Office of Civilian Radioactive Waste Management's system for acceptance, storage, disposal of spent nuclear fuel and high-level radioactive waste. The CRWMS does not include storage at the Hanford site.

Deactivation. The process of permanently ceasing active operation at a DOE facility in a planned and controlled manner. A deactivated facility has been adequately prepared to support ongoing surveillance and maintenance activities and subsequent decontamination activities.

Decision Criteria. A factor that is used to select a preferred alternative. A decision criterion may be quantitative or qualitative.

Decision Maker. An individual having the responsibility for making decisions.

Decomposition. The process of breaking down a whole into its parts. Functions, requirements, and systems each may be decomposed when proceeding from one level to a lower level.

Decontamination and Decommissioning (D&D). As defined by DOE Order 5840.2 for the D&D Program, decontamination is the removal of radioactive and hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques. Decommissioning is action taken to reduce the potential health and safety impacts of contaminated and non-contaminated facilities, including activities to stabilize, reduce, or remove radioactive and hazardous materials or to demolish the facilities.

Design Requirements. The "build to," "code to," and "buy to" requirements for products and "how to execute" requirements for processes. Design requirements are developed through synthesis of detailed performance requirements, engineering standards and design concepts.

Design Requirements Documents (DRDs). Documents provided to projects from program elements, which define the project mission. DRDs establish the baseline which the program elements maintain.

Design Solution. Selected alternative approach or architecture that best satisfies the functions and requirements.

Development Test and Evaluation (DT&E). A program consisting of technology and design testing, initiated to verify performance parameters of various system functions or elements, conducted during the development phase of a program or project.

Document Control. The act of ensuring that documents are reviewed for adequacy, approved for release by authorized personnel, and distributed to the appropriate people and groups.

End State. The desired condition at the completion of a program or project.

Evaluation. (1) A process to determine the significance or worth of a product, process, system, function, or result, or the impacts of proposed changes. The act of determining or verifying adequacy and effectiveness through audits, surveillance, reviews, self-assessments (including appraisals), or other means. (2) Establish fitness for continued use based on Federal and State regulatory requirements, U.S. Department of Energy (DOE) policy, Hanford Site needs, and WHC Environmental Division criteria.

Evaluation Criteria. Standards by which accomplishments of required technical and operational characteristics or resolution of operational issues may be assessed.

Function. A specific task, action, activity, or process that supports the achievement of an objective, e.g., an operation that a system must perform to accomplish its mission.

Functional Analysis. The first step of the functions requirements analysis at each level of the systems-engineering process. This step identifies what the system, or function is intended to accomplish.

Functions and Requirements Analysis. The determination of specific characteristics based on analyses of customer needs, requirements, and objectives; missions; projected environments for personnel, products, and processes; constraints; and measures of effectiveness.

Functions and Requirements Document. A document containing the high level definition of functions, requirements and candidate architectural concepts that are in-line with the stated mission objectives and defined mission constraints.

Hierarchy. A structured tree arrangement used to describe relationships produced by and subordinate to other relationships for system descriptions such as functions or requirements.

Human System Integration. The process of integrating the full range of manpower, personnel, training, human factors engineering, system safety and health hazards, to improve total system performance throughout the life cycle of the product, system, etc.

Independent Review. A review conducted by individuals with no vested interest in the outcome of the review.

Independent Reviewer. Reviewers are not associated directly with the work under evaluation. May be part of the cognizant DOE organization overseeing the Activity in which the review is taking place.

Interface. A functional or physical system boundary between two or more sub-systems or end items, across which materials, data, or energy passes.

Interface Control Documents (ICDs). A document, representing a design agreement between interfacing hardware, or software systems, which fully defines the interface. An ICD is placed under Configuration Control and is considered part of the baseline.

Interface Requirement. A necessary function input that is defined at the system boundary across which material, data, or energy passes.

Life Cycle Cost. The sum total of direct, indirect, recurring, non-recurring, and other related costs incurred or estimated to be incurred in the acquisition, operation, decommissioning and disposal of a designated item.

Measure of Effectiveness. A set of attributes that define how the measure of success is satisfied. The measure of success is a general statement; the measure of effectiveness is more specific. Definition used by DOE managers to accept or reject deliverables.

Measure of Success. A set of attributes that, when compared to actual results, shows how well the mission was accomplished.

Memorandum of Agreement (MOA). Written agreement between organizations, agencies, etc., which formally describes and documents specific relationships between them.

Memorandum of Understanding (MOU). A written agreement between organizations, agencies, etc., broadly states and documents a basic understanding of tasks and describing a method for performing these tasks.

Milestone. An important or critical event, with zero duration, that represents the achievement of a stated objective on a schedule. Each milestone will be specifically defined and uniquely identified, and will provide an objective statement of the criteria for its completion.

Mission Analysis Report. A high level evaluation of the mission statement, generated to provide sufficient information to allow the accomplishment of functional decomposition, the derivation of requirements, and the evaluation of architectures that will meet the mission objectives.

Mission Statement. A declaration (usually written) of what is to be accomplished.

Modification. Any work that involves a design configuration change to a facility, structure, system, subsystem, equipment, or component.

Multi-Year Program Plan (MYPP). Objectives, performance criteria, system (program) requirements, schedules, and high-level cost estimates for the foreseeable life of the program. The approved MYPP becomes the multi-year program baseline description document.

Need. A user related capability shortfall (such as those documented in a mission analysis or engineering change notice), or an opportunity to satisfy a capability requirement because of a new technology application or breakthrough, or to reduce costs.

Operational Effectiveness. The overall degree of mission accomplishment of a system when used in the environment planned or expected for operational employment of the system.

Operational Readiness Review (ORR). A review conducted by the responsible contractor for determining that an activity, project, process, or facility is ready to proceed to the next phase of operation (e.g., startup, restart, operation, or occupancy).

Operational Test and Evaluation (OT&E). A program consisting of pre-operational and operational testing initiated to verify performance parameters of various system functions or elements.

Performance. A quantitative measure characterizing a physical or functional attribute relating to the execution of a mission of function. Performance attributes primarily include quantity (how many or how much), quality (how well), cost (how much), and timeliness (when and how responsive, how frequent) and may include coverage (how much area, how far), and readiness (availability, mean time between failure). Performance is an attribute for all system personnel, products and processes including those for development, production, verification, deployment, operations, support, training, and disposal.

Performance Requirement. The extent to which a mission or function must be executed, generally measured in terms of quantity, quality, coverage, timeliness or readiness. Performance requirements are initially defined through requirements analyses and trade studies using mission need, objective, and/or requirement statements. Performance requirements are assigned to lower level system functions through top-down allocation, and are assigned to programs, program elements and projects through synthesis.

Physical System. Facilities, systems, equipment, materials, information, activities, and the personnel required to perform those activities necessary to manage waste remediation.

Program. An organized set of activities directed toward a common purpose or goal undertaken or proposed in support of an assigned mission area. A program may include one or more major system acquisitions or major projects, other projects, operations, or some combination thereof.

Project. Unique discrete work within the TWRS Program or program element that has firmly established objectives (deliverables), budget (cost) and scheduled beginning, intermediate, and ending date milestones. These discrete elements of work have unique constraints due to capital funding requirements and reporting to Congress. (These are some times called a program element.)

Public. Any person, organization, company, or foreign country having interest in information concerning site activities, but not having a specific contract or agreement obligating it to protect the information.

Public Involvement. Process by which the views of all parties interested in Hanford decisions (interested and affected individuals, organizations, customers, State and local governments, and other federal agencies) are integrated into Hanford's decision-making process. The public involvement process provides a means by which public concerns, needs, and values are identified prior to decisions, so that decisions reflect the views of the public, to the extent possible given environmental, financial, legal, and technical constraints.

Quality Assurance. All planned and systematic actions necessary to provide adequate confidence that a facility, structure, system or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements.

Remediation. Action taken to safely store, maintain, treat, and dispose of tank waste, the main focus of the TWRS Program mission.

Requirement. (1) Characteristics that identify the accomplishment levels needed to achieve specific objectives for a given set of conditions. (2) How well the system needs to perform a function. The extent to which a function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or safety. Requirements include constraints, performance requirements and interface requirements.

Requirements Analysis. The determination of system specific characteristics based on analyses of customer needs, requirements, and objectives; missions; projected utilization environments for people, products, and processes; constraints; and measures of effectiveness.

Restoration. Return of a system to the operating condition for which it was originally designed, or the return of an environment to its natural state.

Risk. A measure of the uncertainty of attaining a goal, objective, or requirement pertaining to technical performance, cost, and schedule. Risk level is categorized by the probability of occurrence and the consequences of occurrence. It is assessed for program, product, and process aspects of the system, and includes the adverse consequences of process variability. The sources of risk include technical (e.g., feasibility, operability, producibility, testability, and systems effectiveness); cost (e.g., estimates, goals); schedule (e.g., technology/material availability, technical achievements, milestones); and programmatic (e.g., resources, contractual) uncertainty.

Risk Analysis. Process to determine the probability of events occurring and the consequences the potential events would have on the program, should they occur. The purpose of risk analysis is to discover the causes, effects, and the magnitude of perceived risks.

Risk Assessment. The process of reviewing, examining and judging whether potential risks are acceptable.

Risk Handling. The development and the implementation of techniques and methods to reduce or control the risk.

Risk Management. An organized, analytic process to identify what can go wrong, to quantify and assess associated risks, and to implement/control the appropriate approach for preventing or handling each risk identified.

Risk Planning. The process of organizing an approach to identifying, quantifying, determining impact, and then eliminating, minimizing, or containing the effects of undesirable occurrences and minimizing the probability of those occurrences.

Specification. (1) A document prepared to support acquisition and life cycle management that clearly and accurately describes essential technical requirements and verification procedures for items, materials and services. (2) A statement of a set of requirements to be satisfied by a product, material, or process indicating, whenever appropriate, the procedure by which it may be determined whether the requirements given are satisfied.

Specification Tree. The hierarchical depiction of all the specifications needed to control the development, manufacture, and integration of items in the transition from customer needs to the complete set of system solutions that satisfy those needs.

Stakeholder. An individual or group who is likely to be affected by, or who perceives itself to be affected by, and has an interest in a DOE policy, program, or project.

Stakeholder Values. Principles and standards held by stakeholders, which are used in the decision making process for a DOE Activity.

System. A combination of related functions or equipment integrated into a single activity.

Synthesis. The translation of functions and requirements into possible integrated solutions (resources and techniques) satisfying basic input requirements. System element alternatives that satisfy allocated performance requirements are generated; preferred system element solutions that satisfy internal and external physical interfaces are selected, system concepts, preliminary designs and detailed designs are completed as a function of the development phase; and system elements are integrated into a physical architecture.

System. (1) An integrated compilation of people products and processes that provides a capability to satisfy a stated need or objective. (2) A combination of related functions or equipment integrated into a single activity.

System Life Cycle. The period extending from inception of development activities, based on an identified need or objective, through decommissioning and disposal of the system.

Systems Engineering. A comprehensive, iterative problem-solving process that is used to: (a) transform validated DOE needs and requirements into a life cycle balanced solution set of system product and process designs, (b) generate information for decision makers, (c) integrate to optimize and (d) provide information for the next program phase. The problem-solving process and success criteria are defined through requirements analysis, functional analysis, and systems analysis and control. Alternative solutions, evaluation of those alternatives, selection of the best life cycle balanced solution, and the description of the solution through the design package are accomplished through transitioning from a functional concept to a physical concept using systems analysis and modeling techniques.

Systems Engineering Management. Organizing and directing tasks, activities, and performances related to the technical baseline work, defining the Systems Engineering process, ensuring that the process is followed, reviewing technical results, and making strategic technical decisions based on those results for the system under development.

Systems Engineering Management Plan (SEMP). The document that defines the policies and guidance for the application of systems engineering.

Tank Waste Remediation System (TWRS). An integrated solution for carrying out the specific functions associated with remediating tank waste. The TWRS encompasses: existing facilities; waste storage tanks (including the tank waste); evaporators; pipelines; supporting facilities that comprise the total TWRS infrastructure, including upgrades to existing facilities/equipment; and new facilities.

Technical Performance Measurement. An evaluation, preferably quantitative, that predicts the future performance of a physical system, subsystem, or component, and compares that prediction to performance requirements.

Technical Reviews. A series of systems engineering evaluations by which the progress of a program is assessed relative to its technical or contractual requirements. These are conducted at logical transition points in the development effort to reduce risk by identifying and correcting problems/issues resulting from work completed before the program can be disrupted or delayed. Technical Reviews provide a method for the performing contractor and the DOE to determine that the development of a project and its documentation have met its requirements.

Technical Requirements Specifications (TRS). Documents containing the results of functional decomposition, requirements analysis, architecture selection and test methodology development that defines the performance characteristics of a system necessary for the system to achieve its objectives. The document is approved during the Technical Requirements Review.

Test and Evaluation. The complete set of activities that verify that End Products meet customer requirements. T&E includes (1) reviews and analysis performed during the design process, (2) inspection activities during manufacturing and construction, and (3) testing performed during design, manufacturing, construction and turnover activities.

Trade Study. (1.) A process of comparing or trading the strengths and weaknesses of alternative approaches or attributes; (2.) A feedback process for resolving inconsistencies between the levels of an activity; (3.) the analysis of the ability of a design solution to meet its stated objectives.

Uncertainty. Lack of technical, schedule, cost, or institutional information that could adversely impact the outcome or ability of a program to accomplish the mission.

Validation. (1) An assessment to verify system requirements will satisfy mission objectives. (2) A demonstration that a predictive model and its mathematical expression adequately reflect reality. Validation usually consists of comparing the results of the applied mathematical expression to measured results from the system being modeled (or from similar or identical systems), and showing that any differences were expected and/or within acceptable error.

Value System. The identification and definition of public and stakeholder values -- their measures of success, effectiveness, and performance. These values include constraints and criteria.

Verification. The act of determining and documenting whether items, activities, processes, services, or documents conform to specified constraints, requirements or commitments. This process is performed at each level of system architecture development (i.e., from hardware item components through the system level). The method used to show compliance (test, inspection, demonstration, or analysis) is dependent on architecture complexity, engineering test data availability, and validated analytical methods availability or existence.

Work Breakdown Structure (WBS). A product-oriented family tree composed of hardware, software, services, data, and facilities which result from systems engineering efforts during development and construction, completely defining the program or projects. Provides framework for work planning, scheduling, budgeting, cost accumulation and reporting of performance during the life of program or project.

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APPENDIX A

SYSTEMS ENGINEERING GRADING GUIDELINES

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A.1 INTRODUCTION

Because activities within TWRS differ greatly in type, cost, scope, and complexity, it is appropriate that the level of detail related to SE be tailored to the particular effort. This "graded approach" will allow for a screening of the proposed activity by program/project personnel and, based on consideration of key elements and present state of the activity, establish the appropriate level of SE and documentation to be generated. Agreement on the chosen SE approach must then take place between project management and the DOE customer. The graded approach will be applied to ensure that:

- The appropriate level of planning is performed,
- Necessary and sufficient documentation is created,
- Needed levels of reviews are conducted, and
- The project is integrated with the overall program.

A screening process is used to determine the level of implementation of systems engineering to a project. The steps to be followed are:

1. Determine the project risk/complexity factors (high/moderate/low) using Table A.1.

2. Assign an SE level;

   - SE-1: Rigorous application of SE (high risk/complexity)
   - SE-2: Full set of SE, but tailored to project (moderate risk/complexity)
   - SE-3: Selective application of SE (low risk/complexity)
   - SE-4: Does not require SE products (management decision, virtually no risk)

3. Select project SE requirements using guidance from Table A.2.

Application of the first step is described in Section A.2.

The assignment of SE level to the project is discussed in Section A.3.

Section A.4 gives guidance on selection of required project SE activities and documents, based on the results of the previous steps. Examples are included that show how the results might be applied to generic projects.

Section A.5 describes how present stage of the project influences the application of systems engineering. This recognizes the fact that within TWRS some projects have already begun.

A.2 DETERMINING THE PROJECT RISK/COMPLEXITY FACTORS

The initial task for application of a graded approach to systems engineering is to determine the possible impacts to safety, environmental compliance, safeguards and security, programmatic importance, magnitude of the hazard, and financial impacts, system capability from the project-specific requirements. A screening of the project with respect to these elements is the first step in determining the level of systems engineering required for the project. This is accomplished through use of Table A.1, "Graded Project Risk Areas/Complexity Factors." This table is taken from a draft of PMG-10, the "Project Execution and Engineering Management Planning Guide," (9/15/95), one of the guides that will be used in application of DOE-430.1. The elements of this table should be used by the project manager and the DOE counterpart to identify and determine the risk and complexity factors of the project. The table is qualitative in that it involves an assignment of "low," "medium," or "high" to each element of the table.

A.3 ASSIGNING SE LEVEL TO THE PROJECT

Once the elements of the table have been assigned a value, it is up to the project management and their DOE-RL customer to agree on an overall screening level; high, medium, or low. This is a subjective process, and should be guided by an objective appraisal of the results of the application of Table A.1 to the project.

An overall project risk/complexity value of high will result in the project being assigned a systems engineering level of SE-1. At this level the full suite of systems engineering activities and products must be accomplished.

An overall project risk/complexity value of moderate will result in the project being assigned a systems engineering level of SE-2. Assignment at this level will also result in a full suite of systems engineering activities and products, however they will be tailored to be commensurate with the project risk/complexity. This means, for example, that even though this level project must develop a design requirements document (DRD), the document may be less comprehensive and the level and extent of review may be less than that required for an SE-1 project.

A overall project risk/complexity value of low will result in the project being assigned a systems engineering level of SE-3. SE-3 level projects require selective application of systems engineering. In many cases this means that a specific SE activity may be performed informally, and documentation is not necessarily required.

The project is assigned a systems engineering level of SE-4 if it is decided that the risk/complexity of the project is low enough that no systems engineering is required.

Table A.1 Graded Project Risk Areas/Complexity Factors

RISK/COMPLEXITY FACTOR	LOW RISK	MODERATE RISK	HIGH RISK
TECHNOLOGY	Common/off-the-shelf technology Civil/conventional construction	Proven/state-of-the-art technology Engineered equipment Testing	Unproven technology New system Highly engineered equipment R&D or investigative requirements Extensive testing Nuclear facility
TIME	Ample time to perform work	Reasonable time to perform work (tight but possible)	Compressed time frame to perform work DOE commitments with other agencies (e.g., DoD, NASA, EPA, NRC), states, etc.
INTERFACES	No major impact on site operations, other contractors, projects, programs etc.	Potential impact on site operations, other contractors, projects, programs, etc.	Potential **major** impact on site operations, other contractors, projects, programs, etc.
NUMBER OF KEY PARTICIPANTS	1	2-3	3 or more
CONTRACTOR CAPABILITIES	Proven track record	Limited experience	Newly acquired capabilities
MAGNITUDE AND TYPE OF ENVIRONMENTAL CONTAMINATION	Hazardous or low-level waste, fully characterized	Hazardous or low-level waste, moderately characterized	High-level or mixed waste, regardless of characterization
REGULATORY INVOLVEMENT	None	EPA, NRC, or states	EPA, NRC, or states
NEPA **ENVIRONMENTAL PERMITS (RCRA, CWA, CAA, etc.) or LICENSING**	Categorical Exclusion **and** No permitting	Environmental Assessment **and** Ordinary permitting required	Environmental Assessment or Environmental Impact Statement **or** Unique permitting required

Table A.1 Graded Project Risk Areas/Complexity Factors

RISK/COMPLEXITY FACTOR	LOW RISK	MODERATE RISK	HIGH RISK
NUMBER OF LOCATIONS	1	2-3	4 or more
SITE OWNERSHIP	DOE property	Government, state, or participant property	Private property
SITE IMPROVEMENTS/ACCESS	No infrastructure/improvements required and accessible	Minor infrastructure/improvements required and accessible	Major infrastructure/improvements required or difficult access
LABOR SKILLS	Low or moderate skill labor	Moderate or highly skilled labor	Moderate or highly skilled labor
AVAILABILITY	Readily available	Availability restricted	Availability severely restricted
STAFF BUILD-UP	Gradual	Measured or phased	Rapid
PRODUCTIVITY	Low or average productivity assumed and low schedule risk	Low or average productivity assumed and moderate schedule risk	Average or high productivity assumed and moderate or high schedule risk
QUALITY REQUIREMENTS	Large quality tolerances and low productivity risk	Moderate quality tolerances (re-work likely) and moderate productivity risk	Precision work (re-work expected) and moderate or high productivity risk NQA1
FUNDING	Less than one-year duration Small project (e.g., GPP size)	2-3-year duration Other Line Item Project size	2 or more year duration Other Line Item, MP, MSA size
POLITICAL VISIBILITY	None	Minor	Major
COST SHARING	None	1	2 or more

Table A.1 Graded Project Risk Areas/Complexity Factors

RISK/COMPLEXITY FACTOR	LOW RISK	MODERATE RISK	HIGH RISK
PUBLIC INVOLVEMENT	None	Minor	Independent oversight
OVERALL COMPLEXITY	Low technology Low schedule risk 1 contractor 1-2 subcontractors 1 location No interfaces or dependencies with other participants, projects, programs, etc. No regulatory involvement CX or minor EA etc.	Low or moderate technology risk Low or moderate schedule risk 1-2 major prime contractors 2-3 major subcontractors 1-2 locations Few interfaces or dependencies with other participants, projects, programs, etc. Some regulatory involvement EA etc.	Moderate or high technology risk Moderate or high schedule risk 2 or more major prime contractors Multiple subcontractors 2 or more locations Several interfaces or dependencies with other participants, projects, programs, etc. EA or EIS etc.

A.4 PROJECT SE REQUIREMENTS

The following sections describe the different levels of projects, resulting in a graded application of systems engineering. Specific criteria are given, along with examples of types of projects that fit those criteria. Given a project, the level of systems engineering to be applied will depend on the highest category (SE-1 being the highest) in which the criteria fit the project. Table A.2 gives a summary of requirements for SE activities and documents based on the assigned SE level.

Because most of the projects described involve systems, structures, and/or components, additional sections describing analysis and software projects are included.

A.4.1 SE-1 Projects

The SE-1 level projects are those which are rated as a high risk/complexity as described in Section A.2. These are usually major projects of significant importance to the Hanford Mission, involving systems, structures, and/or components (SSCs) where project failure would result in significant delay to the TWRS mission, and could prevent accomplishment of the TWRS mission.

Projects within this category generally include, Major System Acquisitions and Major Projects. For example, under this definition a project to develop a TWRS waste retrieval system or major storage system would be determined to be at the SE-1 level.

The SE-1 level projects require rigorous application of SE as defined in this SEMP and shown in the diagonal diagram of Figure 2-2. SE-1 level project SE requirements are also shown for comparison to the other SE level projects in Table A.2.

A.4.2 SE-2 Projects

The SE-2 level projects are those which are rated as a moderate risk/complexity as described in section A.2 and A.3. These are usually major projects of significant importance to the Hanford Mission, involving systems, structures, and/or components (SSCs) where project failure would result in significant delay to the TWRS mission.

Projects within this category generally include, (a) an existing systems modification with significant complexity and other factors as described in Table A.1, and (b) modification to facilities or systems undergoing a change in status if they have been in one condition or had one purpose or function for an extended period of time (months), and a substantial change in condition or purpose is planned (includes facilities that have been in stand-down or shutdown for several months, and are being returned to service).

The SE-2 level projects require full application of SE as defined in this SEMP and shown in the diagonal diagram of Figure 2-2. However, the documentation and level of review for SE-2 projects may be less than SE-1. SE-2 level project SE requirements are also shown for comparison to the other SE level projects in Table A.2.

A.4.3 SE-3 Projects

The SE-3 level indicates a project that scored a low on the screening process in Section A.2. This type of project is typically one that is only moderately complex, and for which failure of the SSCs would cause or allow only minimal off-site impact and minor cost and schedule impacts.

Projects within this category may include, an equipment/system changeouts not-in-kind, and other projects that are relatively uncomplicated. In addition, many analysis and software projects may fall into this category, even though they do not involve SSCs.

The SE-3 level projects require selective application of systems engineering as shown in Table A.2.

A.4.4 SE-4 Projects

The SE-4 level indicates a project that consistently scored a value of low during the screening process and, in the opinion of the project manager and DOE counterpart, does not require systems engineering. Projects within this category include, "changeout-in-kind," where the change is a form, fit and/or function replacement of essentially identical specification to the replaced part.

The SE-4 level projects do not require systems engineering, however some documentation as shown in Table A.2 is required to document changes to the system from the work done.

A.4.5 Analysis Projects

Analysis projects do not produce SSCs. They are typically set up with very specific goals, with the product being documents or management systems. This type of project is typically graded as an SE-3 project, requiring selective SE documentation.

An example is a project to develop a safety document such as a Safety Analysis Report. This is an analysis that is well defined by regulations. It does not satisfy an "architecture" in the systems engineering sense, the project is carried out to define requirements for the the safety envelope in which future SSCs must operate. The project mission must be clearly defined and requirements specified, and kept distinct from other ancillary projects. As such, a Mission Analysis must be performed and documented. This Mission Analysis should clearly tie the project back to other program or project functions & requirements. Additional SE products, such as functions & requirements analyses, trade studies, and various system specifications are not applicable to this type of work.

Another example is a project to resolve a specific program or project issue. For example, do organic materials in the TWRS waste tanks pose a safety problem. In this case a project is set up to initially analyze by various means to see if there is indeed a problem. This analysis project must perform a mission analysis to develop agreed-upon requirements to be met and a clear mission. If, as a result of the analysis, it is determined that there is a safety problem, and the decision is to develop a mitigation system to resolve the problem, the project must be re-evaluated according to the criteria in Sections A-2.1 through A-2.4 as it now includes developing SSC. Because the original issue was one of safety, this probably will elevate the SE level requirements.

If it is clear from the start that there is a safety problem, and a SSC project is developed to solve this problem, then the screening method shown in Table 2-1 should be used to evaluate the SE level of the project. In this case it is no longer an "analysis" project.

A.4.6 Software Projects

Software projects are a special case of project. Requirements and procedures for development of software are well defined at Hanford and must be followed (See WHC-CM-3-10, "Software Practices"). In this sense it has its own well-defined version of systems engineering. However, when the software is integral to an SSC project it must be driven by the functions and requirements analysis performed by the project. Once it is thus defined the software development will again follow the normal software development path.

Table A.2 Required SE Activities and Products for Given SE Level Project.

SE ACTIVITY	SE LEVEL 1 (SE-1)	SE LEVEL 2 (SE-2)	SE LEVEL 3 (SE-3)	SE LEVEL 4 (SE-4)
o Mission Analysis	Yes	Yes(1)	Yes(1)	Yes*
o Functions & Requirements Analysis & Allocation	Yes	Yes(1)	Yes	Yes*
o Alternative Generation and Analysis	Yes	Yes(1)	Yes(1)	No
o Trade Studies	Yes	Yes(1)	I	No
o System Effectiveness	Yes	Yes(1)	I	No
o Life-Cycle Cost	Yes	Yes(1)	I	No
o Test and Evaluation	Yes	Yes(1)	Yes(1)	Yes**
o Risk Management	Yes	Yes(1)	I	No
o Configuration Management	Yes	Yes(1)	Yes(1)	No
o Interface Management	Yes	Yes(1)	Yes(1)	No
o Requirements Traceability	Yes	Yes(1)	Yes(1)	No
o Decision Management	Yes	Yes(1)	I	No
PROJECT PRODUCTS				
o SEMP	Yes	Yes(1)	Yes(1)	No
o Project Mission Analysis Report	Yes	Yes(1)	Yes(1)	M
o Trade Study Documents	Yes	Yes(1)	M	No
o Risk Management Plan & List	Yes	Yes(1)	I	No
o Project Interface Control Documents	Yes	Yes(1)	Yes(1)	M
o Project Design Concept	Yes	Yes(1)	I	No
o Project Design Specification	Yes	Yes(1)	I	No
o Mass/Energy Flow Sheets	Yes	Yes(1)	No	No

Table A.2 Required SE Activities and Products for Given SE Level Project.

	SE ACTIVITY	SE LEVEL 1 (SE-1)	SE LEVEL 2 (SE-2)	SE LEVEL 3 (SE-3)	SE LEVEL 4 (SE-4)
o	Piping & Instrument Diagrams	Yes	Yes(1)	Yes(1)	No
o	Technology Development Reports	M	M	No	No
o	Project Logistics Plan	Yes	Yes(1)	I	No
o	Project Reports	Yes	Yes(1)	M	M

Table Notes:

(1) Activity or product is tailored in size and complexity to the project size/complexity
I "Informal;" No documentation required, but process should be used.
M Management direction/decision required.
* The decision to accomplish the activity must be documented.
** Some level of testing is always required, even if only to make certain the replacement functions as previously.

A.5 PRESENT STAGE OF PROJECT

The diagonal diagram shown in Figure 2-2 indicates that the normal start of a project involving SSCs is determined by a specification, called a Design Requirements Document (DRD), generated by the program. This is the "birthright" of the project. However, some TWRS projects were started prior to program generation of a DRD. In these cases, where it has been decided to continue the project, a modification to the normal SE process must be carried out. In most cases this involves project generation of an "equivalent" DRD, along with an up-front determination of the program risks assumed by this process. Once the project DRD has been generated, and the review completed, the project can continue until complete traceability to program requirements is established. Reassessment of project activities will be necessary to assure linkage to program-level requirements.

Analysis and Software projects are treated as described in Sections A.4.5 and A.4.6, respectively. In cases where such projects have been underway without meeting the minimum SE requirements of this SEMP, the projects must develop the necessary SE products to support project continuation.

APPENDIX B

TECHNICAL REVIEWS

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B-1 Introduction

Independent technical reviews are performed to provide management and the customer an opportunity to assess progress, evaluate program risk, and refocus program activities. Organizers and participants of technical baseline reviews will vary from review to review. For example, an Technical Requirements Review will be organized by the Program while a Preliminary Design Review will be organized by the project. The reviewing authority will transfer from DOE for Program level reviews to the M&O for Project level reviews. Stakeholders will participate in reviews, as required, to ensure the consistency and technical adequacy of the evolving TWRS Technical Baseline.

B-2 Technical Review Descriptions.

The following paragraphs describe the purpose, scope, organizer, and reviewing authority for each review.

B-2.1 System Requirements Review (SRR) The SRR is a program level review, conducted to evaluate progress in defining Program F&R, the architectural concept to satisfy mission needs and to approve the Functional Requirements Baseline. The WHC TWRS Technical Integration organization will organize the review with RL TWRS Office participation. DOE is the reviewing authority.

B-2.2 Technical Requirements Review (TRR). The TRR is a program level review of system requirements. It is conducted to; (1) evaluate the system requirements for adequacy and risk; (2) ensure a mutual understanding among TWRS Program and Project participants of TWRS Program system requirements, the corresponding system architecture (design concepts), and test strategies, (3) assess the SE process that produced the system requirements, and (4) approve the Technical Requirements Baseline.

The WHC TWRS Technical Integration will organize and conduct the TRR, with DOE/RL participation. DOE is the reviewing authority. The TRRs will be phased, reviewing the portion of the baseline applicable to specific architecture elements with sufficient commonality to combine into one review.

B-2.3 Design Requirements Review (DRR). A DRR is held for each project to demonstrate readiness for proceeding to design development. DRRs are conducted to; (1) verify project requirements conform with system requirements; (2) identify requirements to be refined by the project; (3) approve the project DRD, project architecture, and the Design Requirements Baseline.
For each project, the responsible WHC Project organization organizes and conducts the DRR. The RL TWRS Program Office will participate in selected reviews, and the M&O is the reviewing authority. The products presented at DRR form the foundation for the Key Decision 0 review.

B-2.4 System Design Review (SDR). The SDR is conducted to evaluate the optimization, traceability, correlation, completeness, and risk of the allocated requirements, including the corresponding test requirements to fulfill the project technical requirements. This review encompasses the total system requirements and includes a summary review of the System Engineering management work (e.g., integrated test planning, specialty discipline studies, and Configuration Management) that produced the system definition products. Successful completion of the SDR results in the approval of the Design Configuration Baseline Phase 1. The project is responsible to identify all required participants. DOE/RL will participate in selected reviews, and the M&O is the reviewing authority. For additional information on the scope of the review including a listing of products required for a technically complex project, see *DOE/RL-95-12 TWRS Systems Engineering Standard, Rev AE (Draft)*. The products presented at the SDR form the foundation for the Key Decision #1 review.

B-2.5 Preliminary Design Review (PDR). The purpose of a PDR is to review each project's basic design approach, the associated risks and to approve the Design Configuration Baseline Phase 2. The review is organized by the project and includes review of: requirements development, design activities, trade studies, risk analysis, specialty engineering, test planning and conduct, interface management, risk analysis and configuration management. The project is responsible for identifying required participants. DOE/RL will participate in selected reviews. The M&O is the reviewing authority. For additional information on the scope of the review including a listing of products required for a technically complex project, see *DOE/RL-95-12 TWRS Systems Engineering Standard, Rev AE (Draft)*.The products presented at the PDR form the foundation for the Key Decision #2 review.

B-2.6 Definitive Design Review (DDR). A DDR is held for each project to demonstrate readiness to start procurement, construction, manufacturing, and coding of projects for verification. DDR is conducted to; (1) verify design conformance with the design requirements; (2) approve the design specifications updates; (3) evaluate the adequacy of the detailed design; (4) assess design producibility, constructability, testability, inspectability, and risk areas; (5) assess design readiness to proceed with procurement and construction; and (6) to approve Design Configuration Baseline Phase 3.

The project will organize and conduct the DDR ensuring the participation of the appropriate WHC organizations. RL TWRS Program Office will participate in selected reviews,and the M&O is the reviewing authority. The DDR can be used for design verification purposes if it meets requirements of applicable quality assurance procedures. For additional information on the scope of the review including a listing of products required for a technically complex project, see *DOE/RL-95-12 TWRS Systems Engineering Standard, Rev AE (Draft)*. The products presented at the DDR form the foundation for the Key Decision #3 review.

B-2.7 Operational Readiness Review (ORR). ORRs are held following completion of facility construction. This review is conducted to; (1) compare the as-built configuration with the design configuration; (2) assess start up; (3) allow for the orderly pre-operational testing and turnover of the facility to the WHC facility operations; and (4) to approve the As-Built Baseline.

The ORR is conducted and organized by the project and the A/E. The organizers will ensure participation by the WHC Program Office and RL TWRS Program Office. The Construction, Test, and Turnover Packages and the Operations and Maintenance Packages are presented at the ORR. The as-built system will be reviewed against the technical baseline to support the DOE review milestones and to permit facility operation approval. The M&O is the reviewing authority.

B-2.8 Decontamination and Decommissioning Review (D&DR). A D&DR is held to ensure that D&D activities can be performed safely and to ensure that all necessary permits properly reflect the baseline.

The responsible M&O organization will organize and conduct the D&DR and will ensure the participation of all responsible parties including the D&D organization. D&D baseline documentation and the updated operational baseline configuration are presented at the D&DR.

After successful completion of the D&DR, the D&D baseline configuration will be submitted for approval and configuration control. Approval will authorize proceeding with the D&D.

The boundary between D&D and the ERC has not been defined. After it is defined, this section will be modified to describe the review to proceed with the ERC work.

B-3. Technical Review Entry and Exit Criteria

The following is a sample set of entry and exit criteria set developed for the Program level TRR, provided as an example. In conjunction with their DOE/RL monitor, each project will develop its own project review criteria. Each project will have entry and exit criteria signed by the review authority prior to initiating the review.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Functional Analysis -----	* Show that a complete set of functions which satisfy the mission have been developed. - includes showing that the SRR has been completed, and updating the functional analysis as needed to reflect any modifications or interpretations of the mission since the SRR. - "complete set of functions" is defined as all items needed to specify the content and boundaries of the functions that include the necessary and sufficient solutions to the problem. - each function should be traceable to the TWRS and Site mission needs. - the set of functions should satisfy the mission goals and objectives as defined by the TWRS Strategic Plan and the Hanford Mission Plan. * Show that functional interfaces are defined. - interface definitions should be of sufficient detail to identify organizational interactions that will be needed in interface control working groups.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Mission and Requirements Analysis -----	* Demonstrate that the system requirements are: - complete -- all items needed for the specification of the requirements of the solution to the problem have been identified and included. (i.e., that meeting the requirements is sufficient to satisfy the functions.) - correct -- each item in the requirements specification is free from error. - unambiguous -- (and, preferably, also precise and clear) -- there is a single interpretation of each item in the requirements specification -- (and, preferably, each item is exact and is not vague, and the meaning of each item is understood, and the specification is easy to read). - consistent -- no item in the requirements specification conflicts with another in the specification. - relevant -- each item in the requirements specification is pertinent to the problem and its solution. (i.e., that meeting each requirement is necessary to satisfy its function.) - testable -- during program development and acceptance testing, it will be possible to determine whether the item in the requirements specification has been satisfied. - feasible -- each item in the requirements specification can be implemented with the techniques, tools and resources that are available (and, preferably, within the specified cost and schedule). - traceable -- each item in the requirements specification can be traced to its origin in the problem environment. - manageable -- the aggregate requirements specifications are expressed in a way that each item can be changed without excessive impact on other items. - free of unwarranted design detail -- the specifications are statements of the requirements be satisfied by the selected architecture.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
System/Cost Effectiveness Analysis -----	* Provide evidence that life cycle cost and risk management are considered in all decisions regarding selection of alternatives. - Measures of success are defined. - Life Cycle Cost Analysis has been performed and documented. - analyses should include the - expected range of potential values for performance (technical processes and ES&H), - expected range on potential values for schedule, and - sensitivity of performance parameters to cost.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Trade Studies -----	* Trade-offs among operational needs, stakeholder values, program schedule and budget, and life cycle costs, are identified (and preferably assessed). * Trade-off studies have been scheduled or accomplished to support the decision needs of the system engineering process. -- Results of the studies will include supporting rationale and impact on the TWRS program. * Trade studies / decision analyses have been completed or are planned to provide a basis for TRS decisions necessary to establish the technical baseline architecture. These studies/analyses: • are explicitly tied to decisions/issues identified through the system engineering functional and requirements analysis process; • resolve (or provide a clear approach to resolve) all open decisions/issues; • have explicitly identified decision makers who are the consumers of the study/analysis results and will make the decision; and have explicitly identified organizational responsibilities for resulting actions; • are completed or are scheduled for completion to meet program requirements derived from system engineering; • have well-defined, explicit, and documented scope; • use a consistent approach to establishing values and decision criteria to be applied; • use values/decision criteria that are explicitly linked to an established basis, i.e., system constraints, requirements, stakeholder values, etc.; • document (or reference) the values/decision criteria used, their basis, and how they were identified;

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Architectural Evaluations -----	* Demonstrate that alternatives have been screened with constraints appropriate for consideration at the system level being addressed. - Show risks for each alternative have been analyzed. - If an approach has been selected, show that a basis for selection has been provided. * Show that a range of feasible architectures have been defined and evaluated using a - systematic, - defensible, and - traceable process. This includes demonstration that: • the broadest practically possible range of alternative architectures has been considered within time and resource constraints; • the range of alternatives has been screened to produce a manageable set of feasible alternatives using a consistent, traceable approach based on clearly identified constraints appropriate for the architecture level (or, if necessary, on clearly identified assumptions, each of which includes an approach for verifying that assumption); • the selected architectures are necessary and sufficient to satisfy all functions and requirements, and the necessity and sufficiency is documented and traceable; • selection of preferred architectures is based on trade studies/decision analyses subjected to the TRR trade study/decision analysis criteria, or other bases of selection are documented and approved (including any inherent assumptions); and • architecture selections and their bases are documented in the RDD-100 database.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Standards to be imposed on Projects -----	* Nationally recognized codes and standards imposed on projects are identified in DOE Order 6430.1A, "General Design Criteria". DOE Order 6430.1A - The following requirement (constraint) will reside in the TWRS requirements database at the TRR milestone: *The general design criteria provided by DOE Order 6430.1A shall be applied to all facilities which shall be reported on in the Department's Real Property Inventory System (RPIS), or which shall be reported on in the General Services Administration annual "Summary Report of Real Property Owned by the United States Throughout the World".* *[DOE Order 6430.1A, 4.a.* - The above requirement levies the applicable design standards and guides to be implemented on the design of facilities to be reported on the Department's RPIS. Division 1, Section 0109 gives a listing of all the standards and guides called-out in 6430.1A. It also encompasses the requirement called-out in DOE Order 5820.2A, Chapter I, 3.a.(1)(b), "Designs for new storage and treatment facilities shall meet the requirements of DOE 6430.1, applicable EM Orders and 40 CFR 264", since the applicable sections of 40 CFR 264 are in the TWRS requirements database. - Note: Other general requirements from 6430.1A will also be present and allocated t functions and architectures in the TWRS requirements database (e.g., flexibility) as they apply to the technical requirements baseline. * Hanford Plant standards will be imposed where national standards are insufficient or not developed as required by RL directive, RL 6430.1C, "Hanford Plant Standards (HPS) Program." Hanford Plant Standards.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Standards to be imposed on projects, continued.	**GENERAL** SDC-1.2 Hanford Plant Standards and National Codes and Standards SDC-1.3 Preparation and Control of Engineering and Fabrication Drawings SDC-1.4 Preparations and Control of Multi-use Hanford Specifications **ARCHITECTURAL-CIVIL** SDC-3.1 Standard Design Criteria for Railroads SDC-3.2 Minimum Depth of Underground Water Lines SDC-4.1 Design Loads for Facilities SDC-4.2 Design and Installation of Expansion Anchors **MECHANICAL** SDC-5.1 Heating Ventilation, and Air Conditioning **ELECTRICAL** SDC-7.2 Outside Lighting and Aerial Distribution Systems SDC-7.4 Underground Power Distribution SDC-7.5 Interior Power and Lighting SDC-7.7 Communications, Signaling, and Low-Voltage Control Systems SDC-7.8 Fire Alarm Systems **SAFEGUARDS AND SECURITY** SDC-8.1 Installation Details for Safeguards/Security Equipment **OTHER** Other standards as appropriate to each project. *TRR success criteria: Proper allocation of the design criteria to the functions and architectures contained in the TWRS requirements database, or specific plans for how these criteria will be allocated and verified.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Identification of projects supported, and Review of plans to plans to proceed into the next phase. -----	* The TWRS TRR Planning chart should be updated, reflecting latest plans for DRD scheduling based on TRR results. - Planning schedules are available at the time of the TRR depicting the timing of availability of necessary and sufficient systems engineering documentation to permit necessary TWRS projects to proceed to the DRD phase. - Processes are identified for tailoring systems engineering documentation for work activities not requiring complete systems engineering application. * Identify project(s) encompassed by the functionality. - Functions in the TRS are analyzed and associated with existing and proposed TWRS work activities (e.g. projects). - Every function is traceable to (allocated to) specific work activities. - Functions not directly allocable to existing projects are highlighted so that appropriate work activities can be proposed. * Demonstrate evidence of initial planning and scheduling for - completion of Technical Baseline, based upon functional baseline, to include technical requirements specification (requirements allocated to functions and physical interfaces between programs), and associated ICD's (interface control documents) and supporting documentation. - approach for transition to Design Requirements Baseline, based upon technical baseline, which would include DRD, associated ICD's, and supporting documentation. - approach for development of Design Configuration Baseline, based upon design requirements baseline, which would include specifications, drawings, operating and maintenance manuals, and associated ICD's and supporting documentation.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Risk Analysis and Decision Management -----	* Program definition includes risk management, risk analysis and appropriate mitigation of the risks associated with the related cost, schedule, and technical parameters. * Program definition also identifies critical areas. * Risk management is integrated into the decision process. - A procedure is defined and implemented that incorporates operational requirements, life cycle cost and risk information, stakeholder values, and program schedule and budget into a structured, well-documented decision process that articulates the trade-offs among these attributes. - The initial risk assessment screening process is used to provide risk information to the TRS development.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Configuration Management and Data Management -----	* Provide evidence that configuration control procedures and documents are in place, and that a configuration status accounting system for reporting the implementation of changes to the configuration baseline is in place. - Show the basis for the TWRS configuration management system. - Procedures that delineate the configuration control process for the TWRS Systems * At the TRR the following configuration control procedures and mechanisms will be in draft or in place for the TWRS Systems Engineering generated technical baseline (Hanford Cleanup System Element 4.2, "Tank Waste Remediation"): • Identification of the documents (preferably by document number and title) and electronic information proposed to form the Technical Baseline. Identification of those enabling studies and analyses that support the results described in the technical baseline. • Evidence showing approval of all proposed Technical Baseline information to the Program Management level in WHC and DOE. Evidence showing acceptance of the proposed information as the current complete Technical Baseline. (Note the complete technical baseline at the TRR is expected to be the RDD-100 database and its referenced documents.) • Control of the TWRS technical baseline, "TWRS Mission Analysis", and the associated Interface Control Documents for the TWRS baseline, and Technical Requirement Specification, the Baseline System Description, plus the trade studies, risk analyses, and other enabling documents that are the basis of the results in these documents.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Configuration Management and Data Management (continued) -----	* Show that an information management system is being developed to manage information necessary for defining and maintaining the TWRS technical baseline. The first phase of the information management system is to develop an information locator database and mapping software. The next step of the process is to develop a strategy to input data and facilitate use of the database by the TWRS and Site programs. * Data management plans and procedures will control the basis of (and future changes to) the TWRS technical baseline so the baseline is traceable to that basis and responsive to changes in the basis. - Procedures for (or approaches for) control of In-house drawings, analysis reports, raw test data, work orders, and other technical data are traceable, responsive to changes of requirements, and consistent with the configuration management change control requirements. - These data are identified for control purposes in a manner similar to engineering drawings. - The data management system interacts with the design capture system and the decision data base. - The mechanism that provides traceability will also depend on some manual interfaces. * At the TRR phase, includes the functional portion of the TWRS technical baseline, but does not include configuration management nor data management of the physical systems and relevant documents, such as the engineering document control system, change control system and work control system, (i.e., these are not funded). The design reconstitution element of the CM process may provide a mechanism for establishing this traceability or these products.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Milestone schedules -----	* Show that an integrated program schedule - has been developed, - considered alternatives within the constraints imposed by the TPA, DOE objectives, and other requirements, - is consistent with , and a driver of the Program Multi-Year Program Plan (MYPP). * The schedule must identify critical tasks and milestones, including system engineering milestones.
Preliminary test planning -----	* Show that a preliminary test plan is being developed that includes - the total system scope and objectives (i.e., that details an approach to verifying the subsystem architectures satisfy the functions and requirements allocated to them, and to integrated verification of total system performance), - subsystem scopes for characterization, laboratory and bench-scale testing, and pilot demonstrations necessary to define the subsystems and reduce the system risk. * The objectives, scope, and type of system testing will be products of the engineering effort.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Technical performance measurement planning -----	* Show that a TPM plan is being developed to include cost , schedule, and technical performance measurements coincident with the Program Work Breakdown Structure. TPM parameters selected for tracking will be key indicators of program success. * Technical performance measurement is explicitly defined to confirm progress and identify deficiencies that may jeopardize meeting a critical system requirement. This will include demonstration that: • organizational responsibility for selecting, profiling, and evaluating technical performance measures (TPM's) is assigned; • the TPM's selected for tracking are appropriate, i.e., critical to mission success, uncertain, and quantifiable; • the number of TPM's is relative small; • the basis for the TPM's is clearly established and linked to requirements; • the specific TPM's are linked to specific functions and WBS elements; • the methods for evaluating each TPM are defined (using models/analysis and/or test data); • a schedule for performing the evaluations is defined; and • a profile for each TPM has been prepared that includes achievement-to-date, the current estimate of the TPM at tracking completion, and the profile in between.

TECHNICAL REQUIREMENTS BASELINE CRITERIA

CRITERIA (and points of contact)	DESCRIPTION (proposed standards for the TRR)
Specialty Discipline Studies; includes: -reliability analysis, -maintainability analysis, -logistics support, -system safety, -human factors, -manpower requirements personnel analysis, -value engineering studies, -environmental considerations. -----	* Demonstrate that the integration and coordination of the program efforts for the engineering specialty areas, to achieve a best mix of the technical/performance values, is described in the SEMP. - The SEMP depicts the integration of the specialty efforts and parameters into the system engineering process and shows their consideration during each iteration of the process. - Show that engineering analysis incorporates specialty discipline considerations as appropriate.
Systems Engineering Management Plans -----	* Demonstrate that a comprehensive SEMP has been produced which describes an integrated engineering effort. The SEMP should identify: - organizational responsibilities and authority for system engineering management, - levels of control established for performance and design requirements and the control method used, - technical program assurance methods, - plans and schedules for design and technical program reviews, and - control of documentation. * The plan will contain a - detailed description of the process to be used, including the specific tailoring of the process to the requirement of the system and program, - procedures to be used in implementing the process, - in-house documentation, - trade study methodology, and - models to be used for system and cost effectiveness evaluations.

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APPENDIX C

ROLES AND RESPONSIBILITIES MATRIX

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Activities	Technical Integration	Safety Issue Resolution	Tank Farms Transition Projects	Characterization	Waste Retrieval	Low-Level Waste	High-Level Waste	Storage and Disposal	DOE	TWRS Management
Functions & Requirements Analysis & Allocation	S	L1	L1	L1	L1	L1	L1	L1	-	S
Alternative Generation & Architecture Selection	S	L1	L1	L1	L1	L1	L1	L1	-	S
Trade Studies	S	L1	L1	L1	L1	L1	L1	L1	-	S
System Effectiveness	S	L1	L1	L1	L1	L1	L1	L1	-	S
Life-Cycle Cost	S	L1	L1	L1	L1	L1	L1	L1	-	S
Design to Cost	S	L1	L1	L1	L1	L1	L1	L1	-	S
Test and Evaluation	S	L1	L1	L1	L1	L1	L1	L1	-	S
Risk Management	S	L1	L1	L1	L1	L1	L1	L1	-	S
Configuration Management	S	L1	L1	L1	L1	L1	L1	L1	-	S
Interface Management	S	L1	L1	L1	L1	L1	L1	L1	-	S
Requirements Traceability	S	L1	L1	L1	L1	L1	L1	L1	-	S
Decision Management	S	L1	L1	L1	L1	L1	L1	L1	-	S
Products										
Mission Analysis Report	L	S	S	S	S	S	S	S	AC	AP
TWRS Functions & Requirements Document	L	S	S	S	S	S	S	S	AC	AP
Baseline System Description	L	S	S	S	S	S	S	S	AC	AP
Interface Control Documents	S	L1	L1	L1	L1	L1	L1	L1	AC	AP
Technical Requirements Specifications	L	S	S	S	S	S	S	S	AC	AP
Design Requirements Documents	S	L1	L1	L1	L1	L1	L1	L1	AC	AP

Project Products										
Project Mission Analysis	S	L1	L1	L1	L1	L1	L1	L1	AC	AP
Project Interface Control Documents	S	L1	L1	L1	L1	L1	L1	L1	-	I
Project Design Concept	I	L1	L1	L1	L1	L1	L1	L1	AC	AP
Project Design Specification	I	L1	L1	L1	L1	L1	L1	L1	AC	AP
Mass/Energy Flow Sheets	I	L1	L1	L1	L1	L1	L1	L1	-	I
Piping & Instrumentation Diagrams	I	L1	L1	L1	L1	L1	L1	L1	-	I
Technology Development Reports	I	L1	L1	L1	L1	L1	L1	L1	I	I
Project Logistics Plan	S	L1	L1	L1	L1	L1	L1	L1	I	I
Project Reports	I	L1	L1	L1	L1	L1	L1	L1	I	I

KEY: S = Support, L = Lead, L1 = Lead for own section or document, I = Information, AC = Accept, AP = Approve, - = No role

APPENDIX D

SPECIALTY ENGINEERING DESCRIPTIONS

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D1.0 INTRODUCTION

The following descriptions describe each of the specialty engineering areas and their role in system development.

D1.1 REGULATORY COMPLIANCE INTEGRATION

Regulatory support personnel will begin their involvement with the technical baseline requirements definition and alternatives development. This early integration into the SE process provides an evolutionary development of inputs and outputs based on compliance criteria. Regulatory support and TWRS personnel must continuously interface during the entire acquisition process for successful implementation of the TWRS Program.

In general, the role of regulatory compliance will continue over the life of the TWRS Program. It will start on receipt of program strategy from which the bounds of applicable regulatory requirements can be established. A complete set of compliance constraints and the associated compliance approach will be produced for integration into the program. Later efforts will concentrate on obtaining the necessary regulatory approvals for operating the TWRS, maintaining those approvals, and confirming the compliance status of the TWRS Program. Regulatory integration will continue throughout the TWRS life-cycle.

To ensure that the TWRS Program and technical baseline meets regulatory requirements, the following activities will be implemented.

- Identify regulations applicable to the TWRS Program and its technical baseline
- Develop criteria and strategies along with associated technical requirements for regulatory compliance
- Integrate permits, approvals, and other prerequisites with the SE process for construction, operation, and deactivation of the TWRS Program
- Determine the acceptability of technical regulatory compliance activities and SE verification process against applicable regulations
- Prepare regulatory documents supported by the SE and technical baseline processes

D1.2 HEALTH AND SAFETY

Health and safety personnel will participate with TWRS personnel throughout the life-cycle of the system. Health and safety will be integrated with the systems engineering process. These specialists can identify health and safety requirements, identify health and safety issues related to architectures, and aid in health and safety risk assessment and mitigation. The TWRS Program will address public health and safety and occupational health and safety.

D1.2.1 Public Health and Safety

Public health and safety requirements will be included as an integral part of the TWRS Program technical baseline. These requirements may be public values or from Environmental Protection Agency guidelines or other public health and safety regulations. Proposed architectures will be evaluated for public health and safety hazards and exposure scenarios during operation and after D&D when the area may be given to the public.

D1.2.2 Occupational Health and Safety

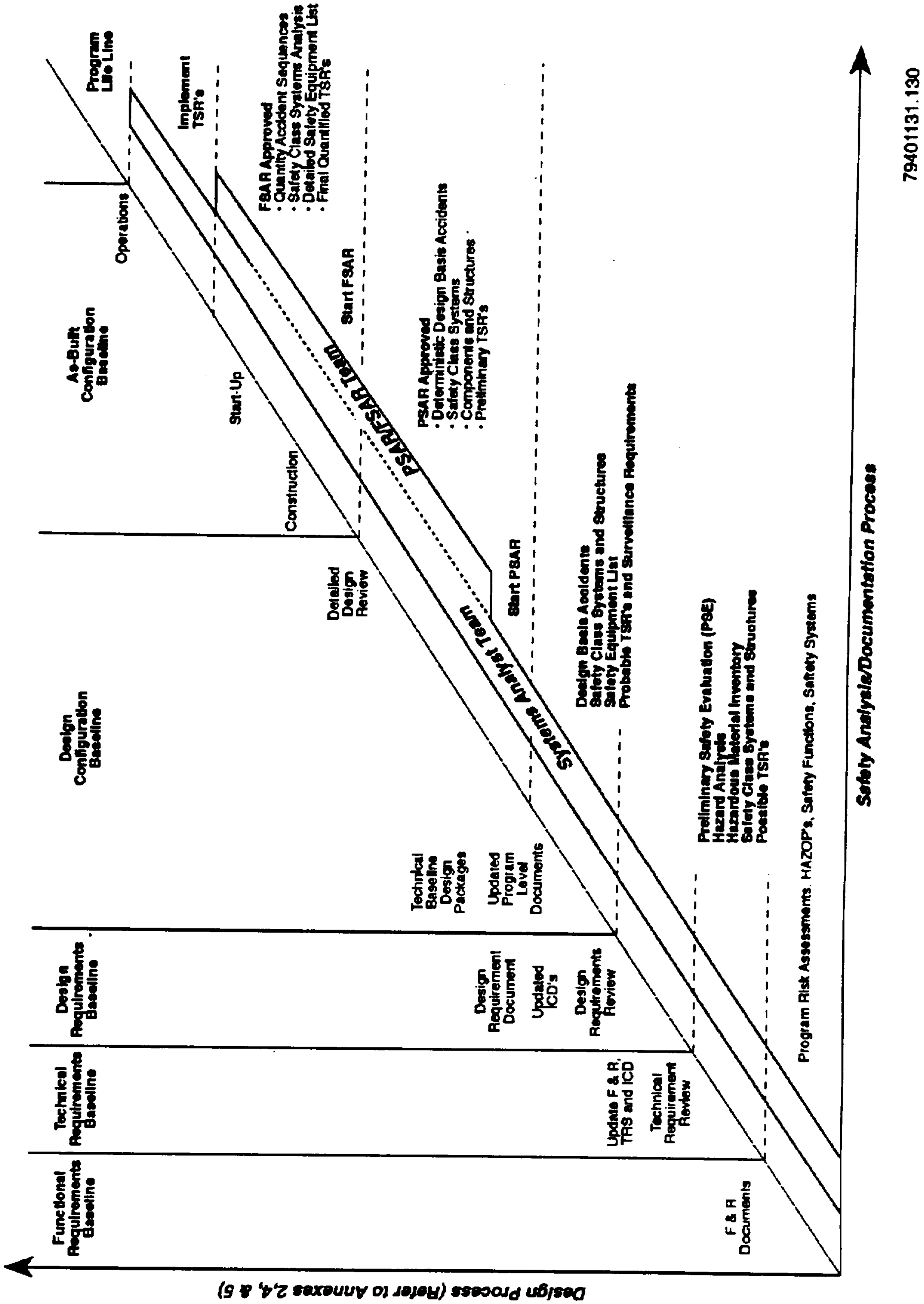
Occupational health and safety requirements will be included as an integral part of the TWRS Program technical baseline. These requirements may be employee values or concerns or from occupational health and safety regulations such as Occupational Safety and Health Administration. Propose architectures will be evaluated for occupational health and safety hazards and exposure scenarios throughout the systems life cycle.

The TWRS Program safety program will ensure that system safety is integrated into all phases of the SE process. Figure 4-1 shows how safety integrates with the technical baseline. The M&O contractor establishes and manages the safety program. The safety program will interface with the regulatory compliance program which addresses compliance with environmental, nuclear, safety, and health regulations. This interface will ensure that safety aspects are addressed, particularly the provision for engineering support for the preparation of safety documentation such as the Safety Analysis Report (SAR). Industrial and radiation safety requirements and standards will often require special interpretation and guidance by the Safety discipline. These standards will be identified, analyzed, and allocated during the F&R process.

The TWRS safety program will include the Hazard and Operability (HAZOP) process to identify potential hazards and provide operability requirements that will be incorporated into the SE process. Potential hazards will be systematically identified, potential consequences analyzed, and reasonable efforts taken to ensure that the hazards are eliminated, controlled, or mitigated. Identification of hazards related to these requirements will be documented for design verification and safety reporting.

Minimizing exposure to hazardous, toxic, and radioactive materials will be a primary goal of the TWRS safety program. This will be achieved using the As Low As Reasonably Achievable (ALARA) program. The ALARA program will establish requirements and evaluate designs to ensure that exposure to hazardous, toxic, and radioactive materials is minimized throughout the TWRS Program. ALARA requirements will be established during

Figure D-1. Safety and Design Engineering Interface.



the F&R analysis and allocation process. Designs will be evaluated against these requirements during alternative generation and architecture development. Because TWRS Program will process mixed waste that contains toxic chemicals, safety requirements will be developed and designs evaluated for safe operation.

D1.2.3 Nuclear Specialties

These are specialties directly related to the fact that the TWRS program deals with radioactive materials. Specialties include nuclear criticality, radiation shielding, nuclear ALARA, and general nuclear safety.

D1.3 DECONTAMINATION AND DECOMMISSIONING

The D&D specialists ensure that shutdown and D&D requirements for TWRS Program facilities are identified and addressed during the SE process. D&D requirements will be developed throughout the evolution of the technical baseline and embedded in the baseline. D&D requirements will be developed, deactivation guidelines will be written, and advice on D&D requirements implementation will be given to the TWRS designers.

D1.4 ENVIRONMENTAL ENGINEERING

Environmental engineers ensure that the system is designed to meet environmental constraints and verify that environmental monitoring systems are properly designed, installed, and operated during the life-cycle. Environmental requirements will be identified and allocated to the program elements/projects during all phases of the SE process. These requirements are based on applicable Federal and state regulations, standards, and Statutes, along with DOE directives and environmental compliance documentation. Environmental engineers will verify that environmental requirements are properly interpreted and embedded in the technical baseline.

D1.5 FACILITY STARTUP

Facility Startup specialists identify early in the design process design requirements that enable facility commissioning and startup to be efficiently accomplished. These specialists will be included in the SE process throughout the development of the technical baseline. The goal is to incorporate design features that could reduce the cost and schedule of the commissioning phase of a facility.

D1.6 HUMAN SYSTEMS INTEGRATION

Human systems integration engineers ensure that designs are compatible with the capabilities and limitations of the personnel who will operate, maintain, transport, supply, control, and dispose of the system. Human system performance requirements address all relevant information in the following domains: 1) Human factors engineering, 2) Manpower, and 3) Personnel. Human factors engineering will be applied during development and design of the TWRS Program and its projects. Where human interfaces occur within the physical system, the interfaces will be appropriately engineered. Special attention will be given to those requirements and design attributes affecting the safety of personnel who operate and maintain the system. Additionally, special attention will be given to the potential for the system to release radioactive or toxic materials to the environment through human error or through a poorly designed human-equipment interface.

D1.7 INTEGRATED LOGISTICS SUPPORT

Operational servicing personnel will provide the logistics support for the system. They will review the evolving design for logistics requirements and will address logistics support issues. The logistics support personnel will participate in the system development by developing the logistics program for the architecture. The program will address availability of the system, maintenance planning, facilities needed, supply support, support equipment, technical data requirements, computer resources support, manpower, training support requirements, and packaging, handling, storage, and transportation requirements. The Operational Servicing model will be used to support the logistics planning. The logistics program is documented in the Project Logistics plan.

D1.8 PRODUCIBILITY AND CONSTRUCTABILITY

The Producibility and Constructability specialists consider equipment production, fabrication, facility construction, facility startup testing, and operational requirements. The technical baseline will be reviewed for compliance to these requirements on an ongoing basis. Cost trade studies will be performed where other design requirements conflict with producibility and constructability requirements. Fabrication and construction disciplines will use the technical baseline as the basis for planning efforts. The design approach can significantly impact the ability to construct, test, and operate equipment or facilities. Therefore, producibility and constructability requirements will be established, along with design guidelines, at the start of the SE process. These requirements will be given consideration throughout the technical baseline development and SE process.

D1.9 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

The reliability, availability, and maintainability (RAM) specialists provide RAM inputs into development of the technical baseline. As part of the requirements development and design process, RAM requirements are developed and assigned to the designs. Examples of RAM requirements are; (1) mean time between failures, (2) mean time to replace, (3) availability, (4) corrective maintenance times, and (5) preventive maintenance. The RAM data will be collected from appropriate sources to monitor the status of the system. When RAM system requirements are not met, these specialist will recommend corrective action. RAM requirements are developed and designs are evaluated against these requirements throughout the SE process.

D1.10 SAFEGUARDS AND SECURITY

Safeguards and Security personnel identify safeguard and security issues and develop safeguards and security plans throughout the TWRS program. Safeguard and security issues will be identified and defined during the programmatic F&R analysis and allocation stage. These issues affecting the development of the technical baseline will become requirements. In addition to identifying requirements, safeguards and security personnel will provide inputs regarding methods for verifying design conformance.

Safeguards and security planning will be incorporated into all phases of the systems engineering process. The planning will be developed to establish and maintain adequate safeguard requirements, including physical security, to protect nuclear materials and program facilities. The TWRS Program safeguards and security planning will describe the safeguards and security programs that need to be defined, documented, and implemented.

D1.11 STANDARDIZATION MATERIALS AND PROCESSES

The Standardization, Materials, and Processes specialists emphasize reducing the variety of parts, variability in processes, and associated documents used with items. This discipline ensures that Hanford Site design standards are used to the greatest extent possible in the design of all elements of the TWRS Program. Hanford Site design standards will be used in the TWRS Program design as appropriate. Standard equipment, materials, and processes will be incorporated into the design where these standards exist and can be used. This discipline will be incorporated into all phases of the SE process.

D1.12 SYSTEM LIFE-CYCLE COST

System Life-Cycle Cost (LCC) analyses develop the requisite cost information to support decisions on alternatives, personnel, product, process solutions, and risk assessments. LCC is the total of the direct, indirect, recurring, nonrecurring, and related costs incurred or estimated to be incurred during the anticipated life span of the system. The life span consists of design development, production, construction, operation, maintenance, support, and final disposition. System LCC analyses will be performed and maintained by the M&O contractor according to applicable DOE directives. Early design evaluations will include system trade studies that establish a desirable balance among performance, risk, supportability, schedule, cost, and other significant attributes while complying with safety, regulatory, and permitting requirements. The TWRS Program LCC analysis will be performed on a continuing basis as the program evolves and will be established specifically at each technical baseline review.

D1.13 TRAINING

The training discipline provides requirements into the SE process by performing a training analysis. This analysis determines the number of personnel and skills required to operate and maintain the facilities and equipment in the TWRS Program. The analysis also identifies the training and training equipment required to support the program. Training tasks are identified through analysis of the personnel tasks which are derived during the F&R analysis and allocation step of the SE process. After training tasks have been identified, further analysis determines student task requirements, instructor requirements, and trainer requirements. Instructor requirements are further analyzed to determine the instructor training requirements for the program. After all requirements have been determined, they are compared with current training resources to determine additional resources that may be needed to train personnel. Training analysis is conducted during F&R analysis and allocation and training requirements are given consideration throughout the development of the technical baseline.

D1.14 TRANSPORTABILITY

Identifies the local, state, and federal requirements constraining movement of system elements on public transportation routes and physical limitations of system elements due to existing interferences or capacities.

D1.15 VALUE ENGINEERING

System Value Engineering (VE) studies will assist in development of design configurations or alternative designs to achieve the optimum design configuration and value based on LCC (Section 1.3.11) and other value criteria. VE study results must be consistent with satisfying constraints and requirements for the following; (1) constructability, (2) quality of performance, (3) reliability, (4) availability, (5) productivity operability, and (6) safety. VE studies will be incorporated into all phases of the SE process.

D1.16 QUALITY ASSURANCE

Quality Assurance includes all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service [ASME NQA-1, 1994]

D1.17 OPERABILITY (INCLUDES DEACTIVATION)

Operability deals with the ease of operation, the ability of the system to be operated by individuals with basic skills and a minimum of special training, and whether the system operation can be accomplished with a minimum of error. It also includes shutdown of the plant by the operating staff for turnover to the D&D contractor. Operability has to be considered throughout the engineering process and lifetime of the system.

D1.18 TEST AND EVALUATION

This refers to the examination and judgement of a system (or an element of a system) in terms of worth, quality of performance, degree of effectiveness, condition and the like. Evaluation is an ongoing iterative process which begins during the conceptual phase and extends through the product use and logistic support phase until the system is retired. The purpose is to determine the true characteristics of the system and to ensure that is successfully fulfills its intended mission [Blanchard & Fabrycky, 1981]

D1.19 TECHNOLOGY

To achieve an efficient, effective product, it is essential to ensure that new technologies are identified, evaluated, selected, and incorporated into an organization's activities and processes. To do this, individuals knowledgeable about new, innovative technologies applicable to the system being designed must be a part of the engineering process. This is especially important during the formulation and evaluation of alternatives for performing system functions.