RACER

ACCREDITATION

RECOMMENDATION

PRICEWATERHOUSECOOPERS

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

JUL 11 2001

MEMORANDUM FOR SEE DISTRIBUTION

FROM: HQ AFCESA/CD
139 Barnes Drive Suite 1
Tyndall AFB FL 32403-5319

SUBJECT: Accreditation of the Remedial Action Cost Engineering Requirements (RACER) System in Accordance with DoD Instruction 5000.61, DoD Modeling and Simulation Verification, Validation, and Accreditation (VV&A)

1. In accordance with the requirements outlined in the referenced DoD Instruction, HQ AFCESA has completed the process for VV&A of the RACER system. This process was initiated by HQ AFCESA in Jan 2001 and completed in Jun 2001.

a. This accreditation addresses the RACER system, models, and their interfaces. It does not address user qualifications and activities, except to say an individual who has been trained on the use of the system and given good information about a site can use the software to fulfill the above user objective.

b. The accreditation was conducted on the RACER 2001, Version 3.0.0 System, and remains in effect for subsequent system releases that are certified by the RACER Government Technical Review Group, as complying with the established system validation and verification process.

c. Further information regarding the VV&A process, the system purpose and intended uses, and the general accreditation recommendation is included in the "RACER Accreditation Recommendation" report prepared by Pricewaterhouse Coopers, LLP. This report will be made available from the HQ AFCESA website, http://www.afcesa.af.mil/Directorate/CES/Civil/CostEngr/dtgltr.html.

2. HQ AFCESA/CESC and HQ USACE/ITTRW CX served jointly as the Validation and Verification Agent. Pricewaterhouse Coopers, LLP, was contracted to serve as the independent Accreditation Agent, and HQ AFCESA is the Accreditation Authority. I have accepted the accreditation recommendation presented by the VV&A Team, and concur that RACER is fully accredited for the following intended use:

"To provide an automated, consistent, and repeatable method to estimate and document the program cost for the environmental cleanup of contaminated sites and to provide a reasonable cost estimate for program funding purposes consistent with the information available at the time of the estimate preparation."

3. Technical questions may be directed to the RACER POC, Mr. Stuart Millard, HQ AFCESA/CESC, DSN 523-6171, (850) 283-6171, or e-mail, stuart.millard@tyndall.af.mil.

JAMES R. EINWAECHTER, P.E.
Executive Director

cc:
HQ USACE-CECW-EI
HQ USACE-HTRW CX
HQ AEC
HQ NFESC
HQ NAVFAC
DUSD-ES
DOE-NETL
DOE-EM
DOI-OEPC
HQ USEPA/OSWER
HQ USEPA/OUST

DISTRIBUTION:
HQ AFMC/CE
HQ AFSPC/CE
HQ AETC/CE
HQ AMC/CE
HQ PACAF/CE
HQ ACC/CE
HQ USAFE/CE
HQ AFSOC/CE
ANG/CE
HQ AFRC/CE
HQ USAFA/CE
11CES/CE
HQ USAF/ILEVR
HQ USAF/ILEVQ
AFAA
HQ AFCEE
HQ AFBCA

Table of Contents

A. EXECUTIVE SUMMARY 1

1.0. Recommendation 1

2.0. Need for Accreditation 1

3.0. Accreditation Process 2

3.1. Accreditation Plan 2

3.2. Accreditation Report 2

3.3. V&V Report 2

4.0. Summary 2

B. ACCREDITATION PLAN 3

1.0. Executive Summary 3

2.0. Background 3

2.1. Need for Accreditation 3

2.2. User Requirements 4

2.3. *Racer* Overview 5

2.4. Accreditation Status of RACER 12

3.0. Accreditation Project Management 14

3.1. RACER Accreditation Scope 14

3.2. Points of Contact 16

3.3. Project Risk Management 17

4.0. Project Responsibility And Milestones 18

4.1. Responsibility Matrix 18

4.2. Recommended Responsibilities 19

4.3. Description of Milestones 19

4.4. Proposed Timeline 20

5.0. Performance 21

5.1. Development of Acceptance Criteria 21

5.2. Review Conceptual Model Validation Report(s) 24

5.3. Review Functional and System Verification Report(s) 24

5.4. Review *RACER* Results Validation Report(s) 26
5.5. Generate Accreditation Report 26
C. ACCREDITATION REPORT 27
1.0. Executive Summary 27
2.0. RACER Accreditation Scope 27
2.1. Risk assessment 27
2.2. Accreditation Scope 28
3.0. V&V Report Summary 29
4.0. Accreditation Conclusions And Recommentations 30
4.1. Conclusions 30
4.2. Recommendations 30
D. V&V REPORT 32
1.0. Executive Summary 32
2.0. Performance 32
2.1. Conceptual Model Validation 32
2.2. Functional and System Verification 32
2.3. Results Validation 33
3.0. Results 33
3.1. Conceptual Model Validation 33
3.2. Functional Design Verification 36
3.3. System Design Verification 36
3.4. Statistical Analysis 44
4.0. Conclusions And Recommendations 46
4.1. Conclusions 46
4.2. Recommendations 46

APPENDICES:

APPENDIX A: Accreditation Support Documentation 47

APPENDIX B: Definitions and Abbreviations 49

APPENDIX C: Risk Assessment Guidelines 50

APPENDIX D: System Documentation Checklist Description 52

APPENDIX E: Statistical Analysis 57

APPENDIX F: References 62

FIGURES:

FIGURE 1: RACER can generate a detailed cost estimate using minimal required 7

FIGURE 2: By modifying secondary parameter information, the user can increase the accuracy of the estimate 8

FIGURE 3: To obtain the most accurate estimate reflecting specific project conditions, the user may change the quantity and unit cost data for each assembly. 9

Acronyms

ACC – Air Combat Command

AETC – Air Education and Training Command

AFCEE – Air Force Center for Environmental Excellence

AFCESA – Air Force Civil Engineering Support Agency

AFI – Air Force Instruction

AFSPC – Air Force Space Command

CM – Configuration Management

CRB – Change Review Board

CTC – Cost to Complete

DERP – Defense Environmental Restoration Program

DoD – Department of Defense

DOE – Department of Energy

DOI – Department of Interior

DUSD(ES) - Deputy Under Secretary of Defense for Environmental Security

ECHOS - Environmental Cost Handling Options and Solutions

EPA – Environmental Protection Agency

FUDS - Formerly Used Defense Site

HQ - Headquarters

IG – Inspector General

ILEV – Installation and Logistics Environmental Division

ILEVR – Installation and Logistics Environmental Restoration Division

IRP – Installation Restoration Program

JASA – Joint Accreditation Support Activity

M&S – Modeling and Simulation

MAJCOMs – Major Commands

MIL-STD – Military Standard

O&M – Operation and Maintenance

PA/SI – Preliminary Inspection/Site Inspection

PACAF – Pacific Air Force

PM – Project Manager

PVC - Polyvinyl Chloride

PwC - PricewaterhouseCoopers LLP

RACER – Remedial Action Cost Engineering and Requirements

RFI/CMS - RCRA Facility Investigation (RFI)/Corrective Measure Study (CMS),

RI/FS – Remedial Investigation/Feasibility Study

RPG – Recommended Practice Guide
SME – Subject Matter Expert
USACE – United States Army Corps of Engineers
USAF – United States Air Force
V&V – Verification and Validation
VV&A – Verification, Validation and Accreditation
WBS – Work Breakdown Structure

A. EXECUTIVE SUMMARY

1.0. Recommendation

As the Accreditation Agent, PricewaterhouseCoopers LLP (PwC) recommends that the Remedial Action Cost Engineering and Requirements (*RACER*) system be fully accredited for the following intended use:

To provide an automated, consistent and repeatable method to estimate and document the program cost for the environmental cleanup of contaminated sites and to provide a reasonable cost estimate for program funding purposes consistent with the information available at the time of the estimate preparation.

This accreditation is only addressing the *RACER* models and their interface with the system. *RACER* does not address user activities while using the models except to say that an individual that has been trained on the use of the system and given good information about a site, can use the software to fulfil the above user objective. This Accreditation is for the general use of the models as they were primarily intended to be used. The following items elaborate on this general use:

- *RACER* does not estimate emerging technologies consistently and repeatably due to the lack of background information regarding the technologies.
- *RACER* models are designed for a standard generic engineering solution. They are not designed for projects that deviate substantially from normal engineering practices.
- *RACER* is not resource loaded and was not designed for use as a scheduling tool.
- *RACER* does not distinguish between different seasons (weather) and their impact on the engineering solution.
- *RACER* is completely reliant on user input. As such, the reasonableness of the estimate is determined in large part by level of site knowledge input into *RACER* by the user.
- *RACER* was designed to be flexible enough to allow users to input their own information and circumvent the models.
- *RACER* is subject to both general commercial software limits and general parametric cost estimating limitations (i.e., *RACER* performs top-down estimating and not bottom-up estimating).
- Every model has its own unique assumptions and limits that are detailed in the *RACER* on-line help file

The rest of this document describes in more detail the steps taken to come to this recommendation.

2.0. Need for Accreditation

There are four primary reasons for getting RACER Accredited. The first three reasons listed deal with meeting regulatory requirements. The final reason listed deals with increasing confidence in decision making.

- The Air Force Audit Agency found that RACER did not conform to Department of Defense (DoD) Instruction 5000.61 – DoD Modeling and Simulation Verification, Validation, and Accreditation".

- DoD Instruction 5000.61 requires that models and simulations (M&S) used to support the major DoD decision making organizations and processes… (DoD Planning, Programming, and Budgeting System) shall be accredited for that use…
- Air Force Instruction (AFI) 16-1001 requires accreditation.
- Increases credibility in the M&S outputs and reduces the risk of using the M&S. Overall this increases the confidence level of decisions made based on the outputs.

3.0. Accreditation Process

Accreditation is the official certification that a model or simulation is fit for its intended purpose. A rigorous review of the system was undertaken to make this accreditation recommendation. This process involved reviewing the relevant published government guidance on VV&A and working with the government and contractor personnel that produced the guidance to attain the best understanding of the accreditation process possible. Once all of the accreditation participants had a firm understanding of the process, the accreditation process began. The accreditation was planned and executed from start to finish, with the government participants and end user requirements in mind. The following sections of this document describe the process and results in greater detail.

3.1. Accreditation Plan

The Accreditation Plan outlines the plan for performing the accreditation. The plan provides an overview of *RACER*, the accreditation project management guidelines, the project responsibilities and milestones, and the performance measurements for the accreditation.

3.2. Accreditation Report

The Accreditation Report describes the *RACER* risk assessment, the scope actually undertaken, a summary of the V&V Report and conclusions and recommendations for the future.

3.3. V&V Report

The V&V Report describes the activities of each of the elements that was reviewed in support of the accreditation. This includes the specific approach that was taken and the results of the review.

4.0. Summary

This Accreditation Recommendation document provides a detailed analysis for how the accreditation recommendation was reached. It starts with project planning activities, includes the summary of the overall accreditation effort and ends with the results of the V&V activities.

B. ACCREDITATION PLAN

1.0. Executive Summary

The Accreditation Plan is the starting point for the accreditation process. The plan broadly outlines the project activities that will be undertaken to accredit *RACER* for the user's intended purpose. This plan is divided into several sections: background, accreditation project management guidelines, project responsibilities and milestones and performance measurements for the accreditation.

The Background section is further subdivided into the need for accreditation, user requirements, an overview of *RACER* and the current *RACER* accreditation status. The user requirements identify the needs the user has for the system. The overview provides a brief description on how the system works and its components. The accreditation status describes the VV&A history of *RACER*.

The Accreditation Project Management section is further subdivided into Accreditation Scope, Points of Contact, and Project Risk Management. The accreditation scope describes the steps that are currently planned to be taken to accredit *RACER*. The Points of Contact section is a list of the key personnel involved in the accreditation process with a description of their roles. The Project Risk Management section describes the project risk management strategy, including how risks will be identified, tracked, analyzed, reported, and mitigated during the course of the project.

The Project Responsibility Matrix and Milestones section is further subdivided into responsibilities, milestones and timeline. The responsibilities for the Accreditation Project are assigned and described in the Responsibilities section. The Milestone section describes the major milestones that will be accomplished during this accreditation project. The timeline is a brief description of the proposed dates for focused reviews.

The Performance section is further subdivided into different performance measurement activities.

2.0. Background

2.1. Need for Accreditation

On 02 November 99, a memorandum was released by Colonel Brian L Miller, Chief Environmental Division, USAF/ILEV, regarding "Supplemental Management Guidance for the Defense Environmental Restoration Program". The memorandum directed that the referenced guidance be immediately implemented. The guidance was developed by DUSD(ES) to correct certain deficiencies identified in the DoD IG Report 92-209, titled "*Data Supporting the DoD Environmental Line Item Liability on the FY 1998 Financial Statements."*

The guidance was issued to respond to IG Report findings that data supporting CTC estimates in the DERP were not accurate, complete, or supportable. The report cited that, "the Audit Agencies of the Military Departments could not attest to the accuracy and completeness of cost-to-complete estimates for

cleanup; that estimate trails were inadequate and oversight was inconsistent at many installations; and that engineers who prepared the estimates were not required to keep any documentation or supporting rationale due to lack of any local guidance."

Paragraph 2 of the Supplemental Guidance states that:

"The DoD Components often use computerized models to complete DERP CTC estimates. To ensure a standard among all Components, the DERP CTC computer models presently in use require verification, validation, and accreditation at the DoD level. Each Component is responsible to ensure their computer models conform to DoD Instruction 5000.61 – DoD Modeling and Simulation Verification, Validation, and Accreditation".

Thus, it was concluded that, since the *RACER* system is used to develop DERP CTC estimates and annual budgets, it must undergo the cited verification, validation, and accreditation process (commonly referred to as "VV&A").

RACER is a cost estimating system developed by HQ AFCESA for the purpose of estimating environmental remediation costs for the annual budgeting process. The system was initially released for government use in 1992 and has had seven subsequent releases since that time (the most recent named *RACER 2001*, released in March 2001). The Air Force and Army currently use the system for developing major parts of their out year estimates and annual Cost to Complete (CTC) budgets. Other DoD and Federal agencies also use the system to prepare individual project cost estimates and to evaluate cost reasonableness of estimates. Each version of the system has incorporated relevant guidance and policies of the Air Force and DoD Defense Environmental Restoration Program (DERP).

By Accrediting RACER the following objectives are achieved: compliance with audit agency direction, compliance with DoD 5000.61, compliance with Air Force Instruction 16.1001, and increased confidence in the RACER outouts.

2.2. User Requirements

Once a need for a model use is identified, the user must specify the requirements for that use. The user's model requirements should be clearly specified and formally documented. These requirements are the initial step in beginning any Model and Simulation (M&S) Verification, Validation and Accreditation (VV&A) process. Programs are most successful when they endeavor to provide as much specific detail in these requirements early on. But the requirements development process is usually an iterative one and will evolve over the course of the VV&A process, as well as over the course of the M&S using program.

When an M&S is to be reused for a purpose different from what is was accredited, it needs to be accredited for that new purpose. Or, when an M&S has sufficiently changed over time, the M&S should be accredited again to look at how those changes affect its use for the original purpose. Therefore, when capturing the user requirements, the program should consider all uses over the lifecycle of the program in order to minimize the overall VV&A effort.

The following user requirement was identified1 by AFCESA and finalized by the accreditation participants for *RACER*:

1 Please see the signed letter from Mr. James Einwaechter

An automated, consistent and repeatable method to estimate and document the program cost for the environmental cleanup of contaminated sites. This method should provide a reasonable cost estimate for program funding purposes consistent with the information available at the time of the estimate preparation.

The following definitions apply to the above statement and identify the acceptability criteria:

Automated – acting or operating in a manner essentially independent of external influence or control; "a structured methodology for obtaining input parameters that will feed cost estimating algorithms and models"

Consistent *– reliable, steady; "a standardized approach that allows for a basis of comparison"*

Repeatable *– able to do, experience or produce again; "can be followed and recreated"*

Document – to support (an assertion or claim, for example) with evidence or decisive information; "provide an audit trail with detailed backup and output that documents all of the assumptions used by the estimator"

Audit trail *– documentation that allows an examination of the method that was used to create an estimate*

Detailed backup and output *– "Ability to reconstruct from scratch the same document from the original assumptions and change flags that indicate when the user has manually overridden a component of the model"*

Assumptions – something taken for granted or accepted as true without proof; a supposition

Estimator *– from novice users to Subject Matter Experts (SMEs).*

Contaminated sites – a site at which substances occur at concentrations: (a) above background levels and pose or are likely to pose an immediate or long term hazard to human health or the environment; or (b) which exceed levels specified in the policies and/or regulations.

Method – A means or manner of procedure, especially a regular and systematic way of accomplishing something

Reasonable cost estimate *– cost information based on current industry standards: engineering solutions based on data from government and industry, construction management agencies, technology vendors and contractors as well as historical project information*

Program funding purposes *– a formal request for budget allocation*

Information available at the time – this includes site details and current practices: policies, costs, etc.

2.3. *Racer* Overview

This section identifies and briefly describes the key elements of *RACER* as it relates to the above-described intended use. This section is comprised of the version of *RACER* that is being accredited, a description of *RACER*, an example of how *RACER* operates, user system requirements and a description of the components that make up *RACER*

2.3.1. Version Being Accredited

RACER 2001, Version 3.0.0.

2.3.2. Description of RACER

The Remedial Action Cost Engineering and Requirements (*RACER*) system is a parametric, integrated cost estimating software specifically developed for estimating costs associated with environmental remediation projects. The system provides the detail of a definitive estimate, but can also be used at the early order-of-magnitude stage of cost estimating. *RACER* cost-models are based on generic engineering solutions for environmental projects, technologies, and processes. There are currently over 100 cost models in the system. These engineering solutions are based on data from government and industry, construction management agencies, technology vendors, and contractors, as well as historical project information. The system can be used to estimate costs for Studies, (PA/SI, RI/FS and RFI/CMS), Remedial Design, Remedial Action, Long Term Monitoring, Site Closeout, and Site Work and Utilities.

RACER uses a patented estimating methodology to generate parametric cost estimates that are based on generic engineering solutions for environmental projects, technologies, and processes. This methodology uses generic engineering solutions and corresponding equations that are applied based on certain parameters that reflect unique project conditions and quantities. Entering site-specific information allows the user to customize the generic engineering solutions based on specific site conditions. Each engineering solution then generates equations that calculate quantities of appropriate labor, equipment, and materials necessary to perform the work. Once the quantities are calculated, the system uses this information to calculate associated costs.

The *RACER* system is comprised of individual technologies that fall into four primary categories: Studies, Remedial Design, Remedial Action, and Site Work/Utilities. The user prepares the overall cost estimate by entering information for each selected technology, which the system translates into costs.

- *RACER* is a cost estimating system that develops single point cost estimates. Although these single point estimates can be created for different fiscal years, there is no logic control that executes models in an order, providing timing or coordination between them. Therefore, *RACER* is considered a "model", but not a "simulation" in VV&A definition. This is a significant point because there are some verification and validation techniques that are applicable to simulations but not to models.

- Because *RACER* has a long history of prior use and endorsement, it is considered a "legacy" model. This recognizes that *RACER* was developed before the advent and widespread implementation of detailed VV&A standards and practices. While the system has always conformed to basic software design standards and practices appropriate to the development time period (including software verification and validation), it did not historically undergo the formal steps and documentation of M&S VV&A that is in use today. Therefore, the *Recommended Practices Guide* recommends a separate (and more streamlined) procedure for VV&A of legacy models and simulations than for new development efforts of models and simulations.

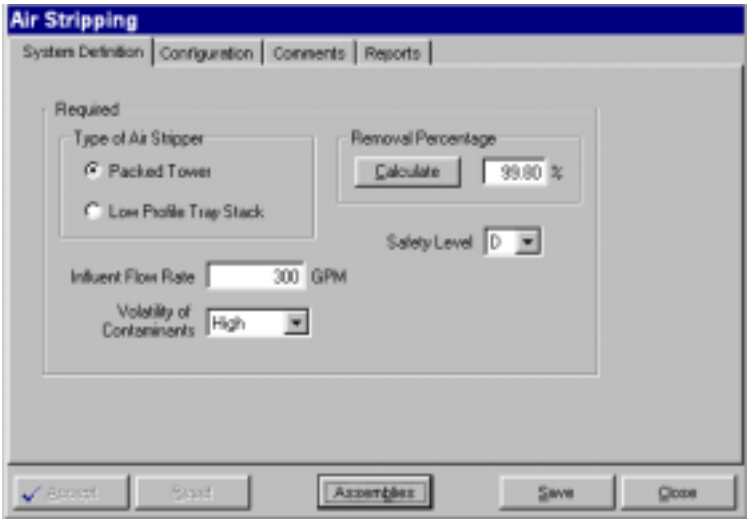
- *RACER* does not require any type of user security clearance (in fact, the system is widely used by environmental practitioners in the commercial sector). Therefore, published VV&A practices applicable to security clearance and/or access are not applicable in this case.

2.3.3. Example of How *RACER* Works

For each technology, the parametric estimating methodology works as follows:

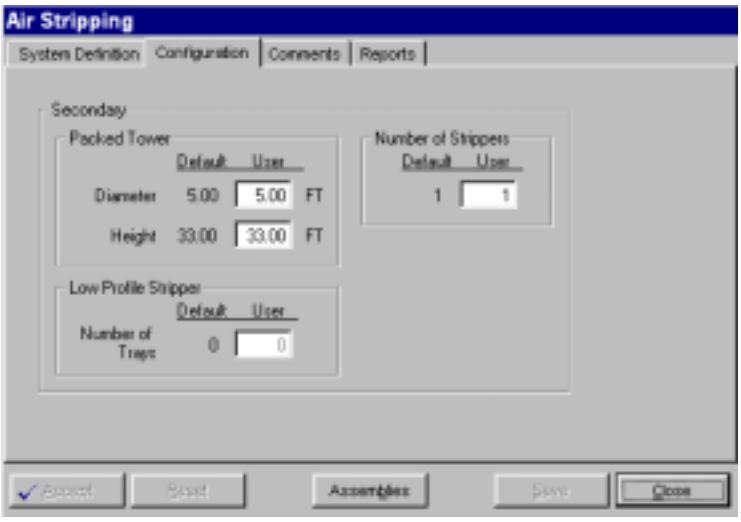
1. The cost technology has certain parameters, called "required" parameters, that must be quantified in order to generate an estimate. An average of four required parameters must be entered for each technology. An example technology is air stripping, with an associated required parameter of total flow rate for the air stripper. An example required parameter screen for the air stripping technology is shown in Figure 1.

Figure 1: RACER can generate a detailed cost estimate using minimal required



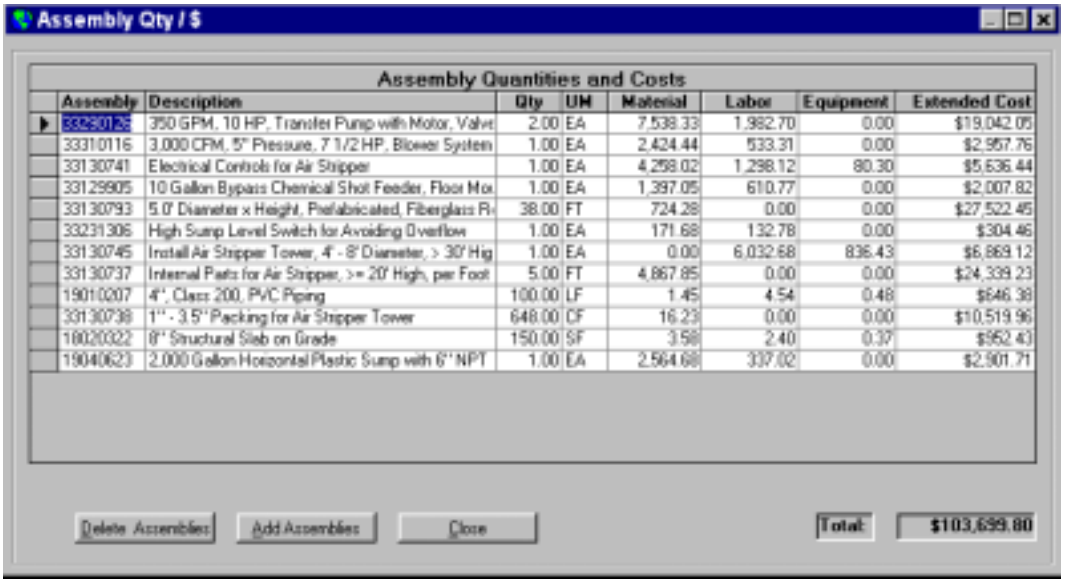
2. Once the required parameters are entered, engineering equations are applied within the system, which automatically calculates default "secondary" parameters. These parameters reflect additional items that specify secondary engineering and construction components of the technology. The user can accept the defaults or modify the defaults for a more precise estimate. An example of a secondary parameter is the diameter of an air stripper. An example secondary parameter screen for the air stripping technology is shown in Figure 2. The secondary parameters in this figure were generated by the system based on the required parameter inputs shown in Figure 1.

Figure 2: By modifying secondary parameter information, the user can increase the accuracy of the estimate



3. Once the secondary parameters have been defaulted (or subsequently modified by the user), the system uses algorithms to specify quantities of individual construction and operations components, called assemblies, that comprise the technology. Each assembly has a unique material, labor, and equipment cost which comes from the underlying system database. The user can accept these assemblies or modify each assembly's quantity or cost components. In addition, the user can delete the default assemblies or add additional assemblies. An example of an assembly relevant to the air stripper example is: 4", Class 200, PVC Piping, with a quantity of 100 linear feet. An example assembly detail screen for the air stripping technology is shown in Figure 3.

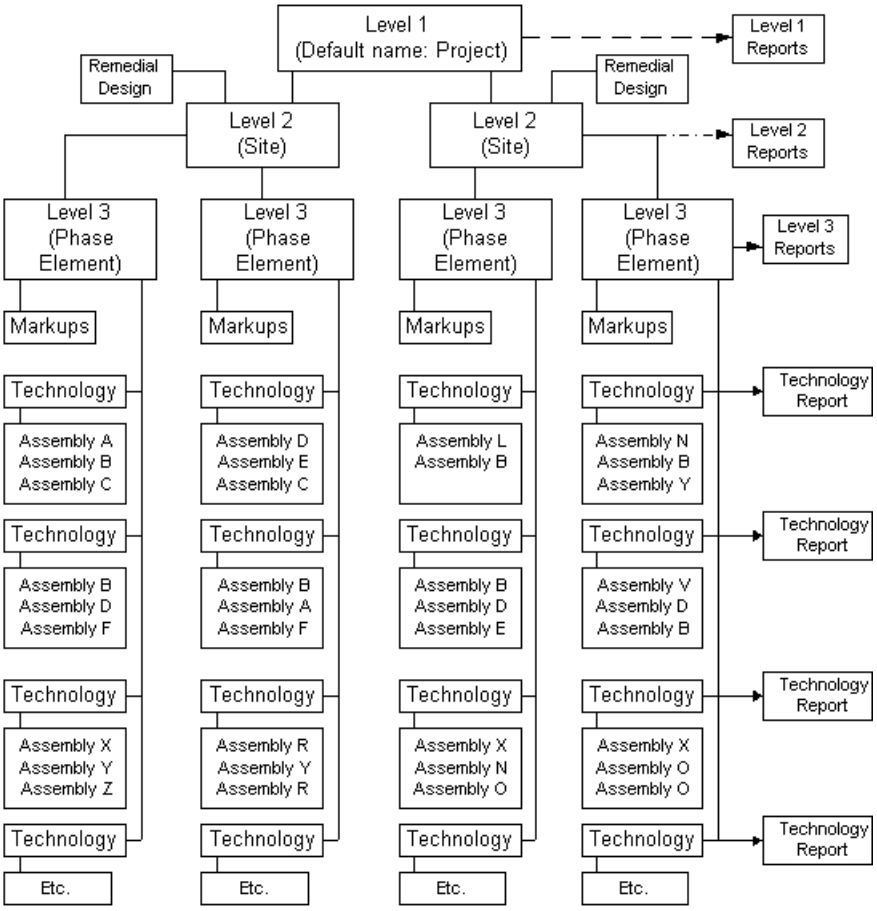
Figure 3: To obtain the most accurate estimate reflecting specific project conditions, the user may change the quantity and unit cost data for each assembly.



4. After the user runs all of the technologies required to estimate the scope of work, the system applies markups consisting of general conditions, overhead, profit, owner costs, and contingencies. The system contains location-specific cost adjustments for over 1,500 cities and also provides the capability to estimate escalated costs over time. A final estimate is then generated once the markups have been applied and is presented via several different reporting options.

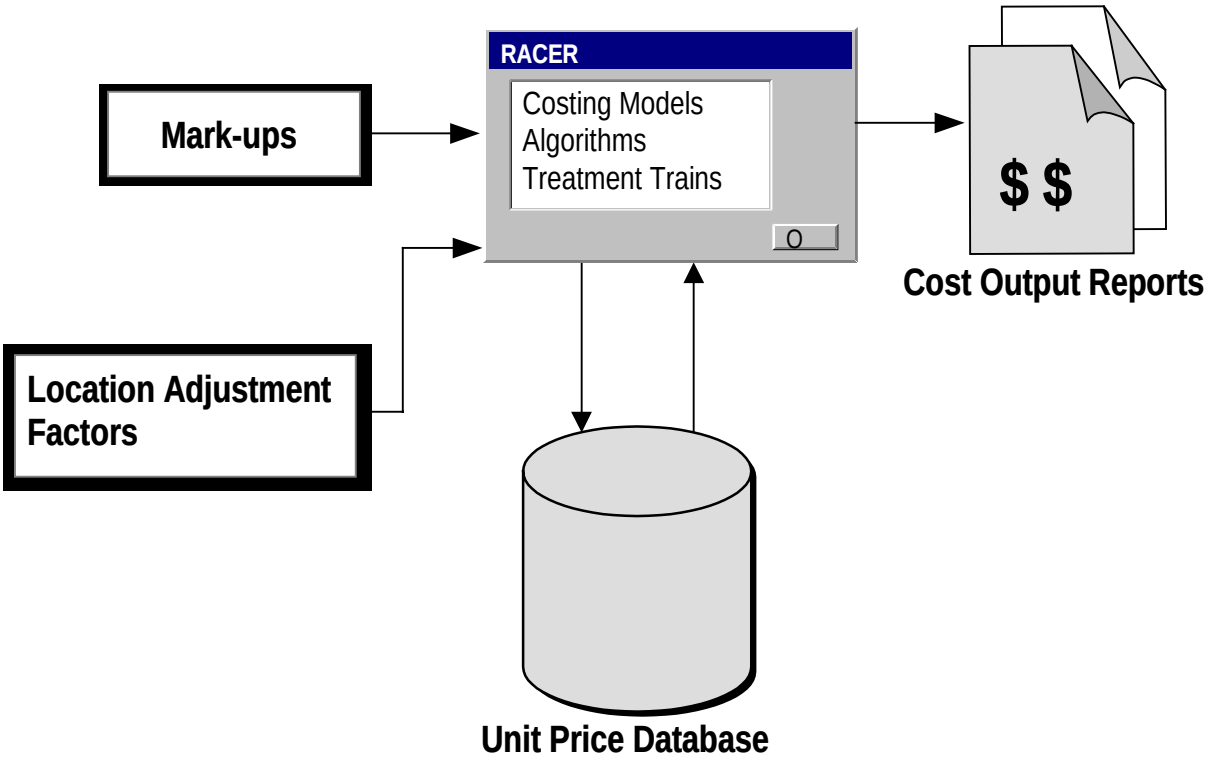
The system estimating hierarchy is shown in Figure 4.

Figure 4: *RACER* uses an estimating hierarchy that allows the user to create cost estimates at any stage of a project. The accuracy of the estimate is increased as the user customizes the estimate at each succeeding level.



The engineering solutions within *RACER* are based on data from government and industry, construction management agencies, technology contractor and vendors, and historical project information. *RACER* currently contains over 100 technologies that can be selected by the user in order to estimate different project and site scenarios. Users select technologies to establish a treatment train and produce a detailed cost for performing a variety of tasks. The system cost database containing unit cost data for materials, labor, and equipment is a duplicate of the ECHOS (Environmental Cost Handling Options and Solutions) cost database. This database contains over 10,000 line items and was developed by a joint venture of Talisman Partners Ltd. and the R. S. Means Company.

2.3.4. System Components



RACER Application – Visual Basic application that serves as the user interface. Contains the costing models (i.e. brownfield cleanup project, storage tank removal project, etc.), algorithms that calculate costs based on user input and unit price database, and treatment trains.

Mark-ups – location specific additions added by user input (i.e. profit, overhead, etc.)

Location Adjustment Factors – DoD provided standards that adjust costs based on locality.

Unit Price Database – Talisman and RS Means jointly developed cost database that provides the underlying costs for individual elements of a cost estimate. Talisman is the party responsible for conducting the cost surveys and populating the database while RS Means provides an independent validation of the data.

Cost Output Reports – Reports detailing line item costs for a given model/project.

2.3.5. User System Requirements

The following indicates the minimum hardware and operating system requirements needed to install RACER:

- Pentium 133 MHz (166 or above recommended)
- 64 MB RAM
- 50 MB free Hard Disk Space (100 or above recommended)
- CD ROM Drive
- Windows 95/98/NT/2000 Operating System

2.4. Accreditation Status of RACER

This is the first Accreditation ever performed on *RACER*. However, since *RACER* was developed and fielded eight years ago, there is a significant body of data, testing, etc. that document various levels of V&V activities. The overall level of V&V that has been conducted to date is summarized below.

2.4.1. VV&A Activities Prior to 1997

RACER was first fielded to the Air Force in 1992 after review and acceptance by HQ AFCESA. The cost estimating methodology underlying the system was patented by the Air Force in 1993. Between the initial release in 1992 and 1997, there were six separate system releases, with each release being an upgrade from the previous release. Numerous testing and verification exercises were performed by HQ AFCESA, AFCEE, MAJCOMs, and independent contractors during the period 1991-1995. In addition, two independent validations of system output against actual cost data were performed in the mid 1990's. (It should be noted that the remediation industry was not mature enough until that time to have a wide spread body of cost data in sufficient detail for validation purposes of actual costs versus system-generated estimates). When appropriate, system modifications were made in order to comply with recommendations from different verification and validation tests, as directed by the Air Force.

During this time period, the system was judged by the Air Force to be in compliance with its requirements for content and accuracy, and it was provided to the federal government for the purpose of preparing cost estimates and for developing remediation budgets. In January 1995, a perpetual exclusive worldwide license was granted to the software development contractor, Talisman Partners, Ltd., that allows commercial distribution and enhancement of the software. In return, the Air Force receives an annual royalty payment, and also receives royalty-free software enhancements developed by the contractor.

By 1997, the system had approximately 500 users, with the majority from DoD. Also by that time, the Air Force used the system as a significant budgeting and CTC estimate development tool. Other Federal government agencies (Army, USACE, Navy, DOI, DOE, EPA) used the system in various stages of their cost and budget estimating process, but not as their primary tool for developing CTC estimates.

2.4.2. VV&A Activities from 1997 to Present

During the period 1997 – 1998, the system was significantly upgraded, both in technical content and software design. During this time, the software developer invested an amount equal to the Air Force's funding in order to cover the costs of moving the software from its then current platform to an industry standard (Windows ™) and to add enhancements to the system that were deemed important by the government but that the Air Force could not fund. The government received these enhancements at no cost, and they were included in the government review process.

A formal review, requirements definition, verification, and validation process was instituted, with approximately 25 participants from the Air Force, Army, USACE, Navy, DOI, DOE, EPA, and industry. These individuals comprised the formal "Technical Review Group". Numerous testing, validation, and verification efforts were conducted, and the results documented over the two-year period. The system was formally accepted by the Review Group as having met the defined standards for requirements, accuracy, usability, etc and the verification and validation process for that release was completed. It was requested by the agencies that the release be made available for widespread use by the federal government in late December 1998.

A new release of the system (*RACER 99*) occurred in December 1998, with a recommendation by HQ USAF/ILEVR that the system be used by Air Force MAJCOMs in developing their budget estimates. It should be noted that since ILEVR did officially require that the software be used for the purpose of preparing budget estimates, an informal "accreditation" was given. (As mentioned previously, accreditation is "the official certification that a model is acceptable for use for a specific application". In this case, the documented body of evidence that was built over 2 years in the V&V process as well as the formal use of the system is essentially an accreditation without using the term accreditation). The recommendation was not performed using the formal acceptance and accreditation process documented in the *Recommended Practices Guide.*

Several Air Force MAJCOMs (AETC, PACAF, AFSPC, ACC) adopted the new release as their primary computerized estimating tool for environmental remediation budget estimates. In addition, the USACE adopted *RACER* as a primary estimating tool for developing the Army's Formerly Used Defense Site (FUDS) CTC estimate. By the end of 1999, there were approximately 900 government/government contractor users of the system, including the Air Force, Army, USACE, Navy, DOI, DOE, and EPA.

The release of *RACER 2000*, occurred to these same users in late December 1999. This release contains additional functionality and enhancements beyond the *RACER 99* release. This version also underwent validation and verification by the Technical Review Group, and was accepted for release in November 1999.

The release of the current version of the system, RACER 2001, occurred to the same users in March 2001. This release contains additional models, reports, and functionality beyond RACER 2000. This version underwent validation and verification by the Technical Review Group in December 2000 and March 2001, and was accepted for release in March 2001.

3.0. Accreditation Project Management

3.1. RACER Accreditation Scope

This section describes the level of effort and methodology that will be used for the accreditation project.

3.1.1. Scope

The overall level of effort will be determined by the *RACER* risk assessment. At this point (prior to an official comprehensive risk analysis discussed in the Accreditation Report), it is assumed that the level of effort required will be minimal. This assumption is based on two premises: 1. The system is a legacy system that has had heavy user involvement in its development cycle. 2. As a cost modeling system the criticality of the system is perceived to be minimal.

Below is the proposed Work Breakdown Structure (WBS) for this effort. If, during the risk assessment phase (which still needs to be accomplished), it is discovered that the level of effort needed for accreditation is minimal, then the level of detail that goes into each activity may not be as great as higher risk systems. **The risk posed by the system to user needs determines the overall accreditation effort required.**

1.0. Pre-Planning

- 1.1. Define Application
- 1.2. Develop *RACER* Requirements

2.0. Planning

- 2.1. Perform *RACER* risk assessment
- 2.2. Determine Accreditation Requirements
- 2.3. Develop Accreditation Plan

3.0. Verification

- 3.1. ID *RACER* Assumptions Limitations & Errors
- 3.2. Perform Functional Verification
- 3.3. Perform System Verification
- 3.4. Document Verification Results

4.0. Validation

- 4.1. Perform Conceptual Model Validation
- 4.2. Perform Results Validation
- 4.3. Document Validation Results

5.0. Accreditation

5.1. Generate Accreditation Report

5.2. Make Accreditation Decision

5.3. Document Accreditation Decision

3.1.2. Methodology

Since *RACER* is a legacy system, there will be two primary methods for determining an accreditation recommendation: subject matter expert interviews and existing documentation review. Actual code verification was not planned due to the fact that the system is a legacy system with extensive review having been conducted by the Technical Review Group and due to the overall assumed low risk of the system.

3.1.2.1. Subject Matter Experts (SMEs)

There are several good reasons for employing SMEs as part of the accreditation process. First of all, environmental engineering, programming and cost estimating professions cannot be summarized in the totality of all the official, written documents and guidelines. So much of what engineers, programmers and cost estimators do is learned on the job, in an operational context. SMEs will have that operational experience. Secondly, there are various *RACER* parameters or scenarios that due to cost, or complexity, will have little or no quantitative data with which to evaluate *RACER.* SMEs must be relied upon for defining what is likely and reasonable real world behavior in these cases. Thirdly, the extensive knowledge of their subject area allows SMEs to sort quickly the chaff from the wheat and focus attention on the critical aspects of *RACER* with regard to the user's problem.

SMEs are human resources and, as such, are going to be highly individual. Within the same field, two SMEs may reach different conclusions when reviewing the same event. Where possible, peer review by other SMEs is always desirable.

Using subject matter experts is called Face Validation. This technique is a qualitative rather than a quantitative method. It identifies gross problems and validates only general trends and predictions. SMEs were used extensively for the *RACER* accreditation.

3.1.2.2. Document Review

As a legacy system, *RACER* has a well documented past. This documentation will be used substantially during the accreditation process.

3.2. Points of Contact

The following individuals are key participants in the accreditation process.

Name/Org.	Role	Address	Phone	Email
Kate Peterson CENWO-HTRW-CX	M&S User, Subject Matter Expert: Configuration Management, Technical Evaluation, Usage History	12565 West Center Rd. Omaha, NE 68144	402-697-2610	Katherine.m.peterson@usace.army.mil
James Peterson CENWO-HX-T	M&S User, Subject Matter Expert: Configuration Management	12565 West Center Rd. Omaha, NE 68144	402-697-2612	James.K.Peterson@usace.army.mil
Stuart Millard HQ AFCESA	M&S Proponent, V&V Agent, Subject Matter Expert: Configuration Management	139 Barnes Drive Suite 1 Tyndall AFB, FL 32403	850-283-6171	Stuart.millard@tyndall.af.mil
James Einwaechter HQ AFCESA	Accreditation Authority	139 Barnes Drive Suite 1 Tyndall AFB, FL 32403	850-283-6102	James.Einwaechter@tyndall.af.mil
Todd Sutton PricewaterhouseCoopers	Accreditation Agent: Quality Assurance	Two Easton Oval Suite 500 Columbus, OH 43219	614-428-5133	Todd.sutton@us.pwcglobal.com
Max McFarland PricewaterhouseCoopers	Accreditation Agent	2403 33rd Avenue Greeley, CO 80634	303-808-2503	Max.mcfarland@us.pwcglobal.com
Greg Roux Tesseract Technologies	Accreditation Agent: Quality Assurance	10875 Main Street Suite 104 Fairfax, VA 22030	703-691-1707	Roux@tesstech.com
John Claypool Talisman Partners	Engineer	9100 E. Panorama Dr. Suite 200 Englewood, CO 80112	303-771-3013	Jclaypool@talpart.com
Dan Murphy	Programmer	9100 E. Panorama Dr. Suite 200 Englewood, CO 80112	303-771-3013	Dmurphy@talpart.com
Jacque Rast Talisman Partners	Developer	9100 E. Panorama Dr. Suite 200 Englewood, CO 80112	303-771-3013	Jrast@talpart.com

3.3. Project Risk Management

Please Note: This section on Risk refers to the Project Risk and not the System Risk. The System Risk is discussed in the Accreditation Report.

This section describes the project risk management strategy, including how risks will be identified, tracked, analyzed, reported, and mitigated during the project. In addition, the initial identified project risks are described for both schedule and technical risks.

The risk management procedures are: identify the risk, assess the risk, plan to mitigate the risk, and control the risk.

1. Ensure team members understand and assign the same meaning to the terms: Risk, Issue, Problem
2. Empower team members to resolve their own problems
3. Know when to escalate
4. Maintain a risk log

Initial risks identified and dealt with:

Schedule

- Lack of government experience in performing V&V process.
- Potential lack of government time and resources dedicated to V&V process due to this activity being an additional duty for most participants.
- June 30 date at risk due to the difficulty in coordinating the schedules of all of the participants.
- The Accreditation Authority has not been identified.

Technical

- Lack of understanding of the scope and purpose of VV&A. Accreditation is "the official certification that a model or simulation is acceptable for a specified purpose." This means that *RACER* can only be accredited for the specific tasks / problems that the users apply *RACER* to. The initial expectation is that *RACER* will receive a blanket accreditation for a series of uses (essentially for all *RACER* users and all *RACER* uses). However, due to the project constraints it was determined to accredit RACER only for its primary use.
- There is no acceptability criteria already established.

4.0. Project Responsibility And Milestones

This section describes the assigned accreditation responsibilities and identifies the major milestones to be accomplished during the accreditation project. The last part of this section is a timeline with a brief description of the proposed dates for focused VV&A efforts.

4.1. Responsibility Matrix

This matrix assigns a responsibility activity to each responsible entity for a particular milestone and milestone completion target date.

Project: *RACER* Accreditation													X – e**X**ecutes the work D – takes **D**ecision solely d – takes **d**ecision jointly P – manages **P**rogress C – must be **C**onsulted I – must be **I**nformed A – available to **A**dvise	**Companies/Departments/Functions/Type of resource**						
Planned date:	Period: Mar 8, 2001 – Jun 30, 2001												Approved by: All Stakeholders	Date approved:	Accreditation Agent	Accreditation Authority	User	Developer	M&S Program Manager	V&V Agent	V&V Team
													No.	Milestone description.							
03/30														When VV&A requirements are understood	P,d				d		
04/07														When responsibilities and milestones have been agreed upon	P,d		C	C	d	C	
05/11														When Model Requirements have been defined	P,d	C	d	I,A	C		
05/11														When accreditation needs have been identified and planned	D,X		A	A	A	A	
05/11														When V&V efforts have been planned	A		A	A	A	D,X	
06/08														When Collection and Evaluation of all information has occurred	P,D, X			X			X
06/22														When Accreditation Assessment has been performed	D,X		I	I	I	I	
06/29														When Accreditation Decision has occurred	C	D					

4.2. Recommended Responsibilities

This section assigns the key participants to the responsible entities identified above.

User: AFCESA

AFCESA will be responsible for defining the problem (e.g., M&S requirements, measures, and acceptability criteria).

M&S PM: AFCESA

AFCESA is responsible for planning and resourcing any modifications needed, overseeing the preparation of the simulation for use, and configuration management and maintenance of either this version of the simulation or for the overall simulation program.

Developer: Talisman

Talisman is responsible for making code modifications, developing new code, and preparing the data. Talisman is also a member of the V&V Team.

V&V Agent: AFCESA

The V&V Agent is responsible for developing the V&V Plan and managing the V&V effort.

V&V Team: Includes representatives from USACE, AFCESA and Talisman – these are also the Subject Matter Experts

The V&V Team is responsible for conducting the verification and validation (V&V) effort.

Accreditation Authority: AFCESA

The Accreditation Authority is responsible for making the decision to accredit.

Accreditation Agent: PwC

PwC is responsible for assessing *RACER* to ensure it is fit for its intended purpose. To accomplish this, PwC is responsible for developing an Accreditation Plan, overseeing the accreditation efforts and making an accreditation recommendation.

4.3. Description of Milestones

When responsibilities and milestones have been agreed upon

Description: This task should be accomplished at the very beginning of the process to ensure all stakeholders understand their roles and responsibilities. This task is primarily an agreement on the Responsibility Matrix and Recommended Responsibility section above.

Primary Resources**:** All Stakeholders identified above.

When RACER requirements have been defined

Description: Define user needs and acceptability criteria, evaluate all available, relevant model documentation, and assess the operational risk of the model.

Primary Resources: AFCESA and PwC.

When Accreditation needs have been identified and planned

Description: Based on the documentation review and the risk assessment, make a determination of the outstanding needs that must be satisfied for accreditation. Develop the accreditation plan. The accreditation assessment is a disciplined comparison between *RACER*'s capabilities, correctness, accuracy, and utility and the user requirements of the current application. The accreditation assessment also entails a final determination as to the adequacy of the overall depth and scope of the evidence in light of operational risks. An effective assessment in each of these areas depends on the availability of particular types of information. The accreditation plan must provide or identify sources for all the needed information.
Primary Resources: AFCESA and PwC, Talisman.

When V&V efforts have been planned

Description: The V&V plan is an agreement of what needs to be done, what V&V products should be produced, what resources are needed and what causal relationships are involved between the V&V plan, simulation preparation plan, and accreditation plan.

Primary Resources: AFCESA and V&V Team.

When collection and evaluation of all information has occurred

Description: PwC should collect the information resulting from the V&V effort, information generated by any modification activities, as well as information from additional sources (e.g., data producers). PwC should also monitor the simulation preparation and V&V efforts to ensure that their products will satisfy the accreditation information needs.

Primary Resources: PwC and V&V Team.

When Accreditation Assessment has been performed

Description: An accreditation assessment involves a review of the four basic factors of fitness (capability, correctness, accuracy and usability).

Primary Resources: PwC.

When the Accreditation Decision has been made

Description: Once the accreditation assessment is completed, PwC will submit the report (e.g., accreditation package) and a recommendation of one of the accreditation options. This accreditation recommendation is provided then provided to AFCESA (the Accreditation Authority).

Primary Resources: PwC and AFCESA (Accreditation Authority).

4.4. Proposed Timeline

Two working sessions will be required in Colorado at the Talisman site.

1. The first session will occur on 30 April. It must be attended by someone (or several people) who can officially define the *RACER* system requirements, read through the available documentation to determine sufficiency, review the accreditation plan to be developed that week and develop the V&V Plan.

2. The second session will be determined by the sufficiency of information collected during the first session. If a V&V effort must occur (including additional testing), then it would occur during the second session. The second session must be finished no later that June 1.

5.0. Performance

5.1. Development of Acceptance Criteria

Acceptability criteria provide a means of evaluating *RACER* from the perspective of the user's application requirements. The acceptability criteria were developed through discussions with the user and Subject Matter Experts.

The first column provides the requirement definition. These requirement items are taken directly from the user need statement. The second column defines the acceptability criteria. The determination of whether or not *RACER* satisfies the acceptability criteria will be captured in the third column. This determination will be made through Face Validation with Subject Matter Experts as part of the Conceptual model validation and the results will be found in the Accreditation Report. In addition, the Functional and System Verification and Results Validation will ensure that the Conceptual model has been correctly implemented in the operational system. The fourth column describes the fact that Subject Matter Experts will be used in addition to a review of the *RACER* 2000 Business Plan to determine whether or not the acceptability criteria have been met.

Requirement Definition	Acceptability Criteria	Acceptability Criteria Measurement	Methodology
Automated - acting or operating in a manner essentially independent of external influence or control; "a structured methodology for obtaining input parameters that will feed cost estimating algorithms and models"	The system provides a mechanism for inputting information and for mathematically calculating a result without external influence on the mechanism for calculating. Cost estimating algorithms and models that can not be altered by the user	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Consistent - reliable, steady; "a standardized approach that allows for a basis of comparison"	Does the system allow users input information and have a standardized method applied to the information to produce a result. Please note: The system is flexible enough to allow users to input all of their own information and completely bypass any automated calculations. This part of the process can not be accredited. As a business process, users should have better information than can be provided by the system if they bypass the system. Standardized process – the process does not change between models	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Repeatable - able to do, experience or produce again; "can be followed and recreated"	The same output is created every time the same information is input	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Document - to support (an assertion or claim, for example) with evidence or decisive information; "provide an audit trail with detailed backup and output that documents all of the assumptions used by the estimator" **Audit trail** – documentation that allows an examination of the method that was used to create an estimate **Detailed backup and output** – "Ability to reconstruct from scratch the same document from the original assumptions and change flags that indicate when the user has manually overridden a component of the model"	The system allows the user to print out the details (Please note: this is a capability that requires the support of business processes)	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan

Requirement Definition	Acceptability Criteria	Acceptability Criteria Measurement	Methodology
Assumptions – something taken for granted or accepted as true without proof; a supposition **Estimator** – from novice users to Subject Matter Experts (SMEs).			
Environmental clean up of Contaminated Sites - a site at which substances occur at concentrations: (a) above background levels and pose or are likely to pose an immediate or long term hazard to human health or the environment; or (b) which exceed levels specified in the policies and/or regulations	Includes laws and regulations that pertain to the cleanup of contaminated sites	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Method - A means or manner of procedure, especially a regular and systematic way of accomplishing something	Parametric cost estimating tool.		Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Reasonable Cost estimate – cost information based on current industry standards: engineering solutions based on data from government and industry, construction management agencies, technology vendors and contractors as well as historical project information	System relies on current industry standards	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Programming Funding Purposes – a formal request for budget allocation	Aides in the budgeting process	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan
Information Available at the time - this includes site details and current practices: policies, costs, etc	The system component information and the input information must be the best available at the time an estimate is created	Yes No	Interview: Subject Matter Experts Review: *RACER* 2000 Business Plan

5.2. Review Conceptual Model Validation Report(s)

A conceptual model is a statement of assumptions, algorithms, and architecture that relates the elements of the model to one another. Additionally, the conceptual model describes the data that is used by, embedded in, or produced by the model.

Conceptual model validation examines the *RACER* assumptions, architecture, and algorithms in the context of the intended use. It verifies that all user requirements can be traced to the conceptual model. Further it validates the correctness of the algorithms, assumptions, limitations, and architecture. The degree of correctness of these items is measured by how well they support the *RACER* user requirements.

The conceptual model validation will involve a review of the above Acceptability Criteria Table and a review of the assumptions and limitations. The assumptions and limits will be reviewed to determine how well they are documented.

5.3. Review Functional and System Verification Report(s)

5.3.1. Functional Design Verification

The goal of the *RACER* functional design verification is to establish the consistency and faithfulness of the functional design specifications to the validated conceptual model and *RACER* requirements.

The V&V functional design verification phase is "based on the M&S system specification, which defines the hardware, software, and personnel that comprise the M&S. The [functional] design process has two primary components: the architectural system design, which addresses the hardware and software architecture, data structures, and interfaces; and the detailed software design, which addresses key elements of the software such as critical algorithms and data issues.

Functional design verification ensures that all the features, functions, behaviors, algorithms, and interactions defined by the *RACER* user requirements and the conceptual model are correctly and completely included in the *RACER* design representations and documentation.

The activities involved in the functional verification are described in the system verification section.

5.3.2. System Verification

System verification is the formal, documented testing and review process of *RACER*. It demonstrates that *RACER* accurately represents the functional design and provides traceability of each system component back to the conceptual model. System verification looks at timing and protocol constraints. It examines how *RACER* accommodates unanticipated, or out of specification, inputs. It examines how well the software components were developed in accordance with contemporary engineering and DoD standards of structure and documentation. It examines how well hardware components comply with system specifications.

Since *RACER* is a legacy system, this system verification will be performed by reviewing prior V&V efforts and relying on SMEs. The following table describes the documents to be reviewed, the acceptability criteria for document, the measurements for the acceptability criteria and the methodology used to determine the measurements.

The acceptability criteria measurements are highly subjective. The measurements reflect the Accreditation Agent's, V&V Teams' and Subject Matter Experts' best effort in accessing the available information.

System Documentation	Acceptability Criteria	Acceptability Criteria Measurement	Methodology
Configuration Management	Policy and Procedures: Treatment - Thorough - Partial - None Followed - Always - Regularly - Never Documentation - Full - Partial - None	Treatment Thorough – configuration management is important and there are well thought-out well structured policies in place Partial – configuration management exists but is treated more as an afterthought None – no configuration management Followed Always = substantially all the time Regularly = usually followed Never = very seldom followed Documentation Full = well documented Partial = some documentation None = no documentation	Documentation Review Subject Matter Expert Interview (Kate Peterson, James Peterson, Stuart Millard)
Documentation Assessment A. Software Users Manual B. Operational Concept Description C. Software Design Description D. Software Development Plan	Policy and Procedures: Treatment - Thorough - Partial - None Followed - Always - Regularly - Never Documentation - Full - Partial - None In order of importance: 1. Treatment 2. Followed 3. Documented	Treatment Thorough = industry standard (MIL-STD-498) Partial = some component of MIL-STD-498 are covered (or other substituted standards are covered) None = not following any defined industry standards Followed Always = substantially all the time Regularly = usually followed Never = very seldom followed Documentation Full = well documented Partial = some documentation None = no documentation	Documentation Review Subject Matter Expert Interview (Kate Peterson, James Peterson, Stuart Millard) Programmer Interview (Dan Murphy, John Claypool)
Usage History	Usage History - the system usage history demonstrates a strong commitment to the use of - the system and a consistent pattern of usage the system usage history demonstrates a changing or erratic usage history		Documentation Review Subject Matter Expert Interview (Kate Peterson, James Peterson, Stuart Millard)

5.4. Review *RACER* Results Validation Report(s)

The V&V results validation is "the formal test/review process that compares the responses of the M&S with known or expected behavior from the subject it represents, in order to ascertain that the M&S responses are sufficiently accurate for the intended uses."

Results validation normally involves comparison of the results of a model to some authoritative reference data that defines what the expected results should be.

The DoD RPG defines metadata as the information describing the characteristics of data, and defines referent as the authoritative data to which the M&S results would be compared. Real world, empirical data are preferable sources of referent, or validation, data. Examples of empirical data are telemetry data from operational systems and measurement data from test events.

When real-world data are not available, subject matter experts (SMEs) are relied upon to provide assessments as to the credibility of the M&S results. In addition, M&S results can be compared, or benchmarked, against other similar validated M&S results when no other referent resources are available.

For *RACER* a comparison of budgeted cost compared with actual executed cost is very difficult. The level of information changes dramatically from when the budget estimate is completed to when work is actually accomplished. In addition, there are many factors that impact the amount of money spent in relationship with the scope. Given these difficulties, we will rely on Face Validation and some rudimentary statistical analysis performed inputting actual costs and scope of work into *RACER* and comparing it with the actual costs. This analysis does not directly support the user requirement but does provide some results validation.

5.5. Generate Accreditation Report

The Accreditation Report will document whether or not *RACER* meets the acceptability criteria described above.

C. ACCREDITATION REPORT

1.0. Executive Summary

The Accreditation report describes the scope actually undertaken, provides a summary of the V&V Report and provides conclusions and recommendations for the future.

The scope is driven by the risk assessment. The first part of this section describes the risk assessment and the second part describes the actual scope.

The V&V Report is summarized in a table. This simple table identifies whether each V&V activity meets the user needs or not.

The last section documents the accreditation conclusions and recommendations.

2.0. RACER Accreditation Scope

2.1. Risk assessment

Risk is driven by several factors: impact categories, level of impact, and frequency of impact. The first step in doing a risk assessment is to identify the impact categories that apply to *RACER*. The following categories were deemed to apply: cost, political, human health/exposure, and environment damage. Once the categories were identified, the level of impact that *RACER* presents in each category had to be assessed. The next step is identifying the frequency of impact occurrence. Once all of these items have been determined, an overall risk assessment can be made. This risk assessment determines the level of credibility required by the accreditation process.

The User and Subject Matter Experts used the figures in Appendix C to develop the following *RACER* risk assessment:

Cost

Level of Impact – Negligible; *RACER* was designed to meet the user needs of being able to document a consistent, repeatable cost estimating method. Programming for funding is a dynamic process. If the initial values provided to the system are incorrect (given all of the current information) and must be changed later (given better information), this is OK as long as there is supporting documentation to show it was due to an information change and not user whim.

Probability of Occurrence – Frequent; as better information about a contaminated site becomes available the remediation costs will become more accurate.

Overall Risk Level – Low.

Political

Level of Impact – Negligible; a change in the cost to complete a project is defensible if due diligence is documented and performed in attaining information about a site. *RACER* allows users to document all inputs and assumptions.

Probability of Occurrence – Frequent; changes to project costs are directly tied to the amount of information available about a site. As more information becomes known, better estimates can be made.

Overall Risk level – Low.

Human/Health and Exposure

Level of Impact – Negligible; cost is only one factor in considering which site to remediate and it is rated 7th on a scale of 9 with 1 being the most important factor.

Probability of Occurrence – Frequent; changes to project costs are directly tied to the amount of information available about a site. As more information becomes known, better estimates can be made.

Overall Risk level – Low.

Environment

Level of Impact – Negligible; cost is only one factor in considering which site to remediate and it is rated 7th on a scale of 9 with 1 being the most important factor.

Probability of Occurrence - Frequent; changes to project costs are directly tied to the amount of information available about a site. As more information becomes known, better estimates can be made.

Overall Risk level – Low.

Overall Risk Assessment

Risk level – Low.

The risk assessment identified all known risks associated with an incorrect *RACER* output as being: Low. Given this risk assessment it is determined that only a nominal amount of credibility is required in order to accredit *RACER*.

2.2. Accreditation Scope

Given this nominal credibility requirement, the following specific items from the WBS will be executed using less invasive methodologies. The project will rely primarily on Face Validation with SMEs and existing documentation review.

WBS 1 and 2 has been accomplished.

1. Pre-Planning
    1.1. Define Application
    1.2. Develop *RACER* Requirements
2. Planning
    2.1. Perform Risk Assessment
    2.2. Determine Accreditation Requirements
    2.3. Develop Accreditation Plan
3. Verification
    3.1. Perform Functional Verification
    3.2. Perform System Verification

3.3. Document Verification Results

4. Validation

4.1. Perform Conceptual Model Validation

4.2. Perform Results Validation

4.3. Document Validation Results

5. Accreditation

5.1. Generate Accreditation Report

5.2. Make Accreditation Decision

5.3. Document Accreditation Decision

3.0. V&V Report Summary

This section summarizes the findings of the V&V effort.

Overall	**Meets User Needs**
User Need Statement satisfied	**Meets User Needs**
Configuration Management	**Meets User Needs**
RACER Documentation Assessment	**Meets User Needs**
Usage History	**Meets User Needs**
Limits and Assumptions	**Meets User Needs**
Statistical Analysis	**Meets User Needs**

4.0. Accreditation Conclusions And Recommentations

4.1. Conclusions

RACER meets all of the user needs and should be fully accredited for the following intended use:

To provide an automated, consistent and repeatable method to estimate and document the program cost for the environmental cleanup of contaminated sites and to provide a reasonable cost estimate for program funding purposes consistent with the information available at the time of the estimate preparation.

This accreditation is only addressing the *RACER* models and their interface with the system. *RACER* does not address user activities while using the models except to say that an individual that has been trained on the use of the system and given good information about a site, can use the software to fulfil the above user objective. This accreditation is for the general use of the models as they were primarily intended to be used. The following items elaborate on this general use:

- *RACER* does not estimate emerging technologies consistently and repeatably due to the lack of background information regarding the technologies.
- *RACER* models are designed for a standard generic engineering solution. They are not designed for projects that deviate substantially from normal engineering practices.
- *RACER* is not resource loaded and was not designed for use as a scheduling tool.
- *RACER* does not distinguish between different seasons (weather) and their impact on the engineering solution.
- *RACER* is completely reliant on user input. As such, the reasonableness of the estimate is determined in large part by level of site knowledge input into *RACER*.
- *RACER* was designed to be flexible enough to allow users to input their own information and circumvent the models.
- *RACER* is subject to both general commercial software limits and general parametric cost estimating limitations (i.e., *RACER* performs top-down estimating and not bottom-up estimating).
- Every model has its own unique assumptions and limits.

4.2. Recommendations

To reduce application risk and aid in maintaining the current Accreditation as well as supporting future Accreditation efforts, the following activities should be undertaken:

Formalize overview and activity level for processes for Configuration Management. There should be a document that clearly describes the overall management process as well as each organization's role.

Define group and group members and each of their roles. The roles for each organization and person in the process should be clearly documented.

Formal letter for release of software. There should be a formal release letter that authorizes the release of software to the field.

Standard format for user input. There should be a single format for user complaints, suggestions or problems. Right now there are multiple avenues to submit complaints, suggestions and problems as well as multiple formats.

Baseline for all documentation. There should be a baseline captured of all the documents relied upon for this accreditation recommendation. This will aid future accreditation efforts.

D. V&V REPORT

1.0. Executive Summary

The V&V Report describes the activities of each of the elements that was reviewed in support of the accreditation. This includes the specific approach that was taken and the results of the review.

The Performance section describes the approach that will be taken for each V&V component.

The Results section describes the results of the V&V effort.

The final section provides an overall conclusion in regard to how well the results meet the needs of the user. In addition, there is also a brief discussion of recommendations for going forward.

2.0. Performance

2.1. Conceptual Model Validation

This section describes the overall approach for validating the *RACER* conceptual model.

The conceptual model will be validated against the Acceptability Criteria by reviewing the *RACER* 2000 Business Plan and by interviews with Subject Matter Experts. The Subject Matter Experts have been involved with *RACER* for several years and have been an integral part of the development process and concept development. The Business Plan describes the Conceptual Model in broad terms. The Subject Matter Experts will elaborate on the Business Plan description and help formulate the list of assumptions and limits.

2.2. Functional and System Verification

2.2.1. Functional Verification

The following activities will be performed with the system developers for functional verification: reviewing *RACER* functional design documentation and participating in *RACER* design walk-throughs with the developer to ensure that the functional design is tied to the conceptual model and supports the acceptability criteria. The results of the Functional Verification will be integrated with the system verification results.

2.2.2. System Verification

The System Verification approach is comprised of three parts: system documentation review, configuration management review and usage history review.

2.2.2.1. System Documentation

The System Documentation review approach will be to interview system developers using MIL-STD-498 guidelines.

2.2.2.2. Configuration Management

The approach to reviewing Configuration Management is to review artifacts (in many cases these documents do not exist as single documents, there are procedures in place that are followed and artifacts from those procedures). This document review is primarily a review of those artifacts from the configuration management process and to use Subject Matter experts to describe overall process and then provide specific examples on how configuration management would work given different scenarios.

2.2.2.3. Usage History

Talisman has produced a Usage History. This Usage History will be reviewed and validated with Subject Matter Experts.

2.3. Results Validation

The approach for Results Validation will be to rely on Face Validation and some rudimentary statistical analysis performed inputting actual costs and scope of work into *RACER* and comparing it with the actual costs. This analysis does not directly support the user requirement but does provide some results validation.

3.0. Results

3.1. Conceptual Model Validation

3.1.1. This chart summarizes the Conceptual Model Validation

The first column provides the requirement definition. These requirement items are taken directly from the user need statement. The second column defines the acceptability criteria. The acceptability criteria were determined through discussions with the user and Subject Matter Experts. The determination of whether or not the conceptual model for *RACER* satisfies the acceptability criteria is captured in the third column. This determination was made through Face Validation with Subject Matter Experts. The fourth column describes the fact that Subject Matter Experts were used in addition to a review of the *RACER* 2000 Business Plan.

Requirement Definition	Acceptability Criteria	Acceptability Criteria Results	Methodology
Automated - acting or operating in a manner essentially independent of external influence or control; "a structured methodology for obtaining input parameters that will feed cost estimating algorithms and models"	The system provides a mechanism for inputting information and for mathematically calculating a result without external influence on the mechanism for calculating. Cost estimating algorithms and models that can not be altered by the user	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Consistent - reliable, steady; "a standardized approach that allows for a basis of comparison"	Does the system allow users input information and have a standardized method applied to the information to produce a result. Please note: The system is flexible enough to allow users to input all of their own information and completely bypass any automated calculations. This part of the process can not be accredited. As a business process, users should have better information than can be provided by the system if they bypass the system. Standardized process – the process does not change between models	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Repeatable - able to do, experience or produce again; "can be followed and recreated"	The same output is created every time the same information is input	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Document - to support (an assertion or claim, for example) with evidence or decisive information; "provide an audit trail with detailed backup and output that documents all of the assumptions used by the estimator" **Audit trail** – documentation that allows an examination of the method that was used to create an estimate **Detailed backup and output** – "Ability to reconstruct from scratch the same document from the original assumptions and change	The system allows the user to print out the details (Please note: this is a capability that requires the support of business processes)	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan

Requirement Definition	Acceptability Criteria	Acceptability Criteria Results	Methodology
flags that indicate when the user has manually overridden a component of the model" **Assumptions** – something taken for granted or accepted as true without proof; a supposition **Estimator** – from novice users to Subject Matter Experts (SMEs).			
Environmental cleanup of Contaminated Sites - a site at which substances occur at concentrations: (a) above background levels and pose or are likely to pose an immediate or long term hazard to human health or the environment; or (b) which exceed levels specified in the policies and/or regulations	Includes laws and regulations that pertain to environmental sites	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Method - A means or manner of procedure, especially a regular and systematic way of accomplishing something	Parametric cost estimating tool.	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Reasonable Cost estimate – cost information based on current industry standards: engineering solutions based on data from government and industry, construction management agencies, technology vendors and contractors as well as historical project information	System relies on current industry standards	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Programming Funding Purposes – a formal request for budget allocation	Aides in the budgeting process	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan
Information Available at the time - this includes site details and current practices: policies, costs, etc	The system component information and the input information must be the best available at the time an estimate is created	Yes	Interview: Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) Review: *RACER* 2000 Business Plan

Overall Rating: Meets user needs by supporting the Acceptability criteria.

3.1.2. Limits and Assumptions

The following limits and assumptions were developed by the user and Subject Matter Experts.

- *RACER* does not estimate emerging technologies consistently and repeatably due to the lack of background information regarding the technologies.
- *RACER* models are designed for a standard generic engineering solution. They are not designed for projects that deviate substantially from normal engineering practices.
- *RACER* is not resource loaded and was not designed for use as a scheduling tool.
- *RACER* does not distinguish between different seasons (weather) and their impact on the engineering solution.
- *RACER* is completely reliant on user input. As such, the reasonableness of the estimate is determined in large part by level of site knowledge input into *RACER*.
- *RACER* was designed to be flexible enough to allow users to input their own information and circumvent the models.
- *RACER* is subject to both general commercial software limits and general parametric cost estimating limitations (i.e., *RACER* performs top-down estimating and not bottom-up estimating).
- Every model has its own unique assumptions and limits.

Overall rating: Meets user needs by supporting the Acceptability Criteria.

3.2. Functional Design Verification

See System Verification.

3.3. System Design Verification

3.3.1. Configuration Management

Software Configuration Management is the life cycle process through which the integrity and continuity of software upgrades and maintenance are recorded, communicated, and controlled.

M&S CM is an umbrella activity that is applied throughout the M&S life cycle. Because change can occur at any time, CM activities are developed to:

- Identify components, interfaces and documentation within each release or version
- Provide a mechanism for suggesting, adjudicating and prioritizing change requests
- Ensure that change is being properly implemented
- Report status to others that may have an interest

An M&S under solid CM will greatly reduce the effort needed to produce V&V reports, as much of the needed M&S development history can be obtained from the Configuration Manager.

During the course of the V&V process, discrepancies between the performance expected by the user and the actual performance of the M&S may be uncovered. It is the responsibility of the M&S Proponent to provide feedback to the M&S developer in the form of change requests to the M&S Change Review Board (CRB) as specified by the CM Plan. Because budgets and schedules are limited, an efficient system for categorizing these change requests must be employed. What follows are suggested change request priority criteria.

Criteria:

The criteria are thoroughly explained in the Accreditation Plan, Section A.

System Documentation	Acceptability Criteria	Acceptability Criteria Measurement	Methodology
Configuration Management	Policy and Procedures: Treatment - Thorough - Partial - None Followed - Always - Regularly - Never Documentation - Full - Partial - None	Treatment Thorough – configuration management is important and there are well thought-out well structured policies in place Partial – configuration management exists but is treated more as an afterthought None – no configuration management Followed Always = substantially all the time Regularly = usually followed Never = very seldom followed Documentation Full = well documented Partial = some documentation None = no documentation	
Documentation Assessment A. Software Users Manual B. Operational Concept Description C. Software Design Description D. Software Development Plan	Policy and Procedures: Treatment - Thorough - Partial - None Followed - Always - Regularly - Never Documentation - Full - Partial - None In order of importance: 1. Treatment 2. Followed 3. Documented	Treatment Thorough = industry standard (MIL-STD-498) Partial = some component of MIL-STD-498 are covered (or other substituted standards are covered) None = not following any defined industry standards Followed Always = substantially all the time Regularly = usually followed Never = very seldom followed Documentation Full = well documented Partial = some documentation None = no documentation	

Overall Configuration Management:

Item	Treatment	Documentation	Followed	Source of Information
Overall System Configuration Management Plan	Thorough	Partial – there is no overall document that describes the Configuration Management process. There are only documents that identify the result of the unwritten process.	Regularly	Subject Matter Experts (Kate Peterson, James Peterson, Stuart Millard) RACER Business Plan Talisman Quality Management Plan
Software Configuration Management Plan	See the Software Development Plan write-up	See the Software Development Plan write-up	See the Software Development Plan write-up	See the Software Development Plan write-up

Overall Rating: Meets user needs by supporting the overall management of the system to ensure that the system continues to satisfy the acceptability criteria.

3.3.2. System Documentation

The following table describes the documents reviewed, the acceptability requirements, acceptability requirement measurements and the methodology used to determine the measurement for the criteria.

System Documentation	Acceptability Criteria	Acceptability Criteria Measurement	Methodology
Documentation Assessment A. Software Users Manual B. Operational Concept Description C. Software Design Description D. Software Development Plan	Policy and Procedures: Treatment - Thorough - Partial - None Followed - Always - Regularly - Never Documentation - Full - Partial - None In order of importance: 1. Treatment 2. Followed 3. Documented	Treatment Thorough = industry standard (MIL-STD-498) Partial = some component of MIL-STD-498 are covered (or other substituted standards are covered) None = not following any defined industry standards Followed Always = substantially all the time Regularly = usually followed Never = very seldom followed Documentation Full = well documented Partial = some documentation None = no documentation	Subject Matter Expert Interview (Dan Murphy – *RACER* software developer and John Claypool – *RACER* engineer) Process Document Artifact review – in many cases these documents do not exist as single documents, there are procedures in place that are followed and artifacts from those procedures. This document review is primarily a review of those artifacts.

For a more thorough description of the information requested for each system document see Appendix D. The items in this Appendix were taken from MIL-STD-498 and the recommended components from the Joint Accreditation Support Activity (JASA).

3.3.2.1. Software Users Manual

Item	Treatment	Documentation	Followed	Source of Information
An overview of the purpose/operation of each component	Thorough	Full	N/A	*RACER* 2000 Business Plan
Relationship of the functions performed by the software with interfacing systems, organizations, or positions	Partial	Partial	N/A	Training Manual/Online Help & Talisman Programming Staff
Security and privacy	Thorough	Full	N/A	Training Manual
Assistance and problem reporting	Thorough	Full	N/A	Online Help
Processing reference guide	Thorough	Full	N/A	Online Help
Capabilities	Thorough	Full	N/A	*RACER* 2000 Business Plan/ Training Manual
Conventions	Thorough	Full	N/A	Online Help
Data backup	Thorough	Full	N/A	Training Manual
Quick-reference guide	Thorough	Full	N/A	*RACER* Quick Reference Guide & Programming Staff

Overall Rating: Meets User Needs.

3.3.2.2. Software Development Plan

Item	Treatment	Documentation	Followed	Source of Information
Software development methods	Thorough	Partial – main source of guidance is OJT	Always	Talisman Programming Staff (Dan Murphy) & Software Configuration Management Plan
Standards for software products	Thorough	Partial – main source of guidance is OJT	Always	Talisman Programming Staff (Dan Murphy)
System requirements analysis	Thorough	Full	N/A	Talisman Programming Staff (Dan Murphy) & Talisman Engineering Staff (John Claypool) & Technical Review Committee Minutes
System design	Partial	Partial	N/A	Talisman Programming Staff (Dan Murphy) & Talisman

Item	Treatment	Documentation	Followed	Source of Information
				Engineering Staff (John Claypool) & *RACER* 2000 Business Plan
Software requirements analysis	Thorough	Full	N/A	Talisman Programming Staff (Dan Murphy)
Software design	Partial	Partial	N/A	Talisman Programming Staff (Dan Murphy)
Software implementation and unit testing	Partial	Partial	Regularly	Subject Matter Experts (Kate Peterson/Jim Peterson/Stuart Millard) & Technical Review Committee Minutes & Talisman Programming Staff (Dan Murphy)
Unit integration and testing	Partial	Partial	Regularly	Subject Matter Experts (Kate Peterson/Jim Peterson/Stuart Millard) & Technical Review Committee Minutes & Talisman Programming Staff (Dan Murphy)
Software configuration management	Thorough	Partial	Regularly	Subject Matter Experts (Kate Peterson/Jim Peterson/Stuart Millard) & Technical Review Committee Minutes & Government Steering Committee Minutes & Talisman Programming Staff (Dan Murphy) & Software Configuration Management Plan
Software quality assurance	Thorough	Partial	Regularly	Talisman Programming Staff (Dan Murphy) & Talisman Engineering Staff (John Claypool)
Corrective action	Thorough	Partial	Regularly	Online Help
Joint technical and management reviews	Thorough	Partial	Always	Subject Matter Experts (Kate Peterson/Jim Peterson/Stuart Millard) & Technical Review Committee Minutes & Government Steering Committee Minutes
Risk management, including known risks and corresponding strategies	Thorough	Partial	Regularly	Online Help

Overall Rating: Meets User Needs.

Recommendations: The processes and procedures could be more formalized. Currently, many of the procedures are passed through on-the-job-training.

3.3.2.3. Software Design Document

Item	Treatment	Documentation	Followed	Source of Information
Concept of execution	Partial	Partial	N/A	*RACER* 2000 Business Plan
Interface design	Partial	Partial	N/A	*RACER* 2000 Business Plan
Interface identification and diagrams	Partial	Partial	N/A	*RACER* 2000 Business Plan

Overall Rating: Meets User Needs.

Recommendations: The processes and procedures could be more formalized. Currently, many of the procedures are passed through on-the-job-training.

3.3.2.4. Operational Concept Description

Item	Treatment	Documentation	Followed	Source of Information
Background, objectives, and scope	Thorough	Full	N/A	*RACER* 2000 Business Plan
Operational policies and constraints	Thorough	Full	N/A	*RACER* 2000 Business Plan
Description of current system or situation	Thorough	Full	N/A	*RACER* 2000 Business Plan
Users or involved personnel	Thorough	Full	N/A	*RACER* 2000 Business Plan
Support concept	Partial	Partial	Always– there is a robust support agreement that is followed but is not directly identified in the contract	*RACER* 2000 Business Plan/Contract Terms
Justification for and nature of changes	Thorough	Full	Always	Technical Meeting Minutes/Government Steering Committee Minutes
Operational scenarios	Thorough	Full	N/A	Training Manual
Summary of advantages	Thorough	Full	N/A	*RACER* 2000 Business Plan/Model Addendum
Summary of disadvantages/limitations/assumptions	Thorough	Full	N/A	Model Addendum/Online Help
Alternatives and trade-offs considered	Thorough	Full	N/A	Model Addendum

Item	Treatment	Documentation	Followed	Source of Information
Description of overall methodology	Thorough	Partial	Always – primary means of training is OJT	Model Repository
Detailed technical description of algorithms	Thorough	Full	Always	Model Addendum
Parameter codes/Variable definitions	Thorough	Full	Always	Model Addendum

Overall Rating: Meets User Needs.

Recommendations: The processes and procedures could be more formalized. Currently, many of the procedures are passed through on-the-job-training.

3.3.4. Usage History

The Usage History shows a strong commitment to the use of the system and a consistent pattern of usage over time that is well documented. In fact, *RACER* is evolving to meet ever more stringent user needs. Please Note: the following usage history is a list of uses that system is being used for, it is not a list of the accredited uses of the system. RACER is only being accredited for the use identified in the User Requirements section of the Accreditation Plan (Section 2.2).

Use	Method of System Use	Likely Phase of IRP When Used
Planning Remediation Efforts	Budget estimates are developed during the planning of each remediation phase by using *RACER*. Estimates are usually developed by individual site using the required parameters and system defaults.	Prior to budgeting for Site Characterization/ Remedy Selection; Remediation; and Long-Term O&M activities.
Selecting Site Investigation Methods	Site characterization techniques and requirements may be compared to determine the most cost-effective approaches.	Prior to when the actual site characterization commences.
Selecting Remediation Technologies and Scenarios	Different remediation technologies and scenarios may be evaluated in *RACER* for cost comparison purposes using required and secondary parameters.	During the alternative evaluation and selection phase.
Developing Detailed Cost Estimates to Support Regulatory Negotiation and/or Pre-Construction Activities	Detailed cost estimates for a preferred or chosen remedy may be developed based on a conceptual and/or final design. The estimates are developed by individual site using required and secondary parameter and perhaps user-defined costs.	During regulatory negotiation and/or the detailed design/ pre-construction/pre-bid phases.
Developing Detailed Cost Estimates to Support Contractor Bid Negotiations	Construction bid estimates May be developed using the detailed cost estimate and comparing and modifying it based on contractor bids. *RACER* is used at its most detailed level, by entering user-defined	During the remedial Construction and O&M contract bidding phases.

Use	Method of System Use	Likely Phase of IRP When Used
	costs and modifying default unit costs to reflect contractor bid prices.	
Developing Historical Cost Compilations	Actual remediation cost data for any phase of a project may be entered into *RACER* to track actual costs.	Anytime after actual cost data is collected (preferably in a format to facilitate entering it in the system).
Remediation Budget Estimating to Support Annual Congressional Air Force Requirements	Individual site estimates are prepared using *RACER* by entering the required (and perhaps secondary) parameters. Estimates are rolled up at the project, site, MAJCOM and Air Staff Level.	Anytime from the site characterization to the long-term O&M phases. As projects moves further along, the accuracy of estimates (and therefore the budget) will increase due to better input data.

Overall Rating: Meets User Needs.

3.4. Statistical Analysis

This statistical analysis is an ancillary validation of the system and not directly tied to the accreditation. Until detailed, validated comparisons are made between budget estimates using RACER and the actual costs of the projects, it will be virtually impossible to determine the actual validity of the estimate numbers produced by RACER. Instead the reliance of this accreditation is on the inputs used to build RACER. The assumption made here is that if all of the inputs used to design RACER are developed in accordance with industry standards and the outputs are reviewed by Subject Matter Experts, then RACER meets the user's needs with any statistical data in regard to the accuracy of the system.

This statistical analysis was performed using actual cost from projects and inputting the actual site specifications into RACER to generate an estimate. Then a comparison is made between the actuals and the estimates.

Actual cost data for 53 projects were compared against RACER cost estimates for those same projects (see Appendix E). The RACER estimates and the actual cost data were submitted by a variety of state and Federal government RACER Users. The 53 projects that were submitted represent a wide range of remedial technologies, all of which are included in the RACER system. In addition, the projects involved various types of contaminants, all of which are addressed by the RACER system.

The accuracy of the RACER estimates were evaluated by calculating a variance for each project. The variance was calculated by subtracting the Actual Cost from the RACER estimate, then dividing by the Actual Cost. Several statistical metrics were calculated using the percentage variance.

An overall average variance of 3.6% was calculated by summing the variances for all 53 projects, then dividing by the number of projects. The standard deviation of the overall average variance is approximately 22%.

The average variance for projects where the RACER estimate was greater than the actual cost was calculated by summing all variances greater than zero, then dividing by the number of projects with variances greater than zero; the average positive variance is 15%.

The average variance for projects where the RACER estimate was less than the actual cost was calculated by summing all variances less than zero, then dividing by the number of projects with variances less than zero; the average negative variance is -12%.

In addition to evaluating the 53 projects as a whole, the projects were divided into groups based on dollar value. This evaluation was done to determine whether there are any trends in the accuracy of RACER as a function of project size. Each of the 53 projects was placed into one of four groups:

Group 1: > $1 Million

Group 2: $500,000 - $1 Million

Group 3: $100,000 - $500,000

Group 4: < $100,000

The overall average variance and the standard deviation on the overall average variance was calculated for each group. The statistics for the four groups are summarized in the table below.

Statistics by Project Size

Group	Average Variance	Standard Deviation
1	(3.3%)	7.9%
2	0.5%	10.5%
3	6.4%	33.5%
4	5.5%	21.1%

4.0. Conclusions And Recommendations

4.1. Conclusions

RACER meets the needs of the user. While there were some areas that could use improvement, these areas do not negatively impact the ability of *RACER* to meet the users needs.

4.2. Recommendations

Formalize overview and activity level for processes (CM). There should be a document that clearly describes the overall management process as well as each organization's role.

Define group and group members and each of their roles. The roles for each organization and person in process should be clearly documented.

Formal letter for release of software. There should be a formal release letter that authorizes the release of software to the field.

Standard format for user input. There should be a single format for user complaints, suggestions or problems. Right now there are multiple avenues to submit complaints, suggestions and problems as well as multiple formats.

Baseline for all documentation. There should be a baseline captured of all the documents relied upon for this accreditation recommendation. This will aid future accreditation efforts.

APPENDIX A: Accreditation Support Documentation

Talisman Data

1. 1997 *RACER* Government Steering Committee Meeting, August 6-7, 1997
2. *RACER* 99 Government Steering Committee, June 7-8, 1999
3. *RACER* 2000 Government Steering Committee Meeting, August 8-9, 2000
4. *RACER* 99 Cost Validation – Comments and Data, 11/16 – 11/18, 1998
5. USACE Comments and Talisman Responses for *RACER* 99 – August – November 1998
6. Meeting Notes – *RACER* Version 3.2 – User Group Workshop, April 14-17, 1997 – Englewood, CO
7. Meeting Notes – *RACER* 98 (later to be called *RACER* 99) – User Group Technical Review
8. Meeting, April 21-22, 1998 – Englewood, CO
9. Meeting Summary – *RACER* 2000 Technical Review Meeting, March 21-23, 2000 – Denver, CO
10. Tank *RACER* Meetings – 1998 – 1999
    (a) Tank *RACER* Validation #2 – December 2-3, 1998
    (b) Tank *RACER* Validation Comments
    (c) Tank *RACER* - September 14, 1998, Summaries of State Cost Run Comparisons
    (d) Tank *RACER* 98/99 Beta Validation – General Navigation/System Usability Comments
    (e) Tank *RACER* 98/99 Beta Validation – Site-Specific Comments
    (f) Tank *RACER* 98/99 – System Validation – Site Information Package
    (g) Meeting Notes – Tank *RACER* Version 1.0 – User Group Technical Workshop – October 20-22-1997, Englewood, CO
11. *RACER* 99 Bug Fixes & Features Pending Notebook – Fall 1998 – Feb 1999
12. *RACER* 99 Bug History Notebook
13. *RACER* 99 Bug Tracker Attachments Notebook
14. *RACER* 99 Talisman Internal Review Documentation Notebook
15. *RACER* 2000 New Cost Models (2 Notebooks) – Algorithms for Review
16. *RACER* 99 – Testing Comments (Books 1 and 2)
17. *RACER* 2000 Testing Rounds I – III Notebook
18. *RACER* 2001 Development Guide
19. *RACER* 2001 Bugs, Fixes & Enhancements & Testing Log Notebook
20. *RACER* 2001 Gov't Technical Review Mtg. – January 2001 - Notebook

RACER Documentation

Additional Documentation Not Contained in Notebooks

Item	Location
Complete Set of *RACER* Model Files, Documentation, Assumptions, Background	Lateral Files in Environmental Area
RACER Software Tracker – Customer, Helpline, Training	Talisman Network
RACER Software Resources (Configuration Management, Procedures, Code, Etc.)	In Software Section of Office, and on Software Development Server

Letters from Subject Matter Experts:

Kate Petterson

Stuart Millard

APPENDIX B: Definitions and Abbreviations

Definitions

In order to assist the reader in further evaluation of this document, the following definitions regarding VV&A are provided:

Verification is the process of determining that a draft or fielded model and any resultant simulation accurately represent what was required to be built.

Validation is the process of ensuring that a model and any resultant simulation conforms to a specified level of accuracy when its outputs are compared to some aspect of the real world.

Accreditation is the official certification that a model or simulation is acceptable for use for a specific application.

A *model* is a conceptualization of some physical phenomenon or process into mathematical equations and solution approaches, called algorithms, each with its own assumptions, limitations, and approximations.

A *simulation* is a software framework that executes models in the proper order, provides timing and coordination between them through associated logic control, and controls inputs and outputs as a function of time.

APPENDIX C: Risk Assessment Guidelines

Impact Categories	Level of Impact			
	Catastrophic	Critical	Marginal	Negligible
Cost	Loss of Program Funds; 100% Cost Growth	Funds Reduction; 50% to 100% Cost Growth	20% to 50% Cost Growth	<20% Cost Growth
Political	National or International (Watergate)	Significant (Tailhook '91)	Embarrassment ($200 Hammer)- Congressional Oversight	Local
Human/Health and Exposure	Death	Severe Injury	Minor Injury	Less Than Minor Injury
Environment Damage	Severe (Chernobyl)	Major (Love Canal)	Minor	Some Trivial

Probability Description	Likely Occurrence over lifetime of an item	Likely Occurrence per number of items
Frequent	Likely to Occur Frequently	Widely Experienced
Probable	Will occur several times in life of item	Will Occur Frequently
Occasional	Likely to Occur Some time in life of item	Will Occur Several times
Remote	Unlikely but possible to occur in life of item	Unlikely but can be reasonably expected to occur
Improbable	So unlikely, it may be assumed occurrence may not be experienced	Unlikely to occur but possible

Probability	Level of Impact			
	Catastrophic	Critical	Marginal	Negligible
Frequent	High	High	Medium	Low
Probable	High	High	Medium	Low
Occasional	Medium	Medium	Medium	Low
Remote	Medium	Medium	Low	Low
Improbable	Medium	Low	Low	Low

Each one of these impact categories is rated as negligible.

Required Accreditation Credibility Level

V&V Information Elements	Required Credibility Level		
	Nominal	Better	High
C/M Baseline Definition	X	X	X
M&S Documentation Assessment	X	X	X
VV&A and Usage History	X	X	X
S/W Quality Assessment			X
List of Assumptions & Limits	X	X	X
Design Documentation		X	X
Logical Verification		X	X
Sensitivity Analysis		X	X
Face Validation		X	
Input Data VV&C		X	X
Results Validation			X
Detailed Code Verification			X

APPENDIX D: System Documentation Checklist Description

Software Users Manual

Logical components of the software, from the user's point of view, and an overview of the purpose/operation of each component.

Relationship of the functions performed by the software with interfacing systems, organizations, or positions.

Security and privacy. An overview of the security and privacy considerations associated with the software.

Assistance and problem reporting. Identify points of contact and procedures to be followed to obtain assistance and report problems encountered in using the software.

Processing reference guide. Procedures for using the software.

Capabilities. Description of the interrelationships of the transactions, menus, functions, or other processes in order to provide an overview of the use of the software.

Conventions. Description of any conventions used by the software, such as the use of colors in displays, the use of audible alarms, the use of abbreviated vocabulary, and the use of rules for assigning names or codes.

Data backup. Description of procedures for creating and retaining backup data that can be used to replace primary copies of data in event of errors, defects, malfunctions, or accidents.

Quick-reference guide. Provide or reference a quick-reference card or page for using the software. This quick-reference guide shall summarize, as applicable, frequently used function keys, control sequences, formats, commands, or other aspects of software use.

Software Development Plan (SDP)

Software development methods. Description or reference of the software development methods to be used. Included shall be descriptions of the manual and automated tools and procedures to be used in support of these methods. The methods shall cover all contractual clauses concerning this topic.

Standards for software products. Description or reference of the standards to be followed for representing requirements, design, code, test cases, test procedures, and test results. The standards shall cover all contractual clauses concerning this topic. Reference may be made to other paragraphs in this plan if the standards are better described in context with the activities to which they will be applied. Standards for code shall be provided for each programming language to be used. They shall include at a minimum:

a. Standards for format (such as indentation, spacing, capitalization, and order of information)
b. Standards for header comments (requiring, for example, name/identifier of the code; version identification; modification history; purpose; requirements and design decisions implemented; notes on the processing (such as algorithms used, assumptions, constraints, limitations, and side effects); and notes on the data (inputs, outputs, variables, data structures, etc.)
c. Standards for other comments (such as required number and content expectations)
d. Naming conventions for variables, parameters, packages, procedures, files, etc.

e. Restrictions, if any, on the use of programming language constructs or features

f. Restrictions, if any, on the complexity of code aggregates

System requirements analysis. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for participating in system requirements analysis. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Analysis of user input
- Operational concept
- System requirements

System design. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for participating in system design. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- System-wide design decisions
- System architectural design

Software requirements analysis. This paragraph shall describe the approach to be followed for software requirements analysis. The approach shall cover all contractual clauses concerning this topic.

Software design. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for software design. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- CSCI-wide design decisions
- CSCI architectural design
- CSCI detailed design

Software implementation and unit testing. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for software implementation and unit testing. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Software implementation
- Preparing for unit testing
- Performing unit testing
- Revision and re-testing
- Analyzing and recording unit test results

Unit integration and testing. This paragraph shall be divided into the following sub-paragraphs to describe the approach to be followed for unit integration and testing. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Preparing for unit integration and testing
- Performing unit integration and testing
- Revision and re-testing
- Analyzing and recording unit integration and test results

Software configuration management. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for software configuration management. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Configuration identification
- Configuration control
- Configuration status accounting
- Configuration audits
- Packaging, storage, handling, and delivery

Software quality assurance. This paragraph shall be divided into the following sub-paragraphs to describe the approach to be followed for software quality assurance. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Software quality assurance evaluations
- Software quality assurance records, including items to be recorded
- Independence in software quality assurance

Corrective action. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for corrective action. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

Problem/change reports, including items to be recorded. (Candidate items include: Project name, originator, problem number, problem name, software element or document affected, origination date, category and priority, description, analyst assigned to the problem, date assigned, date completed, analysis time, recommended solution, impacts, problem status, approval of solution, follow-up actions, corrector, correction date, version where corrected, correction time, and description of solution implemented).

Joint technical and management reviews. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for joint technical and management reviews. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

- Joint technical reviews, including a proposed set of reviews
- Joint management reviews, including a proposed set of reviews

Other software development activities. This paragraph shall be divided into the following subparagraphs to describe the approach to be followed for other software development activities. The planning in each subparagraph shall cover all contractual clauses regarding the identified topic.

Risk management, including known risks and corresponding strategies

Software Design Document

Concept of execution. This paragraph shall describe the concept of execution among the software units. It shall include diagrams and descriptions showing the dynamic relationship of the software units. That is, how they will interact during CSCI operation. Including, as applicable, flow of execution control, data flow, dynamically controlled sequencing, state transition diagrams, timing diagrams, priorities among units, handling of interrupts, timing/sequencing relationships, exception handling, concurrent execution,

dynamic allocation/de-allocation, dynamic creation/deletion of objects, processes, tasks, and other aspects of dynamic behavior.

Interface design. This paragraph shall be divided into the following subparagraphs to describe the interface characteristics of the software units. It shall include both interfaces among the software units and their interfaces with external entities such as systems, configuration items, and users. If part or all of this information is contained in Interface Design Descriptions (IDDs), in section 5 of the SDD, or elsewhere, these sources may be referenced.

Interface identification and diagrams. This paragraph shall state the project-unique identifier assigned to each interface and shall identify the interfacing entities (software units, systems, configuration items, users, etc.) by name, number, version, and documentation references, as applicable. The identification shall state which entities have fixed interface characteristics (and therefore impose interface requirements on interfacing entities) and which are being developed or modified (thus having interface requirements imposed on them). One or more interface diagrams shall be provided, as appropriate, to depict the interfaces.

Operational Concept Description (OCD)

Background, objectives and scope. This paragraph shall describe the background, mission or objectives, and scope of the current system or situation.

Operational policies and constraints. This paragraph shall describe any operational policies and constraints that apply to the current system or situation.

Description of current system or situation. This paragraph shall provide a description of the current system or situation, identifying differences associated with different states or modes of operation (for example, regular, maintenance, training, degraded, emergency, alternative-site, wartime, and peacetime). The distinction between states and modes is arbitrary.

A system may be described in terms of states only, modes only, states within modes, modes within states, or any other scheme that is useful. If the system operates without states or modes, this paragraph shall so state, without the need to create artificial distinctions. The description shall include, as applicable:

a. The operational environment and its characteristics
b. Major system components and the interconnections among these components
c. Interfaces to external systems or procedures
d. Capabilities/functions of the current system
e. Charts and accompanying descriptions depicting inputs, outputs, data flow, and manual and automated processes sufficient to understand the current system or situation from the user's point of view
f. Performance characteristics, such as speed, throughput, volume, frequency
g. Quality attributes, such as reliability, maintain ability, availability, flexibility, portability, usability, and efficiency
h. Provisions for safety, security, privacy, and continuity of operations in emergencies

Users or involved personnel. This paragraph shall describe the types of users of the system, or personnel involved in the current situation, including, as applicable, organizational structures, training/skills, responsibilities, activities, and interactions with one another.

Support concept. This paragraph shall provide an overview of the support concept for the current system, including, as applicable to this document, support agency(ies); facilities; equipment; support software; repair/replacement criteria; maintenance levels and cycles; and storage, distribution, and supply methods.

Justification for and nature of changes. This section shall be divided into the following paragraphs.

Justification for change. This paragraph shall:

a. Describe new or modified aspects of user needs, threats, missions, objectives, environments, interfaces, personnel or other factors that require a new or modified system

b. Summarize deficiencies or limitations in the current system or situation that make it unable to respond to these factors

Description of needed changes. This paragraph shall summarize new or modified capabilities/functions, processes, inter faces, or other changes needed to respond to the factors identified in 4.1.

Operational scenarios. This section shall describe one or more operational scenarios that illustrate the role of the new or modified system, its interaction with users, its interface to other systems, and all states or modes identified for the system. The scenarios shall include events, actions, stimuli, information, interactions, etc., as applicable. Reference may be made to other media, such as videos, to provide part or all of this information.

Analysis of the proposed system.

Summary of advantages. This paragraph shall provide a qualitative and quantitative summary of the advantages to be obtained from the new or modified system. This summary shall include new capabilities, enhanced capabilities, and improved performance, as applicable, and their relationship to deficiencies identified in 4.1.

Summary of disadvantages/limitations. This paragraph shall provide a qualitative and quantitative summary of disadvantages or limitations of the new or modified system. These disadvantages and limitations shall include, as applicable, degraded or missing capabilities, degraded or less-than-desired performance, greater-than-desired use of computer hardware resources, undesirable operational impacts, conflicts with user assumptions, and other constraints.

Alternatives and tradeoffs considered. This paragraph shall identify and describe major alternatives considered to the system or its characteristics, the tradeoffs among them, and rationale for the decisions reached.

APPENDIX E: Statistical Analysis

RACER Validation
6-Jun-01

Ref #	Date of Evaluation	System	Evaluator	Site Name	Phase	Technologies Used	Actual Costs	RACER Costs	Variance	
DOE-3	Apr 01	TR2000	Ratzer/DOE AL	LANL EC Area			$ 1,872,484	$ 1,901,326	2%	0.02
CA-1	Apr 01	TR99	Sotelo/CA	Unknown	RA		$ 1,500,000	$ 1,550,000	3%	0.03
DOE-1	Apr 01	TR2000	Ratzer/DOE AL	LANL SE Area			$ 1,420,513	$ 1,330,161	-6%	-0.06
OK-18	Dec-99	TR99	McKay/OK	064-287/1252			$ 1,379,591	$ 1,390,204	1%	0.01
DOE-2	Apr 01	TR2000	Ratzer/DOE AL	LANL SW Area			$ 1,360,618	$ 1,144,703	-16%	-0.16
OK-14	Dec-99	TR99	McKay/OK	064-1395			$ 826,368	$ 830,000	0%	0.00
OK-21	Dec-99	TR99	McKay/OK	064-1305			$ 673,844	$ 748,000	11%	0.11
OK-16	Dec-99	TR99	McKay/OK	064-1714			$ 630,745	$ 667,500	6%	0.06
FL-1	Sep-98	TR98	Abbott/FL	Quincy/Cluster	RAC		$ 620,137	$ 549,417	-11%	-0.11
OK-9	Dec-99	TR99	McKay/OK	064-871			$ 599,925	$ 606,622	1%	0.01
AF-1	Nov-98	TR98	Dunkle/AFCEE	NAS FW JRB	RFI	GMW, RFI	$ 596,000	$ 455,000	-24%	-0.24
OK-20	Dec-99	TR99	McKay/OK	064-1504			$ 594,560	$ 641,000	8%	0.08
OK-13	Dec-99	TR99	McKay/OK	064-1789			$ 559,563	$ 548,000	-2%	-0.02
OK-8	Dec-99	TR98	McKay/OK	064-284			$ 551,911	$ 534,820	-3%	-0.03
OK-23	Dec-00	TR2000	McKay/OK	064-556			$ 535,400	$ 633,536	18%	0.18
OK-12	Dec-99	TR99	McKay/OK	064-1492			$ 533,753	$ 519,320	-3%	-0.03
OK-11	Dec-99	TR99	McKay/OK	064-7962			$ 514,490	$ 550,000	7%	0.07
OK-19	Dec-99	TR99	McKay/OK	064-603			$ 503,268	$ 495,500	-2%	-0.02
OK-10	Dec-99	TR98	McKay/OK	064-1381			$ 490,692	$ 501,700	2%	0.02
OK-15	Dec-99	TR99	McKay/OK	064-1028			$ 431,619	$ 436,470	1%	0.01
OK-24	Dec-00	TR2000	McKay/OK	064-1177			$ 379,556	$ 467,661	23%	0.23
OK-17	Dec-99	TR99	McKay/OK	064-133/523			$ 376,973	$ 404,100	7%	0.07
OK-6	Dec-98	TR98	McKay/OK	064-1787	O&M	OMS	$ 318,260	$ 102,283	-68%	-0.68
OK-22	Dec-00	TR2000	McKay/OK	064-1922			$ 313,158	$ 299,648	-4%	-0.04
AF-4	Apr 01	R 2001	Noble/AETC	Keesler AFB OT-9	RD/RA	DEC, DEP, EXC, PLM,	$ 277,178	$ 288,093	4%	0.04
OK-5	Dec-98	TR98	McKay/OK	064-1787	RA	AIR, ASP, SVE, PLM, F	$ 229,240	$ 222,565	-3%	-0.03
AF-2	Nov-98	TR98	Dunkle/AFCEE	NAS FW JRB	LTM	GWM	$ 222,000	$ 250,000	13%	0.13
GA-4	Sep-98	TR98	Babb/GA	Delisle Gulf	RA	ASP, SVE	$ 169,356	$ 266,261	57%	0.57
OK-2	Dec-98	TR98	McKay/OK	064-517	LAH	EXC, LAH, PLM	$ 164,688	$ 138,811	-16%	-0.16
OK-3	Dec-98	TR98	McKay/OK	064-517 with OK rates	LAH	EXC, LAH, PLM	$ 164,688	$ 159,186	-3%	-0.03
SD-1	Dec-98	TR98	Lindholm/SD	Casey's General Store	3	SVE, ASP, RMD, TCH	$ 122,788	$ 118,903	-3%	-0.03
AF-6	Apr 01	R 2001	Noble/AETC	Sheppard AFB FT-03	CMS/FS	MON	$ 104,356	$ 186,355	79%	0.79
SD-4	Sep-98	TR98	Lindholm/SD	Food-N-Fuel	RA	ASP, SVE, PLM	$ 76,999	$ 75,656	-2%	-0.02
AF-3	Nov-98	TR98	Dunkle/AFCEE	Key Field Ang	SI	RFI	$ 67,000	$ 63,000	-6%	-0.06
GA-7	Dec-98	TR98	GA	Flash Foods #208	Study	GWM, SUS	$ 61,513	$ 68,952	12%	0.12
GA-5	Sep-98	TR98	Manning/GA	Smile Gas #18	RA	GWM	$ 52,685	$ 58,043	10%	0.10
OK-4	Dec-98	TR98	McKay/OK	064-1787		UST	$ 48,149	$ 40,700	-15%	-0.15
OK-1	Dec-98	TR98	McKay/OK	064-1733	SUS	UST	$ 46,362	$ 45,137	-3%	-0.03
AF-5	Apr 01	R 2001	Noble/AETC	Keesler AFB LF-04	RA-O	GMW	$ 43,846	$ 51,392	17%	0.17

Public/Environmental/ENV Consulting Projects/RACER \WA/ RACER Actual Project Validation.xls

KY-1	Sep-98	TR98	Wilhoite/KY	Scot Market #75	RA	Excavation	$	35,557	$ 35,779	1%	0.01
SD-2	Dec-98	TR98	Lindholm/SD	Jack's Sinclair		SVE	$	34,370	$ 19,308	-44%	-0.44
GA-8	Dec-98	TR98	GA	Swifty Mart #272	Study	GWM, SUS	$	33,446	$ 39,205	17%	0.17
GA-2	Sep-98	TR98	Babb/GA	Poole Hardware	RA	UST, EXC, LAH	$	28,502	$ 21,205	-26%	-0.26
GA-1	Sep-98	TR98	Babb/GA	Poole Hardware	Study	GWM, RAW	$	24,787	$ 26,757	8%	0.08
KY-1	Sep-98	TR98	Wilhoite/KY	Scot Market #75	RA	Professional Labor Mng	$	20,875	$ 24,435	17%	0.17
SD-5	Sep-98	TR98	Lindholm/SD	Food-N-Fuel	OPM	OPM	$	19,348	$ 23,284	20%	0.20
OK-7	Dec-98	TR98	McKay/OK	084-1037	UST	UST	$	18,634	$ 21,907	18%	0.18
GA-6	Sep-98	TR98	Manning/GA	Golden Pantry		ASP, GWM, SNA	$	18,267	$ 22,861	25%	0.25
KY-2	Sep-98	TR98	Wilhoite/KY	Fayette/Broch McVey	GWM		$	14,813	$ 19,048	29%	0.29
GA-9	Dec-98	TR98	GA	Hawsin Texaco	Study	GWM, SUS	$	13,186	$ 19,181	45%	0.45
GA-3	Sep-98	TR98	Babb/GA	Poole Hardware	MON	GWM, MON	$	12,340	$ 13,628	10%	0.10
FL-2	Sep-98	TR98	Abbott/FL	Shell Station	O&M		$	10,184	$ 11,172	10%	0.10
SD-3	Dec-98	TR98	Lindholm/SD	Wall Auto Livery	MON	MON	$	7,101	$ 4,856	-32%	-0.32
						Mean:	**$**	**372,541**	**$ 371,184**		
						Mean of Variance:				**3.62%**	
						ESD of Variance:				**22.17%**	
						TSD of Variance:				**22.38%**	
						Positive Mean:				**15%**	
						Negative Mean:				**-12%**	

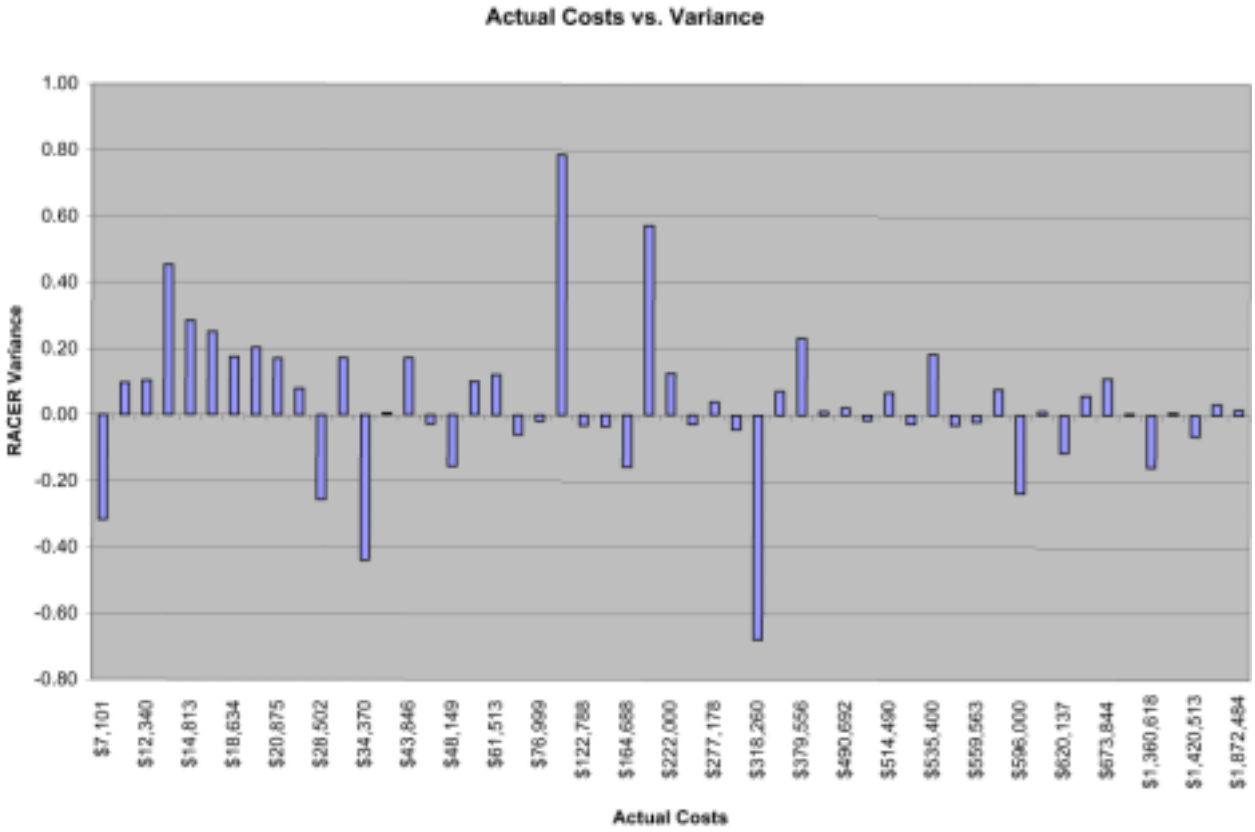
Public/Environmental/ENV Consulting Projects/RACER VVA/ RACER Actual Project Validation.xls

RACER Validation
8-Jun-01

>1MIL										Variance		
Ref #	Date of Evaluation	System	Evaluator	Site Name	Phone	Technologies Used	Actual Costs	RACER Costs	Difference	Absolute	Percentage	Absolute %
DOE-3	Apr 01	TR2000	Ratzer/DOE AL	LANL EC Area			$ 1,672,484	$ 1,901,326	$ (28,842)	$ 28,842	2%	2%
CA-1	Apr 01	TR99	Sotelo/CA	Unknown	RA		$ 1,500,000	$ 1,550,000	$ (50,000)	$ 50,000	3%	3%
DOE-1	Apr 01	TR2000	Ratzer/DOE AL	LANL SE Area			$ 1,420,513	$ 1,330,161	$ 90,352	$ 90,352	-6%	6%
OK-18	Dec-99	TR99	McKay/OK	064-287/1252			$ 1,379,591	$ 1,390,204	$ (10,613)	$ 10,613	1%	1%
DOE-2	Apr 01	TR2000	Ratzer/DOE AL	LANL SW Area			$ 1,360,618	$ 1,144,703	$ 215,915	$ 215,915	-16%	16%
						Mean:	**$ 1,506,641**	**$ 1,463,279**			**-3.32%**	**5.57%**
						Variance:	**-2.88%**					
500K-1M						**SD of Variance:**					**7.83%**	**6.14%**
OK-14	Dec-99	TR99	McKay/OK	064-1395			$ 826,368	$ 830,000	$ (3,632)	$ 3,632	0%	0%
OK-21	Dec-99	TR99	McKay/OK	064-1305			$ 673,844	$ 748,000	$ (74,156)	$ 74,156	11%	11%
OK-16	Dec-99	TR99	McKay/OK	064-1714			$ 630,745	$ 667,500	$ (36,755)	$ 36,755	6%	6%
FL-1	Sep-98	TR98	Abbott/FL	Quincy/Cluster	RAC		$ 620,137	$ 549,417	$ 70,720	$ 70,720	-11%	11%
OK-9	Dec-99	TR99	McKay/OK	064-871			$ 599,925	$ 606,622	$ (6,697)	$ 6,697	1%	1%
AF-1	Nov-98	TR98	Dunkle/AFCEE	NAS FW JRB	RFI	GMW, RFI	$ 596,000	$ 455,000	$ 141,000	$ 141,000	-24%	24%
OK-20	Dec-99	TR99	McKay/OK	064-1504			$ 594,560	$ 641,000	$ (46,440)	$ 46,440	8%	8%
OK-13	Dec-99	TR99	McKay/OK	064-1789			$ 559,563	$ 548,000	$ 11,563	$ 11,563	-2%	2%
OK-8	Dec-99	TR98	McKay/OK	064-264			$ 551,911	$ 534,820	$ 17,091	$ 17,091	-3%	3%
OK-23	Dec-00	TR2000	McKay/OK	064-556			$ 535,400	$ 633,536	$ (98,136)	$ 98,136	18%	18%
OK-12	Dec-99	TR99	McKay/OK	064-1492			$ 533,753	$ 519,320	$ 14,433	$ 14,433	-3%	3%
OK-11	Dec-99	TR99	McKay/OK	064-7962			$ 514,490	$ 550,000	$ (35,510)	$ 35,510	7%	7%
OK-19	Dec-99	TR99	McKay/OK	064-603			$ 503,268	$ 495,500	$ 7,768	$ 7,768	-2%	2%
						Mean:	**$ 595,382**	**$ 598,363**			**0.54%**	**7.38%**
						Variance:	**0.50%**					
100K-500K						**SD of Variance:**	**0.18**				**10.45%**	**7.11%**
OK-10	Dec-99	TR98	McKay/OK	064-1381			$ 490,692	$ 501,700	$ (11,008)	$ 11,008	2%	2%
OK-15	Dec-99	TR99	McKay/OK	064-1028			$ 431,619	$ 436,470	$ (4,851)	$ 4,851	1%	1%
OK-24	Dec-00	TR2000	McKay/OK	064-1177			$ 379,556	$ 467,661	$ (88,105)	$ 88,105	23%	23%
OK-17	Dec-99	TR99	McKay/OK	064-133/523			$ 376,973	$ 404,100	$ (27,127)	$ 27,127	7%	7%
OK-6	Dec-98	TR98	McKay/OK	064-1787	D&M	O&S	$ 318,260	$ 102,283	$ 215,977	$ 215,977	-68%	68%
OK-22	Dec-00	TR2000	McKay/OK	064-1922			$ 313,158	$ 299,648	$ 13,510	$ 13,510	-4%	4%
AF-4	Apr 01	R 2001	Noble/AETC	Keesler AFB OT-9	RD/RA	DEC, DEP, EXC, PLM, L	$ 277,178	$ 288,093	$ (10,915)	$ 10,915	4%	4%
OK-5	Dec-98	TR98	McKay/OK	064-1787	RA	AIR, ASP, SVE, PLM, FE	$ 229,240	$ 222,665	$ 6,575	$ 6,575	-3%	3%
AF-2	Nov-98	TR98	Dunkle/AFCEE	NAS FW JRB	LTM	GWM	$ 222,000	$ 250,000	$ (28,000)	$ 28,000	13%	13%
GA-4	Sep-98	TR98	Babb/GA	Delsle Gulf	RA	ASP, SVE	$ 188,356	$ 296,261	$ (107,905)	$ 107,905	57%	57%
OK-2	Dec-98	TR98	McKay/OK	064-517	LAH	EXC, LAH, PLM	$ 164,688	$ 138,811	$ 25,877	$ 25,877	-16%	16%
OK-3	Dec-98	TR98	McKay/OK	064-517 with OK cat	LAH	EXC, LAH, PLM	$ 164,688	$ 159,188	$ 5,502	$ 5,502	-3%	3%
SD-1	Dec-98	TR98	Lindholm/SD	Casey's General Sto	3	SVE, ASP, RMD, TCH	$ 122,768	$ 118,903	$ 3,885	$ 3,885	-3%	3%
AF-6	Apr 01	R 2001	Noble/AETC	Sheppard AFB FT-02	MS/FS	MON	$ 104,356	$ 186,355	$ (81,999)	$ 81,999	79%	79%
						Mean:	**$ 270,254**	**$ 276,581**			**6.35%**	**20.25%**
						Variance:	**2.34%**					
<100K						**SD of Variance:**	**0.33**				**33.47%**	**26.87%**

SD-4	Sep-98 TR98	Lindholm/SD	Food-N-Fuel	RA	ASP, SVE, PLM	$ 76,999	$ 75,656	$ 1,343	$ 1,343	-2%	2%
AF-3	Nov-98 TR98	Dunkle/AFCEE	Key Field Ang	SI	RFI	$ 67,000	$ 63,000	$ 4,000	$ 4,000	-6%	6%
GA-7	Dec-98 TR98	GA	Flash Foods #208	Study	GWM, SUS	$ 61,513	$ 68,952	$ (7,439)	$ 7,439	12%	12%
GA-5	Sep-98 TR98	Manning/GA	Smile Gas #16	RA	GWM	$ 52,685	$ 58,043	$ (5,358)	$ 5,358	10%	10%
OK-4	Dec-98 TR98	McKay/OK	064-1787		UST	$ 46,149	$ 40,700	$ 7,449	$ 7,449	-15%	15%
OK-1	Dec-98 TR98	McKay/OK	064-1733	SUS	UST	$ 46,382	$ 45,137	$ 1,225	$ 1,225	-3%	3%
AF-5	Apr 01 R 2001	Noble/AETC	Keesler AFB LF-04	RA-O	GMW	$ 43,846	$ 51,392	$ (7,546)	$ 7,546	17%	17%
KY-1	Sep-98 TR98	Wilhoite/KY	Scot Market #75	RA	Excavation	$ 35,557	$ 35,779	$ (222)	$ 222	1%	1%
SD-2	Dec-98 TR98	Lindholm/SD	Jack's Sinclair		SVE	$ 34,370	$ 19,308	$ 15,062	$ 15,062	-44%	44%
GA-8	Dec-98 TR98	GA	Swifty Mart #272	Study	GWM, SUS	$ 33,446	$ 39,205	$ (5,759)	$ 5,759	17%	17%
GA-2	Sep-98 TR98	Babb/GA	Poole Hardware	RA	UST, EXC, LAH	$ 28,502	$ 21,205	$ 7,297	$ 7,297	-26%	26%
GA-1	Sep-98 TR98	Babb/GA	Poole Hardware	Study	GWM, RAW	$ 24,787	$ 26,757	$ (1,970)	$ 1,970	8%	8%
KY-1	Sep-98 TR98	Wilhoite/KY	Scot Market #75	RA	Professional Labor Mng.	$ 20,875	$ 24,435	$ (3,560)	$ 3,560	17%	17%
SD-5	Sep-98 TR98	Lindholm/SD	Food-N-Fuel	OPM	OPM	$ 19,348	$ 23,284	$ (3,936)	$ 3,936	20%	20%
OK-7	Dec-98 TR98	McKay/OK	064-1037	UST	UST	$ 18,634	$ 21,907	$ (3,273)	$ 3,273	18%	18%
GA-6	Sep-98 TR98	Manning/GA	Golden Pantry		ASP, GWM, SNA	$ 18,267	$ 22,861	$ (4,594)	$ 4,594	25%	25%
KY-2	Sep-98 TR98	Wilhoite/KY	Fayette/Broch McVe	GWM		$ 14,813	$ 19,048	$ (4,235)	$ 4,235	29%	29%
GA-9	Dec-98 TR98	GA	Hawsin Texaco	Study	GWM, SUS	$ 13,186	$ 19,181	$ (5,995)	$ 5,995	45%	45%
GA-3	Sep-98 TR98	Babb/GA	Poole Hardware	MON	GWM, MON	$ 12,340	$ 13,628	$ (1,288)	$ 1,288	10%	10%
FL-2	Sep-98 TR98	Abbott/FL	Shell Station	O&M		$ 10,184	$ 11,172	$ (988)	$ 988	10%	10%
SD-3	Dec-98 TR98	Lindholm/SD	Wall Auto Livery	MON	MON	$ 7,101	$ 4,856	$ 2,245	$ 2,245	-32%	32%
					Mean:	**$ 32,760**	**$ 33,596**			**5.37%**	**17.45%**
					Variance:	**2.55%**					
					SD of Variance:	**0.21**				**21.09%**	**12.46%**

Variance Chart



APPENDIX F: References

Air Force Instruction (AFI) 16.1001 – Verification, Validation and Accrediation (VV&A), June 1, 1996.

Department of Defense Directive (DoDD) 5000.59: DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation, January 1994.

Department of Defense DoD Instruction 5000.61 – DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), April 29, 1996.

Department of the Navy, "Modeling and Simulation Verification, Validation and Accreditation Implementation Handbook", February 1999.

Department of the Navy, Modeling and Simulation Verification, Validation and Accreditation Implementation Appendices Handbook," November 2000.

DMSO Verification, Validation and Accreditation Report Templates (Draft Version)

DMSO's DoD VV&A Recommended Practice Guide.

DMSO's DoD VV&A Recommended Practice Guide: "Build 2 Beta Draft Version of The Accreditation Agent Role in the VV&A of Legacy Simulation," February 2001.

DMSO's DoD VV&A Recommended Practice Guide: "Build 2 Beta Draft Version of The V&V Agent Role in the VV&A of Legacy Simulation," February 2001.

Dr. Paul R. Muessig and Mr. Dennis R. Laack. Presentation: "Minimizing the Cost of Simulation Credibility: A Common Sense Approach to VV&A," July 14, 1998.

Dr. Paul R. Muessig. Presentation: "Collecting and Refining V&V Data," July 14, 1998.

Dr. Paul R. Muessig. Presentation: "Key Ideas and Lessons Learned," July 31, 1998.

Dr. Paul R. Muessig. Presentation: "Turning "V&V" Into "A"," July 31, 1998.

Dr. Paul R. Muessig. Presentation: "VV&A Planning: Laying the Foundation," July 14, 1998.

ENTEK/ABQ-92-0115-TR: "Software Verification Requirements Study for the SMART Project," June 26, 1992.

ENTEK/ABQ-93-0144-TR: "Documentation Assessment Report for ESAMS, ALARM, and RADGUNS," December 23, 1993.

JTCG/AS-93-SM-20: "A Comparative Analysis of Tri-Service Accreditation Policies and Practices Volume I," February 1994.

JTCG/AS-93-SM-20: "A Comparative Analysis of Tri-Service Accreditation Policies and Practices Volume II," February 1994.

JTCG/AS-95-M-005: "Configuration Management Requirements Study," January 1995.

JTCG/AS-97-M-008: "V&V From A to Z," March 1997.

JTCG/AS-97-M-009: "How to VV&A without really trying," November 1997.

Marcy Stutzman – Logicon N6M Support, Navy M&S Office, reviewed the final paper and provided guidance throughout the VV&A process.

Simone Youngblood, Defense Modeling and Simulation Office, aided in the development of the VV&A approach.

White Paper: Report of the Verification, Validation and Certification (VV&C) Tiger Team, June 4, 1998.