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Task 11 - Technology Development Integration

Semi-Annual Report

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By
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For

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SYSTEMS ANALYSIS OF ENVIRONMENTAL MANAGEMENT TECHNOLOGIES

1.0 INTRODUCTION/BACKGROUND

A review was conducted of three systems analysis (SA) studies performed by Lockheed Idaho Technologies Company (LITCO) on integrated thermal treatment systems (ITTSs) and integrated nonthermal treatment systems (INTSs) for the remediation of mixed low-level waste (MLLW) stored throughout the U.S. Department of Energy (DOE) weapons complex. The review was performed by an independent team led by the Energy & Environmental Research Center (EERC), including Science Applications International Corporation, the Waste Policy Institute (WPI), and Virginia Tech. The three studies reviewed were as follows:

- Integrated Thermal Treatment System Study, Phase 1 - issued July 1994
- Integrated Thermal Treatment System Study, Phase 2 - issued February 1996
- Integrated Nonthermal Treatment System Study - drafted March 1996

The three studies were commissioned by DOE to be SA studies of environmental management (EM) systems. The purpose of LITCO's engineering evaluation of the MLLW treatment system alternatives was to help DOE in the prioritization of research, development, and demonstration activities for remediation technologies. The review of these three studies was structured to further aid DOE in its current and future decision-making processes. The methodology in the studies was compared to a sound systems engineering (SE) approach to help DOE determine which tasks still need to be accomplished to complete a thorough design/review.

2.0 OBJECTIVES

The goals of the independent review were to provide DOE with the necessary information to determine whether a more detailed analysis of the LITCO studies is warranted, to identify the areas of the studies that would warrant future attention, and to highlight tasks that would complement the LITCO studies to form a thorough SE evaluation.

To achieve the above goals, the following objectives were identified: 1) determine whether the assumptions of the reports were adequate to produce an unbiased review of thermal and nonthermal systems, 2) identify areas of the study that could be expanded/enhanced to produce a better decision-making product, and 3) provide a template to guide future SE studies.

The specific issues included within this review were as follows:

- Review facility designs and engineering and operating assumptions
- Review cost estimation methods, bases, and assumptions
- Evaluate the uncertainty of assumptions

- Review submodels for both baseline and alternative technologies to assess the sensitivity of planning life-cycle costs (PLCCs) to the assumptions
- Determine which assumptions were critical in determining PLCCs for a given technology and which were critical to the relative technology rankings
- Review the systems engineering/systems analysis approach for potential improvements

3.0 WORK PERFORMED/ACCOMPLISHED

The product of the LITCO studies review was a report entitled "Review of the Integrated Thermal and Nonthermal Treatment System Studies." The report covered two primary topics: 1) a description of a technical approach to SE and 2) a review of the LITCO studies.

3.1 Systems Engineering Approach

In order to facilitate the application of the SE process to future studies and to facilitate examination of the three LITCO studies relative to the SE process, a generic SE template was developed. The elements of the template are illustrated in Figure 1. A description of the respective blocks and the questions addressed by each block can be found in the study review report.[1]

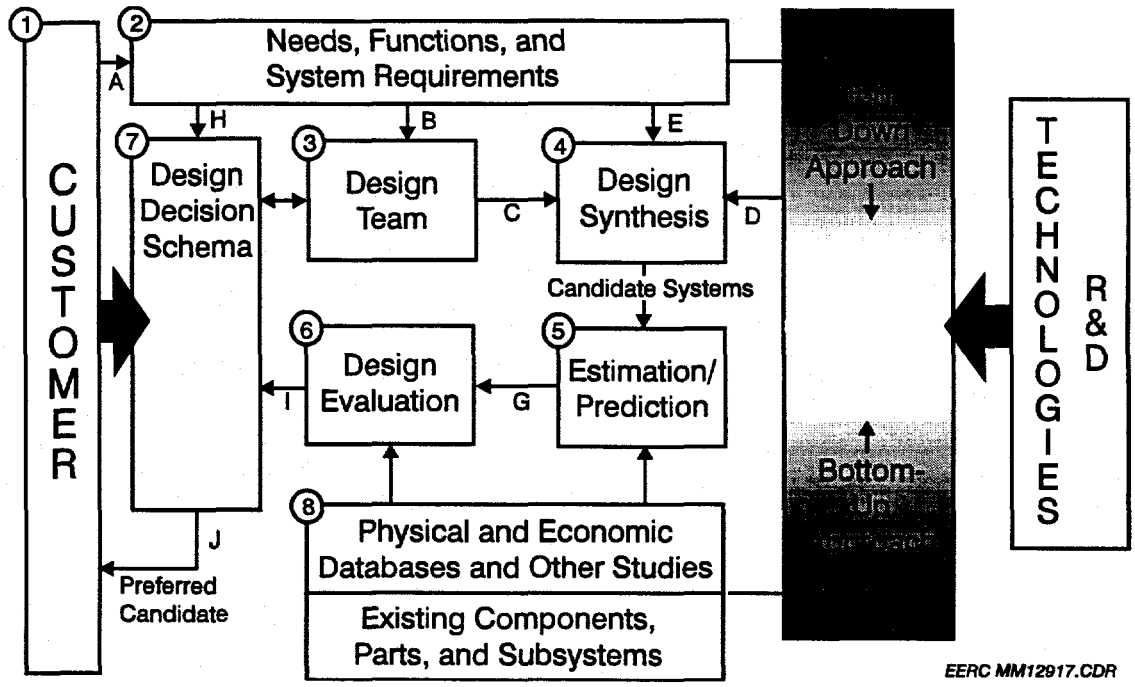

Figure 1. Systems engineering template displaying the eight elements for evaluating a technical approach.

3.2 Study Review

The study review discussed the approach used by LITCO relative to an ideal SE approach, the validity of the assumptions made, the sensitivities of the economics to those assumptions, and the quantification of qualitative performance measures. Major findings of the study review are presented below.

The ITTS and INTS studies used a systems setting to allow the upstream and downstream consequences of the use of different technologies (subsystems) to be judged. In addition, total life-cycle cost was used so that technologies at different stages of development could be compared fairly. However, comparison of the LITCO studies to the generic SE template indicated deficiencies in several areas.[1] The review of the three studies is shown in Table 1. It was recognized that the lack of a complete SE analysis by LITCO in the three studies was a policy decision by DOE. A full SE review is still needed in order to finally make a decision as to which systems look the most promising and therefore which system technologies warrant further development. The EERC recommended that the SE steps that were not done as part of the three studies need to be completed.

A major shortcoming of the LITCO studies was the lack of any recommendations about technology selection. Owing to the design assumptions and the overwhelming operating costs, the studies produced costs that are essentially equivalent for all the ITTS technical options. The EERC demonstrated that the evaluation of noneconomic performance criteria—cost sensitivity, cost uncertainty, regulatory compliance, implementability, flexibility to handle variable waste, operability, maintainability, availability, and decontamination and decommissioning—using expert judgment and Kepner-Tregoe (KT) methods could provide the missing differentiation among technologies. An *example* of such an analysis, using the KT approach, for the ITTS Phase 2 systems was carried out. The example showed that a weighted average performance plotted versus cost will *likely* show clear difference between the technologies. A thorough application of this method was recommended for the analysis of all developmental technologies to assist in decisions about the viability of technology options. While the ITTS Phase 1 study initiated the application of such an approach, it was not carried out as part of the study by LITCO for the reason already cited. The EERC recommends that such analysis needs to be performed by some impartial organization/team in order to provide more focused input to the decision-making process.

In review of the LITCO studies, the EERC identified over 1200 assumptions, and among these assumptions a few critical ones had major impacts on overall life-cycle costs. These major assumptions were subjected to sensitivity analysis to determine their impacts on the overall plant costs defined in the studies. Significant design conservatism was inherent in the studies. For example, all systems were designed for Category 1 seismic region construction, adding 11% to 16% to overall plant life-cycle costs. Facility operation was assumed to be only about half time, adding about 20% to life-cycle cost. Conversely, many developmental systems were assumed to be able to perform; the penalty associated with system failure could add 5% to 10% to life-cycle cost. The summary of the impacts of major assumptions (with $>10\%$ impact on planning life-cycle costs [PLCC]) is shown in Table 2.

TABLE 1

Review of the Approach Used in the ITTS and INTS Reports
Using the Systems Engineering Template

	ITTS Phase 1	ITTS Phase 2	INTS
The Customer (Block 1)	Customer not adequately described. Customer inadequately considered in synthesis, analysis, and evaluation. Special interests (excluding federal regulatory) incidentally mentioned; not directly represented in voice of customer; not part of evaluation process.	Special interests broader in definition but still not represented as customer or included in evaluation process.	Study much more responsive to special interests (i.e., Tribal and Stakeholder Working Group [TSWG]). Tribal and public participation in each stage of technology assessment was the goal. Final report designed to be more understandable to nontechnical readers.
Need, Functions, and System Requirements (Block 2)	Studies lack adequate requirements and need analyses. Partial functional analysis attempted for selection and definition of subsystems. No evidence of functional analysis and subsequent allocation of system requirements.		
Design Team (Block 3)	No details provided for areas of expertise, areas of responsibility, criteria for addition to team. Panel of engineers for system down-selecting not described.	DOE internal review panel reviewed draft report, but contributions not discussed. Larger study team than before.	Many members of study team have changed. TSWG could indirectly be considered part of the design team.
Design Synthesis (Block 4)	Adequate description of alternative systems, but inadequate traceability to system requirements. Heavy reliance on bottom-up approach for system synthesis. Little documentation for selection of most technologies. Documentation provided for down-selecting from 12 to 10 systems.	No documentation provided for down-selecting systems.	TSWG developed list of nontechnical criteria to assist TSWG in technology down-selecting. Evidence for incorporating nontechnical criteria into down-selecting not adequate.
Estimation and Prediction (Block 5)	Lacks performance acceptability criteria and target values. Lacks set of metrics to measure merit of systems. Lacks consideration for customer (special interest) input into acceptability measures. All systems presumed to meet performance requirements.		
Design Evaluation (Block 6)	PLCC estimates calculated using the sound engineering approach (except no consideration of time value of money, which could impact relative costs of the systems). Sensitivity analysis with respect to design and operating assumptions is lacking.		
Design Decision Schema (Block 7)	Study results do not facilitate decision making. No attempt to organize and present technical decision criteria. Systems qualitatively evaluated with respect to technology risk. A quantitative figure-of-merit system comparison started but not finished.	Systems qualitatively evaluated with respect to technology risk but using different criteria from Phase 1. No attempt at quantitative system comparison.	An attempt was made to present technical decision criteria in an organized (tabular) manner. No attempt at quantitative system comparison.
Physical and Economic Databases and Other Studies (Block 8)	No discussion on regulation changes and impact on the systems. The apparently large technology database was not adequately referenced.		Considerably more referencing of technology database.

TABLE 2

Sensitivity Analyses of Critical Assumptions for Selected Systems

Assumption	Change in Assumption	Percent Change in PLCC
ITTS Baseline		
Seismic Category 1	Seismic Category 2	-15.8
50% Waste Sorted	75% waste sorted	+12.3
4032-hr/yr Operation	8064-hr/yr operation	-19.3
Minimum Shielding	More extensive shielding	+11.3
GOCO* Operation	Private operation	-17.5
INTS		
Seismic Category 1	Seismic Category 2	-11.7
75% Waste Sorted	50% waste sorted	-13.0
4032-hr/yr Operation	8064-hr/yr operation	-17.0
Unit Disposal Cost $243/ft^3	Assume $243 $\pm$ $100/ft^3	$\pm$10.2
Minimum Shielding	More extensive shielding	+12.5
GOCO* Operation	Private operation	-15.9

* Government-owned–contractor-operated.

The conclusions of this analysis are as follows:

- Future such studies should adopt a consistent SE approach similar to the template defined in this report.

- Noneconomic factors must be considered in a quantitative manner to gain full value from the analysis of system alternatives, especially those involving developing technologies that are being considered in competition for scarce funding. An approach like that outlined by example in this report should be required for all such systems analysis studies.

- A (relatively small) number of assumptions were found that have major impacts on the PLCC. These assumptions should be reviewed by the whole design team and/or an independent peer-review panel to ensure that they are the most reasonable assumptions at this point in time.

- Some design assumptions were very narrowly defined to allow for the initial analysis. These assumptions need to be reevaluated to ensure that final analyses are applicable to the real world.

4.0 FUTURE WORK

The EERC will continue in its systems analysis capacity to provide support to the EERC–METC Environmental Management Cooperative Agreement tasks. The EERC Systems Analysis Group is assisting in the development of subtask orders to be performed as a subcontractor to WPI.

5.0 REFERENCES

1. Durrani, H.A.; Erickson, T.A.; Erjavec, J.; Fabrycky, W.J.; Musich, M.A.; Schmidt, L.J.; Sondreal, E.A.; Steadman, E.N.; Wilson, J.S. "Review of the Integrated Thermal and Nonthermal Treatment System Studies," final report for U.S. DOE DE-FC21-94MC31388; EERC Publication 96-EERC-10-01, Oct. 1996.

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FORM EIA-459E
(10/80)

U.S. DEPARTMENT OF ENERGY
FEDERAL ASSISTANCE MANAGEMENT SUMMARY REPORT

FORM APPROVED
OMB NO. 1900 0127

1. Program/Project Identification No.	2. Program/Project Title	3. Reporting Period
DE-FC21-94MC31388	Task 11 - Systems Analysis of Environmental Management Technologies	7/1/96 through 9/30/96

4. Name and Address
Energy & Environmental Research Center
University of North Dakota
PO Box 9018, Grand Forks, ND 58202-9018 (701) 777-5000

5. Program Start Date 9/30/94

6. Completion Date 9/29/99

7. FY 96

8. Months or Quarters Quarters

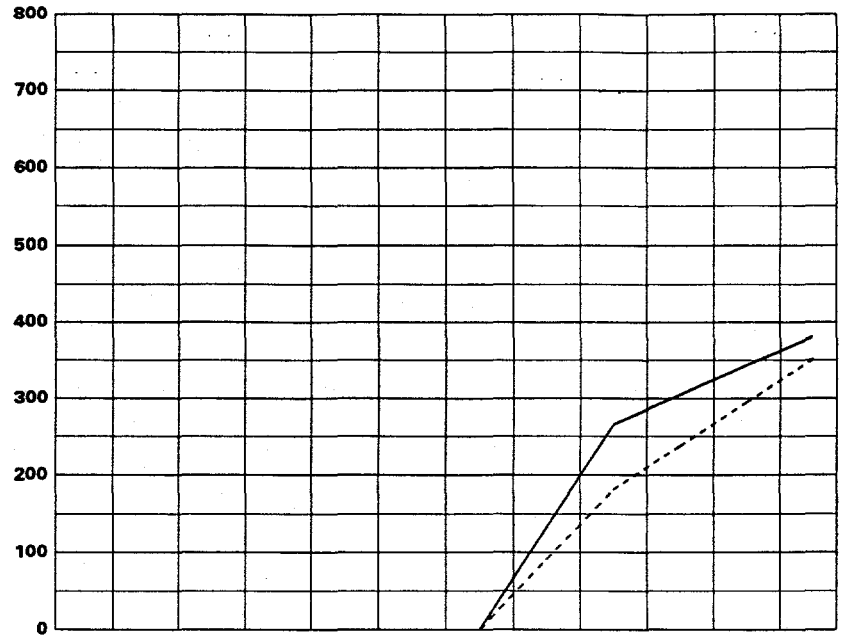
9. Cost Status a. Dollars Expressed In Thousands

10. Cost Chart

Fund Source		Quarter 1st	Quarter 2nd	Quarter 3rd	Quarter 4th	Cum. to Date	Tot. Plan
DOE	P			182	170	352	641
	A			269	113	382	
	P						
	A						
	P						
	A						
	P						
	A						
Total P		0	0	182	170	352	641
Total A		0	0	269	113	382	
Variance		0	0	(87)	57	(30)	

P = Planned A = Actual

b. Dollar Scale



	1st			2nd			3rd			4th		
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

c. Cumulative Accrued Costs

Planned			0			0			182			352
Actual			0			0			269			382
Variance			0			0			(87)			(30)

Total Planned Costs for Program/Project $645

11. Major Milestone Status	Units Planned / Units Complete	
11.1 Systems identification	P / C	
11.2 Systems Evaluation	P / C	
11.3 Reporting	P / C	
11.4 Continuation of Task According to METC Orders	P / C	
	P / C	
	P / C	
	P / C	
	P / C	
	P / C	

12. Remarks

13. Signature of Recipient and Date Mark R. Musich 10/30/96

14. Signature of DOE Reviewing Representative and Date

FORM EIA-459E
(10/80)

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9/30/94

6. Completion Date
9/29/99

7. FY 96/97

8. Months or Quarters Quarters

9. Cost Status

a. Dollars Expressed In Thousands

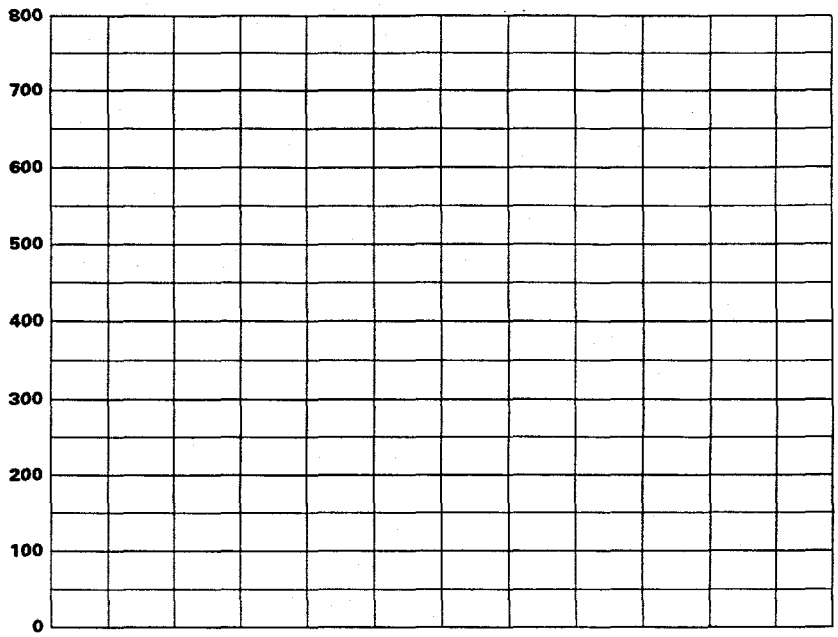
10. Cost Chart

Fund Source		Quarter 1st	2nd	3rd	4th	Cum. to Date	Tot. Plan
DOE	P						
	A						
	P						
	A						
	P						
	A						
	P						
	A						
Total P		0	0	0	0	0	
Total A		0	0	0		0	
Variance		0	0	0		0	

P = Planned A = Actual

Total Planned Costs for Program/Project
$645

b. Dollar Scale



	1st OCT	NOV	DEC	2nd JAN	FEB	MAR	3rd APR	MAY	JUN	4th JUL	AUG	SEP
c. Cumulative Accrued Costs												
Planned												
Actual												
Variance												

11. Major Milestone Status	Units Planned / Units Complete	
	P / C	
	P / C	
	P / C	
	P / C	
	P / C	
	P / C	
	P / C	
	P / C	

12. Remarks

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5. Program Start Date 9/30/94

6. Completion Date 9/29/99

Milestone ID. No.	Description	Planned Completion Date	Actual Completion Date	Comments
Year 1				
11.1	Systems Identification	4/96	6/96	
11.2	Systems Evaluation	6/96	7/96	
11.3	Reporting	7/96	7/96	
11.4	Continuation of Task According to METC Orders	12/96		
	Definition of work statement not completed until May 24, 1996.			