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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352
APR 27 1998

98-WDD-045

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

Dear Mr. Chairman:

DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 92-4 IMPLEMENTATION PLAN (IP), REVISION 2N, COMPLETION OF COMMITMENT 5.2.2(c), "EVALUATE 1997 SYSTEMS ENGINEERING PROCESSES EXISTING ON THE TWRS IMMOBILIZED LOW-ACTIVITY WASTE INTERIM STORAGE PROJECT (PROJECT W-465)"

The U.S. Department of Energy, Richland Operations Office (RL) has completed commitment 5.2.2(c), "Evaluate 1997 systems engineering processes existing on the TWRS Immobilized Low-Activity Waste Interim Storage Project (Project W-465)," as of December 31, 1997, using the method developed in response to Commitment 5.2.2(b). This commitment is identified in DNFSB Recommendation 92-4 IP, Revision 2N, as the "U.S. Department of Energy Plan for Improving the Systems Engineering Approach and Management Practices of the Hanford Site Tank Waste Remediation System (TWRS)."

The results of this evaluation are described in the enclosed report entitled "Defense Nuclear Facilities Safety Board Commitment 5.2.2(c) - Letter Report: Systems Engineering Assessment of Project W-465, March 1998." This evaluation was conducted using the "Tank Waste Remediation System (TWRS) Systems Engineering Maturity Assessment Guide" that was transmitted to you on January 23, 1998, "Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 92-4 Implementation Plan (IP), Revision 2N, Completion of Commitment 5.2.2(b), 'Create a Method for Measuring Systems Engineering Implementation in TWRS Projects'," letter number 97-MSD-298.

As explained in the enclosed report, application of the maturity assessment guide provided useful insights into the implementation of systems engineering on Project W-465, as well as the effectiveness of the assessment guide itself. A discussion of how the results of this effort will be applied to other TWRS projects will be presented to the DNFSB in May 1998 during the semi-annual briefing to be held in accordance with Commitment 6.3.(1) in the subject IP.

RL has completed the action identified under this milestone and proposes closure of this commitment.

If you have any questions, please contact me, or your staff may contact William J. Taylor, Waste Disposal Division, on (509) 372-3864.

Sincerely,

John D. Wagoner
Manager

WDD:PEL

Enclosure

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Defense Nuclear Facilities Safety Board Commitment 5.2.2 (c)

Letter Report: Systems Engineering Assessment of Project W-465

March 1998

Contents:

Defense Nuclear Facilities Safety Board Commitment 5.2.2 (c)

Letter Report: Systems Engineering Assessment of Project W-465

1.0 Summary

This letter report is the deliverable defined by 5.2.2 (c) of DNFSB Recommendation 92-4 Implementation Plan, Revision 2N, August 1997;

"Evaluate 1997 systems engineering processes existing on the TWRS Immobilized Low-Activity Waste Interim Storage Project (Project W-465) as of December 31, 1997, using the method developed in Commitment 5.2.2(b)."

This report presents findings derived from the Systems Engineering maturity assessment tool (ref. LMHC, 1998a) and follow up interviews. Maturity assessment determines the growth and the effectiveness of systems engineering efforts within an organization. The maturity assessment tool is a modification of an International Council on Systems Engineering (INCOSE) model, specifically tailored for application to Tank Waste Remediation System (TWRS) projects. The tailoring established a system that measures performance from a level where "systems engineering is not performed" up to a level where "systems engineering is defined by procedures." Maturity was assessed in 17 key focus areas representing elements of management, organization and systems engineering processes.

The assessment used follow up interviews to gauge the effectiveness of both the maturity assessment tool and the Project's implementation of the TWRS Systems Engineering Management Plan (Peck, 1998). Figure 1 presents the raw score results of the assessment sorted by 17 different key focus areas. Table 3 summarizes follow up interviews used to verify results of the maturity assessment tool and compliance with the TWRS Systems Engineering Management Plan (SEMP). Appendix D contains lessons learned from utilizing the maturity assessment tool.

Summary results found during the Project W-465 maturity assessment were as follows:

1) The assessment found Project W-465 was applying systems engineering processes for all key focus areas. The degree of maturity ranged from a level where "systems engineering is performed informally" up to levels approaching "systems engineering is defined by procedure." The majority of the key focus areas were at or near a maturity level where "systems engineering is performed and managed."

2) Project W-465 exhibited higher levels of systems engineering maturity for key focus areas of:
- planning,
- configuration management,
- quality management,
- risk management,
- concept definition,
- requirements and functional analysis, and
- design.

Several of these key focus areas are fundamental to the current phase of Project W-465. The project need has been established (Acree, 1998/Alm, 1997), project plans have been prepared (Shade, 1997), functions and requirements have been defined (Burbank, 1996), and a conceptual design has been prepared based on the requirements (Pickett, 1998). Feedback on the requirements and iteration of the design requirements is planned.. Project activities are being tracked and reviews are being conducted.

3) Based upon the maturity assessment tool, two key focus areas, technology management and competency development, indicated informal systems engineering performance. However, follow up interviews found that:
- technology management needs had been evaluated and a decision was made that new or emerging technology was not necessary. Therefore the majority of the questions in this focus area were not applicable to the project.
- competency development questions in the tool were appropriate for line/functional organizations that develop and supply a competent labor force rather than projects who define work/schedule/budget and procure needed labor. It did highlight the need for the project to provide feedback to the line/functional organization for competency development.

4) In spite of relative strength in several key focus areas, the Project staff expressed a significant amount of uncertainty over systems engineering terms and expectations. The project is performing many systems engineering processes which are defined by systems engineering, business management and/or engineering. For example, the project did not associate the project file system with the questions on data management. Another example centered around the different definitions of validation. This uncertainty over terms and expectations could be remedied with a mentor, training or expert SE participation that helps provide interpretation, application and integration of systems engineering into the project. The project has recently obtained systems engineering support to enhance integration of systems engineering concepts into the project.

5) The maturity assessment tool provides meaningful feedback to the project when combined with interviews and analysis of the basis for the results. Clarifying terms, focusing the application of the tool to appropriate disciplines and streamlining the interview and analysis efforts would increase the effectiveness and responsiveness of the tool. As noted previously lessons learned from the assessment have been prepared and are summarized in Appendix D.

Project W-465 staff have obtained new insight resulting from this evaluation. The Project has shared this information with other projects within TWRS. The value of the assessment will be realized as Project W-465 uses the information to improve process and project quality. Future use of the tool will allow the value to be measured. Results of the assessment are further explained in Section 5.0, "Conclusions."

2.0 Purpose of Assessment

This assessment was performed to evaluate how well Project W-465 implemented TWRS systems engineering processes and procedures. The assessment measures the extent to which the systems engineering processes have been implemented against requirements established in the TWRS SEMP (Peck, 1998). In addition, the assessment provided a benchmark to assess growth in project systems engineering processes. The assessment allowed for a "demonstration of the institutionalization of systems engineering processes" as described in "U.S. Department of Energy Plan for Improving Systems Engineering Approach and Management Practices of the Hanford Site Tank Waste Remediation System, Rev. 2N. (DOE-RL, 1997)"

This was also the first application of the systems engineering maturity assessment tool prepared for DNFSB commitment 92-4, 5.2.2(b). The maturity assessment tool was developed to allow periodic progress measurements in applying specified, graded systems engineering processes on TWRS projects. This assessment process provided insight into the application of the tool on a project.

Background information on DNFSB recommendation 92-4, Project W-465, commitment 5.2.2(b) and commitment 5.2.2 (c) is presented in Appendix A (DOE-RL 1997).

3.0 Assessment Process

The assessment team used the process outlined in the *Systems Engineering Maturity Assessment Guide for the Tank Waste Remediation System* (LMHC 1998a). The maturity assessment guide is intended to assess systems engineering capability in 19 key focus areas in the 3 process categories presented in Table 1:

Table 1. Process Categories and Focus Areas.

1.0 The Management Process	2.0 The Organization Process	3.0 The Systems Engineering Process
1.1 Planning 1.2 Tracking and Oversight 1.3 Subcontract Management 1.4 Intergroup Coordination 1.5 Configuration Management 1.6 Quality Management 1.7 Risk Management 1.8 Data Management	2.1 Process Management and Improvement 2.2 Competency Development 2.3 Technology Management 2.4 System Engineering Tools and Environment Support	3.1 Concept Definition 3.2 Requirements and Functional Analysis 3.3 Design 3.4 Integrated Engineering Analysis 3.5 Integration 3.6 Verification 3.7 Validation

The TWRS questionnaire was tailored to address the following first four levels of maturity:

Level 0	Initial, Systems Engineering is not performed
Level 1	Systems Engineering is performed informally
Level 2	Systems Engineering is performed and managed
Level 3	Systems Engineering is defined by procedures.

In addition, questions for key focus areas 2.1, "Process Management and Improvement," and 2.4, "Systems Engineering Tools and Environment Support," were removed because they applied to the TWRS organization rather than the project.

The assessment used a process of three sequential and related steps:

1. Use the TWRS maturity assessment tool questionnaire, developed for DNFSB commitment 5.2.2(b), tailored for the W-465 staff

2. Analyze the results of the questionnaire and conduct follow-up interviews with the participants

3. Review project documentation to gain further understanding of the degree of implementation and project compliance with TWRS policy and guidance.

The results provided the foundation for determining strengths, areas for improvement, and possible actions to increase project systems engineering maturity. The process is discussed further in Appendix B.

4.0 Results

The W-465 Project Team composite response to the questionnaire is summarized in Figure 1. The data represent the raw scores from all staff, for all questions, without screening. Planning, configuration management, quality management, risk management, concept definition,

requirements and functional analysis, and design were assessed to be above the level of being performed and managed. In contrast, competency development and technology management were scored as being performed informally. The follow-up interviews were conducted to confirm or explain the results of the questionnaire and assess the compliance of the systems engineering processes to the criteria based on the TWRS SEMP (Peck, 1998). The follow-up interviews also provided a screen to the raw scores. The applicability and phrasing of questions and the impact on scoring were assessed during the follow-up interviews and data analysis.

The processes and products of TWRS SEMP effective December 31, 1997, were compared to the current SEMP. This comparison established the SEMP defined deliverables that were appropriate for the project W-465 maturity assessment. No significant differences in process were identified between the SEMP revisions. That analysis is summarized in Appendix C.

The follow-up interview information is summarized in Table 3. The table is arranged by the **Key Focus Areas** identified in column 1. The **Description/Purpose** of each key focus area is extracted from the TWRS Systems Engineering Maturity Assessment Guide (LMHC, 1998a). The **SEMP-Required Deliverables** are based on a review of the TWRS SEMP (Peck, 1998a). An effort was made to minimize the repetition of deliverables with multiple points of application (e.g., Alternative Generation and Analysis Documents). The **Project W-465 Evidence** lists the documents and information identified by the project in response to the questionnaire and interviews. The last column, **Maturity Assessment Tool and Interview**, summarizes the results and feedback from analyzing both the questionnaire data and the interview results.

5.0 Conclusions

The assessment evaluated the Project W-465 status of implementing systems engineering procedures and practices. The maturity assessment tool and follow-up interviews found that Project W-465 was applying (performing and managing) systems engineering principles. In several areas the project had progressed to a level of systems engineering maturity characterized by compliance with procedures. The follow-up interviews confirmed that evidence existed for the positive responses.

The follow-up interviews with the staff brought out that improved understanding of the systems engineering terminology and expectations would have generated additional positive responses. Discussions uncovered additional evidence that project processes and deliverables were higher than reflected by the raw scores.

Certain key focus areas play a more significant role in the project success during the conceptual design phase. Those key focus areas judged to be most important to Project W-465 during this phase are listed in Table 2.

Table 2. Key Focus Areas During Conceptual Design Phase.

1.0 The Management Process	2.0 The Organization Process	3.0 The Systems Engineering Process
1.1 Planning 1.2 Tracking and oversite 1.3 Subcontract management 1.4 Risk management	2.1 Competency Development 2.2 Technology Management	3.1 Concept Definition 3.2 Requirements and Functional Analysis 3.3 Design 3.4 Integrated Engineering Analysis 3.5 Integration 3.6 Verification 3.7 Validation

Of these significant key focus areas, the maturity assessment tool identified project strength in planning, risk management, concept definition, requirements and functional analysis, and design. The basis for maturity assessment results was confirmed by the follow-up interviews, as indicated in Table 3.

The maturity assessment tool identified areas for improvement in competency development, technology management, verification, and validation. Follow-up interviews identified that several factors led to these results.

Competency Development:

The project did not take credit for the significant role functional organizations play in training and providing qualified staff. Competency training, plans, and records are maintained by the line/functional organizations. The project is responsible for selecting qualified staff from the line/functional organizations or subcontractors. The staff interpreted the assessment model questions as implying the project had primary responsibility for training. The project also did not take credit for on-the-job training.

Technology Management:

Project W-465 did evaluate technology needs, but found that technology development was not necessary for successful execution of the project. Technology development items were identified for the Immobilized Low-Activity Waste Program Office and submitted to the Site Technology Coordination Group for consideration. The technology coordination activities and the submitted items were outside of Project W-465 scope. Based on this situation, many technology management questions in the maturity assessment model did not apply.

Verification:

The expectations for project verification during the conceptual design phase need to be clearly communicated. The project staff responded with more than 50 percent "Not Applicable" and "Don't Know" responses in this key focus area. The project has planned but not yet developed test and evaluation plans. No emerging technology was identified as necessary for the project. Therefore, testing and evaluation emphasis is on the planned acceptance and operability tests. The conceptual design, design requirements, and other key documents were reviewed according to procedures (Pickett 1997). As noted during follow-up interviews, traceability between the design requirements and conceptual design could be strengthened.

Validation:

The expectations of systems engineering validation need to be clearly communicated to and understood by the project staff. The project staff responded with a approximately 60 percent "Don't Know" responses for Level 2 and 3 systems engineering questions. The project staff tended to view validation in terms of the DOE assessment of readiness for capital line item funding. Line-item-funding validation is only weeks away. The project has performed several actions to ensure compliance of the project with specified constraints, requirements, or commitment, including the justification of mission need, TWRS mission analysis, and the readiness to proceed evaluation. The project has a series of scheduled events to ensure that designs, permits, and safety analyses are consistent and appropriate for the project.

Two key focus areas not addressed here, that will assume greater importance as the project moves from conceptual design to detailed design and construction, are configuration management and quality management. Both of these areas scored relatively high during this assessment.

As described, systems engineering practices are being applied by Project W-465. Continued improvement in integrating systems engineering concepts and practices into the project will require improved communications between the project and systems engineering organizations. The role of communicator currently is played by one individual matrixed across all TWRS retrieval projects. Additional support in assisting with the project-systems engineering communications would improve the probability of successfully implementing systems engineering. The support will also assist the project in systems engineering application during the transition from conceptual design to design/construction.

The second purpose of the assessment was to evaluated the application of the maturity assessment tool on a TWRS project. The maturity model provided meaningful feedback to the project when combined with the analysis of information uncovered during the follow-up interviews. Lessons learned are presented in Appendix D.

Figure 1: W-465 SE Maturity Summary (Raw Scores)

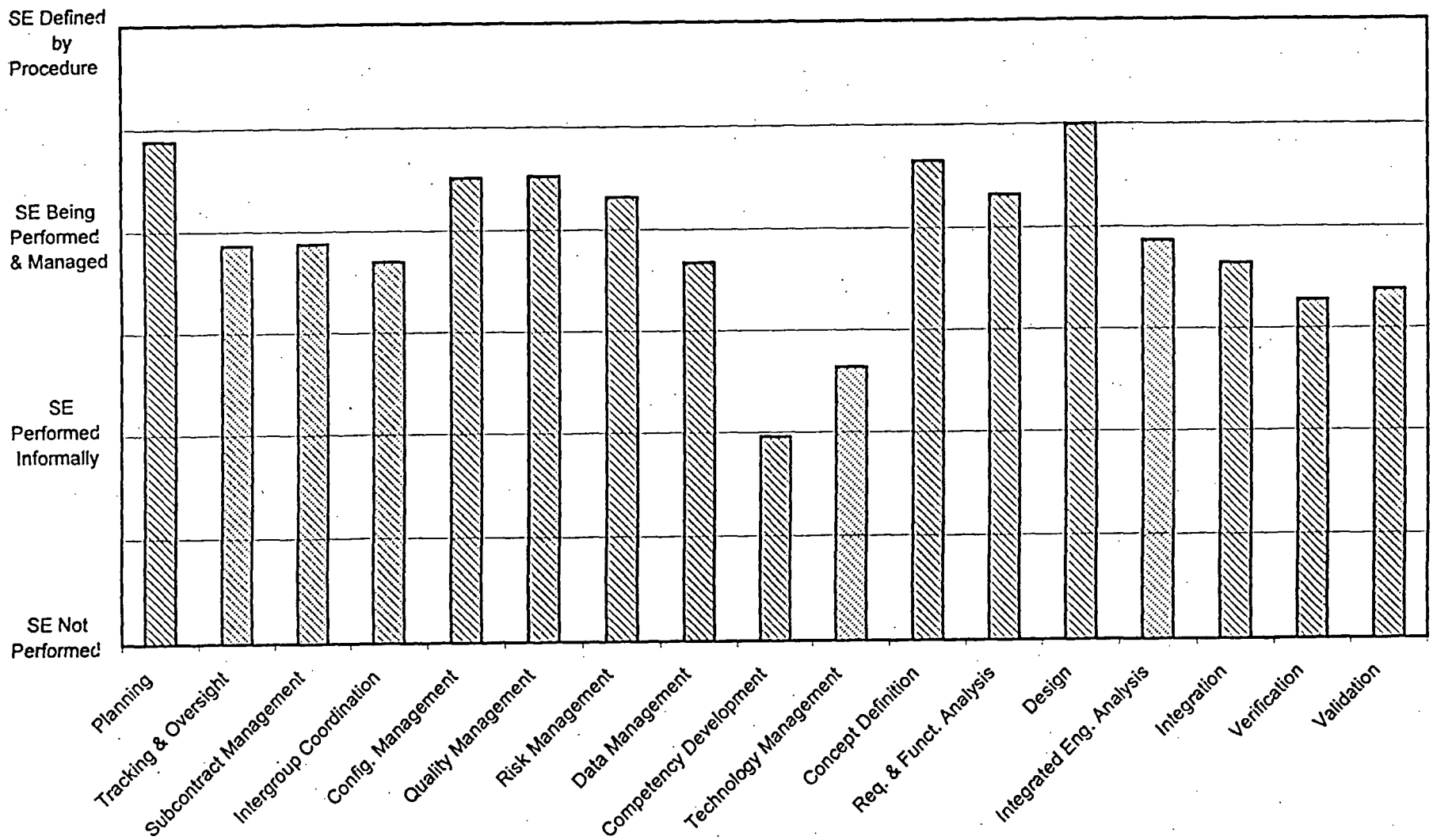

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.1 Planning -Activities to identify, resource load, logically sequence, and schedule project tasks. -Activities to prepare for the conduct of tasks.	Planning involves the identification of technical and programmatic requirements and constraints at the project level. These requirements define the technical and programmatic baseline.	Documented SE Level Graded SSCs Systems Engineering Implementation Plan Level 1 Logic Decision/Level 1 Logic Crosswalk	Systems Engineering graded approach Level 2 was assigned in Immobilized Low-Activity Waste Disposal Plan (Shade 1997). Grading of structures, systems, components deferred to Systems Engineering Implementation Plan A Project Systems Engineering Implementation Plan is in progress (Parsons 1998) Level 1 logic (LMHC 1998b and 1998c) and Technical Basis Review packages (Swita 1998). A crosswalk has not been prepared Other evidence: - Multi-year Work Plan (LMHC 1997a) - Waste Disposal Division Planning Guidance (Taylor 1997) - Multi-Year Work Plan Guidance - TWRS Program Plan (Powell 1998)	- The project work breakdown structure has been established. - Roles and responsibilities have been defined. - Systems engineering is included in the planning. Logic, schedule, and resources have been planned. - Training is "on-the-job" training. - The planning process is defined. However, guidelines for tailoring the planning process are not defined. - The project is given discretion for definition of its levels of the work breakdown structure, layout of logic, and resource planning.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.2 Tracking and Oversight -Tracking -- Assessing the progress to planned technical, cost, and schedule objectives. -Oversight -- Developing meaningful metrics, monitoring progress, and taking corrective actions when necessary.	These functions consist of monitoring, evaluating, and (when necessary) adjusting the technical effort of a project to achieve objectives, goals, and plans.	Technical Performance Measures	Technical Performance Measures are planned with ATP/OTP Other evidence: - Weekly reports - Monthly reports - Status meetings - Monthly status of P3/Site Management System - Variance analysis - Change request process	Project W-465 has plans to develop technical performance measures as it develops a test and evaluation plan. The plan is not in place because the project is not complex and does not require new or emerging technology. - The project team had difficulty relating the Hanford Site cost schedule control system terminology to "metrics." - Plans and thresholds are established. - Status is gathered and reported at all levels.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.3 Subcontract Management -Actions taken to select qualified subcontractors. -Actions taken to ensure subcontractors deliver products and services within designated requirements, cost, and schedule.	Subcontract management selects and controls subcontractors who will meet the defined needs of the subcontract.	No discrete systems engineering products cited	Project generates and manages statements of work, contracts, and task orders. These include systems engineering products and application of processes. Status of work in progress is monitored. Products are reviewed by the project, program, and others as appropriate. Other evidence: - FDH - LMHC Subcontract (FDH 1996) - Lockheed Martin Hanford Corporation (LMHC) - Fluor Daniel Northwest, Inc. (FDNW) subcontract - Statements of work (Carlson 1997) - Task orders	- The Project team had difficulty differentiating business management context from systems engineering descriptions/ questions in the questionnaire. - Contracting policies/procedures are set by Fluor Daniel Hanford, Inc., and TWRS Business Management. - Under the PHMC most work is contracted using task orders to supporting functions or statements of work and external contracts. - Training is typically "on-the-job" Training which the Project team did not associate with subcontract management training. - Some questions did not apply (acceptance testing) since the project is at the conceptual design phase and acceptance testing is normally conducted on physical components or software.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.4 Intergroup Coordination -Actions taken to facilitate effective communication between inter-related groups to ensure project objectives are achieved.	Intergroup coordination facilitates the effective communication and resolution of issues among diverse groups involved in project system development.	Contracts/agree-ments to address programmatic interfaces	Planned Other evidence: - Weekly/Monthly reports - Monthly status meetings (DOE, Ecology, FDH, LMHC) - Monthly status meetings (LMHC, Numatec Hanford Corporation (NHC), FDNW) - Design requirements document/statement of work kick-off meeting - Conceptual Design Report Review (Pickett 1997) - Draft ICDs with private contractors (LMHC 1997b)	- Contracts and task orders are in place for working with other organizations. - The project works with the Privatization Integrated Product Team to develop ICDs with the private contractors. - Status of activities is obtained. - The facility operating contractor decision is scheduled for the future. The project is developing an interim interface to understand the operation's perspective.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.5 Configuration Management -Actions to develop, document, coordinate, and control characteristics of the technical, cost, and schedule baseline.	Configuration management consists of the planning, configuration identification, change control, status accounting, and auditing of the product elements, including requirements, interfaces, and design representations of the products being provided to meet stated project objectives.	Functions and Requirements recorded in the Hanford Site Technical Database	Letter Project W-465 Design Requirements Document Change Request to the Hanford Site Technical Database (Leonard 1997) Other evidence: - ILAW Disposal Plan (Shade 1997) - TWRS Retrieval and Disposal Mission Technical Baseline Summary (Treat 1998) - Change control for cost and schedule - Change control for engineering documents (Engineering Change Notice process)	- Configuration Management is developing consistent with the life-cycle phase of the project. - Key documents were identified in HNF-1901 (Treat, 1998) to be maintained current. The configuration items can be defined as the physical system is defined and the information items linked. - The project files are being established and configuration management established for the documentation. - The project is making the transition to the process contained in the TWRS Configuration Management Plan (Vann, 1998)

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.6 Quality Management -Actions taken to provide for independent evaluation and assessment of the products and processes used to meet project objectives.	Quality management is the set of activities that provide for independent evaluation and assessment of products and processes used to meet project objectives.	No discrete systems engineering products cited	Quality Assurance Project Plan (QAPP) is a planned activity. Other evidence: - ILAW Disposal Plan (Shade 1997) - TWRS Quality Assurance Program Plan (Bores 1998)	- The project specific QAPP is planned. - Training to the plan, status, corrective actions, etc., is not applicable until the project-specific QAPP is in place. In the meantime the Project is working to the references in the ILAW Disposal Plan.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.7 Risk Management -Actions taken to identify, analyze, and mitigate technical, cost, and schedule risk.	Risk management is the technical programmatic management process that addresses risks that may affect the technical, cost, and scheduling aspects of a project in an uncertain environment.	Risk Management List Decision Plans AGAs Decision Documents	Immobilized Waste Risk Management List Letter, "Immobilized Low-Level Waste Interim Storage Architecture Selection Decision Management Plan" (Murkowski 1996b), has risk as a criterion. *Alternative Generation and Analysis* (Burbank 1996) included risk examination. Letter Milestone Completion - "Issue Low-Level Waste Interim Storage Engineering Evaluation" (Taylor 1996) Other evidence: - *Design Requirements Document For Project W-465* (Burbank 1997) identifies issues - *W-465 Conceptual Design Report* (Pickett 1998) identifies uncertainties - *Project Risk Management Plan* (Murkowski 1995a) - *TWRS Risk Management Procedure* (Zimmerman 1998) - Monthly discussion of risk	- Risk management lists have been generated and maintained. - Risk Management Training is on-the-job. - Specific quantitative risk thresholds were not established by TWRS (only qualitative thresholds are listed in procedure). - Additional feedback is needed to the project teams as lower level issues/risks and decisions are required.

Table 3: Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
1.8 Data Management -Actions taken to control project related information in any form.	Administrative control of project and system information in any form.	No discrete systems engineering products cited	Project files are being formally established and placed under control Other evidence: - Site document control system - Record Management Information System training for staff - TWRS Retrieval and Disposal Mission Technical Baseline Summary (Treat 1998)	Several aspects of data management were not recognized by the Project team although they are practiced. These included the Project Files being established and screening of documentation.
2.2 Competency Development -Actions taken to ensure project personnel have the necessary skills and training to successfully attain project objectives.	Competency development increases organizational and project competency to perform the style, scope, and intensity of engineering required over time. It provides a learning environment for individuals who want to increase their knowledge, skills, wisdom, or mastery of engineering, project integration, and management.	No discrete systems engineering products cited	Project reliant on functional organizations and subcontractors to provide qualified resources Other evidence: - Training matrix subsystem - Technical staff has formal education - Technical staff has significant experience (on the job training) - Reading list	- Some confusion was seen over the project's responsibility to develop training plans vs. the functional organization's responsibility to provide qualified staff. The project orients its team and provides feedback on performance. It does not make individual development needs clear to functional organizations. - The project team, in general, did not recognize on-the-job training in their responses. Recognition could be enhanced by having a dedicated systems engineer on the project team.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
2.3 Technology Management -Actions taken to identify, evaluate, invest in, and select new technology to fulfill project objectives.	Technology management is identifying, selecting, evaluating, and investing in new technologies, and incorporating the appropriate technologies into the organization's products and processes.	No discrete systems engineering products cited	Participant in Site Technology Coordination Group (no need identified for new or emerging technology) (Piper 1997)	- The Immobilized Waste Storage & Disposal Program reviewed the needs for new or emerging technology. None were identified. Therefore, the lower level questions in this questionnaire do not apply to Project W-465.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.1 Concept Development -Actions taken to establish a preferred physical concept for meeting mission needs. -Establishing a baseline concept that meets requirements.	Concept Development performs the operations or mission analysis on the system requirements to understand required behavior. It derives alternative concepts that unify system features, functions, performance, and price. It articulates concepts sufficiently for selection and verification through a formal concept review. It also establishes a concept baseline.	Project Mission Review System Assessment AGAs O&M Concept RAM Analysis Project Design Criteria	Mission review was conducted on justification of mission need for KD-0 under the DOE Order 4700 system. CD-1 was obtained December 1996. (Alm 1996) AGA for immobilized low-level waste interim storage (Burbank 1996 & Murkowski 1996c) Facility walkdown activity with CDR (See AGA) Initiated Planned Project equivalent is the design requirements document (Burbank 1997)	- The development of the project mission and system architecture selection are complete. - The "Project Birthright" in accordance with the earlier TWRS SEMP revision is the design requirements document. - Training is on-the-job. - The project "standardization of concept definition" is unclear because this is the process to define the system level given to the project by the program. Therefore, this does not apply.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.2 Requirements and Functional Analysis -Requirements Analysis -- structured method to determine functional and performance requirements for the assigned system, structures, or components -Function Analysis -- structured method to define and decompose necessary functions (mission objectives) to successively lower levels.	The objective of requirements and functional analysis is to completely define the technical requirements for the preferred system concept in response to the customer or user needs.	Functional Analysis Requirements Analysis Level 1 Specification Level 2 Specifications	Functional Requirements - *Immobilized Low-Level Waste Interim Storage* (Murkowski 1995b) Requirements analysis is combined with functional analysis Project equivalent is the design requirements document (Burbank 1997) Project strategy is to use a single architect engineer and to update the design requirements document rather than generate Level 2 component specifications Other evidence: - TWRS functions and requirements (WHC 1995)	- This project followed the defined process. - Decomposition of functions and requirements extends two levels below TWRS functions. - The process was conducted in parallel with the TWRS functions and requirements development. Some higher level requirements were not allocated as a result. - Only a limited decomposition of transportation requirements - The conceptual design report and preliminary safety evaluation have identified additional requirements and will be added by preparation of a revised specification or design requirements document. - Integration with the Hanford Site technical database is needed as a part of the update because changes have been made since the TWRS functions and requirements document was prepared (1996).

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.3 Design -Actions taken to transform requirements and concepts into design solutions.	Design is the process of transforming system requirements into design solutions, including conceptual and detailed design stages of the system life-cycle.	Design baseline products System functional review Trade studies	*Immobilized Low-Activity Waste Interim Storage Facility, Project W-465 Conceptual Design Report* (Picket 1998) Conceptual design report review (Pickett 1997) Planned (remote-handled vs contact-handled storage)	- Training in the form of familiarization with the project and systems engineering documentation was part of the design kick-off meeting. - On-the-job training is the principle form of training. - Traceability of the conceptual design report to the design requirements document requires separate crosswalk.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.4 Integrated Engineering Analysis -Actions taken to bring together multidisciplinary teams representing the spectrum of disciplines necessary to ensure all perspectives have input in the engineering analysis. Early participation of specialty disciplines ensures timely requirements, trade study, and design issues are identified and integrated.	Integrated engineering analysis is the use of multi-disciplinary teams representing multi-functional areas to perform engineering analysis to - Identify issues that require the application of decision theory techniques - Select a decision-making technique appropriate to each technical issue - Involve the right mix of technical disciplines in the decision-making process	Specialty engineering analysis and studies Integrated logistics support plan	Preliminary safety evaluation (Mouette 1997) Planned Other evidence: - Permit requirements evaluation (Deffenbaugh 1997) - Conceptual design review (Pickett 1997)	The integrated engineering analyses are planned and managed as part of integrated team. - The preliminary safety evaluation and environmental permitting were planned in conjunction with the conceptual design report. - The TWRS SEMP provides the policy to the project for specialty engineering.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.5 Integration -Actions taken to ensure that subsystems and components perform as a completed unit to satisfy assigned requirements	Integration is the collection of documentation and processes that result in compatible subsystems that collectively meet the customer and user needs.	Interface control documents	Interfaces identified ICDs planned Other evidence: - Private contractor ICDs (LMHC 1997b) - RTP interface lists - Monthly reviews	- The project has identified its interfaces and plans to develop ICDs following conceptual design. - The conceptual design adds detail needed to develop ICDs and identify additional interfaces. - Draft private contractor ICDs were developed. - Feedback is limited on the private contractor ICDs. This will mature as the contracts are finalized.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.6 Verification -Actions taken to ensure that the system, structure, and components being developed meet assigned requirements. Methods to verify include test, analysis, demonstration, inspection, and simulation.	Verification is the stepwise approach to ensuring that each element of a system satisfies its requirements. When completed at each level, the integrated system satisfies the system-level requirements.	Test and evaluation plan	Planned Other evidence: - Review Comment Records for design and analyses - Preliminary safety evaluation (Mouette 1997)	- The project does not need new or emerging technology. Therefore, test and evaluation have emphasized acceptance testing and operability testing. The primary design verification identified has been the design review process. The conceptual design report identified an uncertainty regarding access to the vaults that may add design verification and testing needs. - The preliminary safety evaluation evaluates whether the design meets the safety requirements. - The TWRS test and evaluation plan is being developed; therefore, the project lacks TWRS guidance for developing a test and evaluation plan.

Table 3. Follow-Up Interview Summary.

Key focus area	Description/purpose	SEMP Required Deliverables	Project W-465 evidence	Maturity Assessment Tool and Interview Results
3.7 Validation -Actions taken to ensure that the system being developed meets mission objectives. (ie. Have correct requirements been assigned to the system?)	Validation is the end-to-end approach to ensure that the completed integrated system will operate as required in its intended environment.	No discrete systems engineering products cited	The TWRS mission analysis includes functional requirements applicable to this project. The W-465 is included in "Equipment Upgrades and New Facility Construction Projects." Other evidence: - Justification of mission need - Project validation - Design reviews	- Some confusion existed between the DOE term "project validation" (project baseline scope, schedule, cost) and the systems engineering validation (ensure traceability to the need). - The project mission has been validated and the project requirements were reviewed. - External events have defined validation points such as the critical decision points, readiness to proceed activity, completion of the TWRS MAR, which examined the need for projects, and the prospect of implementing disposal.

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APPENDIX A: BACKGROUND

Appendix A: Background

DNFSB 92-4 and Commitment 5.2.2(c):

The U.S. Department of Energy issued Revision 2 of the *U.S. Department of Energy Plan for Improving Systems Engineering Approach and Management Practices of The Hanford Site Tank Waste Remediation System* (TWRS Implementation Plan Revision 2N) in October 1997. That plan provided 12 commitments that demonstrate how systems engineering and management improvements are being implemented and institutionalized in the Tank Waste Remediation System (TWRS) Project. The updated plan recognized that processes, procedures, and policy have been developed for both the Hanford Site and TWRS systems engineering approaches. The systematic approach initiated by Revision 1 of the plan had created project changes at the Hanford Site. Revision 2 of the plan reinterpreted the key safety concerns originally identified by the Defense Nuclear Facilities Safety Board and the actions that would be taken by TWRS to resolve the remaining concerns. The commitments presented in Revision 2 of the plan address the following TWRS safety concerns:

1. Design bases need additional definition
2. Integrated, systematic design basis development needs to be institutionalized
3. TWRS privatization project needs more integration with other activities
4. Technical qualifications for U.S. Department of Energy, Richland Operations Office (RL) TWRS technical positions need to be adequately defined, documented, and demonstrated.

This assessment report focuses on Concern 2 particularly, and some portions of 1 and 3. Concern 2 is addressed through this response to DNFSB commitment 5.2.2(c). The purpose of the commitment is stated as:

> "As one demonstration of the institutionalization of systems engineering processes in TWRS, DOE-RL, TWRS will apply the criteria used for measuring progress in implementing systems engineering processes (Commitment 5.2.2(b)) to a new TWRS project, the Immobilized Low-Activity Waste Interim Storage Project (Project W-465) at the end of calendar year 1997, and document the basis for significant items found."

The deliverable is a letter report due April 30, 1998.

Commitment 5.2.2(b)

Commitment 5.2.2 (b) created a method for measuring systems engineering implementation in TWRS projects. The method is documented in HNF-IP-0842, Volume IV, Section 2.12, Rev.1, "Systems Engineering Maturity Assessment Guide for the Tank Waste Remediation System." This guide is based on the International Council on Systems Engineering (INCOSE) Capability Assessment Model, Version 1.50. As such, it is intended to assess systems engineering capability in 19 key focus areas in the following three process categories:

1.0 The Management Process	2.0 The Organization Process	3.0 The Systems Engineering Process
1.1 Planning 1.2 Tracking and Oversight 1.3 Subcontract Management 1.4 Intergroup Coordination 1.5 Configuration Management 1.6 Quality Management 1.7 Risk Management 1.8 Data Management	2.1 Process Management and Improvement 2.2 Competency Development 2.3 Technology Management 2.4 System Engineering Tools and Environment Support	3.1 Concept Definition 3.2 Requirements and Functional Analysis 3.3 Design 3.4 Integrated Engineering Analysis 3.5 Integration 3.6 Verification 3.7 Validation

The guide is intended to measure four levels of systems engineering performance maturity:

Level 0: Initial; systems engineering is not being performed
Level 1: Systems engineering is performed informally
Level 2: Systems engineering is performed and managed
Level 3: Systems engineering is defined by procedure.

Project W-465 (Immobilized Low-Activity Waste Storage)

The scope of project W-465 is to provide a facility and capabilities for transport and interim storage of immobilized low-activity waste. The recommended path forward entails retrofit modification of the existing grout vault storage facilities (Burbank 1996 and Murkowski 1996). These vaults were initially constructed by the Grout Vault Construction Project (Project B-714). Project W-465 is proposed as new fiscal year (FY) 2000 line item. Project W-465 is estimated to provide 3.5 years of storage capacity for immobilized low-activity waste product from privatization. Project W-465 had a scope of storage rather than disposal because early program planning indicated that disposal authorization would not be achievable in time to support privatization start up. The Immobilized Low-Activity Waste Storage and Disposal Project is currently identifying new projects to provide additional storage and disposal capacity after project W-465.

Before project authorization, the Immobilized Low-Activity Waste Storage and Disposal Project established the following systems engineering bases for Project W-465.

1. The functional requirements and the mission for immobilized low-activity waste storage were identified consistent with the TWRS mission analysis and functional requirements and further project decomposition (Murkowski 1995b).

2. Alternative immobilized low-activity waste storage architectures and evaluation criteria were identified (Murkowski 1996c).

3. The decision statement, responsibilities, strategy, criteria, schedule, and basis for selecting the Project W-465 architecture were identified (Washenfelder, 1996).

4. Engineering analyses of alternatives were prepared (Burbank 1996).

5. A letter of recommendation with a preferred alternative was sent to RL (Murkowski 1996a).

6. DOE concurred with Westinghouse Hanford Company's recommendation for the Project W-465 scope (Taylor 1996).

Project W-465 is very early in its life cycle. Critical Decision 1 was received for Project W-465 in December 1996. Conceptual design activities began in February 1997 and were completed in December 1997. A preliminary safety evaluation was prepared concurrent with the conceptual design. A permitting plan was prepared and regulatory actions are proceeding to ensure that permits are acquired on a timely basis. Currently the project staff is working on project cost estimates and basis for the estimates in preparation for project validation. The project is scheduled to become a FY 2000 line item.

Systems engineering guidance for FY 1997 was derived from the TWRS Systems Engineering Management Plan, WHC-SD-WM-SEMP-002, Rev. 0. The project is currently preparing implementation plans for the new TWRS SEMP.

APPENDIX B: ASSESSMENT PROCESS

Appendix B: Assessment Process

The assessment team used the process outlined in the *Systems Engineering Maturity Assessment Guide for the Tank Waste Remediation System*, January 14, 1998. This guide was prepared in response to commitment 5.2.2(b) of DNFSB Recommendation 92-4 Implementation Plan, Revision 2N, August 1997.

The assessment team consisted of the following personnel:

J.A. Voogd	Immobilized Waste Program Office
S.M. O'Toole	TWRS Retrieval and Disposal
E.C. Norman	TWRS Systems Engineering and Integration
R. Hudson	Hanford Site Systems Engineering
L.G. Peck	TWRS Systems Engineering and Integration

The assessment followed a process of three sequential and related steps:

1. Employ the TWRS maturity assessment questionnaire, developed for DNFSB commitment 5.2.2(b), tailored for the W-465 staff

2. Analyze the results of the questionnaire and conduct follow-up interviews with the participants

3. Review project documentation to gain further understanding of the degree of implementation and project compliance with TWRS policy and guidance.

TWRS Maturity Assessment Questionnaire

The maturity assessment questionnaire was based on the Systems Engineering Capability Assessment Model developed by the International Council on Systems Engineering (INCOSE), *Systems Engineering Capability Assessment Model*, Version 1.5, June 1996. The INCOSE questionnaire looks at 19 disciplines that comprise the breadth of the systems engineering approach to complex system acquisition. Answers to the questionnaire provide input for assessment of the maturity of systems engineering in an organization. In the INCOSE questionnaire, the results provide a basis for assessing maturity to one of six levels with the highest levels indicating systems engineering is being measured via metrics and optimized through process improvement techniques. Because systems engineering in TWRS is still being implemented, and to simplify the questionnaire, the TWRS questionnaire was tailored to address the following first four levels of maturity:

Level 0: Initial, systems engineering is not being performed
Level 1: Systems engineering is performed informally
Level 2: Systems engineering is performed and managed
Level 3: Systems engineering is defined by procedures.

Maturity generally builds on the successful attainment of the previous level to reach a higher level. For accomplishing the TWRS mission, nearing or attaining Level 3 is viewed as sufficient for the complexity of the TWRS system and the constraints within which TWRS is performing. While the questionnaire process is subjective, it provides a standardized suite of questions that can be used as a tool to evaluate strengths and weaknesses and in successive assessments to establish progress trends

and provides a focus for process improvement. When used in a large enough organization, the results of the questionnaire provides a basis for statistical analysis.

For application to Project W-465, the questionnaire was supplemented by a series of additional questions focused on assessing the application and implementation of specific TWRS policies and procedures. Two key focus areas of the guide (Process Management and Improvement and Environment and Tool Support) were deleted from the questionnaire because they were assessed as not applicable to the project, but were applicable to the TWRS Systems Engineering functional organization. To facilitate administration and to limit the imposition on participants' available time, the questionnaire was input to an Excel[1] spreadsheet and automated scoring/results roll-up methods were developed.

The core staff working on W-465 completed the questionnaire. Participants were placed in three categories depending on the focus of their tasks in Project W-465. Two participants performed a management role, three performed project engineering roles, and three performed specialty discipline tasks. These participants represented four companies, Lockheed Martin Hanford Corporation, Numatec Hanford Corporation, Fluor Daniel Northwest, Inc., and SGN Eurisys Services Corporation. Because of the small number of personnel taking the questionnaire, the results are not considered statistically significant. However, the results demonstrate trends in understanding and represent significant opportunity for insight into strengths and areas for improvement and general understanding of systems engineering principles.

Before administering the questionnaire, the assessment team conducted a kick-off meeting with the project staff. The participants were briefed on the purpose of the assessment, project specific tailoring of the questionnaire, and specific instructions for taking the questionnaire. Participants also were familiarized with the definition of the key focus areas to assist in understanding of the context of questions.

Participants returned electronic and, in some cases, hard copies of the completed questionnaires to the assessment team. The assessment team reviewed the raw results of the questionnaires and developed a number of tailored spreadsheet outputs to assist in establishing trends in the output and as a tool for formulating tentative areas of strengths, improvement areas, and areas for follow-on questions.

Interview Process

Because of the subjective nature of systems engineering maturity and implementation, a vital part of the assessment was the interview process. This process provided an opportunity for members of the assessment team to follow up on observations and apparent trends from the questionnaires. The results of the interviews provided a means of validating strengths and areas for improvement, as well as feedback on the assessment tool and process.

An interview session was held with each of the three categories of participants; managers, project engineers, and specialty engineers. The assessment team explored certain types of questions to determine the perspective of the participants to establish the basis for trends found in the questionnaire results. The interviews also provided a opportunity to discuss sources and project

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[1]Excel is a trademark of Microsoft Corporation.

documentation that participants considered the basis for their questionnaire answers. Assessment team discussions following the interviews provided the basis for final strengths, areas for improvement, and possible follow-on actions by the project.

Analyses and Assessment of Project Documentation

Based on the results of the questionnaires, results of face-to-face interviews, and review of sample project documentation, the assessment team compiled a series of strengths, areas for improvement, and possible actions the project and the TWRS program could undertake to enhance the maturity of systems engineering in the project and TWRS.

While the focus of this process was Project W-465, the team paid particular attention to the environment within which Project W-465 operated for sources of limitations that may have influenced the results of this assessment. Of particular interest was the TWRS maturity assessment tool itself. Because this was the first application of the questionnaire in TWRS, the validity of the tool for this and future use was of particular interest. Further discussion is included in the section on Lessons Learned in the appendices.

Scoring Process:

Each question had four possible responses: "Yes," "No," "Don't Know," or "Not Applicable" (to Project W-465). Scoring the questionnaire was done by calculating the fraction of questions that were answered "Yes" for each key focus area for each participant. The number of questions in each maturity level in each key focus area was adjusted by subtracting the number of "Not Applicable" responses from the total number of questions. The maturity score was calculated by adding the fraction of "Yes" responses for each of the three maturity levels together. For example, if there were 100 percent "Yes" responses for each of the maturity levels (levels 1 - 3), the maturity would be 3 (1 +1 +1 = 3); if there were 100 percent "Yes" responses for Level 1, 75% "Yes" responses for Level 2, and 50 percent "Yes" responses for Level 3, the maturity would be 2.25 (1 + .75 + .5 = 2.25). The results were averaged across the key focus areas and across all of the participants.

With only eight participants, the results cannot be concluded to be statistically significant. However, indications of systems engineering performance can be detected.

Appendix C: SUMMARY OF TWRS SYSTEMS ENGINEERING MANAGEMENT PLAN CHANGES

Appendix C: SUMMARY OF TWRS SYSTEMS ENGINEERING MANAGEMENT PLAN CHANGES

FEB 1996 **TWRS SEMP** **WHC-SD-SEMP-002** **REV 0**	**Requirements** **(Products and processes)**	**JAN 1998** **TWRS SEMP** **HNF-SD-SEMP-002** **REV 1**	**Change**
Section 1.0, Introduction	DOE Order 4700.1 and, where applicable and not in conflict, DOE Order 430.1	Section 1.0 Introduction Details in Section 2.3.6.2 Details in Section 3.3.2.10	DOE Order 430.1 and associated good practice guides are used as guidelines to mold robust systems engineering efforts 1) Use Critical Decision (CD) Milestones 2) Use life-cycle phases 3) Nomenclature changes: Level 1 (system) specifications and Level 2 (component specifications)
Section 1.2, Implementation	Applies to each TWRS activity being performed under the TWRS portion of the Maintenance and Operations Contract.	Section 1.2, Scope and Applicability	Applies to the TWRS contractor and the associated Project Hanford Management Contract

FEB 1996 TWRS SEMP WHC-SD-SEMP-002 REV 0	Requirements (Products and processes)	JAN 1998 TWRS SEMP HNF-SD-SEMP-002 REV 1	Change
Section 2.2.1, Major Technical Products	TWRS system-level requirements will be published in a functions and requirements document. Further definition of program level requirements will be published in a TRS, DRD, and PDSs using Military Standard 490A formats	Section 3.2, Systems Engineering Process Application to Tank Waste Remediation System Section 3.2.10 Specification Development	The systems engineering process will establish requirements baseline for major facilities allocated to TWRS for development by Site Systems Engineering. These are recorded in the HSTD and the TWRS MAR. (Architecture-based specifications rather than function in earlier SEMP) Level 1 (system) specifications will be generated for the major facilities Level 2 (component) specifications will be generated based on results of the system assessment and alternative analysis
Section 2.2.2, Independent Technical Reviews	Nine baseline reviews were defined to assess development of the technical baseline and provide data to DOE-HQ and RL for DOE Order 4700.1, *Key Decisions*	Section 2.3.6 Technical Reviews	TWRS Project Reviews as required by the TWRS EIS ROD and Project Reviews to support DOE Order 430.1, *Critical Decisions*.

FEB 1996 TWRS SEMP WHC-SD-SEMP-002 REV 0	Requirements (Products and processes)	JAN 1998 TWRS SEMP HNF-SD-SEMP-002 REV 1	Change
Section 3.2.2, Requirements Analysis	All functional and requirements analysis associated information will be entered into RMACS	SECTION 2.3.5 Technical Requirements Traceability Section 3.2.8, Interface Analysis	F&R will be allocated to major facilities. The results will be input to the HSTD Interface analysis results will be input into the HSTD
4.1.5.1, Management System Integration	Develop system integration plan	Section 2.1, Integrated Baseline Section 2.3.4, Decision Management	Top level TWRS Technical Baseline derived from the MAR and used to develop/validate the Level 0 logic. Decomposition will be used to develop Level 1 logic. TWRS will maintain overall compilation of major TWRS Project decisions indexed for cross reference to the Level 1 logic diagrams

APPENDIX D: MATURITY ASSESSMENT MODEL APPLICATION LESSONS LEARNED

Appendix D: Maturity Assessment Model Application Lessons Learned

1. The primary lesson learned from the application of HNF-IP-0842, Volume IV, Section 2.12, Rev. 1, "Systems Engineering Maturity Assessment Guide for the Tank Waste Remediation System," January 14, 1998, to the Project W-465 assessment was that the staff had difficulty understanding the question terminology and the context of the systems engineering processes referred to in the questions. This was in spite of up-front effort to tailor the wording of the questions and to provide the staff with a glossary and descriptions of the key focus areas. Examples of misunderstandings include the following:

- Many of the participants confused the "Validation" key focus area (tracing requirements to needs) with the DOE "Validation" of a line item project (approval of a project baseline).

- In answering questions in the Subcontract Management key focus area category, many participants focused only on major subcontracts, excluding task plans/orders, operational directives, and other work order processes used within the PHMC and enterprise companies team.

- Many participants interpreted "Data Management" as a new systems engineering process as opposed to control of project data and information (administration of documentation, project files, and identification and interpretation of data requirements).

- Understanding of technical performance measures and how they are used was a major issue for a project that does not require technology development.

- Some participants were perplexed by the "Concept Definition" key focus area (mission analysis for the system) confusing it with the "Conceptual Design Report" (CDR) (design concept for project validation).

2. Questions related to training need to be reorganized. Key focus area 2.2 - "Competency Development" as a whole has questions dealing with training. In addition, each separate key focus area has at least one question related to training for the specific key focus area discipline.

3. TWRS technical staff still tends to think of systems engineering as something they do in addition to sound project management and engineering. The TWRS Systems Engineering and Integration needs to tailor future training initiatives to help show that disciplined systems engineering is the way to do sound project management and engineering.

4. The interview process is an essential part of the assessment process. The questionnaire provides a mechanism to focus the interview questions.

5. Because the INCOSE model was tailored by removing level 4 and 5 questions, the assessment process numerical score is not readily correlatable to organizations outside TWRS. The maturity rating process includes positive answers from each of the maturity levels to establish the rating. By removing higher level questions, those that would have been answered positively were removed from the totals.

6. Developing the assessment questionnaire as a software-based tool for taking and consolidating results provided a valuable tool for cutting and cross-cutting the results to determine the impact of variables.

7. More work needs to be done to clearly understand and portray the definition of "Yes," "No," "Don't Know," and "Not Applicable." For the purposes of a maturity assessment, when is "No" an acceptable answer, when is "Not Applicable" the correct answer, and when is "Don't Know" a correct answer. It should not be expected that every person working on a project will or should know the details of areas for which he/she is responsible. Results indicated that tailoring out key focus areas that are not the responsibility of specific types of participants would result in higher assessed maturity. Because of the limited number of people working on W-465, all participants were asked to address all key focus areas.

8. The assessment tool needs to be expanded to address both maturity and compliance. While this assessment was tailored to do both, the maturity guide focuses on maturity. To get the complete picture both maturity and compliance should be assessed.

9. How high and deep into a project structure should the maturity assessment draw participants needs to be clarified. Should subcontractors, Fluor Daniel Hanford, Inc., and DOE be included?

10. The key focus area of Concept Definition needs to be further defined to clarify its applicability to a project. The accepted definition is that of "mission analysis" which would be done by the program level and included as part of the scope/definition package given to the project at initiation. If that definition continues, is concept definition applicable or should the definition be reassessed to include initial project-level system development and verification?

11. While the key focus areas are identified and discussed separately, in actual practice several key focus areas may be integrally performed. This caused some confusion with assessment participants who perceived the fact that the key focus area was discussed separately to imply an expectation that the discipline was expected to be done separately. Consequently the participant may have answered negatively even though the discipline is being performed.