QA: N/A
50040-DD-01-6.0-00
October 2007

Total System Model Version 6.0 GROA Department Design and Bases

Prepared for:
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
1000 Independence Avenue, SW
Washington, D.C. 20585

Prepared by:
Bechtel SAIC Company, LLC
1180 Town Center Drive
Las Vegas, Nevada 89144

Under Contract Number
DE-AC28-01RW12101

TOTAL SYSTEM MODEL VERSION 6.0
GROA DEPARTMENT DESIGN AND BASES

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October 2007

Prepared by:	Russell deCastongrene	Date 10/31/07
Checked by:	Stephen L. Turner	Date 10-31-2007
Reviewed by:	Eric Coryell	Date 11/5/07
	Scott G. Gillespie	Date 11/02/2007
Approved by:	David Siefken Manager, Waste Management Integration	Date 11/6/07

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REVISION HISTORY

Revision Number	Interim Change No.	Issue Date	Description
00	0	10/2007	Initial Issue. Supports TSM Version 6.0, SimCAD™ 7.1 Build 1235.

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ACRONYMS AND ABBREVIATIONS

BSC	Bechtel SAIC Company, LLC
BWR	Boiling Water Reactor
CHF	Canister Handling Facility
Crit	High criticality
CRCF	Canister Receipt and Closure Facility
CRWMS	Civilian Radioactive Waste Management System
CSNF	Commercial Spent Nuclear Fuel
DOE	U.S. Department of Energy
DPC	Dual-Purpose Canister
DTF	Dry Transfer Facility
DOE SNF	DOE Spent Nuclear Fuel
FHF	Fuel Handling Facility
GROA	Geologic Repository Operations Area
HLW	High-Level (radioactive) Waste
IHF	Initial Handling Facility
LRU	Least Recently Used
MCO	Multi-Canister Overpack
MGR	Monitored Geologic Repository
MSC	MGR Site-Specific Cask
PWR	Pressurized Water Reactor
RF	Receipt Facility
SNF	Spent Nuclear Fuel
STC	Site Transfer Cask
TAD	Transportation, Aging, and Disposal
TCRRF	Transportation Cask Receipt/Return Facility
TSC	Transportable Storage Cask
TSM	Total System Model
TSMCC	Total System Model Control Center

ACRONYMS AND ABBREVIATIONS (CONTINUED)

UM	User Manual
VB	Visual Basic
WHF	Wet Handling Facility
WP	Waste Package

1. INTRODUCTION

The Total System Model (TSM) is a planning tool that estimates the logistic and cost impacts of various operational assumptions in accepting radioactive wastes. Waste forms currently tracked are Commercial Spent Nuclear Fuel (CSNF), U.S. Department of Energy (DOE) spent nuclear fuel (DOE SNF), and defense high-level (radioactive) waste (HLW). The TSM uses a TSM Preprocessor (TSMPP) to generate the cask loads and target dates for shipments from waste sites. The TSM then tracks these wastes from pickup at the waste sites until repository emplacement, and calculates the various costs associated with transportation and emplacement. The TSM also provides logistic information regarding the Civilian Radioactive Waste Management System (CRWMS), including information relative to the waste stream movement and the system resources required to accomplish that movement.

This manual provides detail on that portion of the model that simulates the operation of the Geologic Repository Operations Area (GROA). Although some detail is presented as background information, this manual assumes that the reader has a significant familiarity with the current design of the GROA facilities. See the TSM User Manual (UM) (BSC 2007a) and the documents referenced therein for more details on the TSM design and operation.

Note: The TSM model described in this document is Version 6.0. Version 6.0 is primarily based on the GROA design as of September 2006, as described in references BSC 2006a, BSC 2007b, and BSC 2007c. The aging processes are based on information from 2004 in Reference BSC 2004a. This version reflects a major redesign of the surface facilities as compared with the previous versions of the TSM.

The screenshots in this manual may have small differences from the current version of TSM as they are not updated if the changes are minor. It is suggested that the current TSM be opened and used to see the current details in the Graphical User Interface (GUI).

This document was prepared in accordance with AP-ENG-006, *Total System Model (TSM) – Changes to Configuration Items and Base Case.*

1.1 FUNCTIONAL OVERVIEW

The GROA model simulates the capabilities of the five main processing facilities that are currently planned to operate at the Monitored Geologic Repository (MGR). These consist of the Initial Handling Facility (IHF), the Wet Handling Facility (WHF), and the Canister Receipt and Closure Facilities (CRCF1, CRCF2, and CRCF3). In general, these facilities remove Spent Nuclear Fuel (SNF) and HLW from the transportation casks and place them into waste packages (WPs) subject to heat and quantity constraints. The WPs are then closed and sealed in one of the closure cells prior to transport to the subsurface repository.

Most of the SNF that arrives at the GROA is expected to be in canisters which are placed directly into WPs. All bare SNF assemblies or assemblies within dual-purpose canisters (DPCs) are expected to be packaged into Transportation, Aging, and Disposal (TAD) canisters. These TAD canisters are then either processed in one of the CRCFs or sent to the aging pads until nuclear decay allows the fuel to meet thermal limits and be packaged for disposal.

As waste arrives at the GROA, it is routed to one of the cask load buffers that are shaped like a rail yard. Cask loads remain in these buffers until summoned by the appropriate processing facility that is available for processing. In steady state, cask loads are routed directly to the IHF or the WHF or, via a Receipt Facility (RF), to the CRCFs. A cask that has been emptied in a facility is returned via processes that model placing it on either a truck bed or a rail car as appropriate. The cask is then transported from the GROA to the Fleet Management Facility (FMF) for inspection and reuse.

The representation in the model Graphical User Interface (GUI) was designed to mimic the planned site layout to assist in understanding the model. Note that although lines are used to connect many of the processes, there are some connections that are not explicitly drawn. This was done primarily to improve the visual appeal of the model and is especially apparent between the DOE cask buffers and the CRCF Unload processes.

Although SimCAD™ code extensions in the GUI processes were used as much as possible, the bulk of the decision-making is performed in a sizeable Visual Basic™ (VB) module that is called from the model. The decision-making includes which cask to request next; which WP can be filled; when should a canister be returned from aging; and the selection of bare assemblies to be placed into a TAD canister. This VB code is also used to log the WP and Aging heat information to the database.

1.2 MODEL CAPABILITIES

The current GROA model allows the user to see the effects of various mixes of casks, what heat blending is possible with the groupings of assemblies generated by the TSMPP, the effects of facility startup improvements or delays, the effect of the waste acceptance criteria at the waste sites on the size of the required aging pads, and the system effect of changes in WP heat. It will also allow the user to see the effects of changing processing times within each of the facilities.

1.3 ASSUMPTIONS

The current version of the GROA model assumes the following:

- All processing facilities will have a maximum of one transportation cask open at any given time.
- Aging pads will be available as needed.
- Drifts for emplacement will be available as needed.
- No waste will be accepted onsite until some processing capacity for that waste is available.

- All Naval SNF will be processed in the IHF.

- CRCF1 will perform all duties of the RF until the RF comes online.

- CRCF1 preferentially processes short DOE SNF, while CRCF3 preferentially processes long DOE SNF. Until CRCF3 is operational, CRCF1 will process both short and long DOE SNF.

- CRCF2 only processes TAD canisters.

- RF removes TAD canisters from their transportation casks and prepares them for packaging or aging. RF similarly processes DPCs that are to be aged. For modeling purposes, TAD canisters and DPCs that are to be aged are routed through RF even before RF is available.

- The TAD canister design will eliminate any need for special treatment of assemblies with criticality concerns.

The assumptions on the processing capabilities of the CRCFs provide the best fidelity of how the process buildings and process lines will be operated for the best efficiency. It is recognized that the design is intended to allow any CRCF to process any waste except Naval SNF and bare SNF cask loads. However, the most efficient operation is to allow buildings to process a particular stream as much as possible to avoid fixture/tooling changes and improve operator learning/performance because the same items are processed. The flexibility of the buildings is useful for possible process line or building downtimes but these downtimes are not currently modeled and it is anticipated that such downtime will be a small part of the pre-closure steady state operation. The TSM GROA design can be modified as operations are established over the next several years but the simulation has the proper fidelity to provide insight on efficient, steady state operations.

1.4 LIMITATIONS OF TSM-GROA

Limitations of TSM-GROA include the following:

- Currently all assemblies are grouped into one of 10 heat bins that provide an average value for a range of assembly heats. Using this average will cause some uncertainty in the heat content of any particular WP; however, the system as a whole is not affected.

- The minimum time step used in the model is 8 hours. Any operations that require less than 8 hours are rounded up or included in another operation's time.

- The decay algorithm uses average values for all assemblies within each SNF heat bin; this will overestimate or underestimate the actual decay rate for a given assembly.

Each emplacement drift has a preclosure lineal heat limit and a postclosure midpillar temperature limit. These limits are expected to be met by a thermal emplacement strategy that alternateshigh heat content WPs with lower heat content WPs, however, this strategy is not modeled explicitly in the current version of the TSM.

1.5 CHANGES FROM PREVIOUS VERSION

This section provides a summary of the major changes to the GROA Department from Version 5.0 of the TSM (BSC 2007d). Changes were checked with test runs of previous cases used as early as 2004 (the GROA revision is designed to run old Initial State (IS) files as is) as revisions were made. During test runs, the simulation was observed for proper operation, correct mass balance, and process line throughput consistency with preliminary estimates, and to ensure that all object types are processed. The overall effects of these changes on the simulation results are assessed with integrated test runs as documented in *Total System Model Version 6.0 Validation Report* (BSC 2007e). The changes include:

TAD Lines converted to CRCFs

The TAD lines found in Version 5.0 were replaced by the CRCFs to reflect the latest GROA design. CRCFs can handle both DOE and commercial wastes.

WHF Facility

A new facility with a storage pool and wet handling capability, WHF, was added to process bare CSNF into TAD canisters. The WHF handles all bare fuel shipments (typically truck casks and DPCs). These TAD canisters are then either sent to Aging or to one of the CRCFs for packaging and emplacement.

IHF Facility

A new facility for start up operations, IHF, was added to process all Naval SNF and any HLW that arrives before CRCF1 becomes available. Note that the IHF cannot process DOE SNF canisters.

RF Facility

A new facility, RF, was added to remove TAD canisters and DPCs from their transportation casks and place them in Site Transfer Casks (STC) or aging overpacks to improve processing flow through the CRCFs and WHF.

Facility/Process Removal

The Fuel Handling Facility (FHF), Canister Handling Facility (CHF), Dry Transfer Facilities (DTF1, DTF2) and the TAD lines were all removed to reflect the latest GROA design.

The positioner with its associated buffers were removed. This greatly simplifies handling operations and provides a more direct route to transfer loaded casks to the facilities and transport empty casks to the FMF. This change was enabled since the Transportation Cask Receipt/Return Facility (TCRRF) and associated Site Rail Transportation Cask (SRTC) operations were removed from the GROA design.

The “Deploymenttime” process and associated routers that changed the waste routings as facilities came on line during startup have been removed. The startup facility sequencing is now simplified and handled within the other routers and within the RF process.

Arrival buffers have been simplified and consolidated because the need for specialized processing for criticality is no longer required.

The TSC line has been removed. Transportable storage casks (TSCs) are now handled like bare SNF casks and aging at the GROA is not enabled. There are few TSCs in the future scenarios so GROA aging provides no major advantage.

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2. GROA DEPARTMENT STRUCTURE

The GROA is a small model that resides within the TSM as the department "GROABlending", see Figure 1. It accepts transportation casks and waste shipments from the TSM main GUI, and returns transportation casks and filled WPs. This section describes processes that are unique to the GROA Department. See the TSM Glossary (BSC 2007f) for information on triggers and other variables that are used outside of the VB module.

2.1 BUFFERS: CSNF AND DSNF

As transportation casks enter the GROA, they are placed in one of the many buffer processes along the bottom of the GROA department as shown in Figure 2. Although their images reflect a rail yard, truck transportation casks are mixed in with the rail casks in the Boiling Water Reactor (BWR) and Pressurized Water reactor (PWR) buffers. Once waste has arrived at the site, it will reside in one of the buffers until requested by a processing facility.

Navy casks are sent to the IHF Buffer process until the IHF releases them for processing. HLW that arrives before CRCF1 is available is also sent to the IHF Buffer. These early HLW is placed in Codisposal WPs without a matching DOE SNF (the IHF design lacks the capability to make a proper Codisposal package). HLW that arrives after CRCF1 is available is placed in one of the HLW buffers.

DOE SNF in the form of DOE SNF, DOE SNF Long and Multi Canister Overpacks (MCO) are placed in their respective buffers until requested by CRCF1 or CRCF3.

CSNF that arrives in casks other than TAD canisters (referred to as "bare CSNF") is placed in the BWR, PWR, DPC BWR, or DPC PWR buffer, as appropriate. The cask loads reside in these buffers until processed in the WHF. CSNF that arrives in TAD canisters is placed in the TAD Buffer until requested by CRCF1 or RF. This is also the buffer where TAD canisters that return from aging and TAD canisters produced by the WHF are placed to signify that they are available to be processed.

If waste is accepted faster than the GROA can process it, these buffers may fill up and cause the entire system to "back up." This provides an indication that either a decrease in the waste acceptance schedule or an increase in the processing capacity is needed. Many of the buffers may send waste to more than one facility and when a cask is released the buffer will check a flag variable to determine the facility destination.

In TSM Version 6.0, an algorithm was added to assess the maximum number of casks in the buffers for each quarter to provide a means to assess the maximum number of casks on site. Limits on the number of unloaded casks during operations are being considered and this value can be used to assess this parameter.

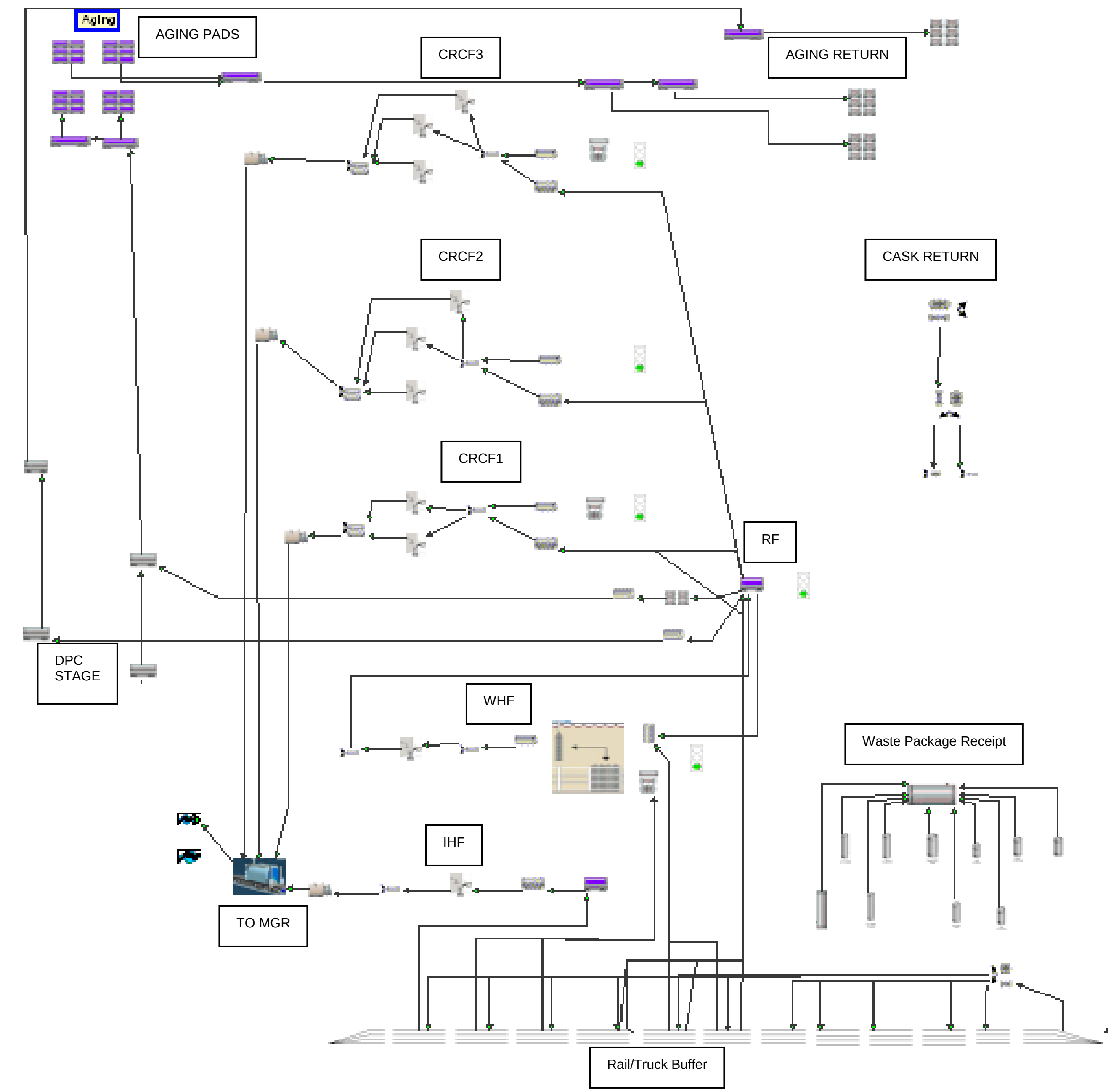

Figure 1. TSM GROA Department

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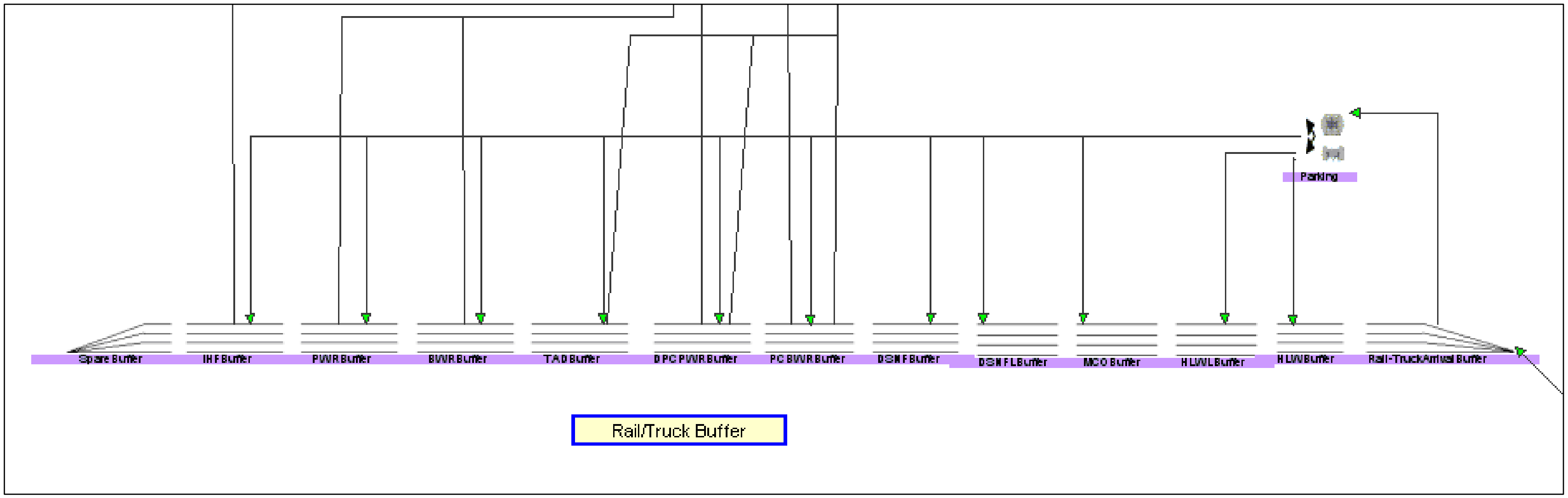
Figure 2.



Rail/Truck Buffer

2.2 PROCESSING FACILITIES: IHF, WHF, CRCF1, CRCF2, AND CRCF3

2.2.1 Process Timing

Although the released version of the model includes process times for activities such as opening a bare transportation cask, filling a WP or TAD canister, and closing a WP based on design information in References BSC 2006a, BSC 2007b, and BSC 2007c, these activities are generally dependent on the actual study being performed. If different timings are used, the revised process timings and their source are specified in the specific study plan or report. For example, see the so-called "Phase 1 TAD Study" (BSC 2005).

2.2.2 Initial Handling Facility Overview

The IHF is a limited-capacity initial processing facility that includes a single processing line and one closure cell. IHF allows Navy canisters or HLW to be removed from transportation casks and placed directly into a WP. Figure 3 provides a visual representation of the IHF. Table 1 provides a listing of all processes that comprise the IHF.

2.2.3 Wet Handling Facility Overview

The WHF (see Figure 3) is a pool-based facility used to transfer bare CSNF assemblies into TAD canisters. A cask is brought into the facility and placed into the pool for cooling and shielding. If the cask is a DPC, it is cut open inside the pool. Bare CSNF assemblies are then transferred to storage racks or directly into a TAD canister. Once a TAD canister is filled, it is drained and then welded closed in a special weld cell. Once the TAD canister is complete, it is sent off to the aging pad if it requires aging or directly to one of the CRCFs to be loaded into a WP. For modeling purposes, we have chosen to send all TAD canisters through the RF (via the TAD Buffer) prior to being sent to a CRCF.

Figure 3 provides a visual representation of the WHF. Table 2 provides a listing of all processes that comprise the WHF model.

2.2.4 Canister Receipt and Closure Facility 1, 2 and 3 Overview

The CRCFs are large, identical facilities designed to process canisters into WPs (see Figures 4 and 5). Although any of the three facilities is able to process DOE SNF, the simulation is designed to have only two of them (CRCF1 and CRCF3) perform this function (see more discussion in Section 1.3). Each CRCF contains two closure cells for closing WPs. Table 3 provides a listing of all processes that comprise each CRCF.

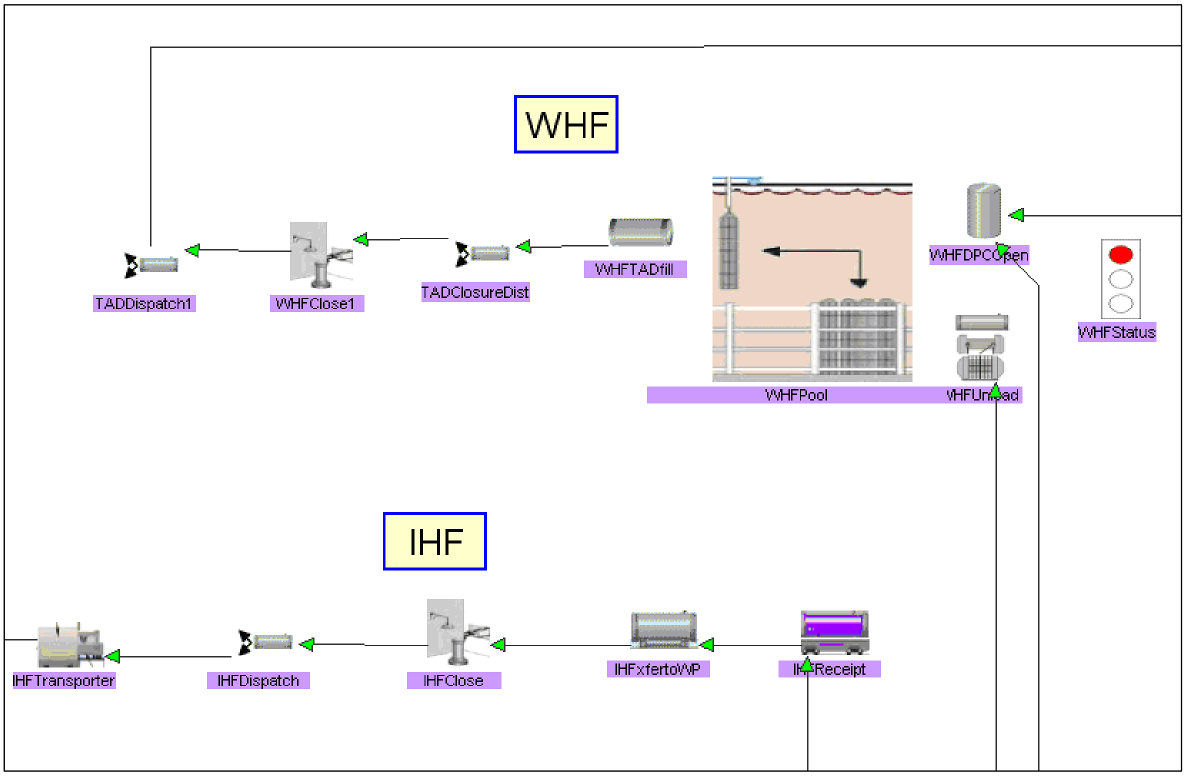


Figure 3. WHF and IHF Processes

Table 1. IHF Processes

Process	Description
IHFReceipt	Unload Casks
IHFxfertoWP	Transfer canister into WP
IHFClose	Close WP
IHFDispatch	Request WP Transporter
IHFTransporter	Transfers the WP to the MGR Transporter

Table 2. WHF Processes

Process	Description
WHFStatus	Facility status indicator: Green if on
WHFDPCOpen	Opens and Unloads a DPC
WHFUnload	Opens and Unloads a bare cask
WHFTADfill	Fills a TAD canister with bare SNF
WHFTADDist	Routes a TAD canister to an available closure cell
WHFClose1	WHF Closure Cell
WHFDispatch	Routes a completed TAD canister to the TAD Buffer or the TADAgePrepWait process for further processing
WHFPool	Graphic element to illustrate function of WHF

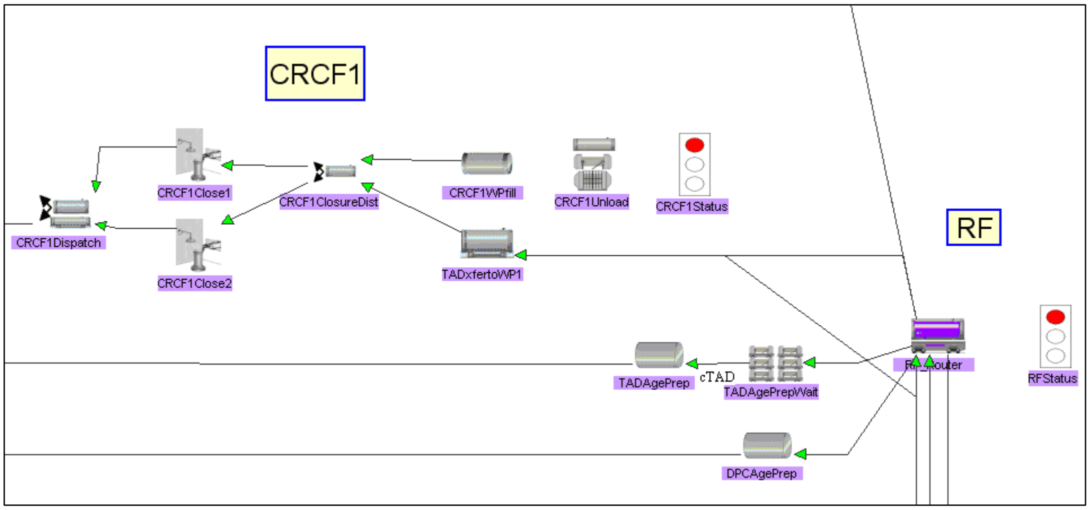


Figure 4. CRCF1 and RF

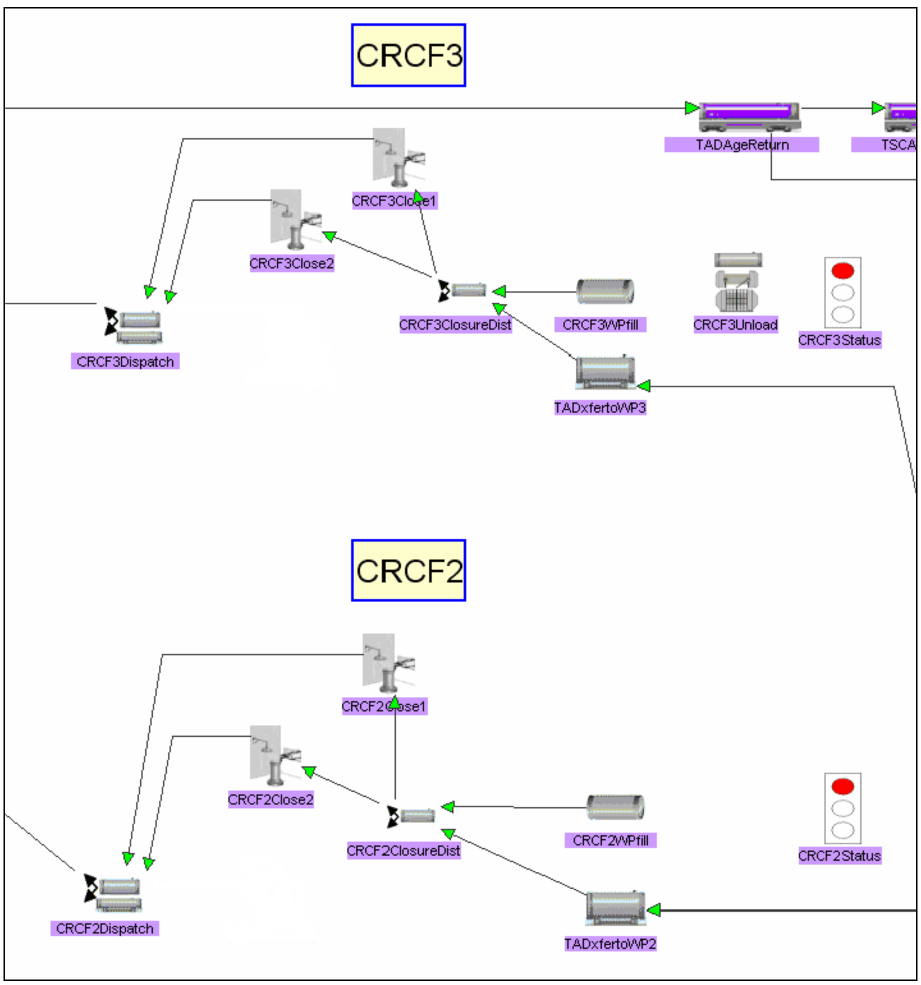


Figure 5. CRCF2 and CRCF3

Table 3. CRCF Processes

Process	Description
CRCFStatus	Facility status indicator: Green if on
CRCFUnload	Unload casks
CRCFWPfill	Fill WP with DOE canisters
CRCFclose	Close WP, weld and inspect
CRCFClosureDist	Distribute WP to Closure processes
CRCFDispatch	Request WP Transporter
CRCFWPtoTransporter	WP Transporter removes WP from facility

2.3 OTHER GROA PROCESSES

2.3.1 Aging Pads

The aging pads (see Figure 1) are used to hold CSNF until it meets emplacement thermal limits or sufficient processing capability is available to place it within a WP. When a TAD canister arrives at the aging pads, the heat information is logged to the database and is used in determining when the TAD canister may be returned. TAD canisters that have been returned for processing will appear in the TADLongReturn process and are transported to the TAD Buffer to await processing. Detail on how the aging and decay process is implemented is provided in *GROA Basis and Check* (BSC 2006b).

2.3.2 Waste Package Receipt Facility

The Waste Package Receipt Facility (see Figure 1) receives WPs and TAD canisters from off-site, prepares them for use within the processing facilities, and stages them until requested. Rather than delay the filling of WPs and TAD canisters while they are being transported, the simulation assumes that WPs are available at the instant that a facility determines the need. As such, the real WP or TAD canister is created (using VB code) in the appropriate fill process and a dummy WP or TAD canister is released to simulate the demand on the GROA transport system. CSNF spent fuel is now loaded into TAD canisters in the WHF so the variety of WPs used in previous versions of the TSM is no longer needed but the CSNF WP processes are retained for possible future use.

2.3.3 Receipt Facility

The RF (see Figure 4) is designed to offload many of the preparation activities from the CRCFs to improve their throughput. These activities include receiving casks (cleaning, sampling, removing personnel barriers, cask inspection), preparing TAD canisters for aging (cleaning, inspecting, placing within an overpack), and transferring TAD canisters via an STC for processing within one of the CRCFs. The TSM currently assumes that the RF will handle all TAD canisters once it comes online, except those sent from the WHF to the aging pad.

Notice in Figure 4 that the downstream process “DPCAgePrep” allows the RF to remove the DPC from the transportation cask and return the cask, place a storage overpack on the DPC, and send it to a “staging” area (in reality, an aging pad). This provides a means to model cases where DPCs cannot be immediately processed because the WHF is too busy or DPCs are arriving before the WHF is online. In these situations sending DPCs to “staging” allows quick return of the transportation cask for reuse. Notice this also allows the model to handle cases where DPCs are intentionally shipped earlier than the WHF is able to process them. The logic to send a DPC to “staging” rather than processing it is set up by the user by specifying the time step that the user wants to begin DPC processing. For nominal cases, this time is set to the time that WHF comes on line. The user can also set up the logic to preferentially do truck casks rather than DPCs in the WHF, thus increasing ability to receive bare CSNF. These settings and studies should be set up and verified by the TSM Development Team. Note that in the current TSM the DPCs in “staging” are not evaluated for radioactive decay, as are the TAD canisters on the aging pads.

2.3.4 Cask Return

Once a cask has been emptied and released by a facility, the cask is released from the cask hold process in the Rail Unbatch or Truck Unbatch departments in the main GUI and the cask jumps to the cask return in the GROA (see Figure 1). The cask is then transported to the FMF modeled by the “Maintenance” Department in the main GUI.

2.3.5 Monitored Geologic Repository

The MGR is the end point for all WPs and is the exit point for the GROA model. As a WP is created, the heat information is logged to the database for later analysis of the heat load within the MGR.

2.4 TIME-BASED ACTIVITY

2.4.1 Waste Routing

All waste that arrives at the GROA remains in the Rail/ Truck Buffer area where it is available for use by the various processing facilities. CRCF1 initially draws casks directly from the TAD Buffer. Once the RF comes online, all subsequent TAD canisters are routed through it before processing in any of the CRCFs.

2.4.2 Facility Start Sequence

The TSM model uses a list of the expected dates each processing facility is expected to be available for processing. Once this date is passed, the facility is presumed to be at full capacity and will start requesting casks and filling WPs. The date that each facility comes online is controlled by global variables: dateWHF, for the number of time steps until WHF is operational; dateRF, for the number of time steps until RF is operational; dateCRCF1, dateCRCF2 and dateCRCF3, for the number of time steps until CRCF1, CRCF2 and CRCF3 are operational, respectively. These variables are entered via the XML data file and may be modified prior to the start of a run using the Total System Model Control Center (TSMCC), allowing the user to see the effects of accelerated or delayed deployment.

2.4.3 TAD Canister Return from Aging

Once the CSNF within a TAD canister has cooled sufficiently, it will be returned from the aging pads for processing into a WP, assuming that TAD canister processing is not currently backed up. Returned TAD canisters are placed in the TAD Buffer until summoned for processing by RF. See Section 3.1.8 for more detail on how items are returned from aging.

2.5 VISUAL INDICATIONS

2.5.1 Facility Status

The stoplight to the right of each facility is used to indicate the operational status. Fully operational facilities will have their indicator set to a green light. When they are within one month of operating, the indicator will be set to a yellow light. Otherwise, they will show a red light, indicating an inoperative facility. Usually, at the start of GROA operations only the IHF is operational and all other facilities will have red lights.

2.6 FACILITY WASTE SELECTION

On every time step, if a cask is not being unloaded, each active unload process will examine the waste buffers to determine the best cask to be requested. Based on this selection, the facility will set a flag to signal the cask destination (if more than one facility may request that type) and signal a cask release. Each of the facilities has its own method of determining the best cask as described below.

2.6.1 WHF Waste Selection

The WHF will process waste found in the BWRBuffer, PWRBuffer, DPCBWRBuffer, DPCPWRBuffer, and the MSCDPCReturnBuffer. DPCs will only be taken from the MSCDPCBuffer if a DPC is to be processed and casks are available in neither the DPCBWRBuffer nor the DPCPWRBuffer.. The WHF will use a Least Recently Used (LRU) algorithm to keep casks flowing through the system, i.e. balancing between the BWRBuffer and the PWRBuffer and also between the DPCBWRBuffer and the DPCPWRBuffer. If any of the buffers start filling up (defined as being within three casks of their queue limits), that buffer will be given preference with the LRU again being selected if there are more than one that meet this criteria. The WHF uses the WHF_TruckDPCRatio to balance the processing of bare casks and DPCs. For example, if the WHF_TruckDPCRatio is set to 10, the WHF will attempt to process 10 bare casks for every DPC and likewise will attempt to process one DPC for every 10 bare casks. A setting above 180 for this variable will assure that no more than 1 DPC per year is processed (given current process timing).

2.6.2 CRCF Waste Selection

2.6.2.1 TAD Canister Processing

In general, a CRCF will preferentially process an arriving TAD canister if one is available to meet the overriding requirement to meet the desired CSNF waste acceptance.

2.6.2.2 DOE Codisposal Issues

The nuclear waste that comes from DOE facilities appears in five forms: HLW, HLW Long, DOE SNF, DOE SNF Long, and MCO. The HLW and HLW Long are combined with the other waste, if available, to form a Codisposal WP. Within a given DOE waste stream, there may be more or less HLW and HLW Long than can be matched with the other waste. If there is insufficient HLW or HLW Long, it is currently assumed that a number of Codisposal WPs will be created containing only a single DOE SNF canister. Conversely, if there is an excess of HLW or HLW Long within the DOE waste stream, a number of Codisposal WPs will be created with the central DOE SNF position left empty. Since the model has no way of determining if the HLW or DOE SNF is mismatched, the number of these packages to create must be entered as HLW_Mismatch or DSNF_Mismatch, set via the XML data file.

2.6.2.3 HLW Mismatch and DSNF Mismatch Calculation

The HLW_Mismatch value is calculated using the following equation:

Mismatched HLW = Floor((Total HLW – 5 * Total DOE SNF) / 5) + Floor((Total HLW Long – 5 * Total DOE SNF Long – 2 * Floor(Total MCO / 2)) / 5)

The DOE SNF and the DOE SNF Long are each matched with 5 HLW and HLW Long, respectively. The MCOs are each matched with 1 HLW Long (actually each MCO WP will contain 2 MCOs and 2 HLW Long). Each Codisposal package will dispose of 5 HLW or HLW Long. The “Floor” function truncates fractions.

The DSNF_Mismatch function’s formula is identical to the HLW_Mismatch formula, DSNF_ Mismatch is the case where the formula result is negative (too much DOE SNF) and the DSNF_ Mismatch variable value is just the absolute value of the result of the above formula if the result is negative.

The HLW_Mismatch and DSNF_Mismatch variables are automatically evaluated by the TSMCC used to run TSM as discussed in the TSM UM (BSC 2007a).

Typical example:

Mismatch Calculation Item	Number
Total HLW	7,469
Total HLW Long	12,198
Total DOE SNF	1,384
Total DOE SNF Long	963
Total MCO	441
Mismatched HLW Shipments	109
Mismatched HLW Long Shipments	1,388
Total Mismatched	1,497

2.6.2.4 CRCF1 Cask Selection Algorithm

CRCF1 has the complicated task of balancing the many different types of waste that it must process without interfering with CRCF3. Currently CRCF1 is set to preferentially process the shorter DOE waste (HLW and DOE SNF) and it will not process MCOs. The current algorithm is expected to change due to uncertainties in the waste acceptance process, but this section documents the current algorithm. The current selection is sequential – later checks are only made if the first ones fail.

1. If the DOE SNF lag storage inside the CRCF is empty and DOE SNF is available and HLW is available, CRCF1 will request DOE SNF.

2. If there is DOE SNF in lag storage and a HLW is available, CRCF1 will request HLW.

3. If lag storage is empty and more than one DOE SNF Long is available, and HLW Long is available, CRCF1 will request DOE SNF Long.

4. If there is DOE SNF Long in lag storage and more than one HLW Long is available, CRCF1 will request HLW Long.

5. If there is no DOE SNF available, but HLW is present and the entire unmatched quota has not been used (see HLW_Mismatch), CRCF1 will request HLW.

6. If there is no DOE SNF available, but more than one HLW Long is present and the entire unmatched quota has not been used (see HLW_Mismatch), CRCF1 will request HLW Long

7. If there is DOE SNF in lag storage and a HLW Long is available, CRCF1 will request HLW Long.

8. If there is DOE SNF Long in lag storage and a HLW is available, CRCF1 will request HLW.

9. If the DOE SNF lag storage is empty and a DOE SNF is available and HLW Long is available, CRCF1 will request DOE SNF.

10. If the DOE SNF Long lag storage is empty and DOE SNF Long is available and HLW is available, CRCF1 will request DOE SNF Long.

The above requests are actions to "pull" the appropriate waste types from the arrival buffers. If CRFC1 is not busy making a WP, and there is no DOE waste to pull, the CRCF1 is available for the RF to "push" a TAD canister to the CRCF1 and CRCF1 will make a TAD WP. CRCF1 can also "pull" TAD canisters before RF is open and TAD canister processing at this time has precedent over DOE processing.

2.6.2.5 CRCF3 Cask Selection Algorithm

CRCF3 has the complicated task of balancing the many different types of waste that it must process without interfering with CRCF1. Currently CRCF3 is set to preferentially process the longer DOE waste (HLW Long, MCO and DOE SNF Long). The current algorithm is expected to change due to uncertainties in the waste acceptance process, but this section documents the current algorithm. The current selection is sequential – later checks are only made if the first ones fail.

1. If lag storage is empty and DOE SNF Long is available, and a HLW Long is available, CRCF3 will request DOE SNF Long.

2. If there is DOE SNF Long or MCO in lag storage and a HLW Long is available, CRCF3 will request HLW Long.

3. If a MCO lag storage is empty and MCO is available, CRCF3 will request MCO.

4. If the DOE SNF lag storage is empty and more than one DOE SNF is available and HLW is available, CRCF3 will request DOE SNF.

5. If there is DOE SNF in lag storage and more than one HLW is available, CRCF1 will request HLW.

6. If there is no DOE SNF Long available, but HLW Long is present and the entire unmatched quota has not been used (see HLW_Mismatch), CRCF3 will request HLW Long.

7. If there is no DOE SNF available, but more than one HLW is present and the entire unmatched quota has not been used (see HLW_Mismatch), CRCF3 will request HLW.

8. If there is DOE SNF in lag storage and a HLW Long is available, CRCF3 will request HLW Long.

9. If there is DOE SNF Long in lag storage and more than one HLW is available, CRCF3 will request HLW.

10. If the DOE SNF Long lag storage is empty and DOE SNF Long is available and HLW is available, CRCF3 will request DOE SNF Long.

11. If the DOE SNF lag storage is empty and more than one DOE SNF is available and HLW Long is available, CRCF3 will request DOE SNF.

The above requests are actions to "pull" the appropriate waste types from the arrival buffers. If CRFC3 is not busy making a WP, and there is no DOE waste to pull, the CRCF3 is available for the RF to "push" a TAD canister to the CRCF3 and CRCF3 will make a TAD WP.

2.7 CASK UNLOAD/ DPC UNLOAD/ TAD CANISTER FILL

The three types of processes, Unload, DPC Open, and WP Fill in the WHF process lines and the non-TAD canister CRCF1 and CRCF3 process lines, all work somewhat independently using the Lag Storage area as a buffer between them. (Note that CRCF2 also has a WP Fill process but it is not currently used; it is inlcuded for possible future revisions to process line actions. CRCF2 currently processes TAD canisters only). As used in this program, the term Lag Storage is a misnomer as it is actually the total storage available instantaneously within a facility. The storage available within a cask is added to the facility lag storage capacity to reflect the temporary additional storage available while the cask is docked. A cask cannot be released from a facility until the total storage required for waste drops to the amount of actual lag storage. Thus a cask will stay docked until any excess waste is moved into a WP or a TAD canister.

2.7.1 WHF-Specific Unload and Fill

As casks arrive at the unload stations, the contents of the cask are added to the appropriate Heat Staging array for that facility (i.e. _B_H or _P_H – see Table 6 for definitions (the entries starting at XXX_B_H). This will track the number of assemblies of each CSNF type within the facility and maintain their original heat bin information. If a TAD canister is not currently being filled, the TAD Fill process will examine all of these arrays to see if a TAD canister can be filled with the CSNF currently in the facility. It checks to see if there is enough CSNF to fill the TAD canister. If there is sufficient CSNF, a TAD canister of the appropriate type is created within the TAD Fill process (this is done to model the fact that the transportation of the TAD canister to the facility is not expected to be on the critical path of facility throughput), and a dummy TAD canister is released to travel though the GROA transport system.

When a TAD canister appears at the TAD Fill process, it is filled using the Heat Recipe described in Section 2.8.1 and in Appendix B.

2.7.2 CRCF-Specific Unload and Fill

As DOE WP's arrive at CRCF1 or CRCF3, they are filled based on WP Type. A Codispose WP will be loaded with HLW, and, if available, one DOE SNF. A MCO WP will be loaded with 2 HLW Long and 2 MCO. Any DOE SNF that is not matched with HLW will remain in lag storage until HLW arrives. A Codispose Long WP will be loaded with HLW Long, and, if available, one DOE SNF Long.

2.8 HEAT RECIPE

Subsurface emplacement of WPs is controlled by the WP heat limit (kilowatts) parameter. The value of this heat limit is nominally set at 18 kilowatts using the WP_Heat variable in the XML data file, and can be adjusted by the user in the TSMCC. The algorithm for selecting the CSNF assemblies that will be placed within a WP is known as the Heat Recipe. The algorithm is based on the use of a single data structure within each facility to track the amount of available waste within the building. The available waste includes that currently in lag storage and the waste that is present within one open cask. The current model assumes that only a single cask will be open at a given time. It also assumes that lag storage is used to the fullest extent possible to provide the largest SNF population for selection. See Appendix B for a graphical depiction of the heat recipe in action.

The Heat Recipe for the WHF selects the assemblies closest to the average heat available in the vessel to be filled. This is done by calculating the average heat remaining in the vessel and finds the heat bin that is slightly under this average. If there are any assemblies in this bin, all of them are moved into the vessel. The remaining average is again calculated. The recipe then looks at the two bins that are adjacent to the original bin (these are designated as Low and High). The recipe then calculates the average of the Low and High bins and compares it to the average remaining heat in the vessel. If the bin average is less than the vessel average, an assembly from the High bin is selected; otherwise an assembly from the Low bin is selected. As bins are emptied out, the selected High and Low bins move further out from the original bin. The selection process will attempt to create a TAD canister that meets the pre-closure heat limits, however, if this is not possible using the available CSNF, it will fill the TAD canister with hotter assemblies and the TAD canister will be sent to aging.

2.9 FACILITY INTERLOCKS

There are two unload processes within the WHF, WHFUnload and WHF DPCOpen. Only one of these processes will be active at a time (modeling the pool constraint). Until a cask has been emptied and released, no other transportation casks are allowed within the facility, however a TAD canister may be filled while this unloading is taking place.

Before RF comes on line, CRCF1 initially requests TAD canisters directly from the TAD Buffer. Once RF comes online, all TAD canisters will come through RF.

2.10 INITIAL STATE FILE FIELDS

The following fields are used from the IS file: Buffer ID, Heat1-10, TotalHeat, Waste Type, MTU, Cask ID, and Shipment ID. The Buffer ID is used for routing the transportation cask to the appropriate buffer during the various phases of operation. In addition, several of the routers also check to see if the cask is a DPC (by looking for the initial 'D' in the Object Name) when deciding where to route the cask. The Heat fields (Heat1, Heat2, Heat3, Heat4, Heat5, Heat6, Heat7, Heat8, Heat9, Heat10) specify the number of assemblies in the transportation cask associated with each heat bin. Each heat bin has an associated heat, based on the Waste Type, which is used to select the appropriate assemblies to load into either a WP in the WHF (see Table A-2 for a listing of the current heat bin values.) The TotalHeat field is used for TAD canisters to determine if they meet WP heat limits (which is more accurate than summing heat bins). The Waste Type field indicates the type of waste within the cask. This is used to determine the appropriate heat values to use, the type of TAD canister to be filled in WHF, and which of the lag storage areas will be filled. The Cask ID identifies the cask in which the waste arrived at the GROA. Once the cask is empty, a trigger will be set to release a cask of this type from the cask hold processes in other parts of the TSM. The MTU field is used to determine how many Metric Tons of Heavy Metal have been processed in a given facility. The Shipment ID is used to uniquely identify shipments to allow tracking of SNF from discharge to emplacement and is currently used by the TSM Developers Group for post-processing analysis of special cases and thermal analyses.

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3. VISUAL BASIC DETAIL

This section provides detail on the interaction between SimCAD™ and the VB portion of the model. In the current version of the TSM, only the GROA Module makes use of any VB code.

3.1 SIMCAD/VISUAL BASIC INTERFACE

On each time tick, several of the processes within the GROA make calls out to VB to: (1) select a cask for processing, (2) see if a WP or a TAD canister can be filled, and (3) request a cask release trigger. Each of these will be detailed in the sections below. In addition, other processes will make calls to VB when a new object begins processing, or completes processing. These include a cask arriving at Cask Unload, a WP appearing at WP Fill, a TAD canister arriving at TAD Fill, a TAD canister leaving TAD Fill, a TAD canister leaving aging (process LongStageDist), a cask leaving the various Buffers, and a waste shipment leaving a Cask Unload. See Table A-1 in Appendix A for a full listing of the Processes and Functions that are called. Each section corresponds to a SimCAD™ event handler and details the processes that call VB routines.

3.1.1 Cask Selection

Each of the facilities has its own function for determining which buffer will be asked to release a cask. CRCF1 and CRCF3 have a strict priority selection, while the WHF uses a complicated selection method that involves a LRU algorithm coupled with a minimum available cutoff. This selection method was designed to balance the competing needs of assuring process starvation does not occur, and buffer overflow does not occur. As each buffer releases a cask, the LRU structure is updated to reflect the release. When selecting a cask, each facility will examine the available wastes and determine which type of available waste was processed least recently. Priority is given to any buffers that are in danger of overflow. The LRU structures are cleared every quarter to maintain balance. Most cask releases require both a release trigger and a destination flag (e.g. a release from the HLWBuffer to CRCF1 Unload requires a trCaskRelHLW trigger and a flgCRCF1HWL flag). Due to a limitation of the current VB implementation, only one string value may be returned to SimCAD™ during a VB Call. The additional flag is stored in a global variable until SimCAD™ can request it. Functions called: GetNextBldgCask and GetCaskReqEvent.

3.1.2 Determine if WP/TAD Canister Can Be Filled

On each time tick, the WP Fill and the TAD Fill processes examine current lag storage buffer contents in each facility to determine if there is sufficient waste to fill a WP or a TAD canister. In general, a WP can be filled if the minimum acceptable amount of waste is present, it meets the current heat constraint and there is a welder available to close it. A TAD canister may be filled whenever there is sufficient waste to fill it, and no heat constraints are evaluated. If either a WP or a TAD canister can be filled, it is immediately created within the appropriate process (i.e. WPfill or TADfill) and a Dummy object is released from the WP or TAD canister receipt process to simulate the load on the GROA transport system. Functions called: CheckStartProcessWHF, CheckStartProcessCRCF1, and CheckStartProcessCRCF3.

3.1.3 Request Cask Release Trigger

On every time tick, each cask unload process will call VB to obtain the release trigger for a cask. If one is returned, SimCAD™ knows that the waste is available, lag storage is not full for that waste type, and no other process is already asking for waste from that buffer. It will then check to make sure that it is not already processing a cask before signaling the event. If the event is signaled, SimCAD™ will usually make a second call to VB to obtain the other half of the trigger. Functions called: FacilityCaskRelease.

3.1.4 Cask Unload

When a cask arrives at an unload process, the contents of the cask are immediately passed to VB, where these contents are added to either the Lag Storage data structure or the unload queue. If a cask is already being unloaded, this information is placed in the unload queue. Once a cask has been unloaded and released, the next cask in the unload queue is processed. Functions called: UnloadCaskInWHF, UnloadCaskInCRCF1, and UnloadCaskInCRCF3.

3.1.5 WP Fill

The fill process is triggered when a WP object arrives at the WP Fill process. The type of WP specifies the waste type(s) that will be loaded. See Table 4 for a listing of the WPs and the waste types to be loaded. When a WP is filled, the facility, contents, and time are logged to the WP Recipe table in the TSM.mdb file (see Section 4 for a full description of this file). Functions called: FillContainerInWHF, FillContainerInCRCF1, FillContainerInCRCF3.

No VB function call is needed for the simple operations of the IHF. CRCF2 only transfers TAD canisters to WPs which is a one-to-one operation so no filling VB is needed.

Table 4. Waste Package Types Used in the TSM

Description	Waste Type	Capacity
Navy Long	Navy Long	1
Navy	Navy Short	1
Codispose	HLW/DOE SNF	5/1
Codispose Long	HLW Long/DOE SNF Long	5/1
MCO	MCO/HLW Long	2/2

3.1.6 TAD Fill

The fill process is triggered when a TAD canister object arrives at the TAD Fill process. Function called: FillContainerInWHF.

3.1.7 Increment LRU

Each of the buffers will make a call to VB to increment the LRU array for that waste type whenever a cask is released from the buffer. Functions called: IncrementLRU, IncrementDPCLRU.

3.1.8 TAD Canister Aging Return

Once the time tick indicated by dateTADret has passed, TAD canisters will start to be returned based on the total heat remaining within the aging casks. Approximately every three months, the TAD Decay query will be run to determine if any items on the aging pad have aged enough to be returned. The first record returned by the query is checked against the maximum return heat. If the total heat in the cask is less than or equal to the maximum return heat, a new TAD canister is created in the TADLongReturn processes and is populated with recorded data from the MSC_Log table. (Note: The term "MSC" used in previous versions was retained in TSM Version 6.0 to avoid extensive revisions and re-validation of the data structures and names.) Based on the decayed heats of the original assemblies, new heat bins are calculated and the assemblies are placed in the new heat bins. Finally, the Returned field of the MSC_Log table is set for that cask to indicate that it has been returned. The freqTADret variable is used to set the minimum interval between returned casks.

3.2 DATA STRUCTURES

3.2.1 Program Control

Table 5 lists the variables that affect the way in which the GROA will operate. Note that a time tick represents an 8-hour shift (i.e., there are 3 time ticks per day). A type followed by parentheses () indicates an array of that type. Many of these variables that previously existed only in VB were moved to be SimCAD™ variables and passed in to VB to allow the user to more easily change them. This also corresponded to an upgrade in SimCAD™ that allowed variables to be automatically exported to VB (no need to pass them). These are noted in the table as being "Exported". Variables that continue to reside in VB are noted as "Internal".

3.2.2 Facility Data Structures

Table 6 lists the variables related to facility data structures. Most of these variables will have prefixes that specify to which facility and/or process (designated by a letter) they apply (e.g. WHFA_ indicates the unload port for WHF). A=Unload, D=Unload DPC; M=Fill TAD; W=Fill WP. A type followed by parentheses () indicates an array of that type.

Table 5. Program Control Variables

Variable Name	Type	Where used	Description
AccessConnect	String	Numerous	String allowing access to the TSM.mdb file. Modify this string to change the name of the file or its location. Internal
bAgeArrivalFlag	Boolean	Arrival Aging	Flag that determines if arriving CSNF will be decayed. Internal
bDebug	Boolean	Numerous	Global flag that determines if debug messages will be displayed. Implemented as a variable so that it may be turned on if certain criteria are met. Useful in cases where problems occur late in the model run to avoid several thousand mouse clicks. Internal
cDataSave	Boolean	Numerous	Global Flag that determines if GROA data will be written to the TSM.mdb database. Internal
dateCRCF1	Long	CRCF1 Processing	Time tick at which CRCF1 will begin processing. Set via the TSMCC and loaded from XML file
dateCRCF2	Long	CRCF2 Processing	Time tick at which CRCF2 will begin processing. Set via the TSMCC and loaded from XML file
dateCRCF3	Long	CRCF3 Processing	Time tick at which CRCF3 will begin processing. Set via the TSMCC and loaded from XML file
dateRF	Long	RF Processing	Time tick at which RF will begin processing. Set via the TSMCC and loaded from XML file
dateWHF	Long	WHF Processing	Time tick at which WHF will begin processing. Set via the TSMCC and loaded from XML file
dateTADret	Long	TAD Return	Time tick at which eligible TAD canisters will begin returning for processing. Set via the TSMCC and loaded from XML fileExported
FreqTADret	Long	TAD Return	Minimum number of time ticks between TAD canisters that are returning. Exported
HLW_Mismatch	Long	CRCF Cask Selection	Number of Codispose WPs that will have HLW without a matching DOE SNF. This will need to be modified if the DOE Waste Acceptance changes. Loaded from XML file
DSNF_Mismatch	Long	CRCF Cask Selection	Number of Codispose WPs that will have DOE SNF without a matching HLW. This will need to be modified if the DOE Waste Acceptance changes. Loaded from XML file
IS_File	String	Initialize	The name of the Initial State file to be loaded at model start. Set via the TSMCC and loaded from XML file
Quit_Action	String	Model_Completion	Signal of what should be done when model is halted. If set to ‘end’, stops model, otherwise the model is paused. Set via the TSMCC and loaded from XML file
Quit_Step	Double	Model_Completion	The step at which the model will halt if Quit_When set to step. Set via the TSMCC and loaded from XML file
Quit_When	String	Model_Completion	Signal of when model should be halted. Values are: All – when all shipments into GROA and all back from aging Ship – when all shipments into GROA Step – at a given step. Set via the TSMCC and loaded from XML file

Table 5. Program Control Variables (continued)

Variable Name	Type	Where used	Description
Scenario_ID	String	Initialize	Identifier for the specific scenario being run. Set via the TSMCC and loaded from XML file
Shipments_Last	Double	Model_Completion	The date of the last shipment in the model run. Set via the TSMCC and loaded from XML file
Shipments_Num	Double	Model_Completion	The total number of shipments expected at the GROA. One of the possible automatic shutdown conditions. Set via the TSMCC and loaded from XML file
Shipments_Rows	Double	Initialize	The number of rows in the Initial State file. Used for automatically loading the IS. Set via the TSMCC and loaded from XML file
Study_ID	String	Initialize	Identifier for the Study of which this run is a part. Set via the TSMCC and loaded from XML file
cTAD_QBypassNum	Long	SelectCaskMPC	If the TAD buffer has more than this number of TAD canisters in it, will start bypass processing -– sending extra TAD canisters out to aging even if they are below the emplacement heat limit. Loaded from XML fileExported.
WHF_TruckDPCRatio	Long	WHF	Number of bare casks to be processed for each DPC that is opened. Input from the TSMCC and loaded from the XML file
WP_Heat	Long	Numerous	Current maximum heat (in watts) allowed in a WP. Input from the TSMCC and loaded from the XML file
Heat Regime structure – these arrays allow the user to modify the heat content of WPs for any range of time ticks. Normally the heat content will be set to 18000 watts, but this may be set to 1 watt to make sure that all assemblies are aged. The structures are predefined to have four separate heat periods.			
g_timeHeatArray_val	Long()	CheckHeatRegime	Heat Regime array containing the heat value to be used
g_timeHeatArray_time	Long()	CheckHeatRegime	Heat Regime array containing the time to switch heat values

Table 6. Facility Data Structures

Variable Name	Type	XXX	YYY	Where used	Description
XXX_ CurrTAD	String	Facility ID	N/A	Processes	Type of TAD canister currently being filled.
XXX_ CurrWP	String	Facility ID	N/A	N/A	Type of WP currently being filled.
XXXYY_ CaskReqEvent	String	Facility ID	Port ID	Routers at buffer areas	Cask Request Event; saves the name of the event used to signal where the requested cask will be sent
XXX_Staging	Long()	Facility ID	N/A	Numerous	Amount of lag storage for each waste type – see gcsaiXXX
XXX_StagingUsed	Long()	Facility ID	N/A	Numerous	Amount of each waste type within the lag storage area – see gcsaiXXX
XXX_TADHeat	Long()	Facility ID	N/A	Numerous	Number of assemblies in each heat bin currently loaded into the current TAD canister
XXX_WPHeat	Long()	Facility ID	N/A	Numerous	Number of assemblies in each heat bin currently loaded into the current WP
XXXYY_SNFType	String	Facility ID	Port ID	Numerous	Type of SNF currently being unloaded or filled (depending on whether this is an unload or a fill station)
XXXYY_Heat	Long()	Facility ID	Port ID	Numerous	Number of assemblies in each heat bin
XXX_B_H	Long()	Facility ID	N/A	Numerous	Number of BWR assemblies in each heat bin
XXX_P_H	Long()	Facility ID	N/A	Numerous	Number of PWR assemblies in each heat bin
arrXXXMinWaste	Long()	Facility ID	N/A	Cask Selection	Minimum number of casks that must be available before processing will start on that waste type – see arrXXXWasteType
arrXXXDPCMinWaste	Long()	Facility ID	N/A	Cask Selection	Minimum number of DPC casks that must be available before processing will start on that waste type – see arrXXXDPCWasteType
arrXXXWasteType	String()	WHF	N/A	MinWaste and LRU arrays	List of waste types the facility may process – see gcwtXXX
arrXXXDPC WasteType	String()	WHF	N/A	DPCMinWaste and DPCLRU arrays	List of waste types the facility may process – see gcwtXXX
arrXXXBufferSize	Long()	WHF	N/A	Cask Selection	Maximum buffer size for each of the buffers used by WHF facility
arrDTFDPC BufferSize	Long()	N/A	N/A	Cask Selection	Maximum buffer size for each of the DPC buffers used by WHF facility

Table 6. Facility Data Structures (continued)

Variable Name	Type	XXX	YYY	Where used	Description
arrWHF_LRU	Long()	N/A	N/A	Cask Selection	Number of casks of each waste type processed by WHF – see arrXXXWasteType
avgXXXHeat	Long()	SNF Type	N/A	Numerous	Storage area for average Heat Bin values
g_heatXXX_Lower	Long()	SNF Type	N/A	Numerous	Storage area for lower Heat Bin values
g_heatXXX_Upper	Long()	SNF Type	N/A	Numerous	Storage area for upper Heat Bin values
XXXYYYInfo_BT	String	Facility ID		TAD Fill, Long Return	Buffer type information for a newly created TAD canister. Cached until SimCAD™ calls for it
XXXYYYInfo_CI	String	Facility ID	TAD	TAD Fill, Long Return	Cask ID information for a newly created TAD canister. Cached until SimCAD™ calls for it
XXXYYYInfo_H	Long Array	Facility ID	TAD	TAD Fill, Long Return	Heat Bin information for a newly created TAD canister. Cached until SimCAD™ calls for it
XXXYYYInfo_WT	String	Facility ID	TAD	TAD Fill, Long Return	Waste type information for a newly created TAD canister. Cached until SimCAD™ calls for it
TSCLTInfo_CI	Long	N/A	N/A	Not currently used	Cask ID information for a TSC heading out to aging – cask to be released when TSC is emptied. Cached until SimCAD™ calls for it.
XXXLTInfo_H	Long	TAD	N/A	TADAgePrep,	Heat Bin information for a TAD canister heading out to aging. Cached until SimCAD™ calls for it.
XXXLTInfo_WT	String	TAD	N/A	TADAgePrep,	Waste Type information for a TAD canister heading out to aging. Cached until SimCAD™ calls for it.
XXX_YYInProcess	Boolean	Facility ID	WP or TAD	Numerous	Flag that a WP or TAD canister is in the process of being filled
gcwtXXX	String constants	Waste Type	N/A	Numerous	Global Constant Waste Type –character constants that describe the waste types. Originally designed to provide a way to reference the buffers, but have since taken on additional duties. **Use extreme caution when changing any of these constants**.
gcsaiXXX	Integer constants	Waste Type	N/A	Numerous	Staging Array Index – all facilities use the same index to track their lag storage. Although most facilities will process different waste, this provides a standard way to reference a storage location. The constants with the prefix "gcsai" are used to reference the storage locations

3.3 VB KNOWN LIMITATIONS

The current version of the GROA Module was primarily developed using SimCAD™ Version 7.1. The scripting available within SimCAD™ still contains a number of limitations and required work-arounds that were discovered during the development process. The most difficult limitation was that of returning only a single value from VB to SimCAD™ during a function call. In many places, it was necessary to cache the information in VB until additional calls from SimCAD™ requested the cached information.

The model was designed around the concept of "Heat Bins" which smears out individual heats into a range, but uses a single typical value for all assemblies assigned to that range. The typical value was calculated from an average of all assemblies in the heat bin range. Using this average will cause some unavoidable inaccuracy in the heat content of any particular WP, however the system as a whole should not be affected. In addition, the method of decaying assemblies over time also uses the average of all decay rates for assemblies within the heat bin.

If a string needs to be passed to a VB function, it must be stored in a variable prior to calling the function. In general, VB tends to be somewhat casual with respect to typing of variables passed to functions. The implementation of VB found in SimCAD™ is much more rigorous in checking types and will yield a run-time error if the types do not match.

It was also discovered that passing more than 12 variables from SimCAD™ to VB resulted in a mysterious error several thousand steps after the first call. The SimCAD™ developer, Create ASoft™ is working on the problem.

The model is currently limited to aging CSNF for a maximum of 100 years.

4. GROA-SPECIFIC DATABASE

In addition to the standard data logging provided by SimCAD™, the VB Module has its own database (referred to as "the MDB file") for heat information and debug parameters. As Casks are unloaded, and WPs and TAD canisters are filled, heat information is logged to the database for later analysis. This information allows calculation of the drift load and TAD canister return.

4.1 DATABASE TABLES

There are seven primary tables in this database: WP_Recipe, Staging, MSC_Log, LU_Heats, LU_Heats_Short, Arrival, and TSM_Debug. These are discussed in the following sections.

4.1.1 WP_RECIPE

This table logs the contents of all WPs and TAD canisters that are filled in the GROA. The heat bin fields are used to log the number of assemblies that are placed in each vessel within IHF, WHF, CRCF1, CRCF2, and CRCF3. Since DOE waste does not need heat bins, the heat bin fields have been used to record the various DOE waste elements (see Table 7).

Table 7. CRCF-Specific DOE Heat Bin Usage

Heat Bin	Waste Type
1	DOE SNF
2	HLW
3	DOE SNFL
4	HLWL
5	MCO

The WP_Recipe table is cleared at the start of every model run.

4.1.2 STAGING

This table will log the contents of casks as they arrive in a facility for unloading. In addition, it records the contents of the lag storage arrays during filling of TAD canisters. This allows the user to examine the sequence of events that resulted in the contents of a given TAD canister. The only usable data from this table (other than debug use) are the records with WP_Type set to "UNLOAD". These records may be used to track all SNF that entered the building. In addition, when the model is halted, the contents of lag storage in each facility is written to this table with WP_Type set to "FINAL". This allows the user to see what waste was still within each facility at the end. This table is cleared at the start of every run.

4.1.3 MSC_LOG

This table will log the contents of all TAD canisters that are sent to Long-Term aging. As casks arrive at the LongStageDist process, all relevant information is saved and the SimCAD™ object is destroyed to minimize the effect on run-time performance. The TAD Decay query links this table to the LU_Heats table to determine when each of these can be returned. In general, the oldest and coldest of the casks are returned first. This table is cleared at the start of every model run.

4.1.4 TSM_DEBUG

This table provides generic data storage to assist in troubleshooting problems within the VB code. Due to the lack of a debugger, it provides an essential record of activity wherever needed. Since it is only used by expert users, it is not automatically cleared and thus data will accumulate if debug log requests are left in the program.

4.1.5 LU_HEATS

This table provides the decay rate for assemblies in five-year increments. Based on the original heat bin to which an assembly was assigned and the elapsed time, this table will indicate the new heat associated with the assembly. The values in this table were obtained from the TSLCC03 data by taking all assemblies, decaying them in 5-year increments, and averaging for each heat bin. The resulting value for each heat bin and elapsed time period were then entered into this table to be used for all members of the heat bin. See Table A-3 for a listing of the values used as of 9/1/07.

4.1.6 LU_HEATS_SHORT

This table provides the decay rate for assemblies in one-year increments for aging of shipments that were delayed in arriving at the GROA. Based on the original heat bin to which an assembly was assigned and the elapsed time, this table will indicate the new heat associated with the assembly. The values in this table were obtained from the TSLCC03 data by taking all assemblies, decaying them in 1-year increments, and averaging for each heat bin. The resulting value for each heat bin and elapsed time period were then entered into this table to be used for all members of the heat bin. See Table A-4 for a listing of the values used as of 9/1/07.

4.1.7 ARRIVAL

This table logs information about all shipments that arrive at the GROA.

4.2 DATABASE QUERIES

The TAD Decay query is used to determine the TAD canisters that are ready to be returned for processing. It uses the current time and the time that each cask was sent to aging (recorded in the

MSC_Log table) to determine how long the cask has been aging. It then performs a lookup in the LU_Heats table to determine the current heat associated with each assembly in the TAD canister based on its original heat bin. The current total heat of all assemblies in each cask is calculated and the list is sorted in ascending heat order. It will only list casks that have not been returned.

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5. REFERENCES

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BSC 2007f. *Glossary for the Total System Model Version 6.0*, 50040-UM-03-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

5.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

AP-ENG-006 REV 1 ICN 0. *Total System Model (TSM) – Changes to Configuration Items and Base Case*. Washington, DC: BSC. ACC: Submit to RPC.

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APPENDIX A

VB CALLS

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APPENDIX A. VB CALLS

Table A-1. VB Calls made by TSM SimCAD™ extensions

Event	Process	Function
InitializeSimulation	N/A	InitializeFacilities
SimulationStepStarted	N/A	CheckLoadingProcesses
SimulationStopped	N/A	LogAllLagStorage
StepStarted	CRCFUnload	GetCaskReqEvent
StepStarted	CRCFUnload	GetNextBldgCask
StepStarted	CRCFUnload	IncrementGROAVar
StepStarted	CRCFWPfill	CheckStartProcessCRCF
StepStarted	WHFDPCOpen	GetCaskReqEvent
StepStarted	WHFDPCOpen	GetNextBldgCask
StepStarted	WHFDPCOpen	IncrementGROAVar
StepStarted	WHFUnload1	GetCaskReqEvent
StepStarted	WHFUnload1	GetNextBldgCask
StepStarted	WHFUnload1	IncrementGROAVar
StepStarted	WHFWPfill	CheckStartProcessWHF
StepStarted	TADLongReturn	CheckStartProcessTADReturn
StepStarted	TSCLongReturn	CheckStartProcessTSCReturn
StepStarted	RF_Router	GetNextBldgCask
ObjectActivated	WHFDPCOpen	UnloadCaskInWHF
ObjectActivated	WHFUnload	WHF_ProcessCasks
ObjectActivated	WHFUnload	UnloadCaskInWHF
ObjectActivated	WHFWPfill	FillContainerInWHF
ObjectActivated	IHFxfertoTAD	FillContainerInIHF
ObjectActivated	IHFxfertoTAD	FacilityCaskRelease
ObjectActivated	Rail-TruckArrivalBuffer	LogObjectArrival
ObjectActivated	TADLongReturn	GetLSRTAD_Cask_ID
ObjectActivated	TADLongReturn	GetLSRTAD_heat
ObjectActivated	TADLongReturn	GetTAD_WasteType
NextProcessDefined	BWRBuffer	IncrementLRU
NextProcessDefined	CRCFUnload	FacilityCaskRelease
NextProcessDefined	CRCFWPfill	CRCF_WP_Finished
NextProcessDefined	CRCFWPfill	FacilityCaskRelease
NextProcessDefined	DPCBWRBuffer	IncrementDPCLRU
NextProcessDefined	DPCPWRBuffer	IncrementDPCLRU
NextProcessDefined	WHFDPCOpen	FacilityCaskRelease

Table A-1. VBCalls made by TSM SimCAD™ extensions (continued)

Event	Process	Function
NextProcessDefined	WHFTADfill	GetWHFTAD_heat
NextProcessDefined	PWRBuffer	IncrementLRU
NextProcessDefined	PWRTruckBuffer	IncrementLRU
NextProcessDefined	TADAgeDist	LogMSCInfo
NextProcessDefined	TADAgePrep	GetTAD_heat
NextProcessDefined	TADAgePrep	GetTAD_WasteType
NextProcessDefined	TSCAgeDist	LogTSCInfo
NextProcessDefined	RF_Router	GetTADDest
ObjectProcessingComplete	cTAD (connection)	CacheTADAgeProperties
ObjectProcessingComplete	cTSC (connection)	StoreTSCInfo

Table A-2. Heat Bin Values

SNF Type	Value	Heat1	Heat2	Heat3	Heat4	Heat5	Heat6	Heat7	Heat8	Heat9	Heat10
BWR	Minimum	0	26	51	101	151	201	251	301	351	401
	Maximum	25	50	100	150	200	250	300	350	400	infinity
	Average	13	38	75	125	175	225	275	325	375	700
PWR	Minimum	0	126	351	451	551	651	751	876	1001	1751
	Maximum	250	350	450	550	650	750	875	1000	1750	infinity
	Average	125	300	400	500	600	700	863	938	1375	2000

The Minimum and Maximum values provide the heat ranges used to determine the appropriate bin for a given SNF assembly. The Average is the value used for all calculations involving the heat bin.

Table A-3 provides the new heat value to be used for a SNF assembly in a given heat bin after the indicated decay period.

Table A-3. Heat Bin Decay Values (Long Term)

SNF Type	Years	Heat1	Heat2	Heat3	Heat4	Heat5	Heat6	Heat7	Heat8	Heat9	Heat10
BWR	5	12	36	70	110	160	198	241	280	315	357
	10	11	34	65	101	146	179	216	250	279	313
	15	10	31	60	93	133	163	196	226	251	280
	20	9	29	56	86	122	149	178	205	227	252
	25	9	27	52	79	112	136	163	186	206	228
	30	8	25	49	74	103	125	149	170	188	207
	35	8	24	46	68	95	115	137	156	172	189
	40	7	22	43	64	88	107	126	143	157	173
	45	7	21	41	60	82	99	116	132	145	159
	50	6	20	38	56	77	92	108	122	134	146
	60	6	18	34	49	67	80	93	105	113	123
	70	6	17	30	44	60	70	81	92	98	106
	80	5	16	28	40	53	63	72	81	86	93
	90	5	14	26	36	48	56	64	72	76	82
	100	5	14	24	33	44	51	58	65	69	73
PWR	5	168	275	362	461	530	619	705	800	972	1273
	10	156	254	332	420	482	563	634	715	847	1078
	15	146	235	306	385	440	508	576	647	758	954
	20	136	219	283	355	404	465	526	589	686	857
	25	128	204	263	327	372	427	482	539	625	775
	30	120	191	244	303	344	393	443	495	571	704
	35	113	179	227	282	319	364	409	456	524	643
	40	107	168	213	262	297	337	379	421	482	589
	45	102	159	199	245	277	313	352	390	445	541
	50	97	150	188	230	259	292	327	362	412	499
	60	88	134	165	205	229	258	284	315	355	426
	70	80	122	149	183	205	228	251	278	311	371
	80	75	112	135	166	184	205	225	248	276	327
	90	70	104	125	151	168	185	203	223	247	291
	100	66	97	116	139	155	170	185	203	224	262

Table A-4 provides the new heat value to be used for a SNF assembly in a given heat bin after the indicated decay period.

Table A-4. Heat Bin Decay Values (Short Term)

SNF Type	Years	Heat1	Heat2	Heat3	Heat4	Heat5	Heat6	Heat7	Heat8	Heat9	Heat10
BWR	1	14	39	75	121	176	216	266	312	355	415
	2	13	38	74	118	172	211	259	302	342	394
	3	13	38	72	116	169	206	252	294	330	377
	4	13	37	71	114	165	202	246	286	320	363
	5	13	36	70	111	162	198	240	279	311	352
	6	13	36	69	109	159	193	235	273	303	341
	7	12	35	68	107	156	190	230	267	296	332
	8	12	35	67	106	153	186	225	261	289	323
	9	12	34	66	104	150	182	220	255	282	315
	10	12	34	65	102	147	179	216	250	276	308
PWR	1	179	293	390	504	577	684	780	896	1170	1643
	2	177	288	381	493	565	667	758	867	1099	1502
	3	174	283	373	483	553	650	738	842	1045	1400
	4	171	278	366	473	541	636	719	820	1003	1323
	5	169	273	359	464	530	622	703	799	968	1262
	6	166	269	352	456	520	608	687	780	937	1213
	7	164	265	346	447	510	596	672	762	910	1170
	8	161	260	340	439	501	584	658	746	886	1133
	9	159	256	334	431	491	572	644	730	863	1100
	10	157	252	329	424	482	561	631	714	842	1069

APPENDIX B

WASTE PACKAGE HEAT RECIPE

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APPENDIX B. HEAT RECIPE

The following pages present a graphical example of the process that selects assemblies for placement within a WP. Although the display shows 11.8 kilowatts, the same algorithm is used for any heat level and any heat bin averages.

Figure B-1. Waste Package Heat Recipe

PWR Heat Ranges and Median Values

Ranges (W)	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000+
Heat Bins	1	2	3	4	5	6	7	8	9	10
Median (W)	50	150	250	350	450	550	650	750	850	1100

Step 1 Determine starting bin (highest bin that allows all assemblies to be transferred)

Average Assembly Heat 11800 Watts/WP / 21 WP Assmb/ = 562 Watts/ Assmb

⇒ Heat Bin 6

Step 2: Transfer assemblies from starting bin

SNF in Staging and Cask

Bin	SNF in Staging and Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	9	0
Bin 7	1	0
Bin 6	8	0
Bin 5	3	0
Bin 4	2	0
Bin 3	0	0
Bin 2	1	0
Bin 1	3	0

Staging / Cask

Bin	Staging / Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	9	0
Bin 7	1	0
⇒ Bin 6	0	8
Bin 5	3	0
Bin 4	2	0
Bin 3	0	0
Bin 2	1	0
Bin 1	3	0

Step 3: Select next higher and lower bins(bracket starting bin)

		Staging / Cask	
Bin	10	19	
Bin	9	8	
Bin	8	9	
Bin	7	1	Higher = Bin 7 (Heat = 650 W)
Bin	6	0	
Bin	5	3	Lower = Bin 5 (Heat = 450 W)
Bin	4	2	
Bin	3	0	
Bin	2	1	
Bin	1	3	

Step 4: Calculate average remaining heat

(11800 W - 8 * 550 W) / (21 Assmb - 8 Assmb) = 569 Watts/ Assmb

Calculate average High/Low Bin Heat

(650 W + 450 W) / 2 = 569 Watts/ Assmb

PWR Heat Ranges and Median Values

Ranges (W)	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000+
Heat Bins	1	2	3	4	5	6	7	8	9	10
Median (W)	50	150	250	350	450	550	650	750	850	1100

(NOTE: Values shown are likely to change in final version)

Step 5 If the average remaining heat is below the average bin heat, select the Low Bin; otherwise, select the High Bin

569 Watts/ Assmb > 550 Watts/ Assmb → High Bin (Bin 7)

Step 6: Transfer one assembly selected bin

Before transfer:

	SNF in Staging and Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	9	0
Bin 7	1	0
Bin 6	0	8
Bin 5	3	0
Bin 4	2	0
Bin 3	0	0
Bin 2	1	0
Bin 1	3	0

→

After transfer:

	Staging / Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	9	0
Bin 7	0	1
Bin 6	0	8
Bin 5	3	0
Bin 4	2	0
Bin 3	0	0
Bin 2	1	0
Bin 1	3	0

Step 7: As bins empty, select next higher/lower bin and repeat from Step 4 until only one slot remains.

	Staging / Cask	
Bin 10	19	
Bin 9	8	
Bin 8	9	Higher = Bin 8 (Heat = 750 W)
Bin 7	0	
Bin 6	0	
Bin 5	3	Lower = Bin 5 (Heat = 450 W)
Bin 4	2	
Bin 3	0	
Bin 2	1	
Bin 1	3	

Step 8: Select hottest assembly that will fit in WP

	SNF in Staging and Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	4	5
Bin 7	0	1
Bin 6	0	8
Bin 5	0	3
Bin 4	0	2
Bin 3	0	0
Bin 2	0	1
Bin 1	3	0

800 W remain →

	Staging / Cask	WP
Bin 10	19	0
Bin 9	8	0
Bin 8	3	6
Bin 7	0	1
Bin 6	0	8
Bin 5	0	3
Bin 4	0	2
Bin 3	0	0
Bin 2	0	1
Bin 1	3	0

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