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United States Government **Department of Energy**

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Office of River Protection

DATE: MAR 0 8 2006

REPLY TO ATTN OF: WED:MLR 06-WED-014

SUBJECT: REPORT OF THE TECHNICAL EVALUATION OF THE SIMULATOR PROCESS MODEL (SOFTWARE) AND THE SIMULATOR FACILITY (D-06-DESIGN-024)

TO: John R. Eschenberg, Project Manager
Waste Treatment and Immobilization
Plant Project (WTP)

Attached is the Design Product Oversight Report of the technical evaluation performed on the Simulator Process Model (software) and the Simulator Facility. The technical evaluation was performed in association with the following WTP Contract Milestone:

Schedule Activity ID 2CBP110400
Description: Complete the process model (software) for use in the Simulator Facility following substantial completion of the Simulator Facility.

As reported, the process model adequately replicates the WTP systems and processes as the plant was designed and configured generally through June 2004. The model satisfies high-level technical requirements and, to the extent evaluated, also meets specific user and model requirements. A configuration management process is in place for controlled updates and changes to the model. All work identified to meet the milestone above has been accomplished and the Simulator Facility construction is complete. The building is currently occupied. No findings or open items or concern were identified in the technical evaluation.

Bill Hamel, Director
WTP Engineering Division

Attachment

Attachment
06-WED-014

Review of Training Simulator Process Model (Software) and the Simulator Facility

Design Oversight: D-06-DESIGN-024

WED:MLR
March 6, 2006

DESIGN PRODUCT OVERSIGHT REPORT

REVIEW OF TRAINING SIMULATOR PROCESS MODEL (SOFTWARE) AND THE SIMULATOR FACILITY

February 21, 2006

Design Oversight: D-06-DESIGN-024

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Table of Contents

Executive Summary 3
Introduction 4
Objectives 5
Evaluation Approach 5
Overview 6
Software Development 8
Requirements 10
Documentation 12
Testing, Verification and Validation 14
Configuration Management 15
Completion of Milestone Schedule Activities 26
Appendix A - Contractor's Milestone Completion Letter 28
Appendix B - Focus Areas and Lines of Inquiry 30
Appendix C - High Level Requirements for Simulator 32
Appendix D - Technical Questions Not Addressed 34

Executive Summary

In February 2006, a technical evaluation was performed on Contractor product deliverables associated with the following Waste Treatment and Immobilization Plant (WTP) Contract Construction Milestone:

Schedule Activity ID 2CBP110400
Description: Complete the process model (software) for use in the Simulator Facility following substantial completion of the Simulator Facility

The primary deliverables that were the subject of this evaluation were:

- The process model software; and
- The Simulator Facility building.

A substantial contract schedule performance incentive fee is associated with the completion of this milestone. However, the evaluation described herein addresses only the technical merits of the milestone deliverables.

The evaluation focused on process model requirements, documentation, the software development process, testing, verification and validation, configuration management, and system checkout. Also, the simulator building was evaluated in terms of the extent of completion.

The evaluation team conducted walkthroughs, observed model and simulation system development demonstrations, attended tours and meetings, reviewed documentation and performed interviews.

The team consensus for this evaluation may be summarized as follows:

- The process model adequately replicates the WTP systems and processes as the plant was designed and configured through June 2004. In addition, the 3D plant model replicates the physical plant design through May 2005, and the Glass Former Reagent (GFR) system and the Autosampling system replicates the plant design through August 2005. Updates to the model will continue in 2006 to incorporate recent design changes in order to bring the model up-to-date with the WTP design.

- The model is consistent with high-level requirements, satisfies well-defined user requirements, and should be a useful tool for providing future training and instruction to control room personnel after the control system emulators have been developed and integrated with the model.

- Configuration Management processes and procedures are in place to maintain the model software and to control model software changes as required in order to maintain consistency with the evolving WTP design process. The process has recently been applied for the removal of concentrate receipt vessels (CRV) from the HLW Concentrate Receipt Process System (HCP) in December 2005. The effectiveness of the CM process as it will be applied to other changes (since the model freeze date) remains to be evaluated.

- All scheduled work activities related to the milestone have been completed and Contractor execution of the milestone work was generally as planned.

- The Simulator building construction is complete; meets Contract requirements, and utility systems have been tested. The facility is currently occupied.

Findings or Open Items of Concern: None were identified in this evaluation.

Introduction

The following report documents the observations and conclusions of an evaluation performed in February 2006, of the WTP Simulator Process Model. The evaluation was made in the course of assessing the WTP Contractor's submittal of contract deliverables associated with completion of the following WTP Contract Construction Milestone:

Schedule Activity ID 2CBP110400
Description: Complete the process model (software) for use in the Simulator Facility following substantial completion of the Simulator Facility

On January 6, 2006, Bechtel National Inc. (BNI) submitted correspondence to the U.S. Department of Energy (DOE), Office of River Protection (ORP) announcing accomplishment of the construction completion milestone described above. (Appendix A) Completion of the milestone was stated in terms of status of the simulator process model and simulator facility as follows:

Simulator Process Model (Software)

- Software depicting the baseline (June 2004) snapshot of the plant's process system design has been developed, tested, and issued under configuration control.
- Software has been loaded on permanent simulation hardware and is functional.
- Simulation software and hardware are ready for integration with simulator facility control rooms (instruction stations and future emulators / process control software).
- Model software and hardware are free from any known deficiencies affecting model software or hardware performance.

Simulator Facility

- The Simulator Facility consists of training areas representing the Pretreatment Main Control Room, Low Activity Waste Facility Control Room, High-Level Waste Facility Control Room, and associated Crane Control Rooms.
- The facility has been approved for personnel occupancy and currently houses the simulator model development personnel.
- The facility environmental controls support continuous operation of process model hardware.

- Building subcontractor's work and documentation is complete with no open/outstanding findings or actions affecting use of the facility.

A substantial contract schedule performance incentive fee is associated with the completion of this milestone. The evaluation described herein addresses only the technical merits of the milestone deliverables.

Objectives

The purpose of this evaluation was to assess the technical merits of the process model (software) as well as substantial completion of the Simulator Facility.

The main objectives in the evaluation were as follows:

1. To ensure the simulator process model software provides an accurate (high fidelity) replication of the WTP processes.

2. To ensure that the simulator process model will be a useful tool in the training of control room personnel.

3. To ensure that the simulator process model software can be appropriately managed to keep up with an evolving WTP design process.

4. To ensure that the simulator process model software development included all the activities defined in the milestone development schedule.

5. To verify substantial completion of the Simulator Facility.

Evaluation Approach

Team makeup is provided on the title page of this report.

The Lines of Inquiry (LOI) in this evaluation addressed:

- Software development
- Requirements
- Documentation
- Testing, Verification and Validation
- Configuration Management
- System Checkout
- Completion of Milestone Schedule Activities

Detailed LOIs are provided in Appendix C and are specifically addressed in this report.

Methods of evaluation took advantage of the following:

- Meetings and presentations
- Facility walkthroughs and model demonstrations
- Document reviews
- Interviews

Overview

High level requirements contained in the WTP Contract, Basis of Design (BOD) and the Operations Requirements Document (ORD) call for the development of a WTP Training Simulator Facility. (Appendix B)

The simulator is required to provide a training environment that closely models the WTP processes and equipment and which utilizes a control room layout that replicates the actual plant control rooms. The simulator will be used to train and retrain control room operators in both normal and abnormal WTP operating situations.

Since the high level requirements regarding the simulator are only general in scope, specific lower level requirements as well as details of the simulator design must be understood from other documentation developed by the Contractor.

System Description for the Training Simulator, (24590-BOF-3YD-TSJ-00001) Rev A, dated November 4, 2004, Section 6.3.1 states "The Plant Process Model is referred to as the plant model in this section, to differentiate from the several smaller process models that make up the Plant Process Model. The plant model for the WTP Training Simulator will consist of the main process, along with the steam and waste systems, ventilation systems, electrical distribution, and the instrumentation and control features." Section 6.3.1 further states "Process models or the entire plant model will provide virtual process parameters, such as pressure, flow and temperature as input signals to the fully integrated and functional ICN emulator. The ICN, PPJ, and PTJ emulators will work together with the dynamic process model to provide the plant responses for the WTP Training Simulator."

Simulator Model Milestone Management Plan, Rev 0, (24590-WTP-RPT-PO-03-042), dated September 24, 2003, Section 3 states "The operator interaction with the training simulator will be entirely through the distributed control system (DCS) interfaces, which will be brought online during DCS integration after this milestone is achieved (Schedule Activity ID 2CBP1104000)."

According to the *System Description for the Training Simulator*, which conveys the Contractors solution to the high level requirements, the simulator system will be composed of the five subsystems listed below.

- Process Model
- Autosampling Model
- Mechanical Handling/CCTV Model
- Control System Emulators
- Simulation System Hardware and Architecture

These systems will be developed and integrated to comprise a fully functional training environment that replicates with high fidelity the WTP processes and operations. These systems are mutually interdependent for performing their functions for full simulation of the WTP process operations. For example, the process model is a dynamic system that depends on the field inputs, outputs, and control logic replicated by the plant control system emulators. This is better understood by considering interaction between the process model and the Integrated Control Network (ICN) emulator as explained below. (Note: The ICN is essentially the Distributed Control System for the WTP.)

The ICN emulator will provide the same types of functionality and output responses expected from the actual Plant Wide Control Systems. This will be achieved (in the absence of actual plant equipment and controllers) by means of emulator-specific hardware and software that will function as soft controllers in order to simulate the plant control logic and pass information back and forth to the plant models. The ICN emulator soft controllers will be downloaded with the same programs used in the actual plant controllers. The plant process model will supply process parameter inputs to the ICN emulator, including temperatures, pressures, flows, and other process variables calculated by transmitter models within the process model. The ICN emulator will scan the plant model for these parameters at the same rates as those established for the actual plant control system. The soft controllers will then solve the logic and send the resulting outputs back to the plant model as typical controller outputs (Proportional, Integral, Derivative [PID] or on/off signals). This exchange of virtual process parameters and control outputs between the process model and the control system emulators will continue throughout a given training session.

Figure 1 (next page) depicts the boundary between the process model and the field I/O and control logic performed by the control system emulators (DCS).

The discussion above highlights the fact that the process model is only one part of the simulator facility and by itself cannot provide all the simulator functions necessary for a complete training environment. Only with the integration of all five systems listed above, can there be a fully functional training simulator.

The process model as it is currently configured is comprised of at least 64 plant systems and nearly 60 types of equipment (valves, transmitters, pumps, vessels, etc.) modeled from WTP design media. The software making up the process model is composed of approximately 55,000 modeling blocks of code. The process model will ultimately be integrated with the control system emulators (currently being developed) through approximately 25,000 input and output (I/O) points.

The software system used for the WTP simulator is referred to as the Operations and Training Industrial System Simulator (OTISS). The OTISS Software Architecture is described in the *WTP Training Simulator Process Model Design Document* (24590-WTP-MDD-SIM-05-001) as follows:

OTISS is a process engineering dynamic simulation tool based on the concept of 'blocks' that are interconnected by streams. The blocks contain the algorithms (software code) needed to model process units. Streams are analogous to process piping. They enable information to be passed between blocks and are similar to those used in many steady state simulations.

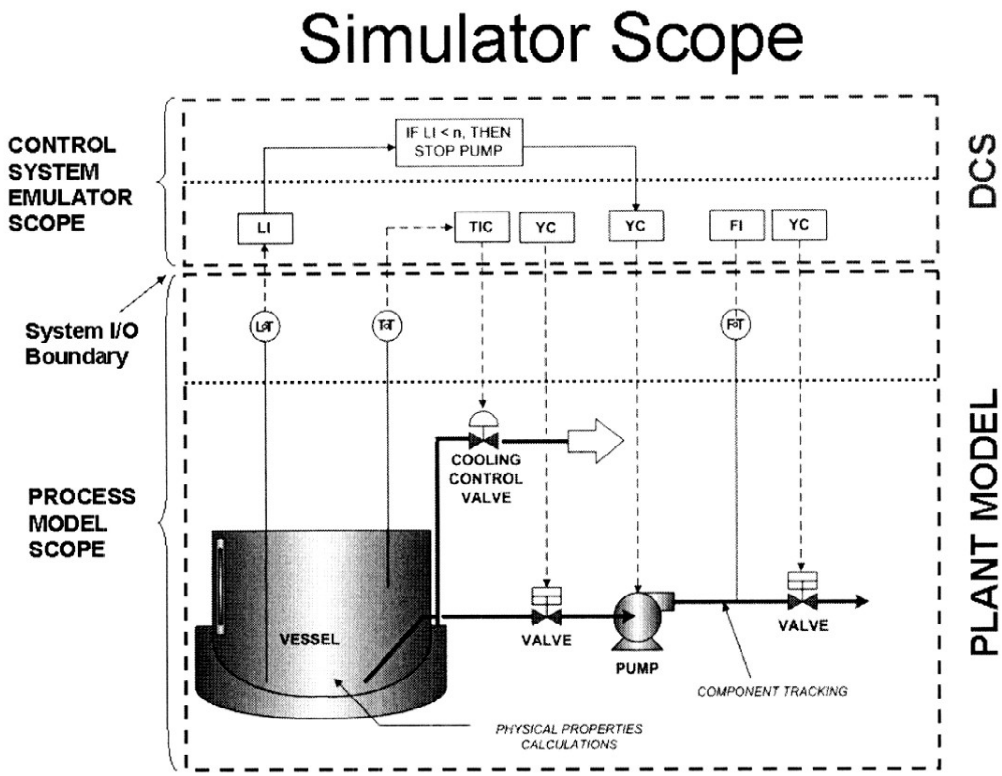

Figure 1

Software Development

<u>What approach was taken to develop the model to ensure fidelity to the WTP system?</u>

The approach for developing the process model software as defined in *Process Technology Department Training Simulator Work Plan* (24590-WTP-PL-PT-02-001) included the following general steps:

- Establish procurements through various contracts for model software, model development services, system hardware, etc.;
- Develop plans for software acceptance testing;
- Develop the dynamic process model;
- Controls and instrumentation model development;
- Peripheral system model development; and
- Integration and testing.

Controls, instrumentation, and peripheral systems model development is separate and distinct from the process model and encompasses the work required for the control system emulators. Software system development involves three main phases: (1) process model development; (2)

system emulator development; and (3) integration and testing of (1) and (2).

The technical approach used in developing the process model software included the following logical steps:

- Evaluate plant system descriptions – System descriptions of all the plant systems were provided to model developers in order to provide understanding of the functions for each system, what they were to accomplish, and how those systems were interconnected.
- Process Flow Diagrams (PFD) were evaluated to gain understanding of system throughput and general parameters.
- The Piping and Instrument Diagrams (P&ID), Ventilation and Instrument Diagrams (V&ID), and electrical single-line drawings were studied to obtain the physical plant features and details to use in the model.
- Data sheets were utilized to obtain equipment parameters. These parameters provided dynamic information by which to model each equipment device or component.
- Mathematical models were developed employing physical and chemical principles in order to replicate process dynamics and equipment unit operations.
- Software was developed using a COTS software operator training product by Aspen Technology*, Inc., called OTISS (Operations and Training Industrial System Simulator).
- Software testing, verification and validation were performed to ensure that modeled systems met plant performance requirements and expectations.

The team found this approach to be logical, systematic, and sufficient to provide confidence that the model adequately replicates with high fidelity, the WTP process operations.

* Aspen Tech recently sold this training product to Honeywell.

What was the basis for selecting the features to be designed in to the model?

Since the simulator will ultimately be a tool for training WTP control room operators, the features included in the process model, according to the model developers, were those features determined to be necessary for providing instruction to plant operators. This also comes across in the *RPP-WTP- Training Simulator User Requirements*, (24590-WTP-US-TE-01-001) document. Thus, elements not included in the model were either insignificant from an instruction perspective or not in the operator's control.

Were qualified personnel involved?

Resumes of key personnel involved in the simulator developments were obtained from the Contractor. These were reviewed by the team and show a strong experience base appropriate for the work activities required in the model development. Through interviews of personnel from the Simulator Group and demonstrations with the model and the simulator development system, knowledge of the system and the engineering that went into its development were clearly revealed. Information provided in key documentation also showed a level of qualification and expertise commensurate with the modeling tasks.

Conclusion (Software Development):

Development of the process model software followed a logical design approach that utilized appropriate design media to replicate the WTP systems and operations. The model satisfied the applicable requirements addressing all elements of the WTP design necessary for operator training. While not all systems and components of the plant were modeled, those elements of the plant deemed necessary for operator training were replicated. Based on review of resumes, personnel interviews, system demonstrations, and document reviews, qualified personnel were involved throughout the model development phases.

Requirements

High-level Requirements

High-level requirements related to the simulator include requirements from the Contract, Basis of Design (BOD), and the Operations Requirements Document (ORD). See Appendix B. These requirements do not specifically address development of the process model software, which is only one part of the Simulator System. However, the *System Description for the Training Simulator* (24590-BOF-3YD-TSJ-00001) was evaluated and determined to be the Contractor's solution to the high level requirements. This document includes an adequate description of the process model and references requirements for the model software. Also, examination of the current progress of the simulator development indicated consistency with the system description document and therefore, with the high level requirements.

Industry Standards

The system description references ANSI/ANS-3.5-1998, *Nuclear Power Plant Simulators for Use in Operator Training and Examination,* as an implementing standard to the extent applicable. As stated in the system description:

> "The accuracy and fidelity requirements of the process model are standardized by adhering to applicable elements of ANSI/ANS-3.5-1998, *Nuclear Power Plant Simulators for Use in Operator Training and Examination*, which specifies tolerances that the process model must meet compared to reference data. Additionally, it contains established criteria for the degree of simulation, performance, and functional capability of the simulated control room instrumentation and controls."

Reference to the ANSI/ANS-3.5 standard appears in documents containing more specific requirements. For example under "System Design Requirements" listed in *RPP-WTP- Training Simulator User Requirements*, (24590-WTP-US-TE-01-001, Rev 2), the following requirements appear:

> "The simulator shall be designed to meet the applicable requirements of ANSI/ANS-3.5, 1998. The capabilities, limits of simulation, evolutions, malfunctions, and remote functions specified in ANSI/ANS-3.5, 1998 section 3 will be adapted and applied to the simulated processes of the WTP facilities. The testing requirements specified in section 4

of ANSI/ANS-3.5, 1998 will also be adapted and applied to the WTP simulator facilities."

"The simulator software performance requirements will meet the standards set forth in ANSI/ANS-3.5, 1998 or any facility developed interpretation thereof."

"The simulator shall simulate the process dynamic and steady state values to the accuracy specified in ANSI/ANS-3.5, 1998."

"The control and monitoring of simulator evolutions should be per the requirements stated in ANSI/ANS-3.5, 1998."

"The simulator must be capable of being modified/updated. Applicable requirements stated in ANSI/ANS-3.5, 1998, section 5 will be adapted and applied as necessary to facilitate simulator modifications."

The Training Simulator User Requirements document also references *Human Factors* (NUREG 700 Rev.1) and DOE ORDER 5480.20A 11-15-94. *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*

WTP Training Simulator Model Requirements

The Training Simulator User Requirements document describes the requirements for providing a process simulator that will be used to train WTP personnel. This requirements document is not intended to provide specifications or design criteria but rather the general needs of the end user and is therefore, not entirely specific to the process model. However, *WTP Training Simulator Model Requirements* (24590-WTP-MDD-TR-03-001) is specific to the simulator process model and draws all the applicable requirements from the User Requirements document.

As reviewed and evaluated by the assessment team, the *WTP Training Simulator Model Requirements* document provides a comprehensive and complete set of requirements to be implemented by the process model. The requirements address model functionality, performance, features, external interfaces, and other software requirements as explained below.

- Functionality requirements based on design documents cover component modeling requirements, component malfunctions, and component operations. All process equipment (components) that affect plant system performance, as of the 2004 baseline, are modeled. This includes equipment such as valves, pumps, ductwork, fans, dampers, heat exchangers, evaporators, filters, ion exchangers, orifices, etc. Component malfunctions are included in the modeling as well as capability to change or modify component operations. Design documents provide the basis upon which the equipment components are to be modeled as well as how extensive the modeling is required to be as a training tool.

- Performance requirements address generally how well the model is to perform. Simulator model transient requirements are indicated as well as mechanical handling and closed circuit television requirements.

- Requirements regarding external interfaces include autosampling model requirements and programmable protection system requirements.

- Other software requirements address operating system and installation considerations, portability, maintainability, quality assurance, acceptance criteria, and access control.

- Instructor station and graphical user interface requirements are also detailed.

Conclusion (Requirements)

Evaluation of the process model requirements indicates that development of the process model software is driven by sound procedures and is requirements based. The model requirements appear to be adequate in terms of comprehension and completeness, and are consistent with industry codes and standards. Most, if not all requirements appear to be verifiable. The degree to which the requirements were met will be addressed in other parts of this report. No findings or open items were identified with respect to process model requirements.

Documentation

What documentation is in place to define the software model baseline?

As verified by the team, documentation for the Process Model and the Simulation Building is contained primarily under the following umbrella documents:

- 24590-WTP-RPT-SIM-05-003, *Rev 0, WTP Training Simulator Milestone Closure Package: Process Model*
- 24590-WTP-RPT-SIM-05-004, *Rev 0, WTP Training Simulator Milestone Closure Package: Building*

The documentation contained in these volumes is very large, comprising nearly 30 large binders.

The documentation included in the Milestone Closure Package for the Process Model covers:

- Scope – essentially high level requirements provided in the WTP contract, BOD, ORD and the PSAR
- Requirements – The Simulator Model Requirements
- Design and Implementation – The system description, simulator building equipment arrangement and connection drawings, equipment specifications, the Model Design Document (MDD), Mechanical Handling Process Simulation requirements, and the Training Simulator User Requirements.
- Testing and Acceptance – Factory Acceptance Test plans, results, and reports for each plant system.
- User Documentation – WTP Simulator User Manual

- Management Programs – Configuration Management procedure

The bulk of this documentation addresses the design basis and system testing.

Perhaps the most important document with respect to the process model is the *WTP Training Simulator OTISS Model Design Document* (24590-WTP-MDD-SIM-05-001, Rev.2). This document provides the "As-Built" design for the simulator process model. The scope of this document is stated:

"The MDD provides a detailed description of the plant model, defines the modeling objects, and documents the methodology used to implement the model objects. The MDD also includes programming code that was produced for the WTP simulator project as well as a description of the standard programming code functionality."

The MDD addresses the following process model details:

- Design Basis References - essentially the Process Flow Diagrams (PFD) and Piping and Instrument Diagrams (P&IDs) for each of the four main facilities, PTF, LAW, HLW, and BOF.
- Simulation Engine Overview - covers OTISS software architecture, stream data, pressure-flow networks, mass balance equations, energy balance equations, pressure calculations, and the OTISS calculation method.
- Standard and Custom Modeling Blocks Utilized - for equipment and unit models of each component.
- Flowsheet connectivity (Model Block Diagrams)
- Special calculations including any deviations from standard - covers stream components, thermodynamic basis, and chemical reactions.
- List of plant model I/O to ICN/PPJ Emulator (Future) and ranges
- Emulated controllers and ranges
- Modeling assumptions
- Boundary conditions and ranges
- Custom Malfunctions and Process Leaks
- Instructor Station Graphics – complete set of model (screen) layouts referenced to plant baseline drawings.

The documentation included in the Milestone Closure Package for the Simulator Building covers:

- Scope – essentially high level requirements provided in the WTP contract, BOD, ORD and the PSAR
- Requirements – The Performance Specification for the Simulator Building
- Design and Implementation – Facility description, specifications, and as-built drawings.
- Testing and Acceptance – Beneficial occupancy documentation, notice of final acceptance, inspection reports, and acceptance test procedures.
- User Documentation – Operations and maintenance manuals

Is the documentation complete and readily accessible?

The large volume of documentation appears to address all aspects of the Simulator systems and is readily available on bookshelves in the simulator building. This documentation is available for viewing to anyone on the project.

Are there user's manuals or other training aids?

For the simulated facility systems there are O&M manuals. Regarding the OTISS Training Simulator, there is the *WTP Simulator User Manual* (24590-WTP-GPG-CMNT-0001). The objective for this manual is to provide guidance and advice on the execution of training sessions on the OTISS Training Simulator. The manual is designed to help instructors become familiar with the simulator and its operations. As reviewed by the team, this manual is very informative and should prove useful when instructors are trained.

Conclusion (Documentation):

The team found that the documentation for the Simulator facility and especially for the process model appears to be complete and is readily available to personnel within the facility and throughout the project. The team noted no findings or open items of concern regarding documenation.

Testing, Verification and Validation

What approach was taken to test, validate and verify the software model?

The team reviewed the documents contained in *WTP Training Simulator Milestone Closure Package: Process Model,* (24590-WTP-RPT-SIM-05-003, Rev.0). This closure package contains the factory acceptance test procedures and the test results including all the observations developed during testing and their resolutions. In brief, the factory acceptance testing and the V&V testing verified the operability of the hardware systems and process model software to meet the requirements in the *WTP Training Simulator Model Requirements*, 24590-WTP-MDD-TR-03-001, Rev. 1. The closure package also includes the reports for V&V testing of both the process model version 1.1 and version 2.0 software.

Review of the closure package information showed a progression from the original version 1.0 baseline software developed to model plant design to the Phase 1 factory acceptance testing. As design on the WTP progressed, changes were made to the process model and Phase 2 factory acceptance testing was performed. The Contractor (Washington Group International, [WGI]) completed V&V testing of the version 1.1 of the process model software. Further changes followed and the latest V&V testing report for the process model version 2.0 software was issued December 11, 2005. Each round of testing verified the acceptability of the recent changes and verified that the model replicated results from previous testing within 1%.

What tests were performed to V&V system requirements defined in the WTP Simulator Model Requirements?

The functional acceptance testing verified all applicable hardware was in place and configured correctly, verified that all process equipment that affected system performance was modeled, and verified that the model simulated the system responses to typical malfunctions that occur in components of process systems. This testing documentation provided all test steps including manipulations that were performed by testing personnel as well as the expected response. As testing was performed, any anomalies or discrepancies were noted on observation forms (over 700 observations for Phase I testing, and over 150 for Phase II), and each observation was dispositioned, based on the significance, for immediate correction and retesting or later correction as part of upgrades.

The V&V test plans also provided specific step by step instructions and the results demonstrated that integrated plant operations could be simulated and that material transfers were completed within mass transfer specifications. These tests also demonstrated hardware flexibility in that hardware component malfunctions during simulation would not disable the entire integrated plant scenario.

Were qualified independent personnel involved in the V&V?

During interviews with the Deputy Test Manager, he indicated that the test team members were part of the WGI organization in Denver, Colorado, and that the individuals were qualified to perform verification and validation testing in accordance with *Nuclear Power Plant Simulators for Use in Operating Training and Examination*, ANSI/ANS-3.5. The test records present at the simulator did not verify these claims, but the names of the testing individuals are provided. Resumes were also looked at and indicated an appropriate level of plant operational experience, which is essential for V&V of simulator responses to input changes.

Conclusion (Testing, Verification and Validation):

The Contractor's testing and V&V program for demonstrating that the simulator process model met the requirements was thoroughly defined and executed, and resulted in many improvements to the system. No findings or open items of concern were identified regarding the Contractor's testing and V&V program.

Configuration Management

Is there a CM program in place?

The team reviewed the document, *Modification Requests and Configuration Management of WTP Simulator,* (24590-WTP-GPP-SIM-001, Rev.0). This procedure defines the Contractor's process for managing the Simulator systems. More specifically, GPP-SIM-001 states:

"This procedure outlines the management of the Simulation System hardware, software products, and applications to be installed in the simulator building. Inclusion of configuration management requirements for these aspects of the Simulation System will be implemented when the operating system, emulator and process model products are installed on the Simulation System. This procedure also dictates the requirement for tracking of changes to the WTP Simulator Facility...."

This procedure is driven by configuration management requirements provided in the following documents:

- 24590-WTP-PL-PO-03-013, *WTP Training Simulator Model Quality Assurance Plan; and*
- 24590-WTP-PL-PO-03-021, *Simulator Development System Management Plan.*

GPP-SIM-001 also requires that tracking of changes to the Simulator Facility be in accordance with the following procedures:

- 24590-WTP-3DP-G04T-00901, *Design Change Control*
- 24590-WTP-3DP-G04B-00046, *Engineering Drawings*
- 24590-WTP-GPP-CON-3110, *Construction Design Change Management*

The scope of GPP-SIM-001 includes administrative controls that are applicable during the lifecycle of the training simulator. These controls include the process for simulator modification through Simulator Modification Requests (SMR), to be discussed shortly.

The GPP-SIM-001 procedure describes the following processes:

- Simulation Model Modification Process
- Software Product and Application Modification Process
- System Hardware Modification Process
- Simulator Facility Modification Process

The procedure also describes in adequate detail the responsibilities of those involved in the change process.

The CM process has already been utilized successfully for two baseline changes to the process model software since the June 2004 freeze date. These revisions are listed in the Model Design Document. One of the changes leading to version 2.0 of the model involved removal of concentrate receipt vessels (CRV) from the HLW Concentrate Receipt Process System (HCP) in December 2005, thus, demonstrating a working process for updating the model to reflect plant design changes. However, it should be noted that, based on the quotation above, the effectiveness of the CM program with respect to installation and integration of the operating system and control system emulators remains to be seen.

<u>*How is the software model changed and updated to keep up with plant design changes? Is it easy to change?*</u>

Changes to the process model software are made as required depending on changes to the plant design media. Plant physical design changes are typically reflected in design media such as

P&IDs, V&IDs, electrical single-line diagrams, etc. as the WTP design evolves. Engineers within the Contractor's Simulator Group, routinely evaluate changes to the design media. When process model software changes become necessary based on changes to the design media, a Simulator Modification Request (SMR) is initiated by a Simulator Group engineer. The SMR is used to formally request and track changes to the Simulator Design Software product applications, which represent the simulation model. The SMR procedure will be used to manage the preparation of version release test plans, V&V testing, and completion of V&V reports. The SMR initiates the software modification process described in the CM procedure (GPP-SIM-001). Software is changed, tested, validated and verified accordingly.

Changes are first made on the Simulation Development System (SDS), tested, validated and verified in the context of the entire plant system. Once this process has been completed, the Simulation Training System is updated for final acceptance testing of the changes. This process will ensure that training will not be compromised while model changes are being implemented, tested, validated and verified.

Typical software changes will involve adding or deleting process components (valves, pumps, vessels, piping, transmitters, etc.) or changing process parameters as necessary based on the changes observed in the design media. This is accomplished through the SDS. Since the most likely plant components have been modeled already, software changes involve simply cutting or copying and pasting existing software elements, redefining the component and establishing required process operation parameters, followed by testing, validation, verification and acceptance.

How is the software maintained? Does the WTP contractor have qualified personnel on hand to change and maintain the software?

The process for maintaining the model software is also described in GPP-SIM-001. Ultimately, updated model files and data generated on the SDS are permanently stored and locked down in a designated location referred to as the Development Repository, which is maintained and controlled by the System Administrator. The software is loaded onto the Simulation Training System for training use after lock down.

As observed, there are knowledgeable and qualified personnel currently on-hand who maintain their skills with the system software by routine involvement. Two engineers within the Simulator Group indicated that on-the-job training with the software in order to be proficient takes about two years.

When is it necessary to require vendor services? What contract vehicles are in place to ensure vendor support?

Based on interviews, vendor services will only be required if there are major changes to the process model that require quick turn-around. A major change would typically be along the lines of a complete system or major piece of equipment addition or deletion, or when there is a large volume of component modifications, additions or deletions. In the case where vendor support is required, the Contractor hires the necessary expertise through Personnel Support Requests

(PSR). The Contractor is also currently working out a contractual agreement with Honeywell for product support of the OTISS software system.

Is the software documentation maintained?

According to interviews with engineers from the Simulator Group, baseline documents will be maintained and updated to reflect the most current configuration of the process model. The most important document to maintain is the *WTP Training Simulator OTISS Model Design Document* (24590-WTP-MDD-SIM-05-001, Rev 2). According to the CM procedure, among the responsibilities delegated to the SMR implementer, is included "preparing changes to and issuing relevant Model Design Document and System Design Document revisions."

Conclusion (Configuration Management):

The Contractor has a CM program for managing changes to the Simulator facility, hardware, software, and documentation. The CM program is adequately defined, is methodical and systematic, and is understood by those currently involved with maintenance of the Simulator systems. The CM process was utilized successfully for two baseline changes to the process model software (Ver. 1.1 and Ver. 2.0), and at least one change involved updating the model to reflect a major plant system change (CRVs in the HCP) since the model freeze date. It remains to be seen how effective the CM program will be with respect to other plant changes that (since June 2004) recently have occurred as well as those changes to the model associated with the control system emulator integration. No findings or open items of concern were identified regarding the Contractor's CM program.

System Checkout

How was human factors addressed in developing the model?

The training Simulator User Requirements document states:

"Since the simulator will be built as a replica of the reference MCR and FCRs, [control rooms] any human factors considerations used in the design of these control rooms will be inherited and incorporated into the design of the simulated control rooms, as described in WTP Control Room Requirements, 24590-WTP-3PS-JQ00-T0001. The Instructor Areas and Instructor Station shall also be designed with human factor considerations to facilitate simulator control and viewing of simulator control room operations."

The Training Simulator User Requirements document also references *Human Factors* (NUREG 700 Rev.1).

According to the *WTP Training Simulator Model Requirements* (24590-WTP-MDD-TR-03-001):

"The simulator Instructor Station will provide a graphical user interface that minimizes instructor actions needed to initiate scenarios, change screens, insert malfunctions, and determine simulator status. The graphical user interface for the simulator Instructor Station will be designed to provide intuitive control to the instructor. The information obtained from this interface will be presented in a consistent manner throughout all screens. The station will allow the instructor to concentrate on training activities while minimizing the effort required to operate the simulator."

The model requirements document (in Section 3.8) is very specific in the requirements that were to be met by the model development taking into account such elements as equipment location, lighting, minimizing instructor actions, hierarchy of the screens, icons for ease of navigation, size and color of font and screen objects, etc. It was apparent to the team that these requirements were met.

Is the model easy to learn and use?

Demonstrations by the Contractor revealed the model to be relatively simple to navigate and use. Multiple screens provide for a wide-range of observation. The operating system platform is Microsoft, Inc, *Windows 2000.* Through this system, custom Instruction Station graphics, system layouts (essentially simplified P&IDs), equipment faceplates, and pull-down menus allow for monitoring and easy change of process parameters. Navigation through the plant systems is readily performed via process stream inputs or outputs.

Does the model provide an adequate (real-time) representation/simulation of plant systems and equipment, process dynamics and parameters?

The team evaluated one of the more complex process systems – the Ultrafiltration Process System (UFP) in order to determine what features, equipment, and instrumentation were included in the UFP model related to washing, caustic leaching, and oxidative leaching processes, and to what extent these processes were modeled.

> Note: The team initially did not understand the mutual interdependence of the process model and the control system emulators as explained in the introduction portion of this report. Hence, since the control system emulators are still in development, many of the questions the team had regarding the UFP system could not be addressed. These questions are provided in Appendix D. When more progress has been made on the simulator system and the process model is integrated with the control system emulators, these questions will be more appropriate.

Contractor staff described and demonstrated simulator process model capabilities to the team on February 2, 2006. As observed, the model included the necessary features to perform washing, caustic leaching, and oxidative leaching operations as currently included in WTP process design. However, as noted above, operating logic to perform these unit operations is currently not included in the model and is planned to be included with the emulator during DCS integration. The Contractor staff also demonstrated UFP system operational capabilities to the team. The model was brought on line with the UFP system running. The valve settings on the UFP system were set manually by the Contractor in order to balance UFP performance. This process took about 1.5 days because the emulators are not yet part of the system. When the emulators are integrated with the model, valve settings will be adjusted automatically to keep system performance within set parameters. Vessel levels, flowrates, and pressures appeared reasonable. To test system dynamics, observers requested the valve downstream from the ultrafilters be closed 40 percent in order to restrict flow. System behavior was as expected. Pressure increased on the slurry side of the ultrafilters, transmembrane pressures increased across the filters, and flux rates increased.

The path for flow of permeate through the ultrafilter was also followed. It was identified that the permeate collection vessel UFP-VSL-00062a was overflowing. This condition was identified through observation of vessel levels and flow paths since alarms are not included in the process model to alert an operator of an upset condition. Features such as alarms will be included in the future with the emulators utilizing logic from the DCS. The overflow path was followed and appropriately worked its way through Pretreatment facility vessels ultimately ending up in the Pretreatment facility process cell pit sumps as expected.

Since the model design was frozen in June 2004, the model presently does not include equipment such as sparge tubes to assist mixing in non-Newtonian vessels and provisions for anti-foam additions. These and other elements must be added during later model revisions in accordance with the Contractor's CM process.

Pulse jet mixers were looked at in the UFP-VSL-00002a/b and HLP-VSL-00027a/b vessels. The team also observed pulse jet mixers in other vessels as well. It was demonstrated that pulse jet mixers are included in the LAW feed receipt vessels (FRP-VSL-00002a/b/c/d). The function of the FRP-VSL-00002 pulse jet mixers was tested. Again, without the DCS or emulator, operation of the pulse jet mixers was difficult. Valves to operate the jet pump pairs had to be manually opened by the operator. Opening valves to all pulse jet mixers in one vessel at one time resulted in an increase in vessel fluid level and increase in vessel vent flow rates as expected. No instrumentation is included in the pulse jet mixers to allow determination of the fluid level or whether an overblow event was occurring. Based on the time the pulse jet mixers were operated in the blow mode, the pulse jet mixers would have been overblowing in the vessels.

The oversight team found the simulator process model inclusion of equipment and instrumentation in the UFP system acceptable. CCN: 124416, dated January 6, 2006, stated the simulator process model design is based on design media frozen in June 2004. Review of the process model for the UFP system found the design consistent with the documents listed below, which define the UFP system up through June 2004. The model will require future revisions to accurately represent the WTP design.

- 24590-PTF-3YD-UFP-00001, Rev. 0, *System Description for Ultrafiltration Process System (UFP)*, dated September 11, 2002
- 24590-PTF-M6-UFP-00002, P&ID – *PTF Ultrafiltration System Vessel UFP-VSL-00002A*
- 24590-PTF-M6-UFP-00010, *P&ID – PTF Ultrafiltration Utility Services – PSA Rack*
- 24590-PTF-M6-HLP-00001, *P&ID – PTF HLP System HLW Lag Storage and Blending Process Vessel HLP-VSL-00027A/B*

What are the capabilities of the model in terms of process chemistry, calculations, etc.?

The team addressed more specific lines if inquiry related to the chemistry of the UFP system. These are listed below:

- How is washing chemistry treated and modeled?
- How are filter flux rates established?
- How is solids dissolution determined?
- How is aluminum leaching chemistry treated and/modeled?
- How is aluminum precipitation modeled/predicted?
- How is chromium and plutonium oxidation modeled/predicted?

These questions will be addressed in order as follows:

How is washing chemistry treated/modeled?

The chemistry of the model is governed by 57 chemical components listed in Table 1. This table was obtained from *WTP Training Simulator OTISS Model Design Document* (24590-WTP-MDD-SIM-05-001, Rev.2).

Table 1: 57 Chemical Components Included in Training Simulator Chemistry Program

OTS Comp-Number	OTS Comp-Name	Description	Molecular Weight	Formula
1	H2O	Water	18	H_2O
2	H2	Hydrogen	2	H_2
3	NH3	Ammonia	17	NH_3
4	HF	Hydrogen fluoride	20	HF
5	N2	Nitrogen	28	N_2
6	CO	Carbon monoxide	28	CO
7	NO	Nitric oxide	30	NO
8	O2	Oxygen	32	O_2
9	H2S	Hydrogen sulfide	34.1	H_2S
10	HCL	Hydrogen chloride	36.5	HCl
11	NAOH	Sodium hydroxide	40	$NaOH$
12	NAF	Sodium fluoride	42	NaF
13	CO2	Carbon dioxide	44	CO_2
14	NO2	Nitrogen dioxide	46	NO_2
15	HNO2	Nitrous acid	47	HNO_2
16	KOH	Potassium hydroxide	56.1	KOH
17	NACL	Sodium chloride	58.4	$NaCl$
18	ALIOOH-S	Boehmite (inert)	60	$AlO(OH)$
19	SIO2	Silicon oxide	60.1	SiO_2
20	HNO3	Nitric acid	63	HNO_3
21	SO2	Sulfur dioxide	64.1	SO_2

OTS Comp-Number	OTS Comp-Name	Description	Molecular Weight	Formula
22	NACOOH	Sodium formate	68	*NaCOOH*
23	NANO2	Sodium nitrite	69	$NaNO_2$
24	ALOH3	Aluminum hydroxide	78	$Al(OH)_3$
25	NAACET	Sodium acetate	82	$Na(C_2H_3O_3)$
26	NAHCO3	Sodium bicarbonate	84	$Cr(OH)_3$
27	NANO3	Sodium nitrate	85	Na_2CO_3
28	MNOH2	Manganese hydroxide	89	$C_4H_6O_4$
29	NAGLYCOL	Sodium glycolate	98	Na_4SiO_4
30	CROH3	Chromium hydroxide	103	ZrO_2
31	NA2CO3	Sodium carbonate	106	$Na_2C_2O_4$
32	H2SUCNAT	Succinic acid	118.1	Na_2SO_4
33	NASIO4-S	Sodium silicate (solid)	122	$NaAlSiO_4$
34	ZRO2	Zirconium (IV) oxide	123.2	$SrCO_3$
35	NA2CO4	Sodium oxalate	134	*CsOH*
36	NA2SO4	Sodium sulfate	142	$KAlSIO_4$
37	NAALS4-S	Nepheline	142	$Na_2Cr_2O_7$
38	SRCO3	Strontium carbonate	147.6	Na_3PO_4
39	CSOH	Cesium hydroxide	150	*CsOH*
40	KALSIO-S	Kalsilite (solid)	158.2	$KAlSiO_4$
41	NACRO7	Sodium chromate	162	$Na_2Cr_2O_7$
42	NA3FS4-S	Sodium orthophosphate	164	Na_3PO_4
43	FEOOH	Goethite	177.7	*FeO(OH)*
44	NA3FS4-S	Trisodium fluoride sulfate	184	$NaF \cdot Na_2SO_4$
45	CITRAC	Citric acid	192.1	$C_6H_8O_7$
46	PUIVOH4	Plutonium(IV) hydroxide	312	$Pu(OH)_4$
47	NA2UO7	Disodium diuranate heptoxide	634	$Na_2U_2O_7$
48	ALOH3-S	Aluminum hydroxide (solid)	78	*Al(OH)3*
49	MNOH2-S	Manganese(II) hydroxide (solid)	89	$Mn(OH)_2$
50	CROH3-S	Chromium hydroxide (solid)	103	$Cr(OH)_3$
51	ZRO2-S	Zirconium(IV) Oxide (solid)	123.2	ZrO_2
52	NA2CO4-S	Sodium oxalate	134	Na_2C_2O4
53	SRCO3-S	Strontium carbonate (solid)	147.6	$SrCO_3$
54	FEOOH-S	Goethite (solid)	177.7	*FeO(OH)*
55	PUVOH4-S	Plutonium(IV) hydroxide	312	$Pu(OH)_4$
56	NA2UO7-S	Disodium diuranate heptoxide (solid)	634	$Na_2U_2O_7$
57	AR	argon	40	*Ar*

These components have been "…limited to major components, …minimizing the number of components without limiting the accuracy of the model" (*WTP Training Simulator OTISS Model Design Document*). The transitions of components between solid, liquid and gaseous phases are calculated by Environmental Simulation Program™ (ESP) software. These 57 components, while not the complete set of chemical components that will be present in WTP during treatment of the tank waste, are sufficient for the model to provide "ballpark" realistic processing times which will allow the operators to become familiar with the protocols they will be following. The changes in the chemistry of the modeled waste with water addition for washing are not directly monitored by the operators; the chemistry portion of the model runs "behind the scenes" to provide an estimate of the change in density of the waste. The change in density is viewed by the operators on the vessel monitoring graphical interface screen allowing them to determine when to cease liquid addition.

How are filter flux rates established?

Ultrafilter flux rates are established based on a correlation with sodium molarity. Flux rates in the process model increase when processing dilute feed and decrease while processing concentrated feed.

How is solids dissolution determined?

Document 24590-WTP-MDD-SIM-05-001, Rev2. *WTP Training Simulator Process Model Design Document* specifies precipitation and dissolution of five solids species (gibbsite ($Al(OH)_3$), sodium silicate (Na_4SiO_4), sodium oxalate (NaC_2O_4), nepheline ($NaAlSiO_4$), and a composite sodium fluoride/sulfate salt ($NaF \cdot Na_2SO_4$)) produced from nine chemical components and also temperature as the tenth component of this model block. These solid species have been focused on as the major solid components of the waste in order to determine the density fluctuations of the waste slurry during WTP operation as documented in *WTP Training Simulator –Solids Chemistry Corrective Action, Project Completion Report* (23960-WEC-WTP-PCR-00001, Rev 0 [WGI], 10/10/05). The equations which govern the formation of these solids in the model are listed in this document as:

$$Al(OH)_3(aq) \leftrightarrow Al(OH)_3(s)$$
$$4NaOH + SiO_2 \leftrightarrow Na_4SiO_4(s) + 2H_2O$$
$$Na_2C_2O_4(aq) \leftrightarrow Na_2C_2O_4(s)$$
$$Al(OH)_3 + SiO_2 + NaOH \leftrightarrow Na_4AlSiO_4(s) + 2H_2O$$
$$NaF + Na_2SO4 \leftrightarrow NaF \cdot Na_2SO_4$$

The solubility constants used to determine the equilibrium in the model are not given, however, the source code listed in the document includes numerical constants which can be assumed to be combinations of the solubility constants in equations representing the combined reactions. CCN 124408 documents that solids formation predicted by the model are within +/- 10% of the actual values observed in collected data.

How is aluminum leaching chemistry treated/modeled?

Sodium hydroxide (*NaOH*) is added to the waste until the desired density reading in the vessel is attained. The model then dynamically computes the changes in the 57 components with $Al(OH)_3$ being the only dynamic aluminum solid. The model also includes boehmite ($AlO(OH)$) as an inactive species. The use of this one solid species to model aluminum dissolution does provide a reasonable estimate of processing time based on the current knowledge of tank waste composition and data collected during caustic leaching tests. Operators will be instructed to take a waste sample near the end of processing time which will be analyzed by the analytical facility.

How is aluminum precipitation modeled/predicted?

Aluminum precipitation is modeled by the formation of gibbsite ($Al(OH)_3$) as described in the SOLIDSCHEM custom block of the model. The use of this one solid species to model aluminum precipitation does provide a reasonable estimate of change in percent solids.

How is chromium and plutonium oxidation modeled/predicted?

Sodium permanganate ($NaMnO_4$) and *NaOH* are added to the waste until the desired density reading in the vessel is attained. The model then dynamically computes the changes in the 57 components. Operators will be instructed to take a waste sample near the end of processing time which will be analyzed by the analytical facility.

Chromium dissolution is modeled by the change of chromium hydroxide solids, $Cr(OH)_3$, to the hexavalent chromium species dichromate ($Cr_2O_7^{2-}$). Hexavalent chromium is assumed to be in the form of chromate (CrO_4^{2-}) in testing reports (WTP-RPP-117* and WTP-RPP-137**) but both chromate and dichromate are soluble and therefore would not affect the accuracy of the model in predicting chromium mobilization. The use of this one solid species to model chromium dissolution during oxidation does provide a reasonable estimate of processing time (based on the current knowledge of tank waste composition and data collected during oxidative leaching tests) that will allow operators to become familiar with their responsibilities during the implementation of this process.

> * Rapko, B., Geeting, J.G.H., Sinkov, S.I. and Vienna, J.D. 2004 *Oxidative-Alkaline Leaching of Washed 241-SY-102 and 241-SX-101 Tank Sludges* WTP-RPP-117. Bechtel National, Inc., Richland, WA
>
> ** Rapko, B., Lumetta, G.J., Vienna, J.D., and Fiskum, S.K. 2005 *Oxidative-Alkaline Leaching of Washed SY-102 and Its Impact on Immobilized High Level Waste* WTP-RPP-137. Bechtel National, Inc., Richland, WA

Plutonium species included in this model are aqueous and solid plutonium (IV) hydroxide, Data included in WTP-RPP-117 indicate that the solubilization of plutonium during permanganate leaching is minimal compared to the dissolution of chromium so the model's exclusion of other species of plutonium does not lead to a gross error in the change in percent solids during oxidative leaching.

Is the model easy to configure and change (levels, flow rates, temperature parameters, valve line-ups, etc.)?

The Contractor demonstrated how process parameters (flow rates, levels, temperatures, etc.) are monitored and changed via equipment/component pull-down menus or faceplates. Changes to parameters can easily be made by changing values in the fields of the pull-down menus.

What is the extent and ability to introduce system/equipment failures, process upsets, and modifications to process conditions?

The Contractor demonstrated how to introduce failures and component malfunction into the process. This is typically performed by invoking programmed equipment malfunctions or failures from component faceplate tabs. The faceplates of several equipment components were looked at and verified that programmed component malfunctions were consistent with those listed in the *WTP Training Simulator Model Requirements*.

The Contractor also demonstrated the process of adding equipment/component blocks to the software model. This process will be required any time there is change to the physical plant that requires a corresponding change to the plant model. The demonstrator added a transmitter to the model. This was performed at one of the Simulation Development System stations. The process essentially involved copying and pasting a pre-existing block of code defining a transmitter and changing the device name, parameters, and interconnectivity features. The process is the same regardless of the component to be added.

What is the process for software model improvements or enhancements?

Model improvements or enhancements will be coordinated and controlled through the Configuration Management process described previously.

What features were engineered into the model software to address the model/emulator interface and what coordination exists with the emulator developers?

The *WTP Training Simulator OTISS Model Design Document* (24590-WTP-MDD-SIM-05-001, Rev 2) (MDD) refers to the interface points between the process model and the ICN/PPJ (Integrated Control Network and Programmable Protection System) emulators as "hooks". The following general model hooks are in place according to the documentation.

Outputs from plant models available for connectivity:

- Analyzers and transmitters have % output and Engineering Unit output
- Motorized equipment – running status
- Valves – actual valve stem position
- Valves – digital Open/Closed indication
- Process switches – digital signal (1 = good, 0 = bad)

The plant model has variables to accept the following inputs from the ICN/PPJ Emulators:

- Analog output to control valve position or motor speed control
- Digital signals to start/stop motorized equipment
- Digital signals to open/close actuated valves

Specific emulator hooks are listed in Appendix G of the MDD. These hooks are associated with approximately 25,000 I/O points between the process model and the emulators. The listing includes the following features:

- Input or Output (From DCS or To DCS)
- Name of the model block of code
- The specific variable (hook, I/O point) within the block
- The type of variable (integer, floating point, etc.)
- Parameters (zero and range)

The team verified a few of the points from the software.

Through interviews and documentation it was apparent there is an ongoing working relationship between the Simulator Group and Engineering (Control and Instrumentation Group). The latter, is responsible for developing the control system emulators. Emulator software is the same software developed for the actual plant ICN and PPJ systems. Simulator engineers stated that interconnectivity and integration of the process model with the emulators will be challenging and will require close coordination with the emulator developers.

Conclusion (System Checkout):

The team observed the process model to be consistent with WTP design media (through June 2004) and relatively easy to navigate as demonstrated from the Instructor's Station. Graphics features, menus, icons, and navigational links appeared adequate to provide convenience and ease to the user. For selected systems that were observed in detail, the model provided an adequate replication of the systems. Process chemistry was adequately modeled and documented based on sound principles and calculations. Changes to the model, as demonstrated on the Simulation Development System, were relatively simple to make by an experience user and changes to process conditions and equipment parameters at the Instructor Station can be performed conveniently. The model also has well defined interface points for eventual integration with control system emulators. No findings or open items were noted by team regarding system checkout.

Completion of Milestone Schedule Activities

Did the Contractor complete all the defined milestone schedule activities according to the baseline in place at the time the milestone was established?

The activities defined in the WTP Level 4 schedule included activities broken out in terms of the process model development and construction of the Simulator Facility building.

With respect to the process model activities, the team evaluated lower level schedules, process model and simulator development system software, test documentation and as-built information. From these reviews, it is clear that all the process model activities defined in the schedule were completed.

Regarding the Simulator building, the team performed walkthroughs, reviewed as-built drawings and evaluated Acceptance Test Procedures. Figure 2 provides a floor plan of the completed facility. Based on this information, all the milestone schedule activities associated with the facility were completed.

The team also evaluated the document, *WTP Simulator Milestone Completion Plan* (24590-WTP-PL-SIM-05-0001). This document provides the approach and criteria adopted by the Contractor to evaluate objective evidence that all the requirements associated with the milestone deliverables were met. The document includes objective evidence check sheets and acceptance sheets that reflect a thorough evaluation of the milestone deliverables. It was noted that the Contractor evaluation could not have been performed unless the milestone schedule activities had been completed.

Conclusion (Completion of Milestone Schedule Activities):

All schedule activities associated with the milestone appear to have been completed and no findings or open items were noted.

Site Facility Walkthrough

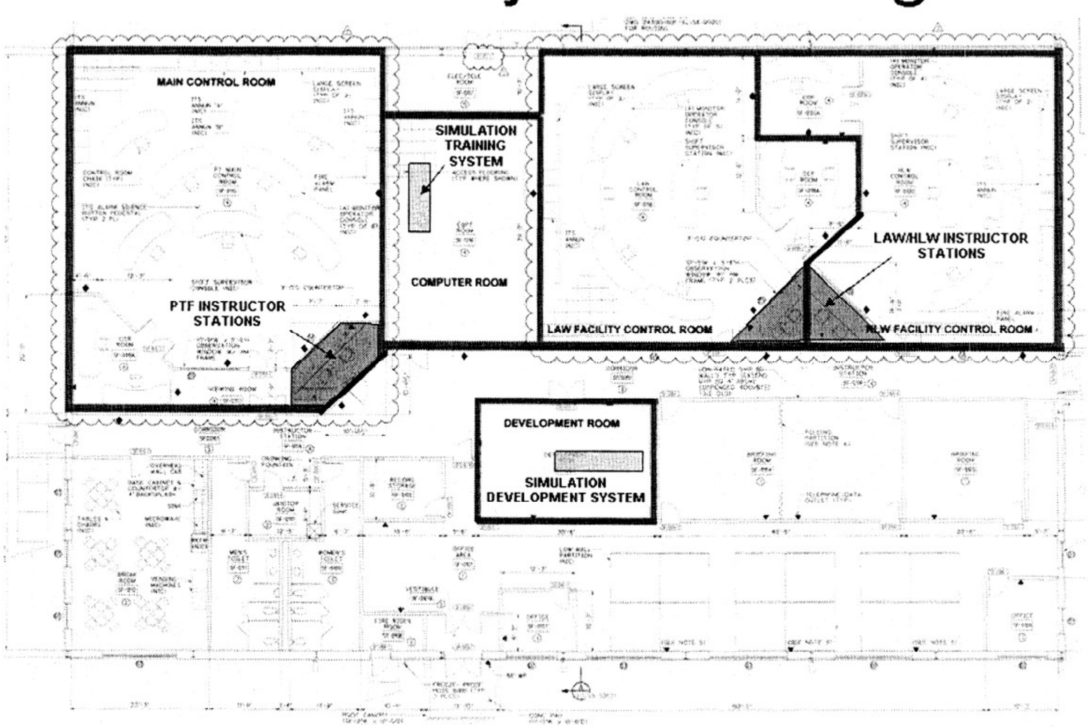

Figure 2

Appendix A - Contractor's Milestone Completion Letter

JAN 0 6 2006

CCN: 124416

U.S. Department of Energy
Office of River Protection
Mr. R. J. Schepens
Manager
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

Dear Mr. Schepens:

CONTRACT NO. DE-AC27-01RV14136 – ACCOMPLISHMENT OF CONTRACT MILESTONE - COMPLETE THE PROCESS MODEL (SOFTWARE) FOR USE IN THE SIMULATOR FACILITY FOLLOWING SUBSTANTIAL COMPLETION OF THE SIMULATOR FACILITY

References: 1) CCN 124415, Memorandum, from K. Ozkardesh to Project File, "WTP Training Simulator - Simulator Milestone Objective Evidence Package Acceptance," dated December 23, 2005.

2) 24590-WTP-RPT-SIM-05-003, Rev. 0, Document, *WTP Training Simulator Milestone Closure Package: Process Model,* dated December 9, 2005.

3) 24590-WTP-RPT-SIM-05-004, Rev. 0, Document, *WTP Training Simulator Milestone Closure Package: Building,* dated December 9, 2005.

Bechtel National Inc. (BNI) is pleased to report accomplishment of the Hanford Tank Waste Treatment and Immobilization Plant (WTP) Construction Completion Milestone for the Simulator Facility process model. This milestone was completed on December 23, 2005. It is described in the subject contract Section B, Table B.1B, as "*Schedule Activity ID 2CBP110400. Description: Complete the process model (software) for use in the Simulator Facility following substantial completion of the Simulator Facility.*"

The condition for earning fee for this Construction Completion Milestone is set forth in contract Section B.4 (b). This performance incentive fee of $15,000,000 is earned and paid when the applicable milestone is achieved. Listed below is the status of the simulator process model and simulator facility:

Simulator Process Model (Software)

- Software depicting the baseline (June 2004) snapshot of the plant's process system design has been developed, tested, and issued by BNI under configuration control.
- Software has been loaded on permanent simulation hardware and is functional.

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JAN 0 9 2006

DOE-ORP/ORPCC

BECHTEL NATIONAL, INC.

2435 Stevens Center Place
Richland, WA 99354 (509) 371-2000

Mr. R. J. Schepens
Page 2 of 3

CCN: 124416

- Simulation software and hardware are ready for integration with simulator facility control rooms (instruction stations and future emulators / process control software).
- Model software and hardware are free from any known deficiencies affecting model software or hardware performance.

Simulator Facility

- Simulator Facility consists of training areas representing the Pretreatment Main Control Room, Low Activity Waste Facility Control Room, High-Level Waste Facility Control Room, and associated Crane Control Rooms.
- Facility has been approved for personnel occupancy and currently houses the simulator model development personnel.
- Facility environmental controls support continuous operation of process model hardware.
- Building subcontractor's work and documentation is complete with no open/outstanding findings or actions affecting use of the facility.

Based on BNI's review, all of the identified completion requirements have been fulfilled per Reference 1. Objective evidence documentation (References 2 and 3) have been placed in the simulator facility conference room and simulator personnel are available to support U.S. Department of Energy, Office of River Protection's confirmation activities. BNI would like to schedule a demonstration of the model during the week of January 9, 2006 and intends to invoice for the completion of the Construction Completion Milestone immediately following completion of the demonstration.

If BNI can provide any additional information or documentation concerning this activity, please contact Ed Rogers at 371-2228.

Very truly yours,

J. P. Henschel
Project Director

KRW/krw

Appendix B - Focus Areas and Lines of Inquiry

1. Requirements and Implementation
   - High level requirements (contract, BOD, & ORD)
   - Industry standards (ANSI/ANS-3.5, NQA-1, NUREG)
   - WTP Training Simulator Model Requirements

2. Documentation
   - What documentation is in place to define the software model baseline?
   - Is documentation complete and readily accessible?
   - Are there user's manuals or other training aids?

3. Software Development
   - What approach was taken to develop the model to ensure fidelity to the WTP system?
   - What was the basis for selecting the features to be designed in to the model?
   - What personnel were involved? Qualifications?

4. Testing and V&V
   - What approach was taken to test, validate and verify the software model?
   - What tests were performed to V&V system requirements defined in the WTP Simulator Model Requirements
   - Were qualified independent personnel involved in the V&V?

5. Configuration Management
   - Is there a CM program in place?
   - How is the software model changed and updated to keep up with plant design changes? Is it easy to change?
   - How is the software maintained? Does the WTP contractor have qualified personnel on hand to change and maintain the software?
   - When is it necessary to require vendor services? What contract vehicles are in place to ensure vendor support?
   - Is the software documentation maintained?

6. System Checkout
   - How was human factors addressed in developing the model?
   - Is the model easy to learn and use?
   - Does the model provide an adequate (real-time) representation/simulation of plant systems and equipment, process dynamics and parameters?
   - What are the capabilities of the model in terms of process chemistry, calculations, etc.?
   - Is the model easy to configure and change (levels, flow rates, temperature parameters, valve line-ups, etc.)?
   - What is the extent and ability to introduce system/equipment failures, process upsets, and modifications to process conditions?
   - What is the process for software model improvements or enhancements?
   - What features were engineered into the model software to address the model/emulator

interface? What coordination exists with the emulator developers?

Completion of Milestone Schedule Activities

- Did the Contractor complete all the defined milestone schedule activities according to the baseline in place at the time the milestone was established?

Appendix C - High Level Requirements for Simulator

Waste Treatment and Immobilization Plant Contract:

Facility Specification C.7(e):

Plant Operator Qualification and Training Facility Design (simulator):_ The Contractor shall develop a "limited" full scope simulator. The simulator may be located off-site. The simulator facility will include three (3) control room replications (main control room, LAW control room, and HLW control room), along with the associated infrastructure and office to support the simulator facility operations.

The "limited" full scope simulator is defined as a training environment that closely models the process and associated equipment located in the actual control rooms. This simulator will provide an environment for understanding the process and control strategies to optimize plant performance and to provide training for situations that would not normally be experienced during normal plant operations.

Basis of Design:

Section 9.13 - Simulator and Trainer

The process and operations of the WTP shall be modeled with a simulator package to support operational testing and training. The simulator package should be available prior to operation of the WTP to support training, commissioning, and mobilization activities.

The simulator package should provide the following:

- Simulation of the features of the plant control systems (for example, process control and mechanical handling). These features include navigation capabilities, alarm annunciation, access levels, mimic hierarchy, data entry, and so forth.
- Simulation of each facility to a level that allows the testing of process sequences and trip actions. The simulation will dynamically mimic the process in terms of operation type and general operating and off-normal operation characteristics.

The trainer package should provide the following:

- The features of the simulator should be used to develop the training system. The features of the simulator are only a subset of the whole trainer package.
- Plant operating and upset scenarios may be incorporated in the trainer.

Operations Requirements Document:

Sections 12.9 – Training Simulator

A simulator shall be provided and have the ability to instruct personnel on the operation of the control systems and processes. Consideration shall be given to a "limited" full scope simulator that would simulate PT MCR, LAW FCR, and HLW FCR for training and process simulation. A limited full scope simulator is defined as a training environment that closely models the process and associated equipment in the control rooms. However, some interfacing systems and peripheral equipment within the control room area might not be modeled and replicated based on potential training benefit relative to cost. The choice of equipment to be modeled will be based on a documented training analysis using a graded approach.

The limited full scope simulator would contain models that respond as the referenced plant systems would in similar situations. All reference plant functions and system interfaces necessary to operate the referenced plant would be included within the scope of the simulation models. A limited full scope training simulator provides a learning environment for gaining a full understanding of the process and the control strategies for optimizing plant performance. A limited full scope simulator would have the capabilities for training and retraining of personnel, training for situations that could not normally be taught, and an engineering tool for control analysis. The simulator system would be configurable to match the plant control system being tested.

Appendix D - Technical Questions Not Addressed

The following questions could not be addressed in this evaluation because the control system emulators are not yet integrated with the process model.

1. Preparing UFP-VSL-00001a/b batches for UFP processing:
   - How are UFP-VSL-00001a/b batch sizes established?
   - How much HLW slurry from HLP-VSL-00022 is used?
   - How much LAW supernatant from FRP-VSL-00002a/b/c/d is used?
   - How full is UFP-VSL-00001a/b in the process? What percent solids is in the UFP-VSL-00001a/b batch?
   - How is the need to concentrate supernatant and HLW feed in the FEP evaporator system determined?

2. UFP-VSL-00002a/b batch processing (washing):
   - What is the batch size to UFP-VSL-00002a/b? How is it established?
   - How long is the concentration cycle in UFP-VSL-00002a/b?
   - What is the final slurry concentration after concentration?
   - How is solids dissolution resulting from washing determined?
   - What are wash solution volumes and how are they established?
   - How is washing chemistry treated/modeled?
   - What is the final slurry volume and solids concentration after washing?
   - How are filter flux rates established?
   - What are the time cycles for each process step and how are they established?
   - How is permeate managed?

3. UFP-VSL-00002a/b batch processing (caustic leaching):
   - Is leaching performed before or after washing?
   - What is the batch size to UFP-VSL-00002a/b? How is it established?
   - How are caustic leach solution quantities established?
   - How long is the complete leach cycle?
   - How much time is required for set-up, caustic addition, heat-up to ~85°C, digestion, and cool down to 25°C?
   - How much time is required for concentration and washing of the leached slurry?
   - How many washes are performed?
   - What are the wash volumes and how are they determined?
   - How are the cycle times established?
   - What is the final slurry volume and solids concentration after leaching?
   - How are filter flux rates established?
   - How are solids dissolution and leaching determined?
   - How is leaching chemistry treated/modeled?
   - How is aluminum precipitation modeled/predicted?
   - How is temperature controlled?
   - How is permeate managed?

4. UFP-VSL-00002a/b batch processing (oxidative leaching):
   - Is oxidative leaching performed after caustic leaching and washing?
   - How are sodium permanganate reagent additions established?
   - How long is the complete oxidative leaching cycle?
   - How much time is required for set-up, reagent addition, and oxidation?
   - How much time is required for concentration and washing of the leached slurry?
   - How many washes are performed?
   - What are the wash volumes and how are they determined?
   - How are the cycle times established?
   - What is the final slurry volume and solids concentration after leaching?
   - How are filter flux rates established?
   - How is leaching chemistry treated/modeled?
   - How is chromium and plutonium oxidation modeled/predicted?
   - How is permeate managed?

5. How is UFP-VSL-00002a/b mixing managed? What are the modes of mixing in the process cycles?

6. How is anti-foam addition determined and controlled? How is foaming detected?

7. Permeate management – What permeate is fed forward to ion exchange and what is recycled through the PWD system?

8. Final slurry management – How are the final slurries in UFP filters and UFP-VSL-00002a/b transferred to the HLP system? How much remains in the UFP system?

9. Filter cleaning – Describe the filter cleaning operations and frequencies.
   - How frequent is backpulsing and caustic washing performed?
   - How frequent is acid cleaning performed?
   - How are cleaning solutions managed?

10. System throughput – What is the system throughput capability for washing, caustic leaching, and oxidative leaching?

11. Hydrogen – How is hydrogen generation and release managed in the UFP system?

12. What operational features or limits are managed/controlled for safety?

13. Identify and explain the purpose of each process parameter measured by the control system (e.g. temperature, pressure, volume, specific gravity, volumetric flow rate, direct chemical measurement).

14. Identify which of the process parameters in the proceeding question is used to control the process. Identify if a backup measurement can be used to provide needed information if the primary control measurement fails.

15. Explain how the UFP pump loop operation is initiated, operated and controlled from the time of an initial batch transfer to the UFP-VSL-00002a/b until the washed/leached solids are transferred to the HLP system.

16. Explain the current form of process control advocated for the UFP (e.g. are manually tuned PID controllers to be used to control the axial velocity within the membrane tubes and control the transmembrane pressure differential (TMP) across each membrane?).

17. Explain how the three possible control loops: pump control, permeate valve control, and recirculation valve control, are to be integrated into a single control loop. Explain how the changes within one control loop do not affect changes within the other control loops.

18. The UFP is being designed to treat slurries with diverse physical and chemical properties and the process of separating this material will change the performance of the UFP with time. Explain how the proposed control methodology will account for the time varying performance of the UFP system?

19. Explain how the proposed form of process control for the UFP system accounts for the time varying nature of the ultra filter performance during different operating modes (e.g. dewatering, solids wash/leach). Explain how the proposed operational strategy will prevent a degradation in UFP system performance during the operating cycle.

Task# ORP-WTP-2006-0034

E-STARS™ Report
Task Detail Report
03/08/2006 0810

TASK INFORMATION

Task#	ORP-WTP-2006-0034		
Subject	CONCUR: (06-WED-014) REPORT OF THE TECHNICAL EVALUATION OF THE SIMULATOR PROCESS MODEL (SOFTWARE) AND THE SIMULATOR FACILITY (D-06-DESIGN-024)		
Parent Task#		**Status**	CLOSED
Reference	06-WED-014	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	03/06/2006 1052	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions

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bcc:
WTP OFF File
W. F. Hamel, WED
M. L. Ramsay, WED

ROUTING LISTS

1 Route List Inactive

- Ramsay, Mark L - Review - Concur - 03/08/2006 0811
  Instructions:
- Hamel, William F - Approve - Approved - 03/08/2006 0811
  Instructions:

ATTACHMENTS

No Attachments

COLLABORATION

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

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Task# ORP-WTP-2006-0034

E-STARS™ Report
Task Detail Report
03/06/2006 1052

TASK INFORMATION

Task#	ORP-WTP-2006-0034		
Subject	CONCUR: (06-WED-014) REPORT OF THE TECHNICAL EVALUATION OF THE SIMULATOR PROCESS MODEL (SOFTWARE) AND THE SIMULATOR FACILITY		
Parent Task#		**Status**	Open
Reference	06-WED-014	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	03/06/2006 1052	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

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ROUTING LISTS

1 Route List Active

- Ramsay, Mark L - Review - Awaiting Response *Instructions:* mlr 3/6/06
- Hamel, William F - Approve - Awaiting Response *Instructions:* WFH 3/8/2006

ATTACHMENTS

No Attachments

COLLABORATION

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --