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Total System Model Version 6.0 Transportation Design and Bases

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TOTAL SYSTEM MODEL VERSION 6.0 TRANSPORTATION DESIGN AND BASES

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ACRONYMS AND ABBREVIATIONS

BSC	Bechtel SAIC Company, LLC
BWR	Boiling Water Reactor
CaS	Create-a-Soft™
CRWMS	Civilian Radioactive Waste Management System
CSNF	Commercial Spent Nuclear Fuel
DOE	U.S. Department of Energy
DOT	Department of Transportation
DPC	Dual-Purpose Canister
FEIS	Final Environmental Impact Statement
FHF	Fuel Handling Facility
FMF	Fleet Maintenance Facility
GROA	Geologic Repository Operations Area
GUI	Graphical User Interface
HH	Heavy Haul
HLW	High-Level (radioactive) Waste
IMF	Intermodal Facility
IS	Initial State
JIT	Just in Time
LWT	Legal Weight Truck
MCO	Multi-Canister Overpack
mph	Miles per hour
MGR	Monitored Geologic Repository
N/A	Not Applicable
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
PWR	Pressurized Water Reactor

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SNF	Spent Nuclear Fuel
SRTC	Site Rail Transportation Cart
STL	State Line Crossing charges
STP	South Texas Project
TAD	Transportation, Aging and Disposal
TSC	Transportable Storage Cask
TSLCC	Total System Life Cycle Cost
TSM	Total System Model
TSMCC	Total System Model Control Center
TSMPP	Total System Model Preprocessor
V	Version
VB	Visual Basic code
WA	Waste Acceptance
WAST	Waste Acceptance, Storage, and Transportation
WO	Work Order (SimCAD tool)
WP	Waste Package

1. INTRODUCTION

The Civilian Radioactive Waste Management System (CRWMS) 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), Department of Energy (DOE) Spent Nuclear Fuel (DOE SNF), and High-Level (radioactive) Waste (HLW). The TSM and associated programs analyze and simulate the actions for waste acceptance from discharge until emplacement.

The TSM is a PC-based, user-friendly, systems model that provides easy to understand Graphical User Interface (GUI) with dynamic simulation screens to serve as a decision aid for overall Office of the Civilian Radioactive Waste Management (OCRWM) disposal objectives. The TSM is:

- a real-time process simulation model that achieves the established requirements to perform systems analysis such as the so-called "Phase 1 TAD Study" (BSC 2005) and the Critical Decision-1 Study (BSC 2006a). The TSM provides a rapid means to evaluate alternative approaches to achieve program and project goals,
- based on established process optimization tools and methods, usability and accepted system analysis techniques; and
- an end-to-end model with interaction of waste acceptance, transportation, and repository parameters and constraints.

As shown in Figure 1, the functional design of the TSM is to integrate the elements of the CRWMS mission. Elements of the TSM are discussed in References BSC 2007a, BSC 2007b, BSC 2007c, and BSC 2007d. Specific values for the transportation parameters in this report are discussed in the TSM Transportation Validation Report (BSC 2007e). This report covers TSM Version 6.0 (V6.0), and changes that could impact transportation are discussed in the TSM User Manual (BSC 2007a), Section 1.5 and in Section 1.4 of this report. There were no impacts to the transportation behavior as addressed in the TSM V6.0 Validation Report (BSC 2007f).

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

1.1 PURPOSE OF THIS REPORT

This report covers the basis for the Transportation Module shown in Figure 1. The description of how to use the overall TSM and the overall systems behavior of the main elements of the CRWMS mission are covered in the TSM User Manual (BSC 2007a). The main requirements for the transportation elements shown in Figure 1 are implemented in the TSM Transportation Module elements shown in Table 1.

Using this report, a TSM user should be able to understand the basis and assumptions for the transportation parameters that set or influence the requirements listed in Table 1. It is assumed the user has a working knowledge of the CRWMS program activities and elements.

1.2 OVERALL TSM STRUCTURE

The TSM functions and modules are shown in Figure 2. The TSM is based on a modular structure for the core CRWMS program functions and requirements and integrates the functions in an end-to-end systems analysis. The modular structure allows independent "top down" analysis in each core module and integrated analysis using the TSM. This provides the flexibility for the core program elements to continue their design and implementation projects and tasks in parallel with the TSM development and implementation. The TSM uses the commercial software SimCAD™ from Create-a-Soft™ (CaS) described in Reference CaS 2006.

The complete TSM consists of the TSM simulator and the TSM Preprocessor (TSMPP) to simulate the CRWMS mission. As shown in Figure 3, the TSM incorporates various elements to form a comprehensive systems analysis tool. The Transportation module discussed in this report is a part of the TSM/SimCAD™ element shown in Figure 3 and this report focuses on the transportation functions in the TSM/SimCAD™ portion of the overall TSM.

The TSMPP shown in Figure 3 provides the information that drives the actions of the transportation module elements during TSM runs. The TSMPP uses databases with the various information for Waste Acceptance (WA) in a logic that properly combines fuel aging, utility allocations, and transportation cask parameters to develop the cask loads and associated schedule for the cask load shipments. The TSMPP models how the ~300,000 CSNF assemblies can be combined into "cask loads" depending on the acceptance scenario. The sequential EXCEL list of cask load shipment parameters and target ship dates generated by the TSMPP are the main input to the TSM. This list is referred to as the Initial State (IS) file or simply the "IS." The individual cask loads are input to the TSM as "objects" that are handled by the TSM processes. Refer to BSC 2007a and BSC 2007g for more information on the TSMPP.

1.3 ASSUMPTIONS AND LIMITATIONS

The model described in this document is based on conceptual CRWMS plans and designs. Due to the preliminary nature of these plans and designs, it was necessary to make assumptions during the development of this model concerning detailed CRWMS operations. It is expected that many of these assumptions will be revised as the CRWMS facility designs and concept of operations are further developed.

The assumptions and inputs cover the main areas of the CRWMS: waste acceptance, transportation, and repository/surface facilities. The assumptions are also consistent with the existing regulatory bases when appropriate. For example the assumed transportation routes are based on considerable technical review and analysis of potential routes as part of the Final Environmental Impact Statement (FEIS) (DOE 2002) process to identify routes. The TSM can also handle alternate routes to those in the FEIS but the established FEIS routes are used for the initial TSM analysis.

The assumptions are as "realistic" as possible because the data is the best information available recognizing that there are uncertainties over the mission times that cannot be resolved. For example, during the next 50 years the overall fuel cycle strategy in the US may shift to reprocessing vs. the current “once through” strategy and this will change the waste stream content (and thermal properties) significantly. The key point is the CRWMS program and the TSM are capable of handling changes in the waste stream or other changes in the infrastructure that supports the CRWMS mission.

The TSM is a simulation model based on abstractions of actual physical processes and activities and must be considered as an approximation for the predicted behavior of a complex system.

Table 1. Transportation Module Requirements and Implementation

TSM Transportation Requirement	**Transportation Module Implementation**
Transportation routes	The routes on the transportation department maps are based on Department of Transportation (DOT) truck routes and rail routes used in the Final Environmental Impact Statement (FEIS).
Cask Capabilities	The cask fleet used in the TSM provides the capability to meet the shipping requirements for all the wastes in the CRWMS mission. Cask handling actions such as loading, transport, and maintenance are modeled.
Cask Availabilities	The TSM logic accounts for the travel time and actions that impact the availability of individual casks such as maintenance requirements. The TSM is also arranged to easily discern the “turn-around” time or “residence” time at the repository - a key parameter directly impacted by the processing capability of the process lines.
Cask Maintenance	Cask maintenance requirements are prescribed in the certification for the cask. Since the final cask selection is not complete estimates for maintenance of truck casks are based on preliminary information from the General Atomic (GA-4 / 9) truck designs and for rail casks on the requirements for the HI STAR casks. Maintenance intervals are estimated in terms of time or number of trips.
Transit times	Transit times are automatically simulated by the TSM as the shipments travel from the waste sites to the repository. Average transport mode speeds (trucks, rail, barge, or Heavy Haul (HH)) are used with distances to estimate transit times. For rail, this mode speed takes into account interchange switches and lower junction speed associated with dedicated rail.
Costs/Unit costs	Unit costs and appropriate algorithms for estimating total costs for equipment and transportation related tasks are included in the TSM logic and processes.
Fleet Management	Functions for cask maintenance and rolling stock maintenance are included in the transportation module.
Truck/rail options	The transportation map departments have capability to handle trucks or rail shipments from the waste sites. The selection is set in the IS file generated by the TSMPP. Rail transportation routes may include barges or heavy haul at some waste sites.

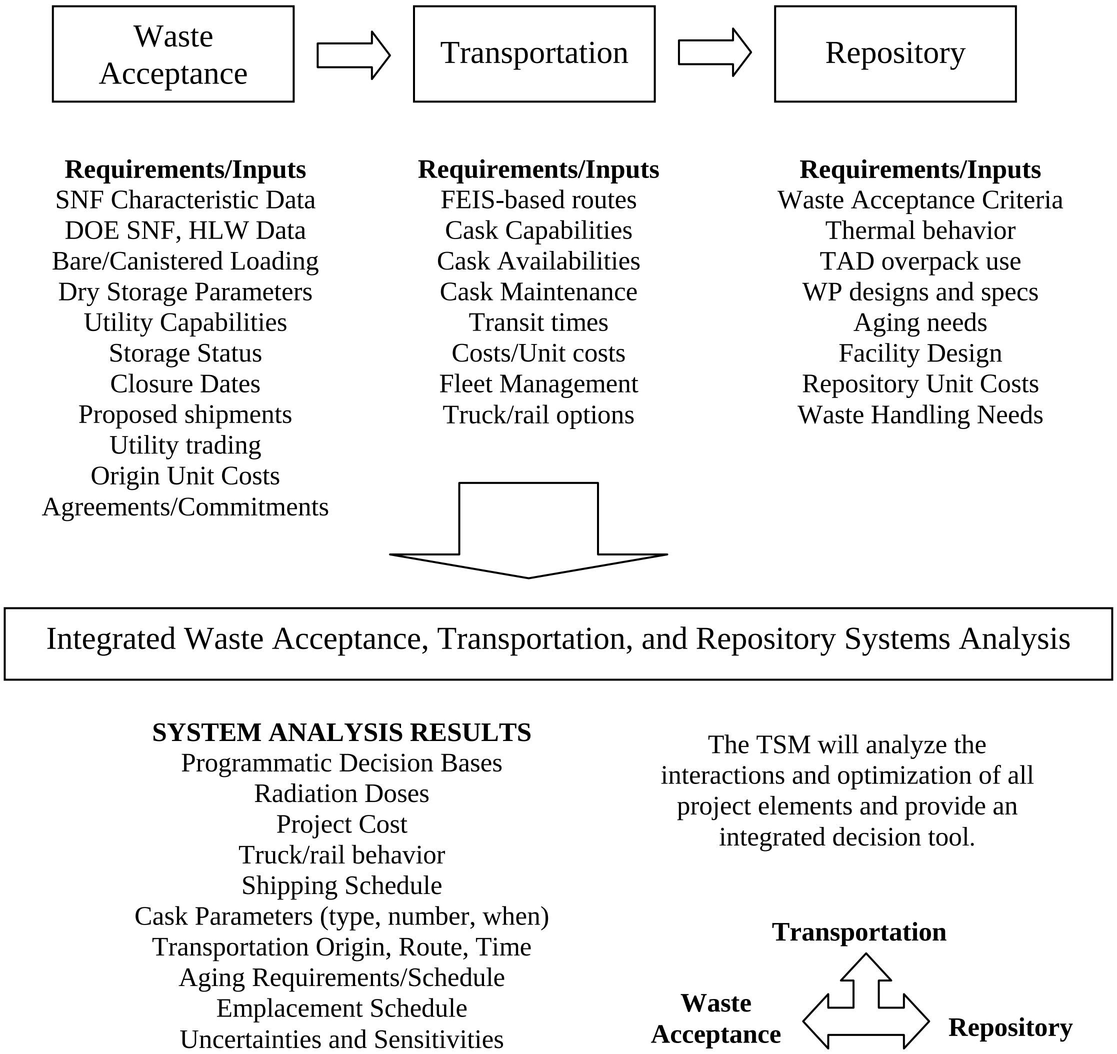

Figure 1. TSM Functional Design

Modules for the main CRWMS elements are integrated to provide a tool for systems analysis and decision basis development.

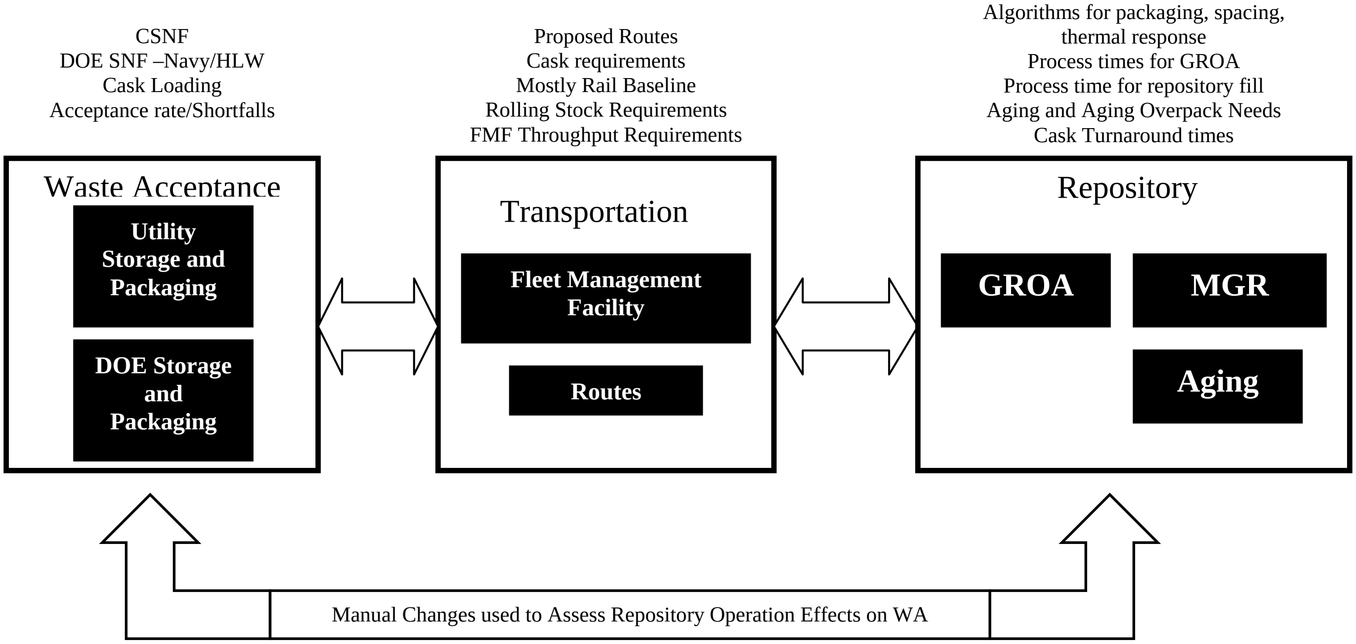

Figure 2. TSM Functions and Modules

The primary CRWMS Waste Acceptance, Transportation, and Repository are integrated. The black boxes represent functions where the TSM uses "rollups" the results of more detailed models and analyses to set the TSM simulation parameters such as process times.

The "feedback" shown includes manual changes to the analysis parameters to evaluate the system behavior in an iterative process to observe changes and effects.

Note: The term "repository" means all the collective facilities and operations at the emplacement site. The term "GROA" (Geologic Repository Operations Area) is applied to the facilities and actions that are applied just after a shipment enters the security gate to the point where the loaded waste packages (WP) are sent for emplacement. The GROA includes the aging pads. The term Monitored Geologic Repository (MGR) is applied to the actions after the WPs are dispatched from the GROA facilities and includes the drifts.

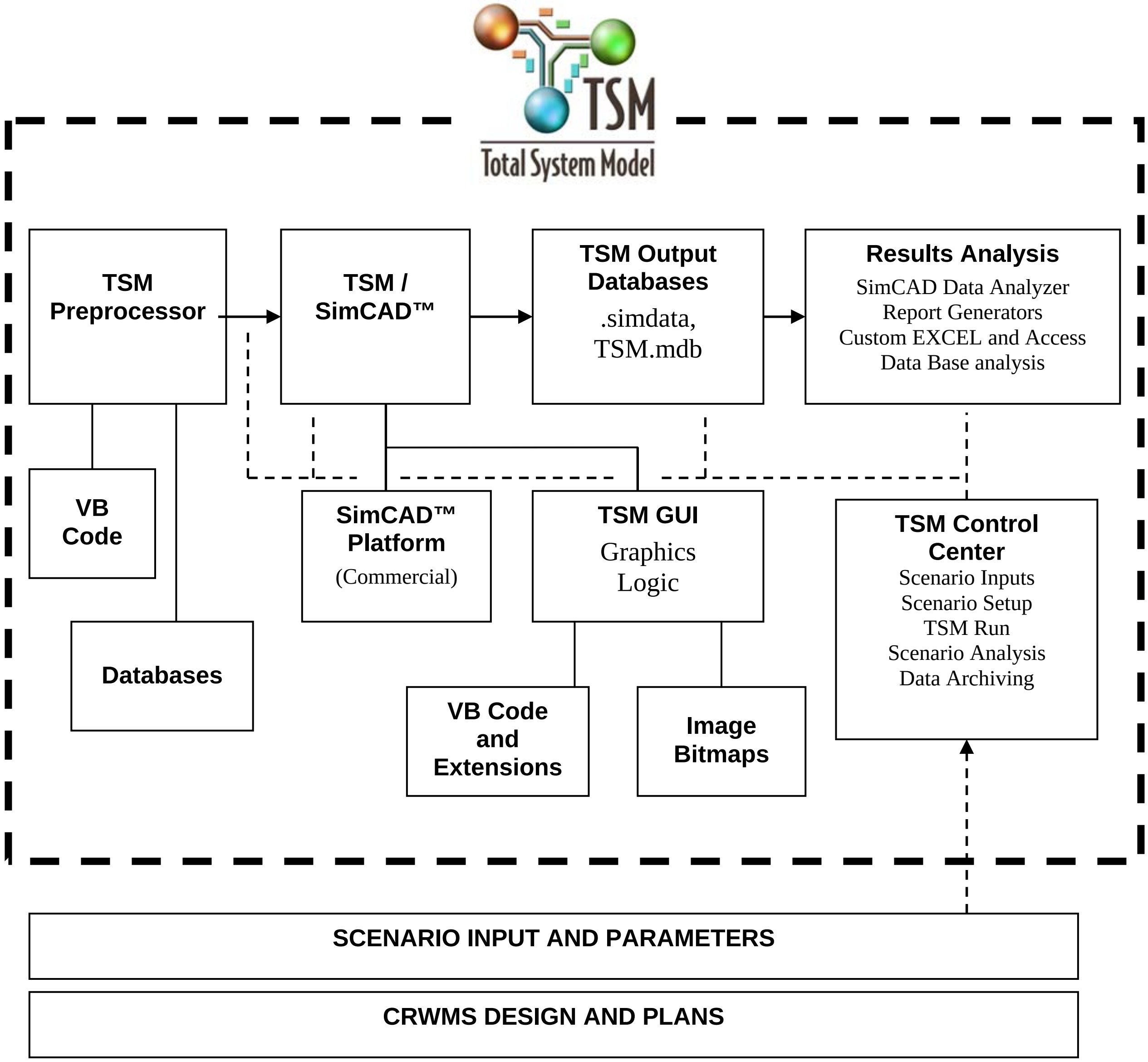

Figure 3. TSM Operating Elements

The TSM includes various programs, databases, and output files that collectively form the systems analysis capability. The program uses the SimCAD™ script language and Visual Basic (VB). The key component is the SimCAD™ commercial software and the other elements are designed with SimCAD™ as the central interface. CRWMS functional plans and the scenario inputs and parameters provide constraints and inputs for the TSMPP and the TSM. The Total System Model Control Center (TSMCC) provides a user-friendly GUI to control the key TSM elements and is designed to standardize the way in which TSM runs are created, archived, and analyzed.

1.4 CHANGES FOR TSM VERSION 6.0

The Section 6.0, "Observations" in the TSM Version 4.0 transportation calculation (BSC 2006b) recommended some refinements in the transportation elements. Other changes were made during the development of Version 6.0 to improve fidelity as discussed in BSC 2007e. The changes include:

- Changes to TSM Version 6.0 connectors and timings for several sites and routes.
    - Moved the connector for Beaver Valley to route via Columbiana vs. Youngstown,
    - Moved the connector from Indian Point to route via Schenectady and changed the connector to 1 time unit,
    - Changed time on the connector from Barstow to NVR to 1 from 0 time steps,
    - Changed time on the connector from Fort Calhoun to Blair from 0 time units to 1 time unit to allow for counting 1 state line crossing,
    - Changed time on the connector from Diablo Canyon to Barstow by changing distance to 1,906,080 feet from 1,087,680 feet,
    - Changed timing on the connector from Kewanee to Blair by changing distance to 3,711,840 feet from 2,845,920 feet,
    - Change Humboldt barge route connectors from 8 to 7 time steps.
- The route for the rail cask return from the GROA was modified to skip the "Basket Return" return process and its downstream connector, to reduce the travel time of the casks from the GROA to the Fleet Management Facility (FMF) and improve fidelity.
- Several of the GROA processes along the cask return processes are no longer required in the updated GROA design. This reduces the time for the cask to be returned from the GROA.
- The process connection from the Truck Cask 1 distribution was revised from 1 to 5 time steps. This provides better fidelity to account for the time to transport the empty cask to the waste site for loading and shipment.
- A new department was added to implement the so-called "basket and shell" approach for DOE canisters and transportation overpacks. (The basket and shell approach is discussed in Section 2.6.1 and Figure 36. The DOE baskets and shells are shown in Figure 15.) The designs for the DOE casks are not established and this department allows the TSM to assess the impact of unique cask designs for each type of DOE waste versus designs where a single overpack design is used to package the waste canisters.
- An algorithm to automatically estimate the number of casks required in the cask fleet was implemented in the TSMPP. This algorithm replaces the manual methods used to establish the TSM Work Orders (WO) that are used to introduce cask objects into the simulation. See Section 2.6 for more discussion.
- A WO algorithm for the truck rolling stock was also developed for the TSMPP. See Section 2.7 for more discussion.

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2. TRANSPORTATION MODULE DESCRIPTION

2.1 INTRODUCTION

This chapter describes the elements of the Transportation Module in the TSM. Screen shots are used to guide the discussion of the functions and assumptions for the transportation elements. It is assumed that the reader has a basic familiarity with the overall TSM/SimCAD™ functions and how they are used as contained in Reference BSC 2007a. More details for the SimCAD™ functions are in the SimCAD™ Users' Manual (CaS 2006).

The transportation elements are discussed starting with the actions for loading the transportation casks at the originating WA site then progressing through the transportation routes to the repository, interfaces at the repository, cask maintenance assumed to be at a Fleet Maintenance Facility (FMF), and the cask allocation (procurement and dispatch) operations. This progression is effectively the cyclical path of the transportation casks and represents the time that a cask is in transit and "in use." The cask total transit time is the key parameter that determines the cask fleet size and is discussed in Reference BSC 2007e.

The main source of the TSM transportation data and parameters is the database that was used for the Phase 1 TAD Study (BSC 2005). This includes the unit costs for the Waste Acceptance, Storage, and Transportation (WAST) elements. WAST costs are briefly covered in this report but the details for the WAST cost estimates are covered in Reference BSC 2007c.

2.2 MAIN TSM GUI AND LOGIC

Figure 4 shows the overall "canvas" for the TSM GUI. The GUI is generally laid out in sections that correspond to the main CRWMS mission elements of WA, Transportation, and Repository operations as shown in Figure 1. Sometimes the layout of processes that make up the mission elements cannot easily be placed in a single function or overlap with other mission element processes.

Additional screenshots of the various CRWMS activities related to transportation are included in Figures 4-35 and are described below.

As shown in Figure 4, the TSM uses connectors (arrows) to depict the path between various processes that represent actions or activities that occur and in most cases are abstractions of actual physical locations. Processes are shown as pictorial blocks. Connectors allow the various objects (such as cask loads or shipments) to move through the simulation model as each process activity is completed. Objects progress through the simulation in "real time" in 8-hour time steps.

2.3 CASK ALLOCATION

The transportation cask procurement, distribution, and loading functions are collectively covered by the “cask allocation” departments that are shown in Figure 4. The allocation departments are shown in detail in Figures 5-15. As discussed in Figures 5 for bare casks and Figure 9 for Transportation, Aging, and Disposal (TAD) canisters, the cask loading processes use a SimCAD™ join process to combine a waste cask load object with a cask object to form a “caskonrail” or “caskontruck” “batched” object. The batched object is then sent to the originating waste site in the transportation department maps to begin the trip to the repository.

The processes in Figures 5-15 have processing times that are used to simulate the cask loading times at the sites. Future versions of the TSM may provide for site specific and cask-specific loading times. However, for the current TSM, the process times for the processes that represent the cask loading all have the same programmed times. These processing times and the effect on the total cask transit time are discussed more in Section 3 and Reference BSC 2007e.

2.4 TRANSPORTATION MAPS AND ROUTES

Figure 16 shows a typical department map that contains the processes and connectors for modeling the transportation of shipments of loaded casks from the waste acceptance sites to Nevada. The transportation routes are included in the 10 transportation map departments: 5 for Legal Weight Truck (LWT, “truck”) routes and 5 for the rail routes. Figures 17-26 show the transportation maps for the TSM. The captions for the figures describe key features for the particular map. Descriptions for the processes and connectors in the maps are discussed below. (Note: The screenshots in this manual may have small differences from the current version of the 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).

2.4.1 Waste Acceptance Sites

The processes that represent the individual waste sites are shown in the transportation maps. In this case “site” means the reactor sites and DOE sites where wastes will be accepted into the CRWMS mission for disposal. The sites are a key element of the TSM and a 2-3 letter designator is used to identify the site. Table 2 lists the site designator and also provides other pertinent information on the site capability in the TSM:

Site Designator: The 2-3 letter designators used in TSM for shorthand of the site identification.
Site Name: The commonly used site name.
TSM Map: Refers to the transportation map department (a map for Northwest [NW], Southwest [SW], Midwest [MW], Southeast [SE], and Northeast [NE] region of the U.S.) that shows the site. There are 5 departments for truck routes and 5 for rail routes.
Transportation Method: The current methods for transportation (R-rail, T-truck, HH-heavy haul to rail, and B-barge to rail) used in the TSM. The TSM includes options for multiple transportation methods at some sites

	to accommodate future scenarios. The particular method for each study using the TSM is documented with that study; this table shows the programmed capabilities.
Waste Types:	The types of wastes that may be shipped from the sites: boiling water reactor (BWR) CSNF, pressurized water reactor (PWR) CSNF, HLW, or DOE. DOE includes HLW, DOE SNF, or Naval fuels.

In the TSM transportation GUI, a single site process represents sites that have multiple reactors and/or pools. On a more detailed level, site characteristics such as pool information, is important for the detailed cask loading analysis performed by the TSMPP. Table 2 is intended to be a basic overview of site information including the designator. For more detailed information on pools or other site characteristics refer to the TSMPP manual, Reference BSC 2007g.

See Figure 27 for a description of the typical waste site configurations used in the TSM map departments. The waste site processes are the point where the loaded casks from the cask loading processes are “batched” with the rolling stock to make “railshipment”, “truckshipment”, or “DOErailshipment” objects. For sites with barge or HH needs, the batched objects are called “z-bargeshipment” or “z-HHshipment”. For CSNF sites and DOE sites, rail shipments consist of 3 casks or 5 casks, respectively, if there are adequate cask loads in the shipments to make a batch. If adequate cask loads are not available, the shipment may be of fewer casks, including shipments of a single cask.

2.4.1.1 Rail Sites

Rail sites on the transportation maps are indicated by the 2-3 letter designator for a site followed by the letter “R”. The “R sites” are where the “Caskonrail” objects jump to / from the load cask allocation processes shown in Figures 5-12 and 14-15. Rail sites use a batch process to create a “railshipment”, “z-railshipbarge”, “z-railshipHH”, or “DOErailship” object that is dispatched via the route connectors to the repository. In some cases the casks are routed to barge and heavy haul sites as discussed below.

As discussed in Reference BSC 2007e, the batching process may require different time steps depending on when the 3-5 caskonrail objects and rolling stock objects arrive for batching. The arrival times can depend on other simulation actions and results such as cask availability and the need for the same cask by several processes. This affects the overall site processing time and this effect must be considered in the overall analysis as discussed in Reference BSC 2007e to avoid over estimates of cask transit times.

When the batch is completed and dispatched on routes toward the repository, the waste site makes a SimCAD™ “function call” to increment the cost estimating routine for rail shipments. The function call uses parameters set at the site process (shipping distance and number of casks in the shipment) to estimate cost using code in the process “RailShipCostCalc” in the extreme upper left of the TSM main GUI. The RailShipCostCalc process increments the cumulative costs for shipping based on these parameters each time a shipment is made. See the TSM cost estimating report (BSC 2007c) for more details. Rail shipments and rail sites also have costs associated with rail crews and these costs are discussed in Section 2.4.3.

Table 2. Waste Site Capabilities

Site Designator	Site Name	TSM Map	Transportation Methods[1]	Waste Types
ANO	ARK NUCLEAR	SW	R	PWR
BF	BROWNS FERRY	SE	B, R	BWR
BRA	BRAIDWOOD	MW	R	PWR
BRP	BIG ROCK	MW	HH, R	BWR
BRU	BRUNSWICK	SE	R	BWR, PWR
BV	BEAVER VALLEY	NE	HH, R	PWR
BYR	BYRON	MW	R	PWR
CAL	CALLAWAY	MW	HH, R	PWR
CAT	CATAWBA	SE	R	PWR
CC	CALVERT CLF	NE	B, R	PWR
CGS	COLUMBIA	NW	R	BWR
CLI	CLINTON	MW	R, T	BWR
CP	COMANCHE PK	SW	R	PWR
CPR	COOPER STN	NW	B, R, T	BWR
CRY	CRYSTAL RVR	SE	R, T	PWR
DB	DAVIS-BESSE	MW	R	PWR
DC	DIABLO CANYON	SW	HH, R	PWR
DCC	COOK	MW	R, T	PWR
DRE	DRESDEN	MW	R	BWR
DUA	DUANE ARNOLD	MW	R	BWR
FAR	FARLEY	SE	R	PWR
FC	FORT CALHOUN	NW	HH, R, T	PWR
FER	ENRICO FERMI	MW	R	BWR
FIT	FITZPATRICK	NE	R	BWR
FSV	FORT ST VRAIN	NW	R, T	N/A
GG	GRAND GULF	SE	B, R	BWR
GIN	GINNA	NE	HH, R, T	PWR
HAD	HADDAM NECK	NE	B, R	PWR
HAN	HANFORD	NW	R, T	PWR, BWR, DOE
HAR	HARRIS	SE	R	BWR, PWR
HAT	HATCH	SE	R	BWR
HC	HOPE CREEK	NE	B, R	BWR
HUM	HUMBOLDT BAY	NW	B, R	BWR
INL	INL-DOE	NW	R, T	PWR, BWR, DOE
IP	INDIAN PT 1&2	NE	HH, R, T	PWR
KEW	KEWAUNEE	MW	HH, R	PWR
LAC	LACROSSE	MW	R, T	BWR
LIM	LIMERICK	NE	R	BWR
LS	LASALLE	MW	R	BWR
MCG	MCGUIRE	SE	R	PWR
MIL	MILLSTONE	NE	R, T	PWR, BWR
MO	MORRIS	MW	R	BWR, PWR

Site Designator	Site Name	TSM Map	Transportation Methods[1]	Waste Types
MON	MONTICELLO	NW	R, T	BWR
MY	MAINE YANKEE	NE	R	PWR
NA	NORTH ANNA	NE	R	PWR
NMP	NINE MILE PT	NE	R	BWR
OC	OYSTER CRK	NE	B, R	BWR
OCO	OCONEE	SE	HH, R	PWR
PAL	PALISADES	MW	HH, R, T	PWR
PEA	PEACHBOTTOM	NE	HH, R	BWR
PER	PERRY	MW	R	BWR
PI	PRAIRIE ISL	MW	R	PWR
PIL	PILGRIM	NE	B, R, T	BWR
POI	POINT BEACH	MW	HH, R	PWR
PV	PALO VERDE	SW	R	PWR
QC	QUAD CITIES	MW	R	BWR
RB	RVR BEND	SE	R	BWR
ROB	ROBINSON	SE	R	PWR
RS	RANCHO SECO	NW	R	PWR
SAL	SALEM	NE	B, R	PWR
SEA	SEABROOK	NE	R	PWR
SEQ	SEQUOYAH	SE	R	PWR
SL	ST LUCIE	SE	B, R, T	PWR
SO	SAN ONOFRE	SW	R	PWR
SRS	SAV RIVER-DOE	SE	R	DOE
STP	SOUTH TEXAS	SW	R	PWR
SUM	SUMMER	SE	R	PWR
SUR	SURRY	NE	B, R	PWR
SUS	SUSQUEHANNA	NE	R	BWR
TMI	THREE MILE ISL	NE	R	PWR
TP	TURKEY PT	SE	B, R, T	PWR
TRO	TROJAN	NW	R	PWR
VOG	VOGTLE	SE	R	PWR
VY	VT YANKEE	NE	R	BWR
WAT	WATERFORD	SE	R	PWR
WB	WATTS BAR	SE	R	PWR
WC	WOLF CREEK	SW	R	PWR
WV	WVDP	NE	R	PWR, BWR, DOE
YR	YANKEE-ROWE	NE	HH, R	PWR
ZIO	ZION	MW	R	PWR

Note 1: B=Barge, HH=Heavy Haul, R=Rail, T=Truck

2.4.1.2 Truck Sites

Truck sites on the transportation maps are indicated by the 2-3 letter designator for a site followed by the letter "T". "Caskontruck" objects jump from the Tload allocation processes shown in Figure 13 to the waste sites on the transportation maps. Truck sites use a batch process to create a "truckshipment" object that is dispatched via the route connectors to the repository.

The truck shipments have a process similar to the rail process discussed previously. However, since truck shipments only involve one cask, the batch only has two objects and the time for batching is more certain; once the two objects arrive the shipment is sent. Truck shipments to the repository have one batched cask object maximum that is batched with a "x-truck" object to make the "truckshipment" batch object.

The truck shipments also have a similar shipping cost estimating function as the rail sites. However, for trucks there are two algorithms for the two types of cask (Cask 1 and Cask 6) that may be used: "TruckShipCostCalc1" and "TruckShipCostCalc6", see Reference BSC 2007c.

2.4.1.3 Barge sites

Barge sites on the transportation maps are indicated by the 2-3 letter designator for a site followed by the letter "B". Barge sites are always used in conjunction with a rail site. For barge sites, the rail site does not ship the casks in a batch to the repository. For barge sites (see site BF example in Figure 27), the rail sites (BFR) receive the cask from the jump from the cask allocation process but does not batch it. Instead it places each cask one at a time on the barge carrier object for transfer to the barge site (BFB). The casks are then batched into a "railshipment" object at the barge site. The batching at the barge site is similar to the batching at a standard rail site as discussed above. The barge sites batch up to three "caskonrail" objects with a "RailRollingStock" object to make a "z-railshipbarge" object that is routed to the repository. Notice that the batched object sent to the repository has a different name from the standard "railshipment" for tracking purposes.

SimCAD™ carriers are used for the barges and require a "start" processes to create the carrier objects as shown in Figure 27. Carriers are active when called upon to make a transfer of the "caskonrail" objects from the rail siding at the reactor to the barge depot. These carriers then return to the rail site to wait for the next cask after delivering the object to the barge site.

Costs for the barges, tugs and crews are estimated as discussed in Section 2.4.3 and Reference BSC 2007c.

2.4.1.4 Heavy Haul Sites

Heavy haul sites on the transportation maps are indicated by the 2-3 letter designator for a site followed by the letters "HH". Like barge sites, HH sites are always used in conjunction with a rail site and behave similarly. The HH sites batch up to three "caskonrail" objects with a "RailRollingStock" object to make a "z-railshipHH" object that is routed to the repository. Like barge sites, HH sites require a start process to make the HH carriers and the behavior is similar.

Costs for the heavy haulers, cranes and crews are estimated as discussed in Section 2.4.3 and Reference BSC 2007c.

2.4.2 Connectors

The maps are constructed using standard SimCAD™ connectors to connect the site processes to the repository. Eventually all routes reach a process that uses a jump from the maps to the TSM main GUI. For truck routes, the map end point is the process “YMT” in the northwest map that jumps the object to the “GROATruckDepot” process. For rail routes, the map end point is the process “NVR” in the southwest map that jumps the object to the “IMFDepot” process.

Connectors are assigned resources to track the use of the rail crews and also to track the number of state lines that the shipment must cross.

Connectors used in the TSM represent a minimum distance that is the carrier speed over the 8-hour time step, because SimCAD™ works better if the transit times are at least 1 time step. For typical speeds, this means routes are usually 320 miles for 40 miles per hour (mph) trucks and 104 miles for 13 mph trains. These distances are sometimes longer than the distances between the nodes on the maps. So, in many cases, the routes from different points overlap between nodes to get the required lengths to get at least one time step. Therefore, some of the lines on the maps that appear to be a single route may actually be as many as 5 routes. To select the route of interest on the GUI, click on the connector just outside of it’s origin point.

The routes and the route distances are based on the route data used in the FEIS as discussed in the backup calculation for this document (BSC 2007e).

2.4.3 Transportation Map Resources

In typical SimCAD™ use, resources are people or equipment needed to perform processes or move objects through connectors. Resources are defined in the Flow Properties dialog box and there may be a limited number available during the simulation. In the TSM the resources are also used to estimate some WAST cost parameters. Costs are estimated by assessing the resources in use at a time step and using the associated unit cost per time step. These cost estimates are discussed in more detail in Reference BSC 2007c.

Resources that include people are indicated in the TSM by small man-like figures. The State Line Crossing charges (STL) are indicated by a dot. See the TSM Flow Properties tab “Resources” for the images used for resources. The resources used in TSM as the basis for cost estimates are shown in Table 3. The columns in Table 3 provide information on:

Resource Name:	The TSM resource name.
Where Used:	Processes and locations in the TSM where the resources are required and used.
Description:	The resources are abstractions of equipment and people that are needed to enable processing or material flow. The description states the items that are abstracted.
Costs Estimated:	The cost item that is influenced or based on the resources use.

As the TSM runs, the number of resources in use are continuously tracked and assessed at each time step. At each time step, extension code in the TSM increments the cumulative costs shown in Table 3. The cost estimating code is in TSM "Properties", "Flow Properties" menu, Tab "Extensions/Events", Event "Simulation Step Started". The barge and HH cost estimates based on TSM resources are currently not implemented. Instead, a fixed cost for each barge or HH use is incremented using set variable values. See the Reference BSC 2007c for more information.

Table 3. Transportation Resources Used in TSM

Resource Name	Where Used	Description	Costs Estimated
Bargeresource	Barge sites	Abstraction for the barge equipment and workers	Not used in TSM V6.0. The estimate is accomplished with variables only.
HHresource	HH sites	Abstraction for the HH equipment and workers	Not used in TSM V6.0. The estimate is accomplished with variables only.
Railresource	On rail routes as a shipment is made	Abstraction for the security crews and operators for a rail shipment	Rail security crew costs. These security crews also apply during barge and HH use.
Truckdemurrage	Truck sites	Abstraction for the resources to support truck waiting time at the waste acceptance sites	Truck demurrage TSM resources are not used in TSM V6.0 for cost estimates.
Truckresource	On truck routes as a shipment is made	Abstraction for the security crews and operators for a truck shipment	Truck security crew costs
costStLineR	On rail routes as a shipment is made	Represents the number of state lines crossed in a route	Fees for casks that cross state lines are not used in TSM V6.0 for cost estimates.
costStLineT	On truck routes as a shipment is made	Represents the number of state lines crossed in a route	Fees for casks that cross state lines are not used in TSM V6.0 for cost estimates.

2.5 REPOSITORY INTERFACE

The repository module shown in Figure 28 includes the final transportation to the GROA, transport of the wastes to the GROA via the DOE rail for rail shipments (truck casks go directly to the GROA), and the cask return from the GROA after unloading. The DOE rail process and connectors route cask loads from the Nevada Intermodal Facility (IMF) to the GROA. The TSM uses three SimCAD™ departments between the IMF and the GROA to properly handle the logistics as shown in Figures 28-32.

On receipt of railshipments at the IMF, the shipments are completely unbatched in the "RailUnbatch 3" department and the constituent objects are routed to the next processes. In this department two unbatch routers are used to breakup the batched objects that are received into their constituent objects. Rolling stock is returned via jumps to the rolling stock processes and casks are placed in "cask hold" functions (see Figures 29 and 30) to await a trigger after the cask is unloaded in the GROA. The cask load waste objects are sent to a join process to be made into a “xfercaskload” for shipment on the DOE rail. Down the line just before the “GROA” department, a second rail unbatch department (“GROARailunbatch2”) is used to unbatch the “xfercask”, destroy the “xfercask” object, and send the waste cask load to the GROA via the “InputtoGROA” process.

After arrival at the repository, the “GROAUnbatchTruck” department unbatches the “truckshipment” objects and the constituents are appropriately routed. Rolling stock is returned via jumps; casks are placed in “cask hold” functions to await a trigger after the fuel is processed in the GROA; and the waste object is sent to the GROA department via the “InputtoGROA” process.

The waste cask loads enter the GROA department via processes that represent the security gates and a process called the “InputtoGROA”. Processes in the GROA Department appropriately route the wastes to the proper surface facilities for unloading and handling to make the WPs for emplacement. As shown in Figure 33, after unloading at the GROA, the transportation casks are returned via process “GROACaskReturn” to the FMF in the main TSM GUI where maintenance is performed. Once in the main TSM GUI the empty casks are routed to the FMF via the “GROARCaskReturn”, “GROATCaskReturn”, and “IMFCaskReceive 1” processes shown in Figure 28.

The “cask hold” processes in the “GROAUnbatchTruck” and “RailUnbatch3” departments are a key feature of the TSM. Casks when released from the cask hold process jump to the GROA cask return process to properly simulate empty cask movements in the GROA Department. The hold processes are also a convenient way to immediately assess the time a cask requires to move from the IMF through transfer processing (rail) or from GROA arrival for processing (trucks). The SimCAD™ dynamic data displays can immediately show this “turn around” time by selecting the hold process for the cask in question and noting the displayed “cycle time” (in time steps).

2.6 CASK BUY AND DISTRIBUTE AND MAINTENANCE

These TSM processes in the cask allocation departments and Figures 5-15 are abstractions for buying and distributing casks to the waste sites. Figure 34 shows the cask return and maintenance functions. These processes are currently modeled as occurring at the FMF.

2.6.1 Cask Buy and Distribute

As shown in Figures 5-15 each type of cask used in the TSM has a “BuyCaskXXX” followed by a “Dist” (distribute) process that are used to create and manage the casks in the simulation. The types of casks presently used in the TSMPP and the TSM GUI by cask number are shown in Table 4. This table presents the casks that are objects in the TSM simulation in normal font; other cask types used in the TSMPP are in *italics*.

The cask fleet presented in the TSMPP has a different cask selection that includes “derated” casks yet excludes rarely used casks but the TSMPP selection is embodied as the objects in Table 4 for the TSM simulation. An example of a specific selection of casks that may be considered in running the TSMPP is in the Phase 1 TAD Study (BSC 2005). The cask fleet descriptions and the matching of cask type to the waste cask load are done in the TSMPP and the results are output to the IS file Cask ID column. See the TSMPP description (BSC 2007g) for more information on how casks and cask loads are distributed and allocated.

Maximum assembly heats are included for casks where cask designs are established. For cases where no design exists, “N/A” is used to indicate that no assembly heat limit is set.

Hook weights are not specified for the “baskets” and “N/A” is used to designate there is no hook weight. The basket weight is included in the hook weight for the overpack (shell) for the basket as listed.

The cask list includes bare spent fuel baskets, Dual-Purpose Canisters (DPCs), TAD canisters, transportation overpacks, and Transportable Storage Casks (TSCs) to support the various missions envisioned for CRWMS. The overpacks (shells), baskets, and DPC logic in the TSM is set up to implement a “basket and shell” approach whereby families of baskets and DPCs are used with a single compatible shell type. This allows one type of shell to handle both the basket and DPC. The “basket and shell” approach was initially implemented for CSNF casks in TSM V5.0. The basket and shell approach for DOE casks was added in TSM V6.0 (see Figure 15). See Figures 5 and 9 that provide examples of basket and shell cask allocation implementations. The TSM triggering logic for the basket and shell approach is very complex and is shown in Figure 36.

Since multiple baskets and/or DPCs may be simultaneously requesting the same shell, the TSM must include logic for which shipment gets priority for the next available shell. In TSM, the allocation logic is implemented by a sequential series of “else if” statements that compares the name of the allocation process calling for the shell and when the name is first encountered in the else-if series, the shell is sent to that location. In other words, the first allocation process that is programmed in the “else if” series has top priority. The result is cask allocation processes later in the “else if” series may have substantial delays obtaining a shell since the prior allocation processes are allocated first. Priorities are set such that “workhorse” baskets or DPC’s that have the most cask loads are given priority except in cases where there are less than 5 cask loads of any type (such as the West Valley cask loads). In this case, the allocation process with only a few calls is placed at the top of the “else-if” series to allow these few loads to be completed quickly. Otherwise, these sites may show cask loads waiting for many years.

There are two modes for operating the cask allocation processes. The user selects the mode by specifying the way that the casks are purchased i.e., controls the number of casks in use in the model.

One mode is an “open” mode where there are no restrictions on the number of cask purchased. In this case the user sets the cask buy processes to buy a cask whenever the cask supply is empty. If a site requests a cask and none is available, the buy process initiates a "buy" to ensure that a cask is delivered for the waste pick up. This mode is used for scenarios where the object is to help ensure that cask loads are picked up as scheduled by the IS file. There may be other TSM elements or resources that may slow the pick up and transport, but the cask will always be available. This mode may include several thousand transportation casks in the fleet.

The second mode is to use a SimCAD™ WO to buy a cask fleet. A good example is a WO process to limit the cask buys and distribution so that the feed to processing in the GROA is Just in Time (JIT). The TSM model is run to study when casks are requested and the status of the GROA at the time. If a particular type of cask has a long residence time in the GROA, it means there are too many of that type of cask arriving and the GROA is overloaded. By iteratively changing the WO in the buy processes and watching the impact on GROA processing and casks residence times, the analyst can set up a JIT scenario (this is recommended for advanced users only). In this mode, any lack of casks because the fleet is limited will delay the cask allocation and cause WA site shipments to be delayed.

One result of using the two modes is that if the GROA does not have adequate throughput for the mission, wastes for processing will back up. In the open mode, the wastes backup and accumulate at the GROA. In the JIT case, the wastes backup and accumulate at the start process in the cask allocation departments.

A further description of “Open” and “WO” modes and how to use them is contained in the TSM Users Manual (BSC 2007a). For TSM V6.0, the TSMPP was modified to include an algorithm that prepares the WOs for a run. This algorithm places the cask WOs at the end of the IS file. See the WO validation report (BSC 2007h) and the TSMPP manual (BSC 2007g) for more details on the WO algorithm.

Table 4. Cask Types Used in the TSM

TSMPP Cask	Type[1]	No. Asy.	Cask Name	Process Connection to Start	TSM Dept. [2]	Over-pack	Assembly Heat Limit (Watts)[3]	Nominal Hook Wt. (Tons)
CASK1	B	9	GA-9 LWT	GA-9	Trucks	None	207	25
CASK6	P	4	GA-4 LWT	GA-4	Trucks	None	682	25
CASK11	B	2	NAC LWT	NAC-LWTB	Trucks	None	1,100	25
CASK12	P	1	NAC LWT	NAC-LWTP	Trucks	None	2,500	26
CASK18	X	1	Truck Fort Saint Vrain	Truck-FSV	Trucks	None	N/A	27
CASK26	B	68	HI-STAR 100 bare fuel basket - BWR	HS-100B	HiStar	202	201	N/A
CASK27	P	32	HI-STAR 100 bare fuel basket - PWR	HS-100P	HiStar	202	552	N/A
CASK28	B	42	Medium bare rail - BWR	MedRailB	Small/ Med Rail	None	357	100
CASK29	P	18	Medium bare rail - PWR	MedRailP	Small/ Med Rail	None	833	100
CASK30	B	20	Small bare rail - BWR	SmallRailB	Small/ Med Rail	None	350	60
CASK31	P	8	Small bare rail - PWR	SmallRailP	Small/ Med Rail	None	875	60
CASK44	H	5	HLW rail	DSNFHLW	DOE	None	N/A	125
CASK44_INS	H	5	HLW rail_OV	DSNFHLW_OV	DOE_OV	2XX	N/A	TBD
CASK50	X	4	MCO rail	DSNFMCO	DOE	None	N/A	125
CASK50_INS	X	4	MCO rail_OV	DSNFMCO_OV	DOE_OV	2XX	N/A	TBD
CASK51	X	9	DOE SNF rail	DSNF18	DOE	None	N/A	125
CASK51_INS	X	9	DOE SNF rail_OV	DSNF18_OV	DOE_OV	2XX	N/A	TBD
CASK52	X	1	Naval SNF rail	DSNFNAVY	DOE	None	N/A	125
CASK56	X	5	DOE SNF Rail	DSNF24	DOE	None	N/A	125
CASK56_INS	X	5	DOE SNF Rail_OV	DSNF24_OV	DOE_OV	2XX	N/A	TBD
CASK58	X	12	Three Mile Island Canister	TMIcanonce	Nuhoms	None	N/A	100
CASK60	P	18	South Texas bare rail	STPBare	STP	229	928	N/A
CASK62	B	85	West Valley rail – BWR	TN-BRPwv	DOE	None	N/A	100
CASK63	P	40	West Valley rail – PWR	TN-REGwv	DOE	None	N/A	100
CASK64	P	26	NAC STC bare fuel basket – PWR	NAC-STC	NAC	214	839	N/A
CASK65	P	24	NAC UMS bare fuel basket – PWR	NAC-UMSP	NAC	238	839	N/A
CASK66	B	68	TN-68 TSC loaded from pool - BWR	TN-68TSC	TSC	None	191	125
CASK68	P	24	MP-187 bare fuel basket – PWR (24 assm)	MP-187-24	Nuhoms	226	566	N/A

TSMPP Cask	Type[1]	No. Asy.	Cask Name	Process Connection to Start	TSM Dept. [2]	Over-pack	Assembly Heat Limit (Watts)[3]	Nominal Hook Wt. (Tons)
CASK69	P	32	MP-187 bare fuel basket – PWR (32 assm)	MP-187-32	Nuhoms	226	552	N/A
CASK70	B	61	MP-197 bare fuel basket – BWR	MP-197	Nuhoms	247	215	N/A
CASK76	P	32	TN-32 TSC loaded from pool – PWR	TN-32TSC	TSC	None	552	125
CASK77	B	56	NAC UMS bare fuel basket – BWR	NAC-UMSB	NAC	238	261	N/A
CASK102	P	24	VSC-24 canister – PWR	VSC-24can	TS	217	N/A	N/A
CASK106	P	21	Castor V21 – one time transport	CastorV21once	TSC	None	N/A	100
CASK109	P	33	Castor V33 - one time transport	CastorV33once	TSC	None	N/A	100
CASK200	B	68	HI-STAR 100 canister - BWR	HS-100Bcan	HiStar	202	N/A	N/A
CASK202 [4] *CASK205* *CASK220*	B *P* *P*	N/A	HI-STAR 100 transportation overpack	HS-OV	HiStar	N/A	201 *552* *N/A*	125
CASK203	P	32	HI-STAR 100 canister - PWR	HS-100Pcan	HiStar	205	N/A	N/A
CASK206	B	24	Small TAD canister - BWR	TADSmallB	TAD	208	N/A	N/A
CASK208 [4] *CASK211*	B *P*	N/A	Small TAD canister transportation overpack	TADSmallOV	TAD	N/A	492 *983*	70
CASK209	P	12	Small TAD canister PWR	TADSmallP	TAD	211	N/A	N/A
CASK212	P	36	NAC STC bare fuel basket - Yankee Rowe	NAC-YRCAN	NAC	214	N/A	N/A
CASK214 [4] *CASK223*	P *P*	N/A	NAC STC transportation overpack	NAC-STCOV	NAC	N/A	N/A *839*	125
CASK215	B	64	TS-125 canister – Big Rock Pt	BRPcan	TS	217	N/A	N/A
CASK217	B	N/A	TS-125 transportation overpack	TS-125OV	TS	N/A	N/A	125
CASK218	P	24	HI-STAR 100 canister - Trojan	HS-TROcan	HiStar	220	N/A	N/A
CASK221	P	26	NAC STC canister - PWR	NAC-STCcan	NAC	223	N/A	N/A
CASK224	P	24	MP-187 canister - PWR (24 assm)	MP-187-24can	Nuhoms	226	N/A	N/A
CASK226 [4] *CASK250*	P P	N/A	MP-187 transportation overpack	MP187OV	Nuhoms	N/A	566 *552*	125
CASK227	P	18	South Texas canister	STPcan	STP	229	N/A	N/A
CASK229	P	N/A	South Texas transportation overpack	STPOV	STP	N/A	928	125

TSMPP Cask	Type[1]	No. Asy.	Cask Name	Process Connection to Start	TSM Dept. [2]	Over-pack	Assembly Heat Limit (Watts)[3]	Nominal Hook Wt. (Tons)
CASK232	B	68	TN-68 from storage - one time transport	TN-68once	TSC	None	N/A	125
CASK235	P	32	TN-32 from storage - one time transport	TN-32once	TSC	None	N/A	125
CASK236	B	56	NAC UMS canister - BWR	NAC-UMSBcan	NAC	238	N/A	N/A
CASK238 [4] *CASK241*	B *P*	N/A	NAC UMS transportation overpack	NAC-UMSOV	NAC	N/A	261 *839*	125
CASK239	P	24	NAC UMS canister - PWR	NAC-UMSPcan	NAC	241	N/A	N/A
CASK242	B	68	HI-STAR HB canister	HS-HBCAN	HiStar	244	N/A	N/A
CASK244	B	N/A	HI-STAR HB transportation overpack	HiStarHBOV	HiStar	N/A	N/A	125
CASK245	B	61	MP-197 canister - BWR	MP-197can	Nuhoms	247	N/A	N/A
CASK247	B	N/A	MP-197 transportation overpack	MP-197OV	Nuhoms	N/A	215	125
CASK248	P	32	MP-187 canister - PWR (32 assm)	MP-187-32can	Nuhoms	*250*	N/A	N/A
CASK251 CASK257 [5]	B	44 68 [5]	Large TAD canister - BWR	TADLargeB	TAD	253 *259* [5]	N/A	N/A
CASK253 [4] *CASK256* *CASK259* [5] *CASK262* [5]	B *P* *B* [5] *P* [5]	N/A	Large TAD canister transportation overpack	TADLargeOV	TAD	N/A	268 *562* *174* [5] *369* [5]	100 *100* *125* [5] *125* [5]
CASK254 *CASK260* [5]	P	21 32 [5]	Large TAD canister - PWR	TADLargeP	TAD	*256* *262* [5]	N/A	N/A
CASK290	P	40	TN-40 - PWR -one time transport	TN-40once	TSC	None	N/A	125
CASK291	B	52	Nuhoms 52B canister (BWR)	NUHOM52Bcan	Nuhoms	247	N/A	N/A
CASK295	P	24	MC-10 - PWR - one time transport	MC-10once	TSC	None	N/A	100
CASK298	P	28	NAC-I28 - PWR - one time transport	NAC-I28once	TSC	None	N/A	100
CASK2XX	N/A	N/A	DOE OV shell	BuyCask2xx in DOE_OV	DOE_OV	None	N/A	TBD

Note 1: Waste types: P - PWR CSNF, B – BWR CSNF, H – HLW, and X – DOE SNF including Naval waste.
Note 2: TSM Departments are shown in Figures 5-15.
Note 3: Assembly heat limits for derated configurations assume a 50% increase in total cask heat limit due to shorter heat conduction paths.
Note 4: Base cask – same transportation overpack defined for different canisters. Unique cask numbers used because overpack specifications differ (e.g., BWR or PWR versions [HI-STAR 100] or different assembly capacities [MP-187]). These cask versions are treated as separate casks in the TSM Preprocessor, but are combined into one cask (the base cask) in the TSM Initial State file.
Note 5: Two Large TAD canister options. This second option differs in capacity, weight, and assembly heat limit. Only one option (Casks 251 & 254 or Cask 257 & 260) may be selected when defining a scenario.

2.6.2 Cask Maintenance

When the empty transportation casks are returned from unloading at the GROA, the need for cask maintenance (based on time or number of trips) is assessed in the "CaskCheck" processes, see Figure 34. Casks that require maintenance are sent to "CaskMaint" processes. In the CaskMaint processes, casks more than 25 years old are sent to a "CaskRepl" process for major overhaul. After the check, maintenance, or major overhaul the casks return to the "CaskDistribute" processes in the cask allocation departments to be reused for subsequent shipments on demand.

The current values and settings in the TSM are assumptions since the final selection of the casks is not complete and detailed plans are not established. Undocumented tests show that variations of the maintenance settings by a factor of 2 do not have a major impact on the overall simulation results.

The process time for a check (every trip) is 24 hours, the additional time if maintenance is required is 48 hours and the additional time for major refurbishment is 48 hours, for total times of 72 hours for maintenance and 120 hours for a major refurbishment.

Currently, the parameters for assessing the number of trips that a cask has made and the time in use are being refined for each type of cask. The current settings are that truck casks (GA-9 and GA-4) are maintained after every third trip and that rail casks are maintained every 5 years (based on the requirements for the HISTAR casks). These maintenance intervals are prescribed in the certification for the cask. For other casks the maintenance interval is conservatively assumed to be 12 months.

2.7 ROLLING STOCK

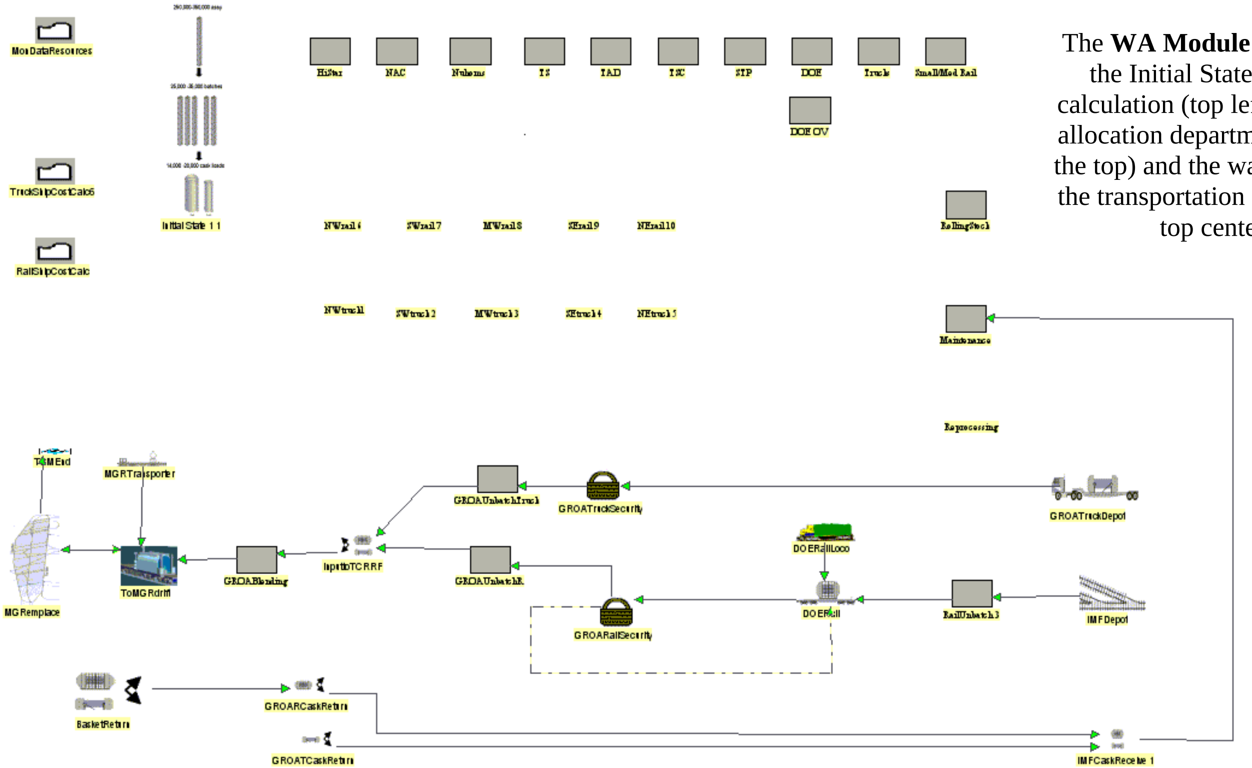
The rolling stock processes are shown in Figure 35. Rolling stock refers to the trucks (object "x-truck") and rail stock (locomotive, 2 buffer cars, and crew car, identified as a single object "x-loco") and these items are cycled through the overall process and are maintained and reused as needed. The need for maintenance or repair of the items is based on the number of trips assessed in the "Inspect" processes. No details are available on these operations so the current settings are 2% of the rolling stock goes to repair that requires 1 extra day of time. Rolling stock is sent to the waste sites on demand from the waste sites when cask loads arrive and batching for a shipment begins. The current TSM uses an x-loco object to represent the locomotive, 2 buffer cars, and crew car. The individual locomotive and cars are not tracked as separate items.

The batching at the waste site to create a railshipment or truckshipment object requires the proper rolling stock before the shipment is transported to the GROA. As the batching occurs the proper resources from Table 3 are assigned to the waste site.

Rolling stock can also be purchased (or allocated) using either "open" mode or WO mode similar to the transportation cask discussed previously. For analyses up to the issuance of TSM V6.0, only the open mode with unrestricted rolling stock has been used. This probably over estimates the rolling stock fleet by 20% or so. Rolling stock usually includes less than 10 trucks and less than 20 locomotives and neither has a major driver of system effects or costs.

For TSM V6.0, the TSMPP was modified to include an algorithm that prepares the WOs for the truck rolling stock. This algorithm places the truck rolling stock WO at the end of the IS file. See the WO validation report (BSC 2007h) and the TSMPP User Manual (BSC 2007g) for more details on the truck rolling stock WO algorithm.

NOTE: For TSM V6.0, the WO programming for the locomotives is not active because the waste site batching process to form a railshipment always requires a “x-loco” object and if this object is not available due to WO shortfalls, railshipment objects can leave the waste site without a x-loco object (this simulates the unrealistic situation of a shipment departing for the repository with no rolling stock). Therefore, locomotives (object x-loco) are set to “Open” buy in the “BuyLoco” process.



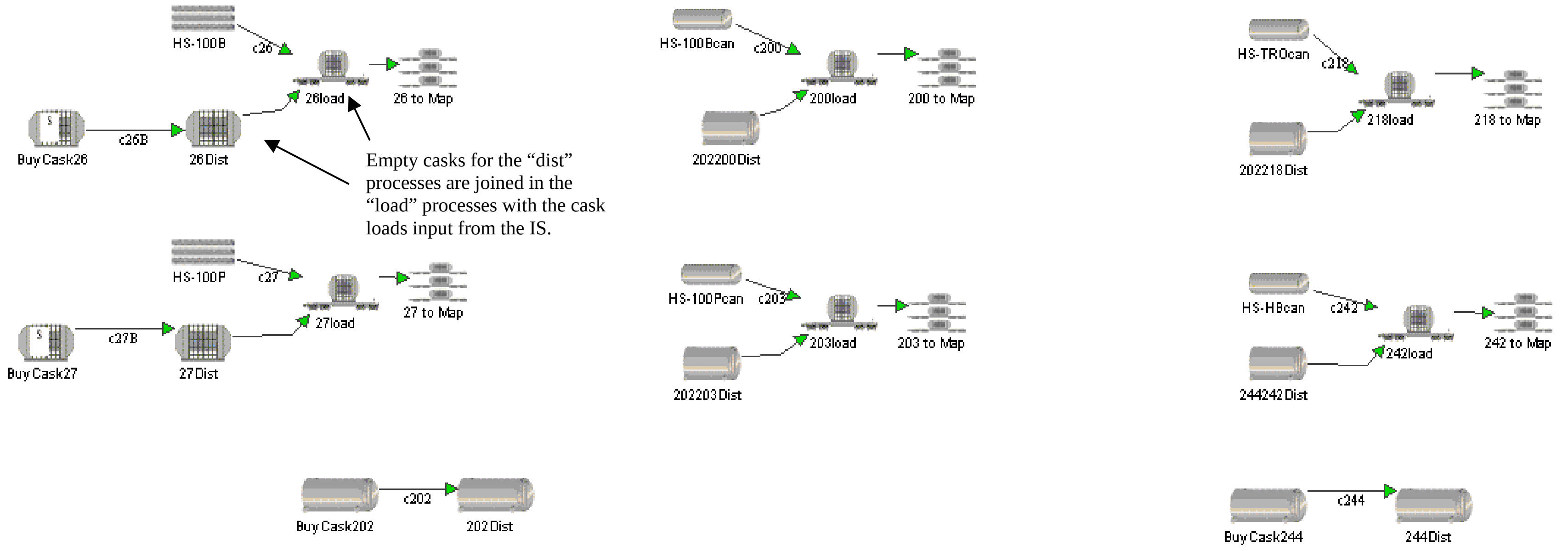
The **Transportation Module** consists of the route transportation maps in the center, the cask allocation departments, the cask maintenance department, and rolling stock department.

The **WA Module** consists of the Initial State file (IS) calculation (top left), the cask allocation departments (along the top) and the waste sites (in the transportation maps in the top center.

The **Repository Module** consists of the final transportation link to the GROA, WP filling operations, aging, and emplacement.

Figure 4. TSM GUI

This figure shows the entire TSM “canvas” that has the modules for the main three areas of the CRWMS mission. Details of each module are on later figures. When running the TSM, the user usually only has a small portion of the canvas visible.



Empty casks for the “dist” processes are joined in the “load” processes with the cask loads input from the IS.

Figure 5. HiStar Department

This figure shows the HiStar cask allocation department with 2 types of bare fuel baskets, 4 types of DPCs and 2 types of overpacks (shells). All baskets and cans except the HS-HBcan use shell 202. The SimCAD™ triggers (events and auto events) control the calls or “triggers” for the shells and the allocation. See Figure 36 and BSC 2007a for more details on the trigger actions.

The bare fuel load arrives at the upper processes in the left most column (such as HS-100B) and initiates the trigger sequence to call a basket (Cask 26 for the HS-100B) and an overpack (in this case Cask 202). If no basket or can is available, the call is deferred until the basket or can is available else the overpack would be unnecessarily allocated for a shipment that is not ready to ship. Notice that bare fuel processes use a “basket” (such as Cask 26 and 27) that is purchased by OCRWM.

For DPC cans (the two right columns), the DPC is joined with the shell to make the cask load. In the DPC cases, the utility has purchased the DPC and OCRWM has purchased the Cask 202 or 244 overpacks so no “buy” processes are needed for the DPC. Other cask allocation departments have similar structure and actions.

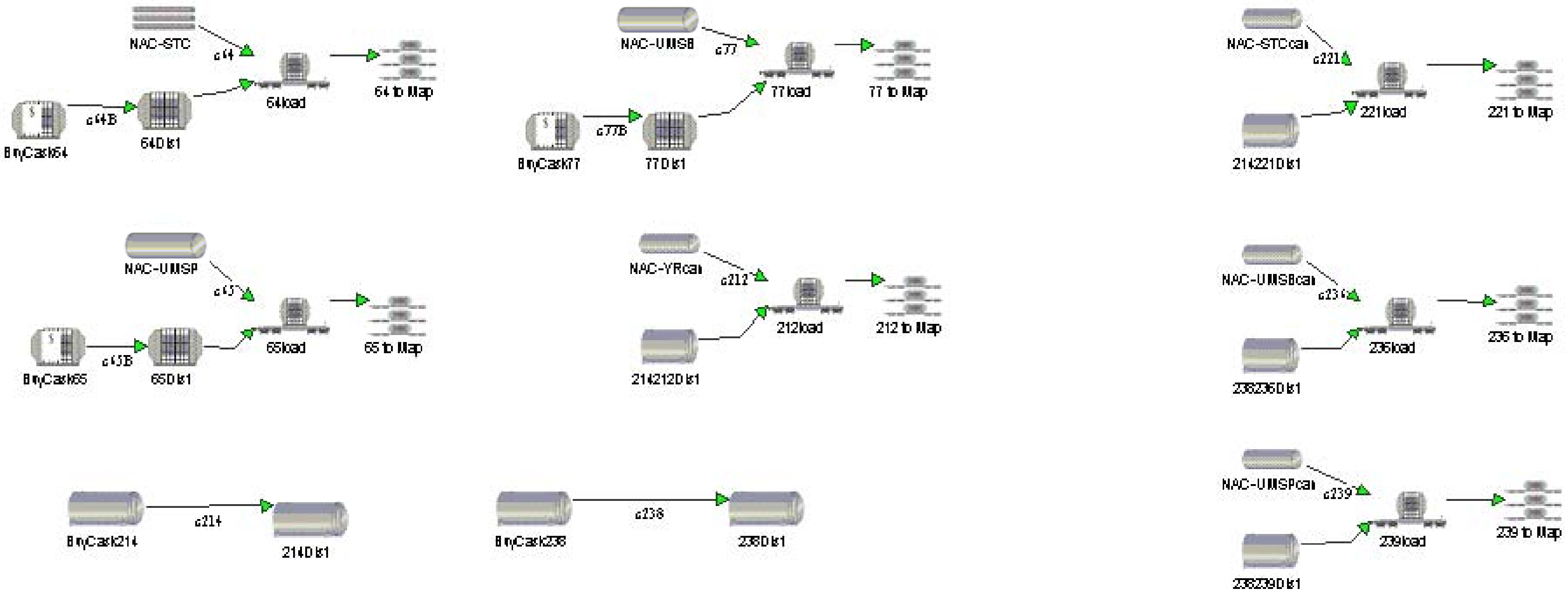


Figure 6. NAC Department

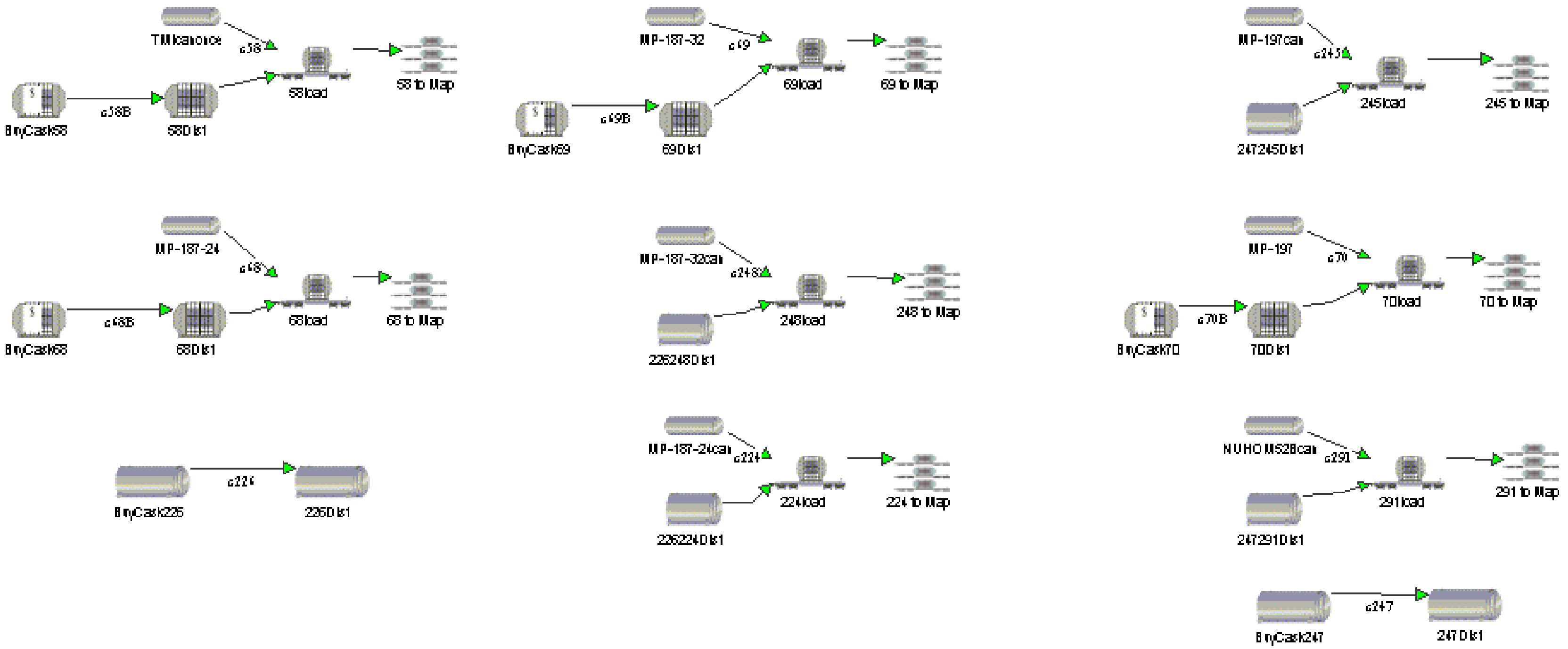


Figure 7.   Nuhoms Department

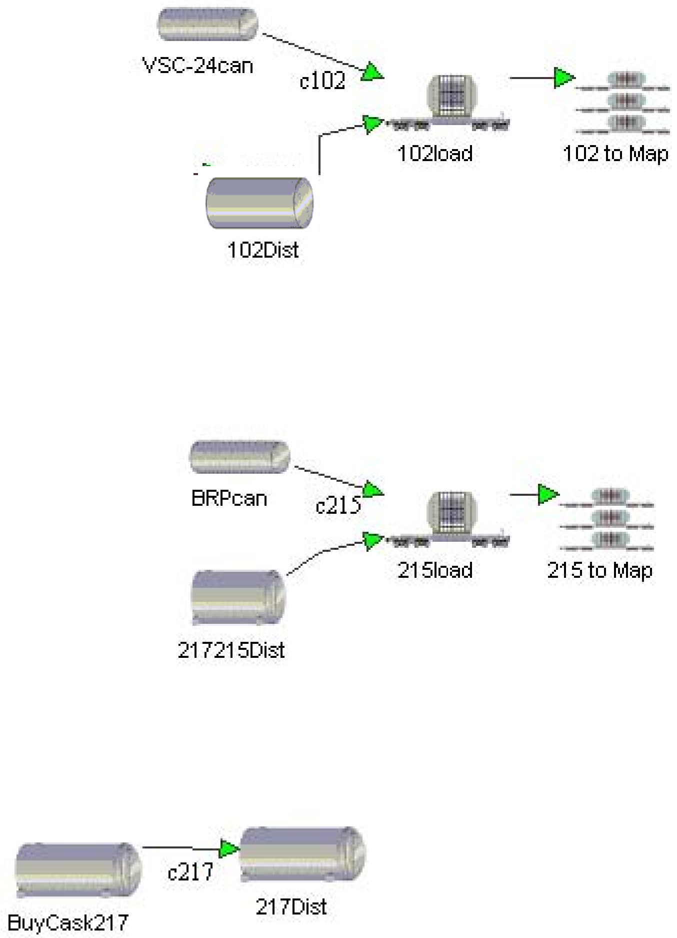


Figure 8. TS Department

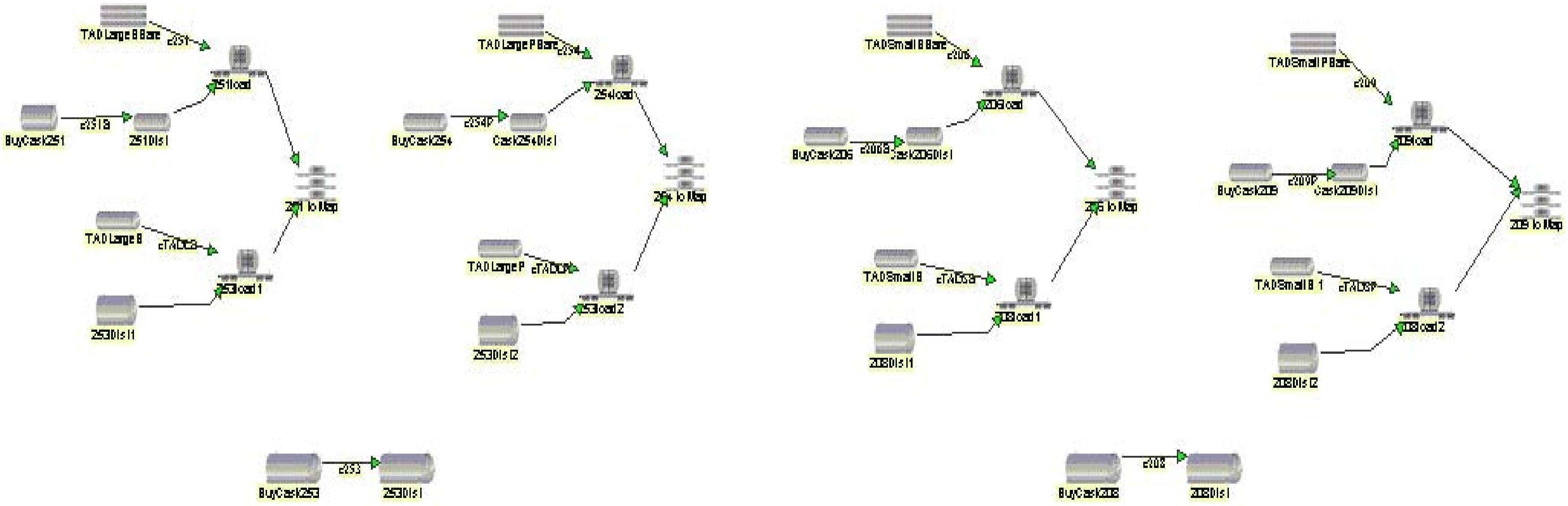


Figure 9. TAD Department

This figure shows a TAD department. In the upper processes, bare fuel picked up from a pool is placed in a TAD canister that is purchased by OCRWM. Therefore, unconstrained "buy" processes are included. In the lower processes, the TAD canister loads are from storage and the TAD canister is purchased by the utility.

In all processes, overpacks are allocated to make the cask load that is sent to the map to simulate transportation to the GROA. In this case, the same overpack Cask 253 is used for all large TAD canisters and Cask 208 is used for all small TAD canisters. For TAD canisters only the overpacks (shells) are returned for reuse.

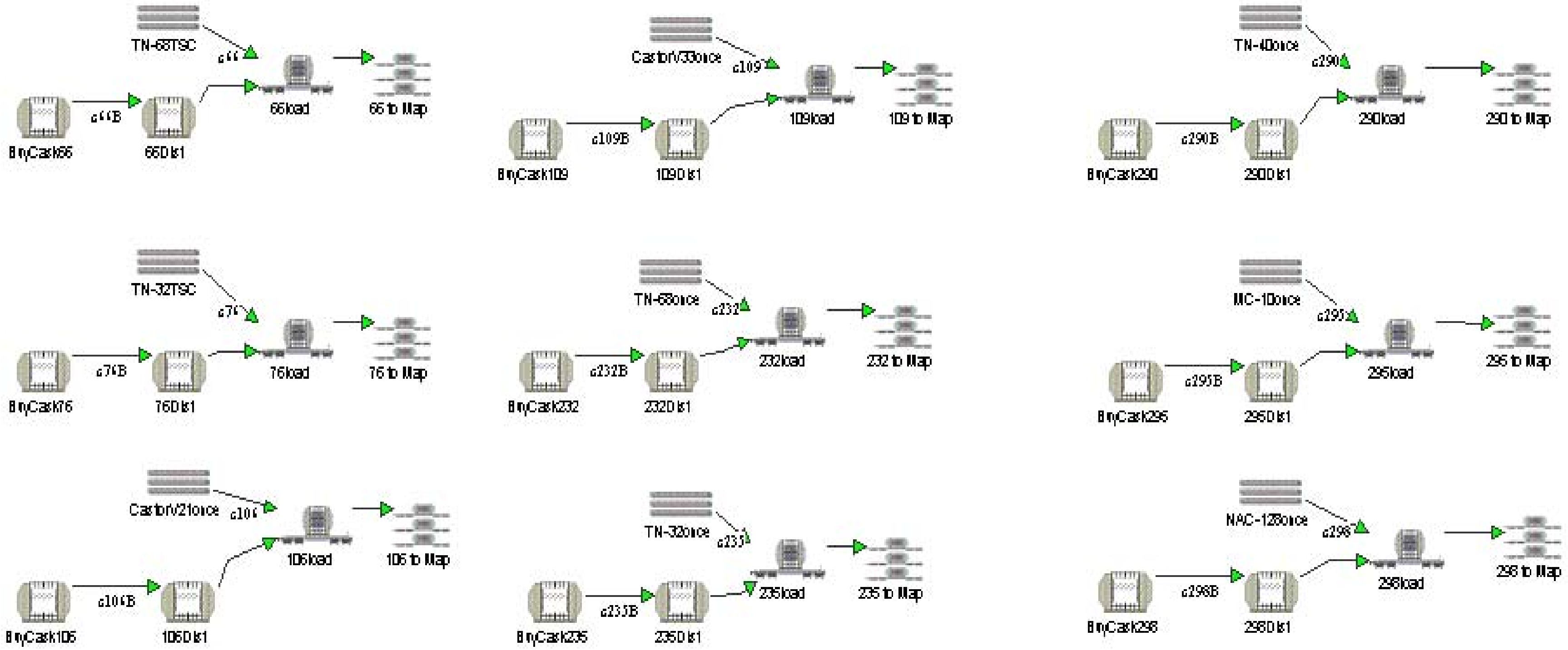


Figure 10. TSC Department

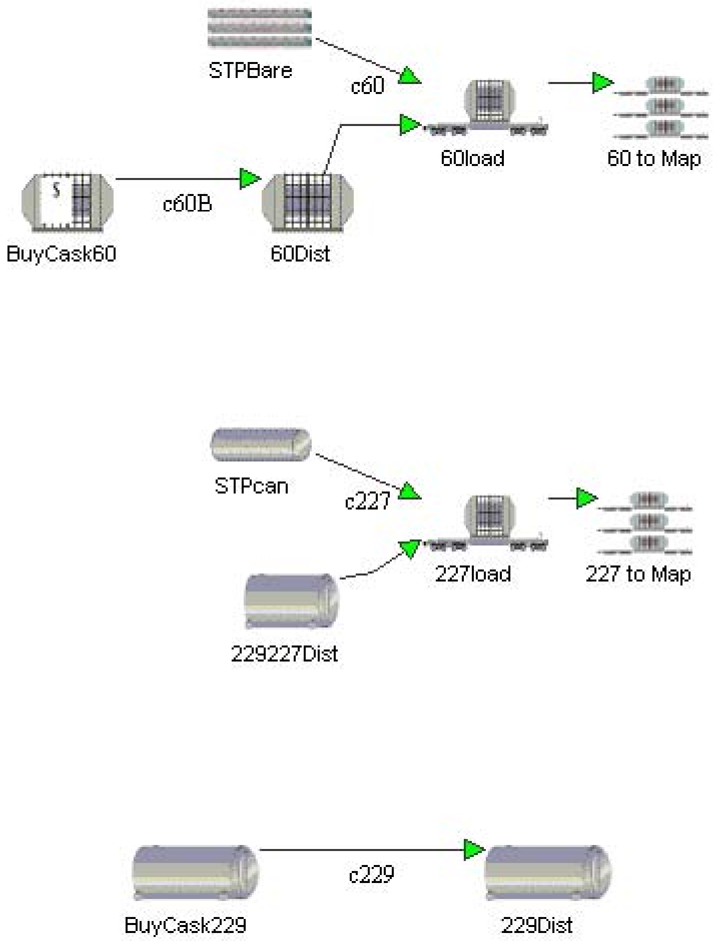


Figure 11. STP Department

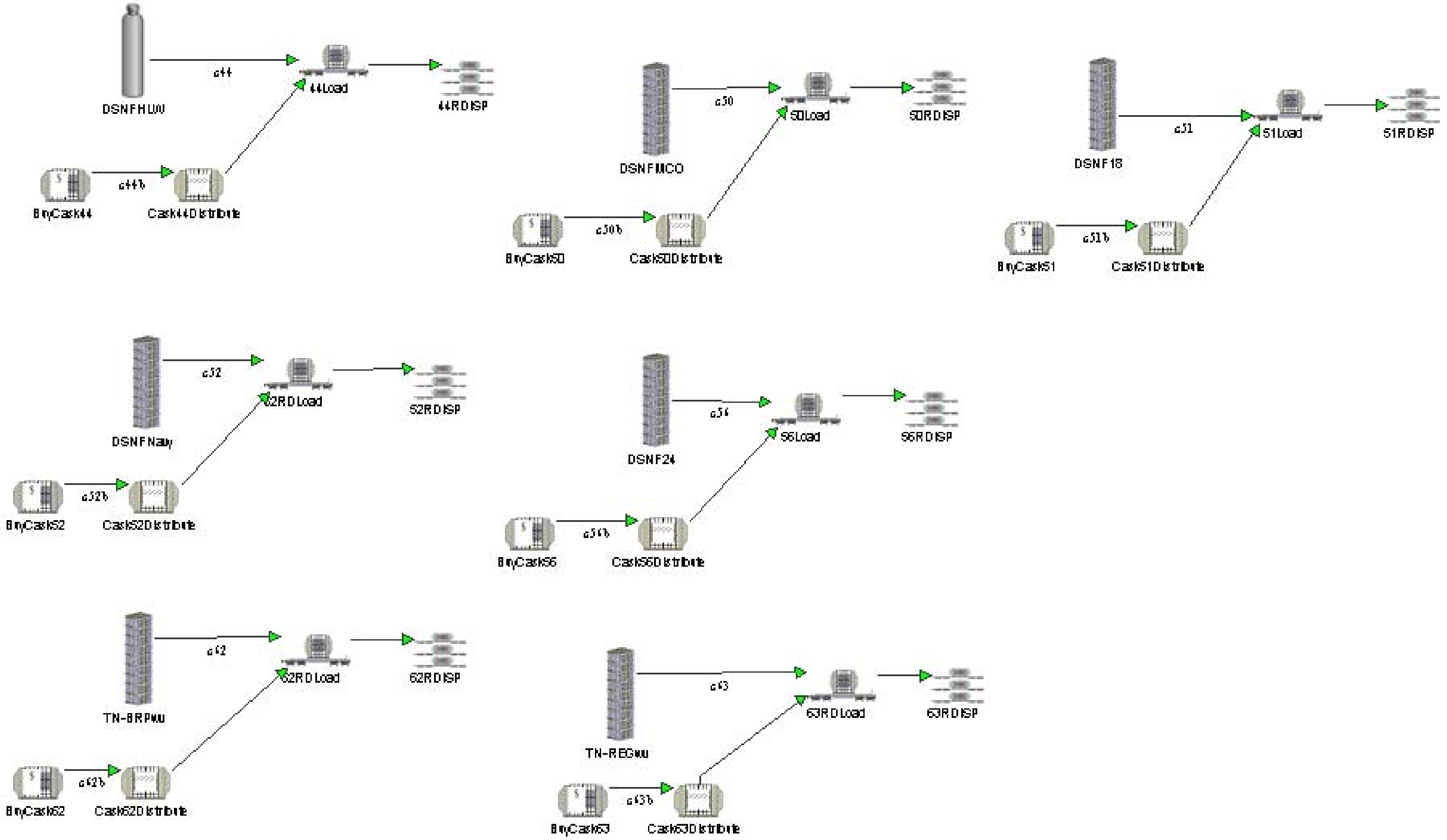


Figure 12. DOE Department

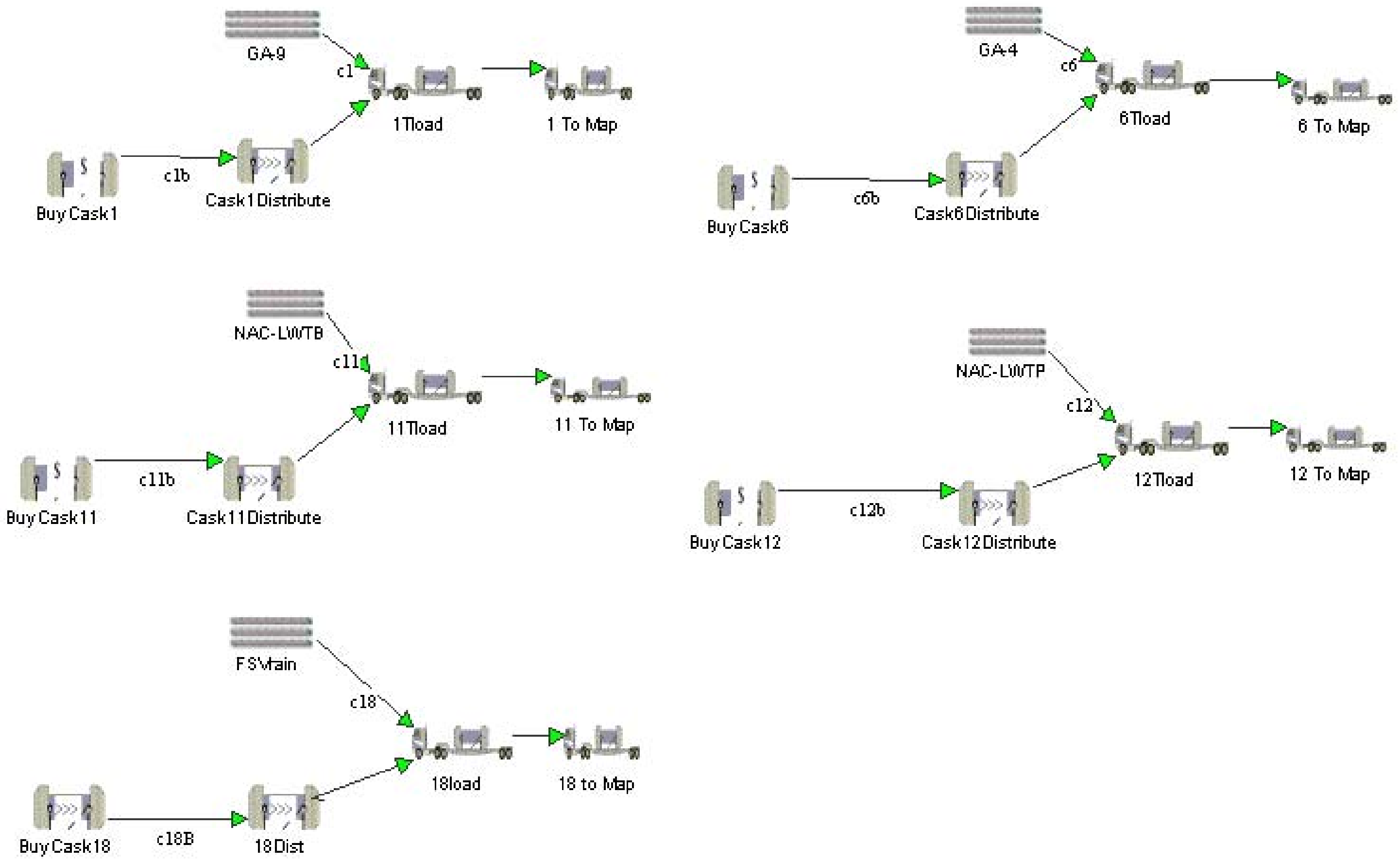


Figure 13. Trucks Department

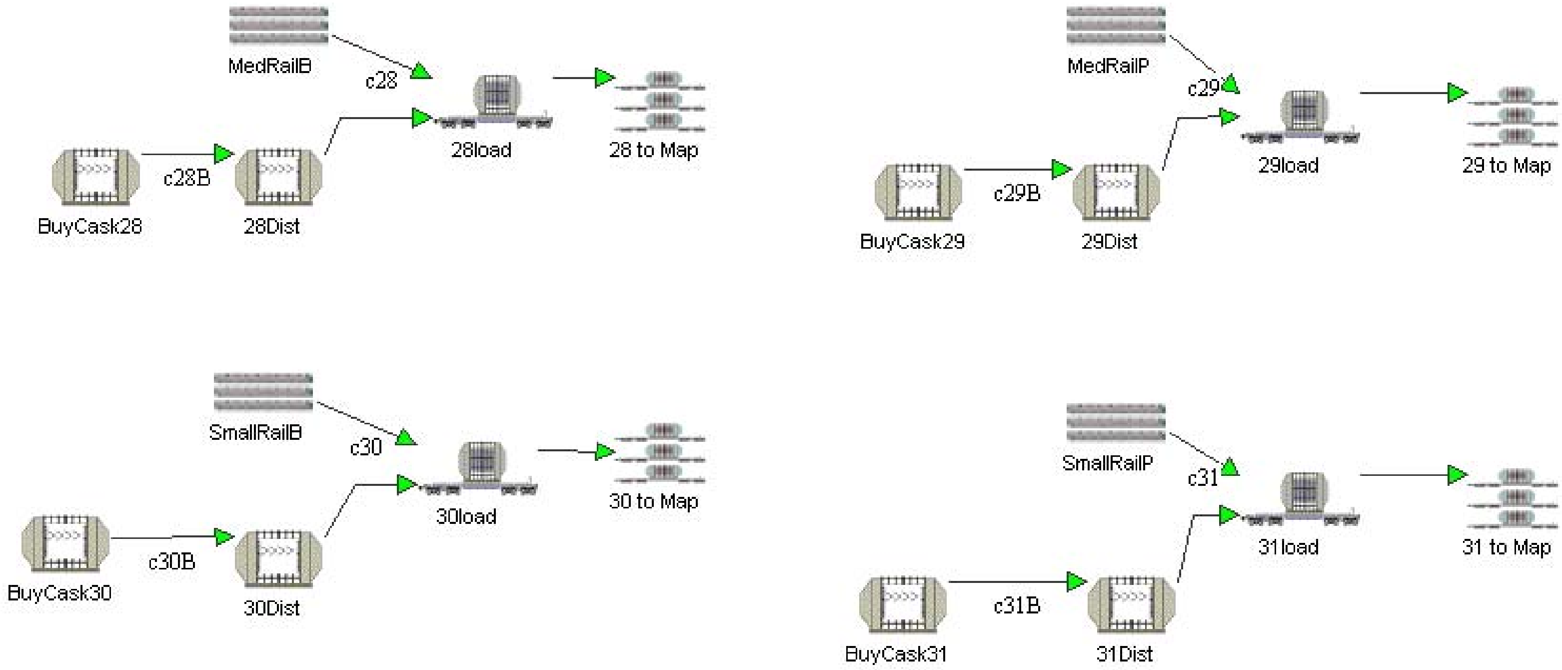


Figure 14. Small/Med Rail Department

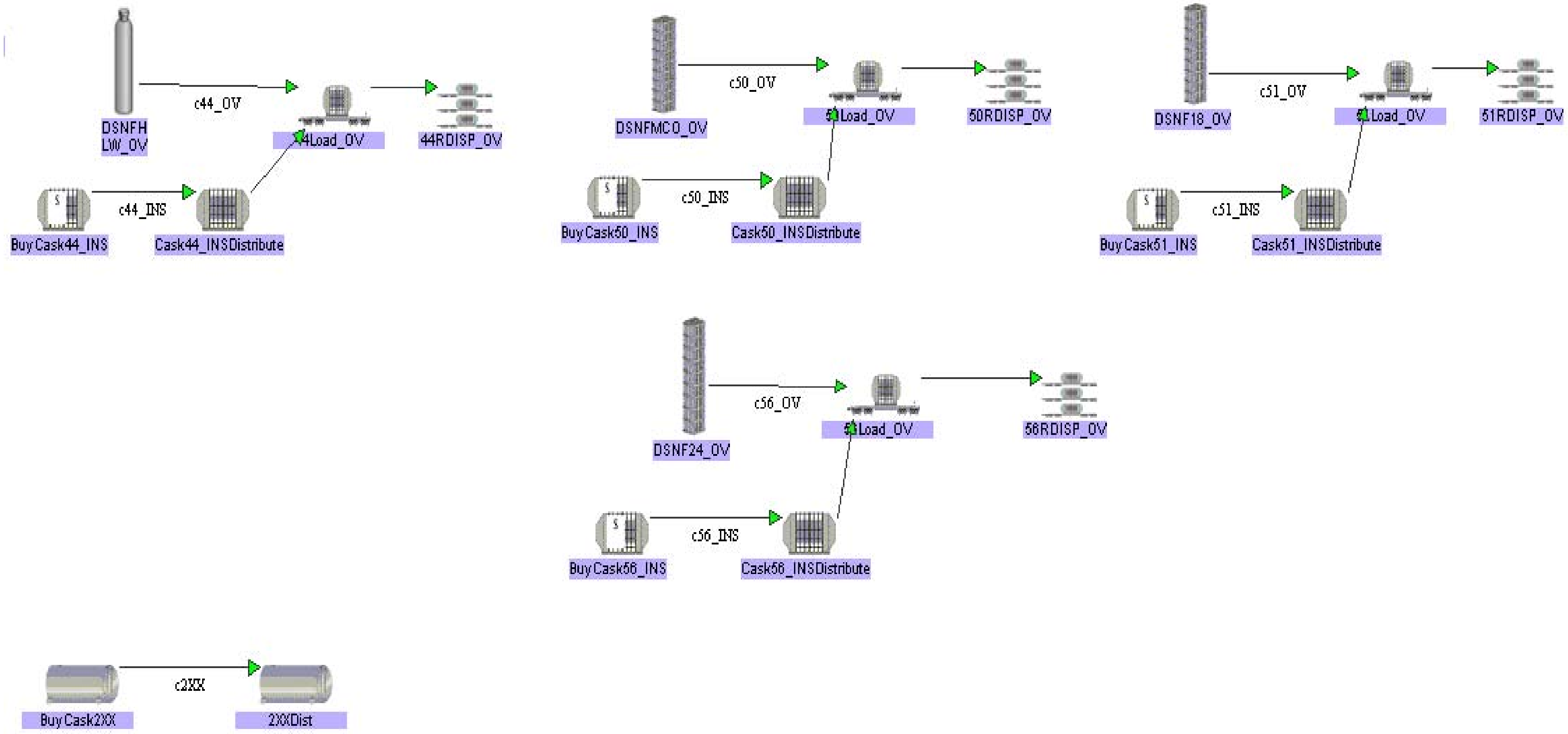


Figure 15. DOE OV Department

A basket and shell approach is implemented for DOE cask allocation in TSM V6.0. The selection to use unique casks for DOE (see Figure 12) or baskets and shells is made in the TSMPP by the selection of the start “buy” process for the cask WO.

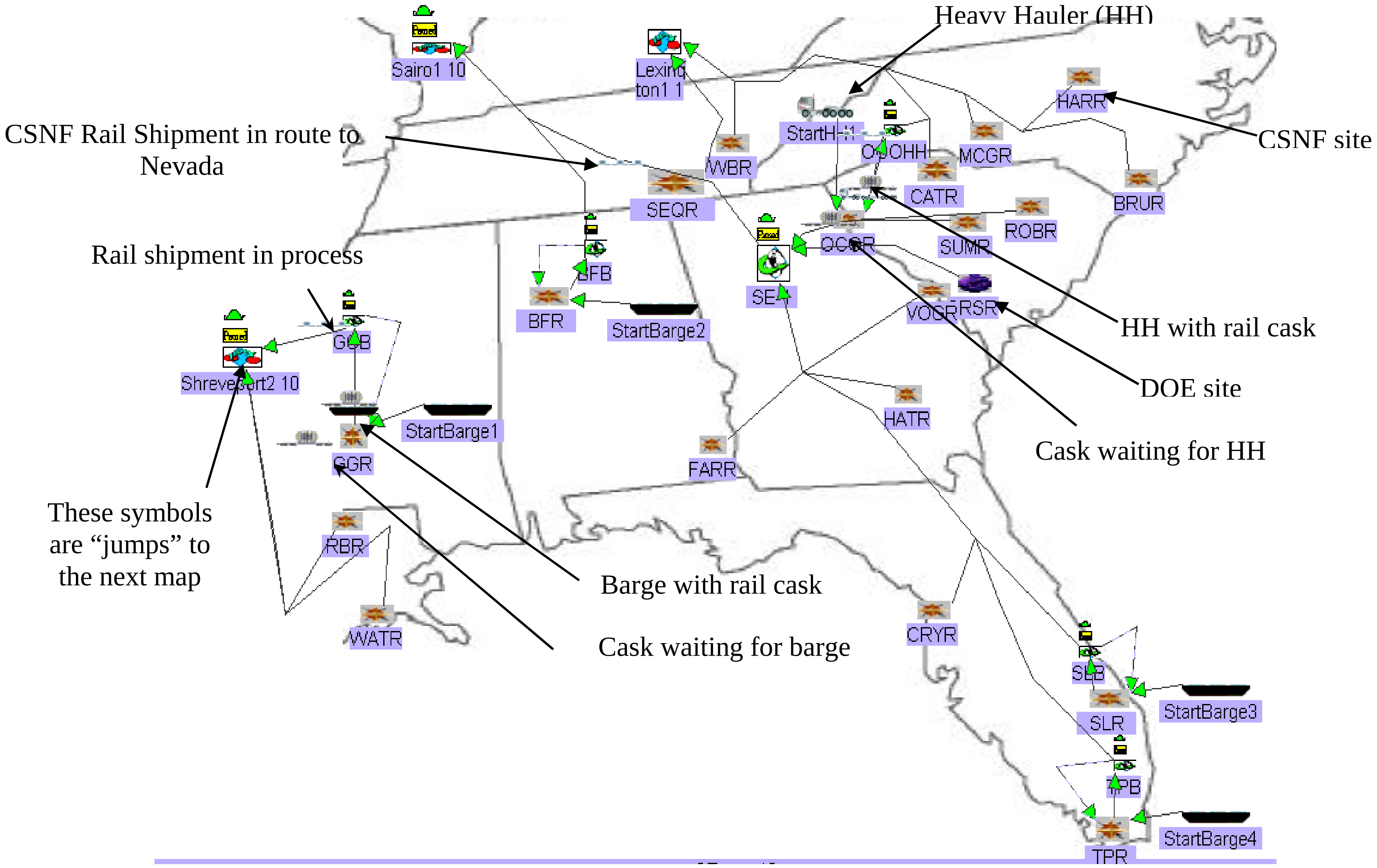


Figure 16. Typical Transportation Department Map

This is a view of the SErail 9 transportation map showing the visual indicators that indicate the status of transportation resources and elements. The lines connecting the sites have information on the distances between the nodes. Other map departments have similar construction.

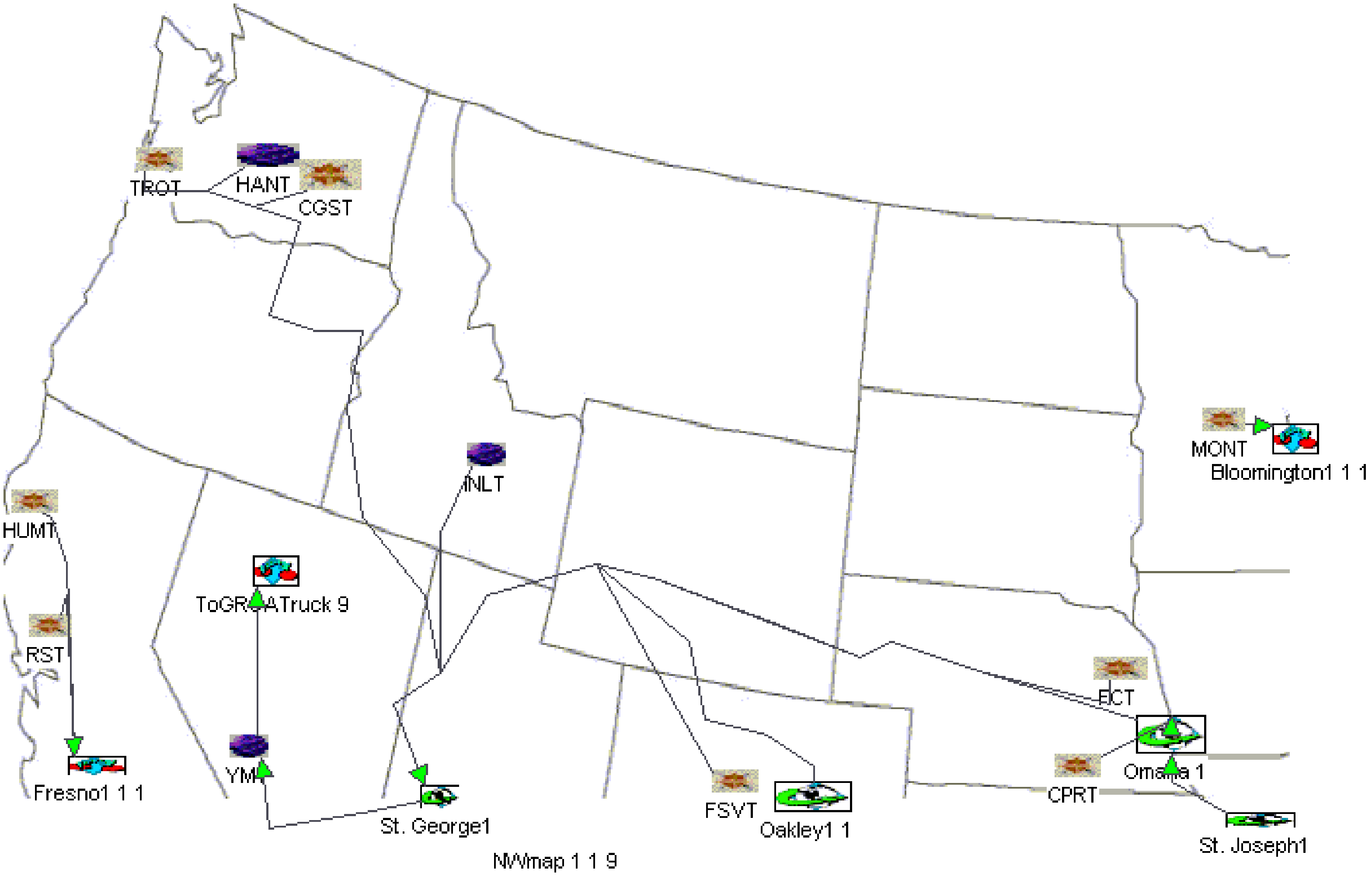


Figure 17. Truck Northwest Routes

All truck shipments are eventually routed to the “YMT” process where the “truckshipment” objects jump to the main TSM GUI process “GROATruckDepot”.

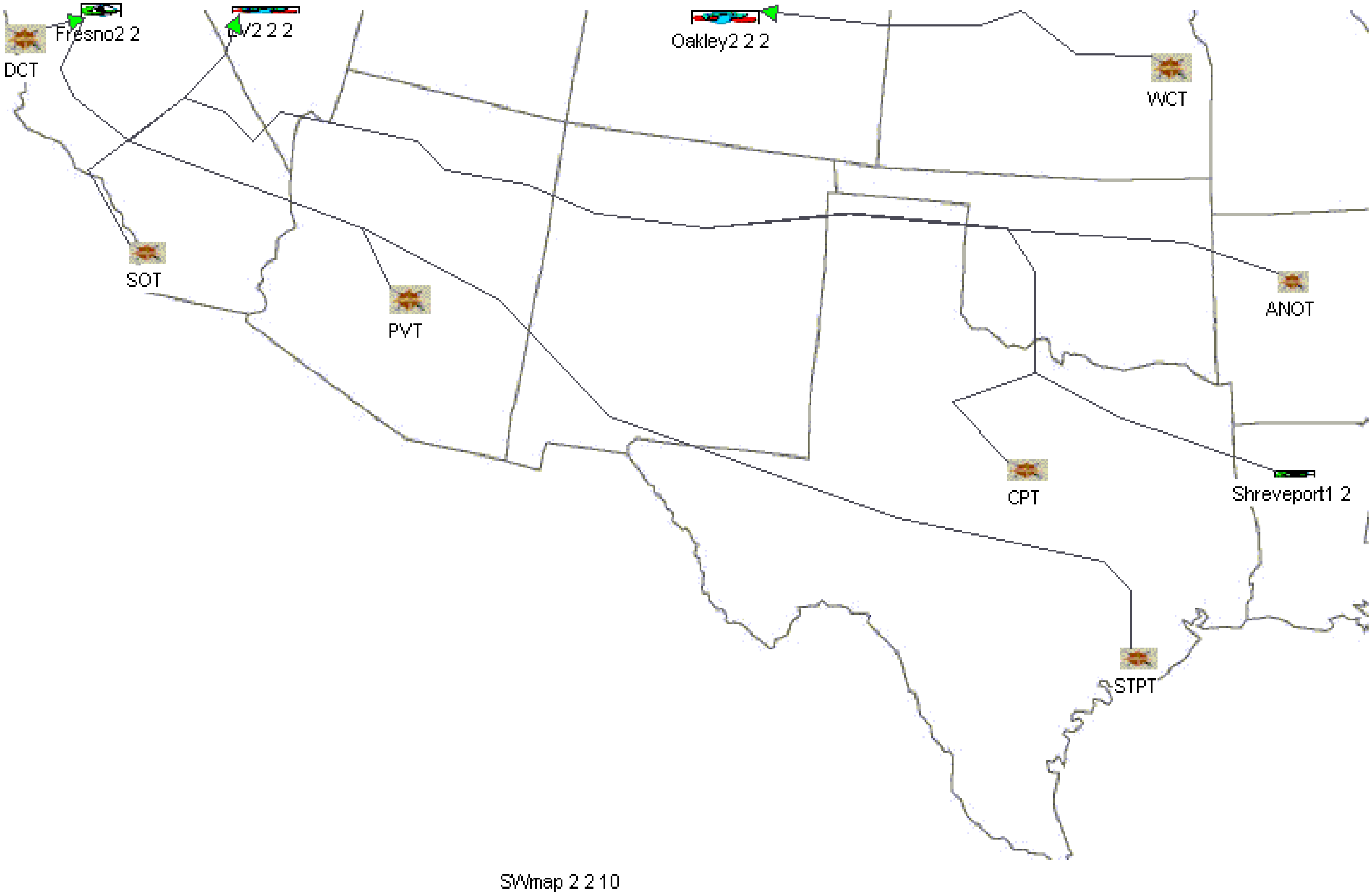


Figure 18. Truck Southwest Routes

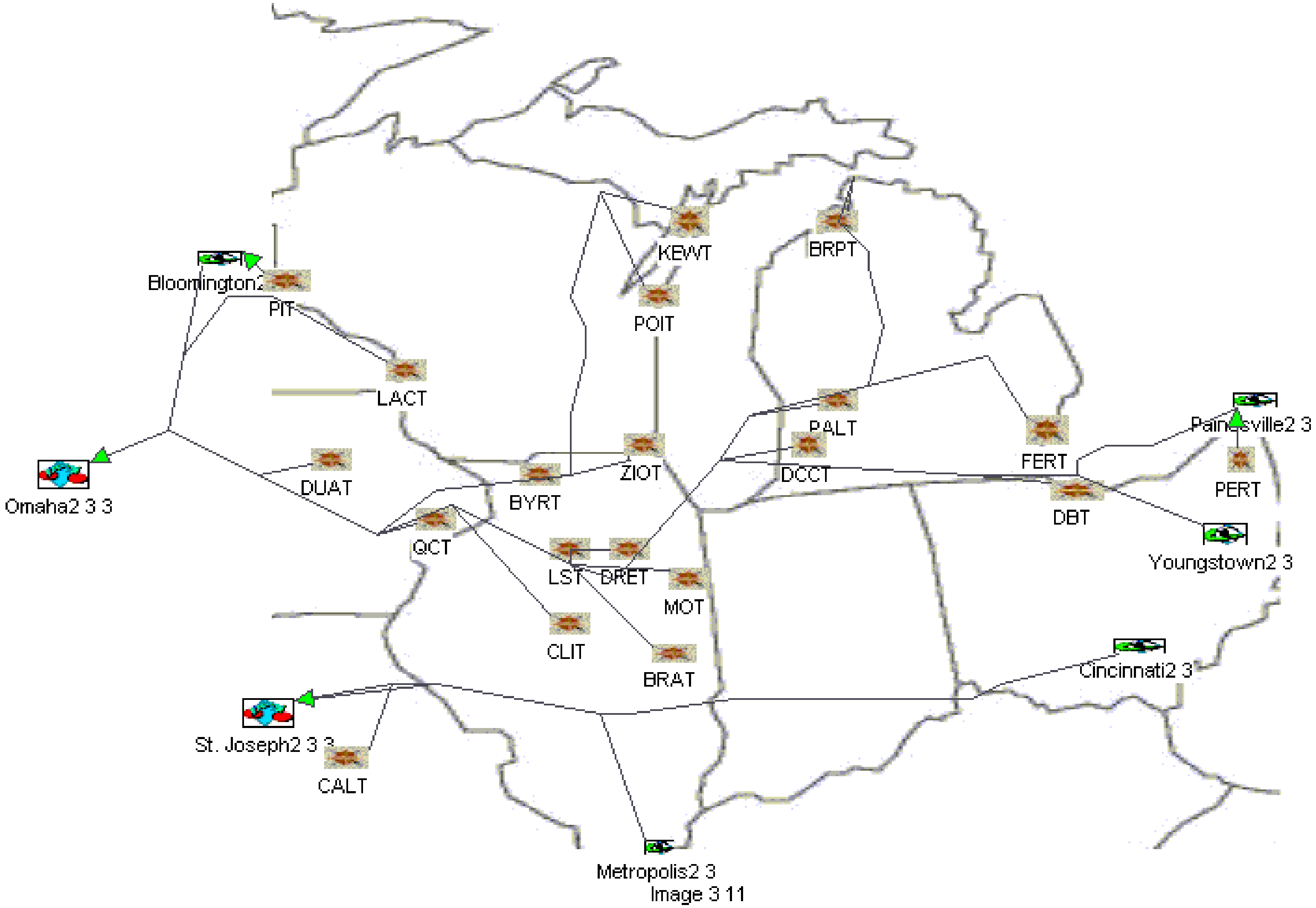


Figure 19. Truck Midwest Routes

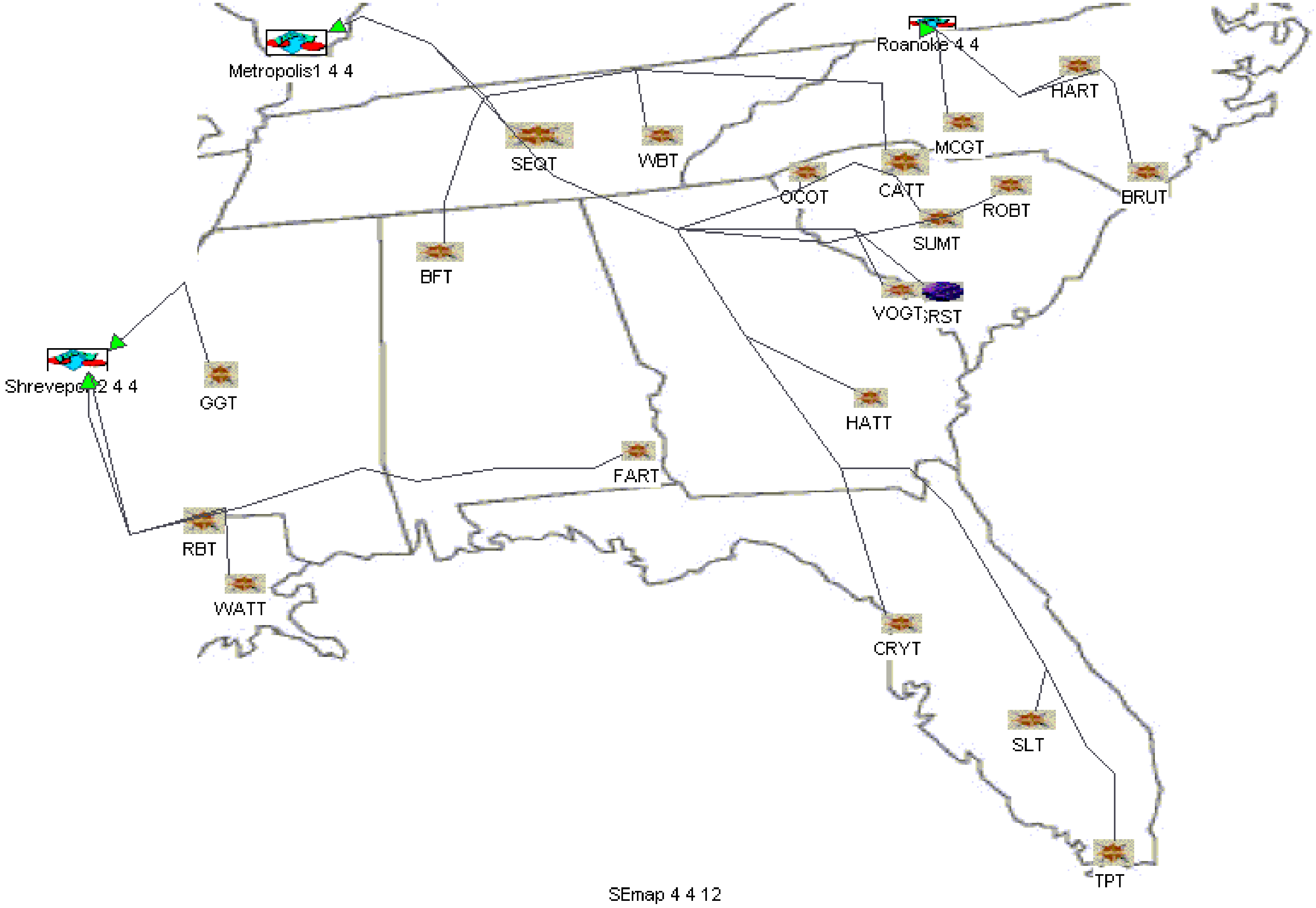


Figure 20. Truck Southeast Routes

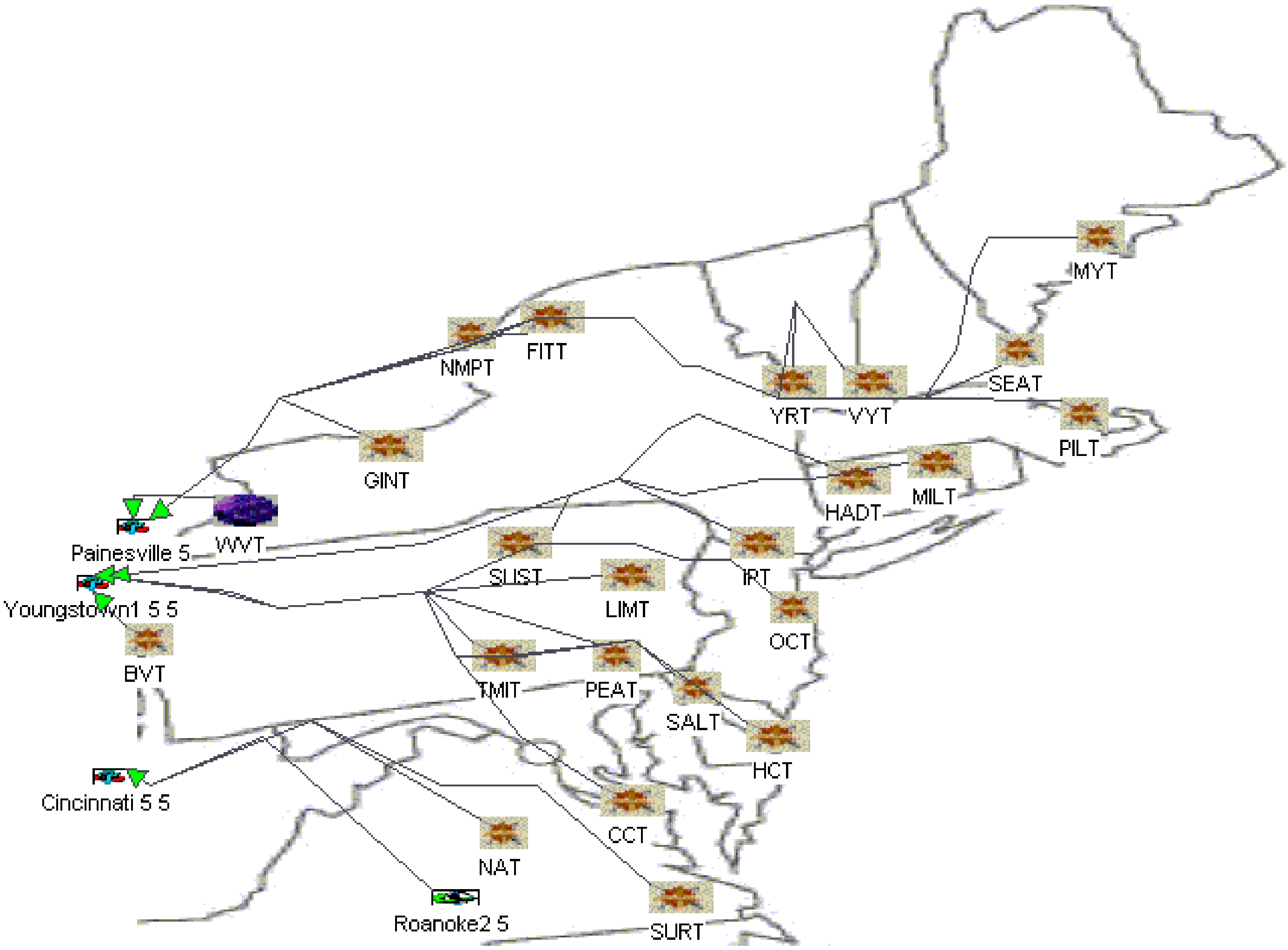


Figure 21. Truck Northeast Routes

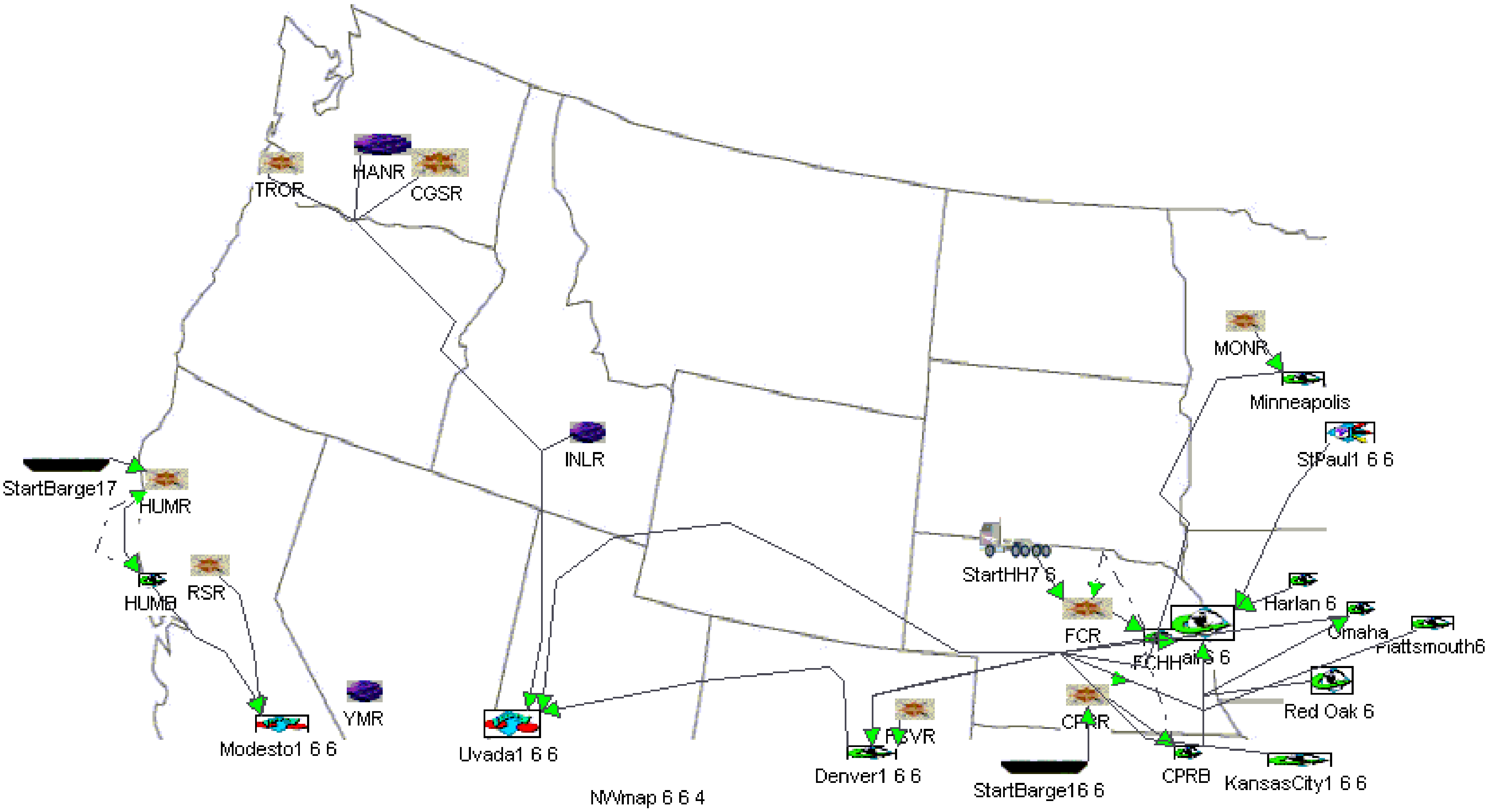


Figure 22. Rail Northwest Routes

The repository "YMR" is shown to provide a landmark but is not an active process. For rail shipments, the jump from the rail routes to the main TSM GUI is in the Southwest rail map.

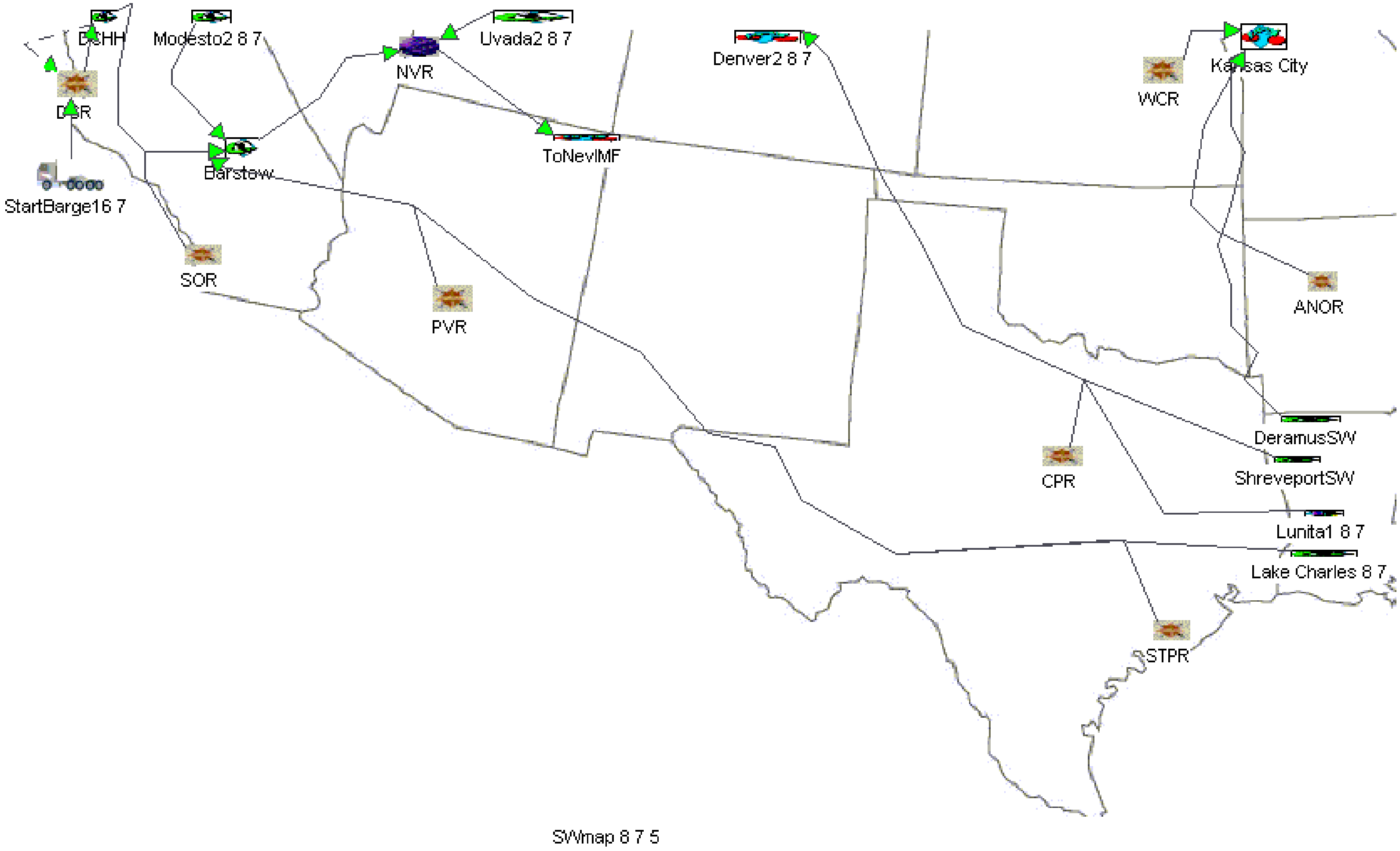


Figure 23. Rail Southwest Routes

All rail shipments are eventually routed to the “NVR” process where the “railshipment” objects jump to the main TSM GUI process “IMFDepot” process.

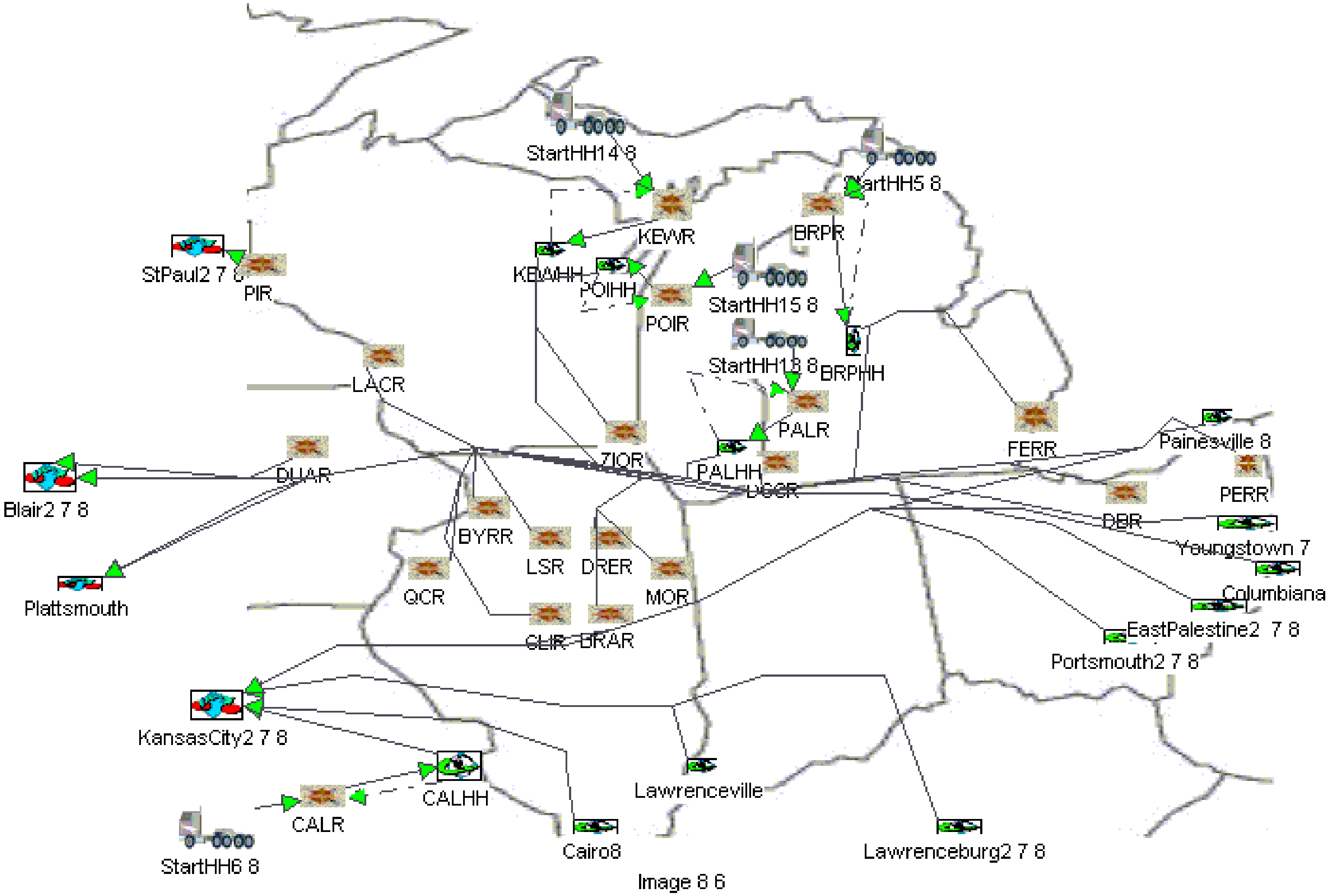


Figure 24. Rail Midwest Routes

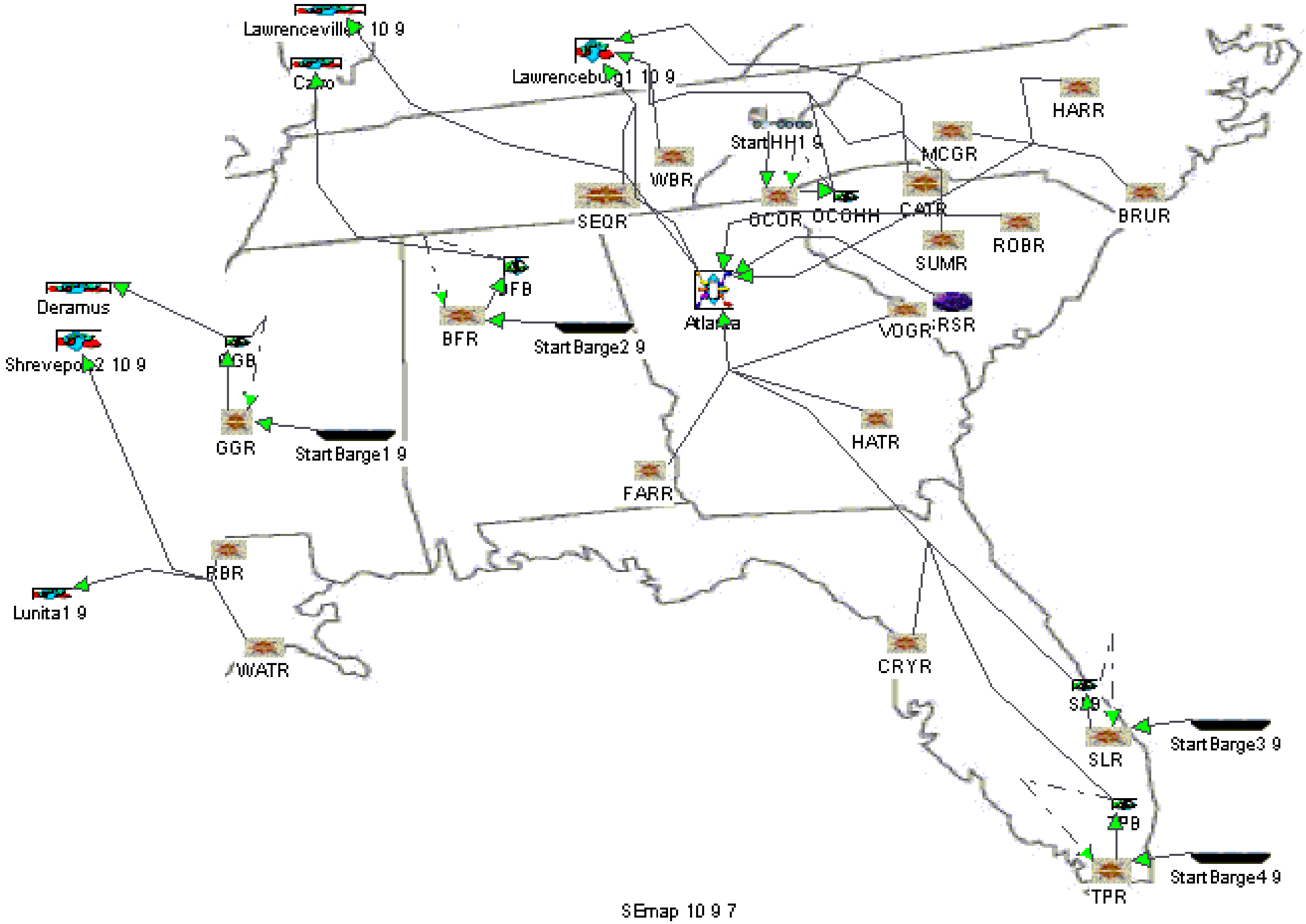


Figure 25. Rail Southeast Routes

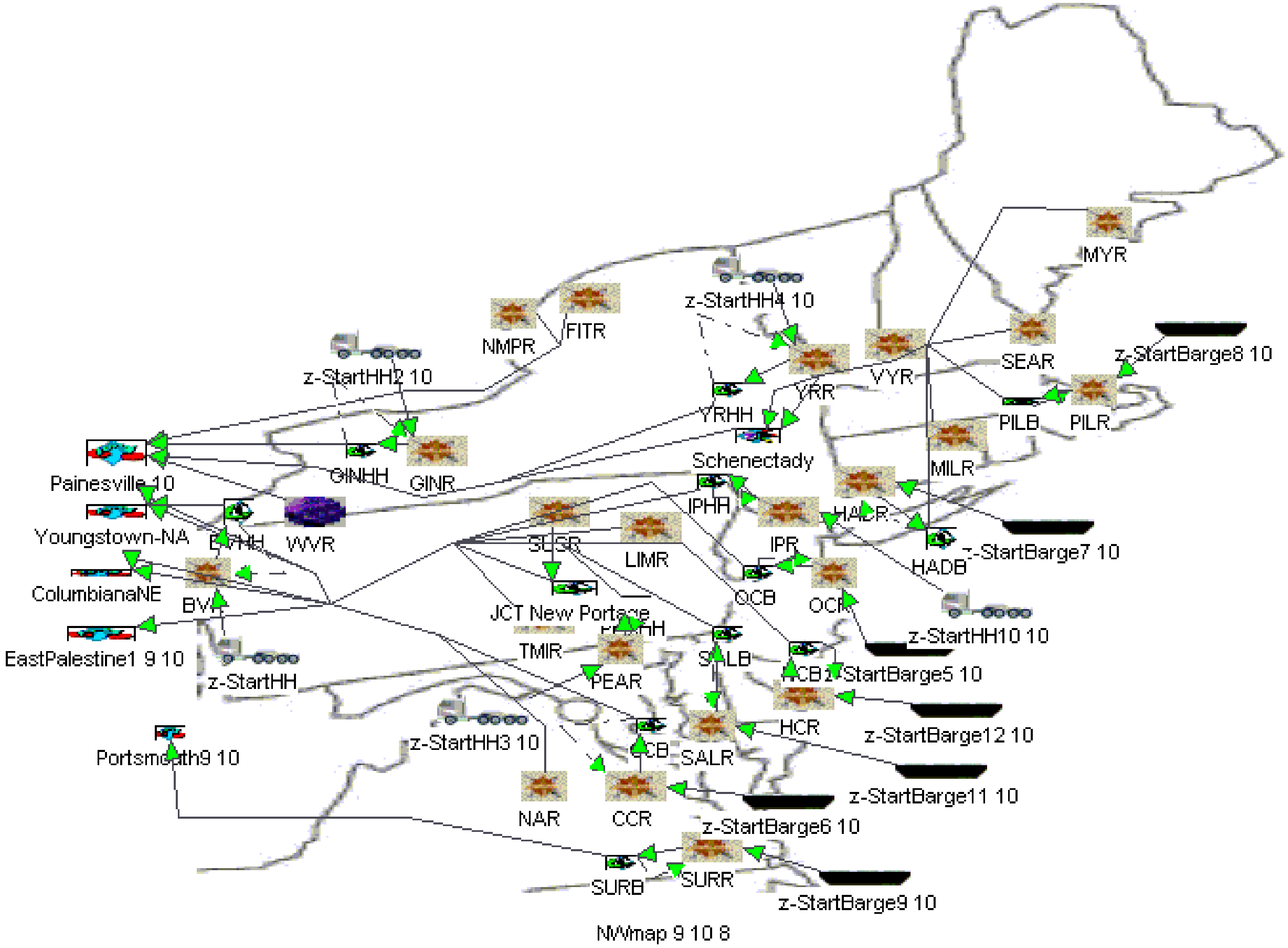
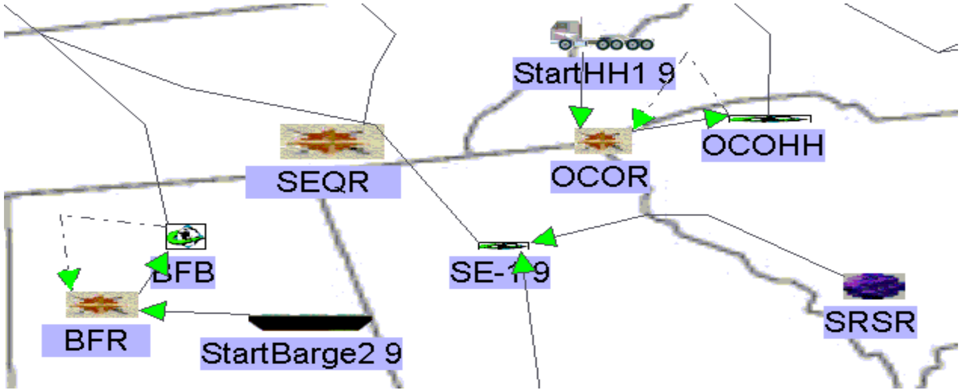
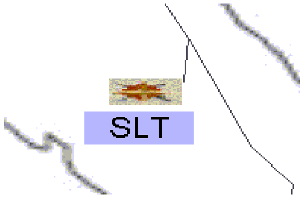


Figure 26. Rail Northeast Routes





St. Lucie is a typical truck site.

Browns Ferry (BF) is a typical barge site, Oconee (OCO) is a typical HH site, and Sequoyah (SEQ) is a standard rail site. Savannah River (SRS) is a typical DOE site. SE-1 9 is a generic process used to combine two routes into a single route; it is not a waste site. Note that barge and HH sites are always used in conjunction with a rail site. (see sections 2.4.1.3/.4)

Figure 27. Typical Waste Site Configurations

This figure shows typical waste acceptance sites. “Caskontruck” and “Caskonrail” objects jump from the “load” processes shown in Figures 5-15 to the “T” sites or “R” sites indicated by the final letter added to the 2-3 letter site designator as described in Table 2. DOE sites such as SRS use a different image. All sites use a batch process to create a “truckshipment”, “railshipment”, “z-railshipbarge”, “z-railshipHH”, or “DOErailship” object that is dispatched via the route connectors to the repository. Truckshipments have one batched caskonrail object maximum. Railshipments, z-railshipbarges, and z-railshipHHs have three batched caskonrail objects maximum. DOErailshipments have five batched objects maximum. Batching occurs at the “T” sites for truck shipments, the “R” sites for standard rail shipments, the “B” sites for barge shipments, and the “HH” sites for HH shipments. SimCAD™ carriers are used for the barges and HH and require “start” processes to create the carrier objects. The carrier return connections are shown as dashed lines. Barges and HH are assumed to carry one cask per trip.

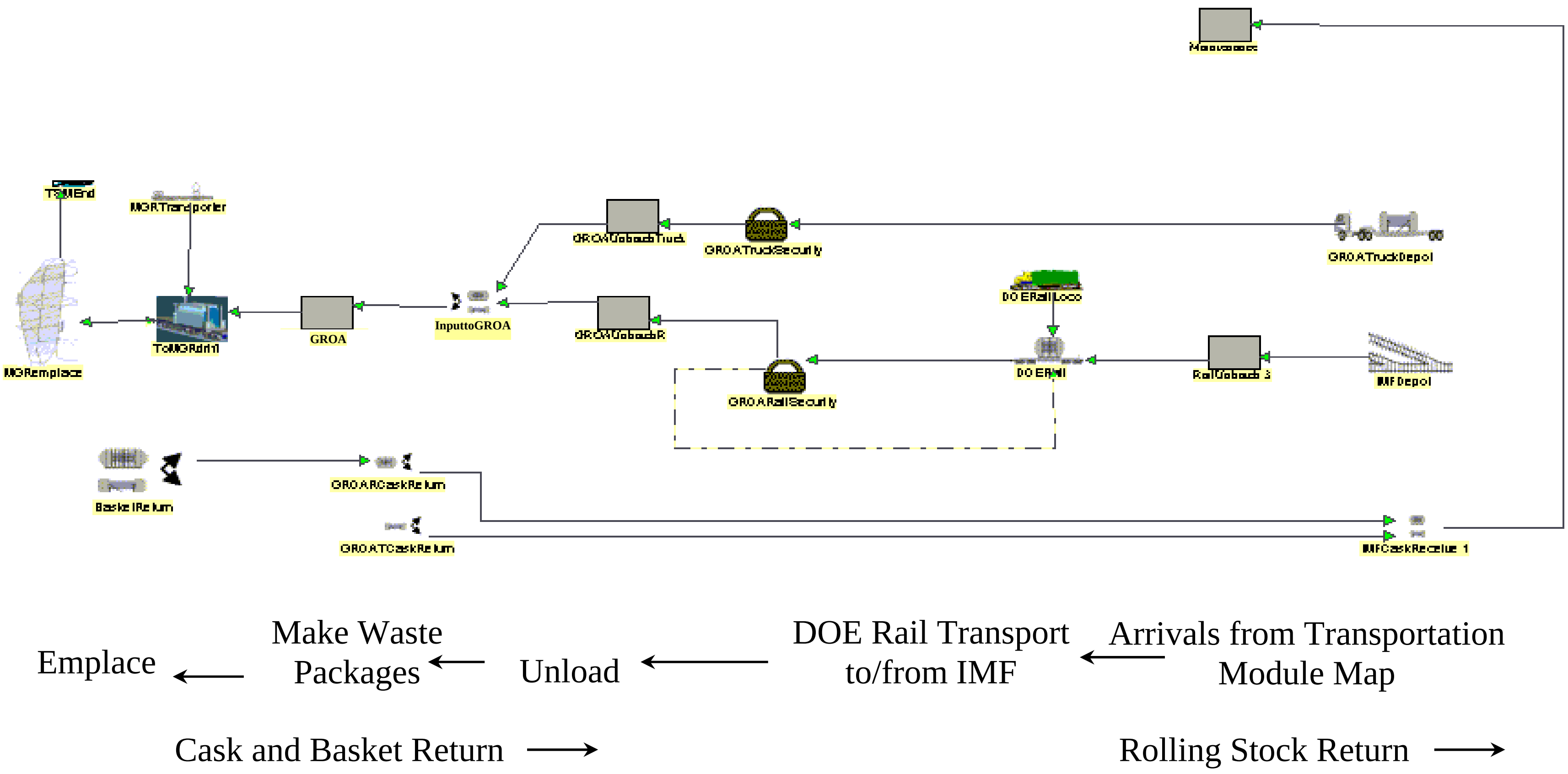
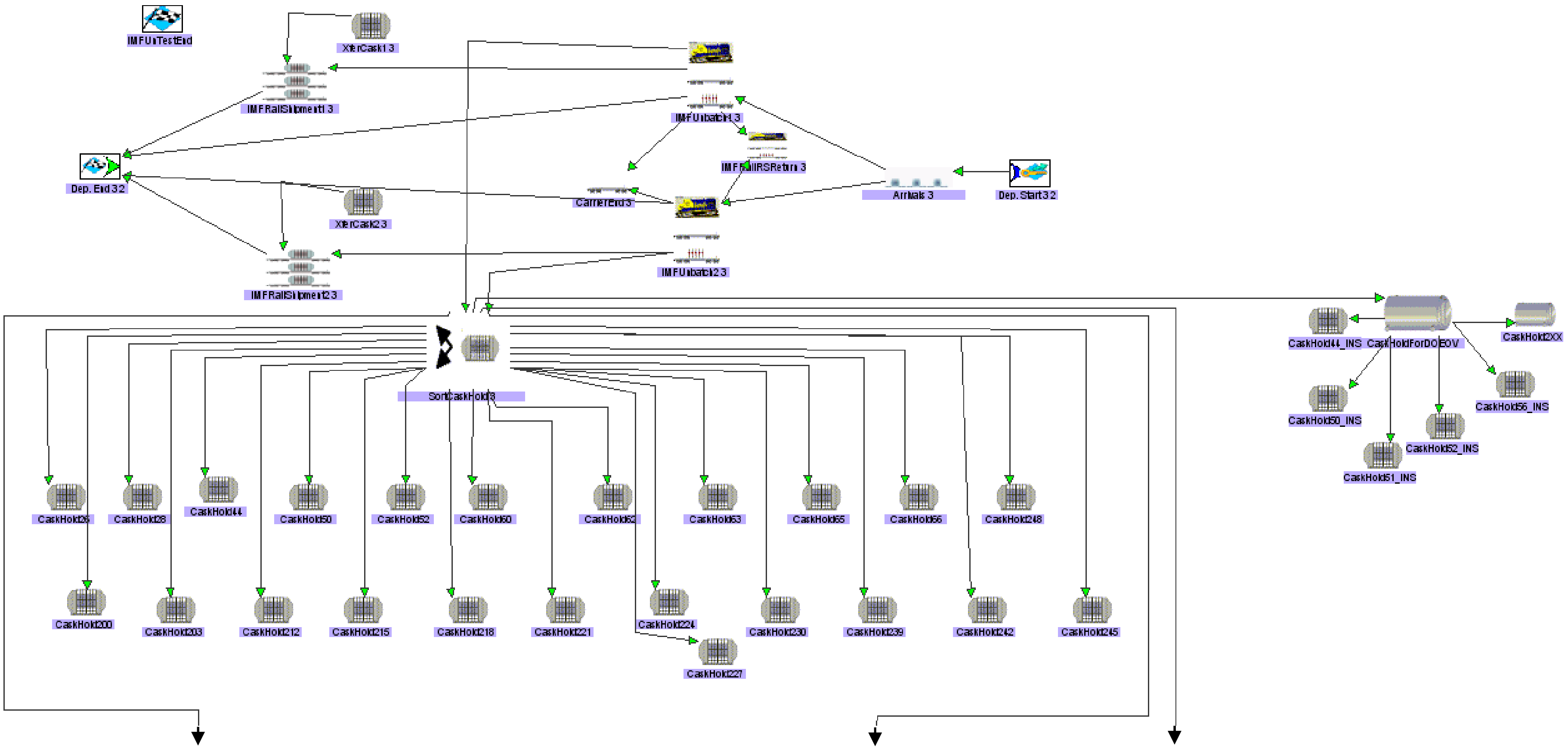


Figure 28. Transportation Interfaces at Repository

The repository module includes the final transportation to the GROA. On receipt of rail shipments at the Nevada Intermodal Facility ("IMFDepot"), the shipments are placed on the DOE Rail for delivery to the GROA. Rolling stock is returned. For rail there are two departments that unbatch and route objects to the GROA. Truck shipments require only 1 department along this path. The TruckUnbatch and RailUnbatch departments have "Cask Hold" processes discussed in a later figure. The detailed logistics for unloading are in the GROA department and the cask handling aspects for the GROA are shown in a later figure.



Arrow leads to additional CaskHold Objects

Arrows leads to additional CaskHold Objects

Figure 29. Repository Module: Rail Unbatch Department

On receipt of rail shipments at the IMF, the shipments are completely unbatched and the constituent objects are routed to their next steps. Two unbatch routers are used to ensure adequate throughput. Rolling stock is returned via jumps; casks are placed in “caskhold” functions to await a trigger after the associated cask load is unloaded in the GROA; and the waste object is sent to a join process to be made into a “xfercaskload” for shipment on the DOE rail. Casks when released from the cask hold “jump” to the GROA cask return process to properly simulate empty cask movements.

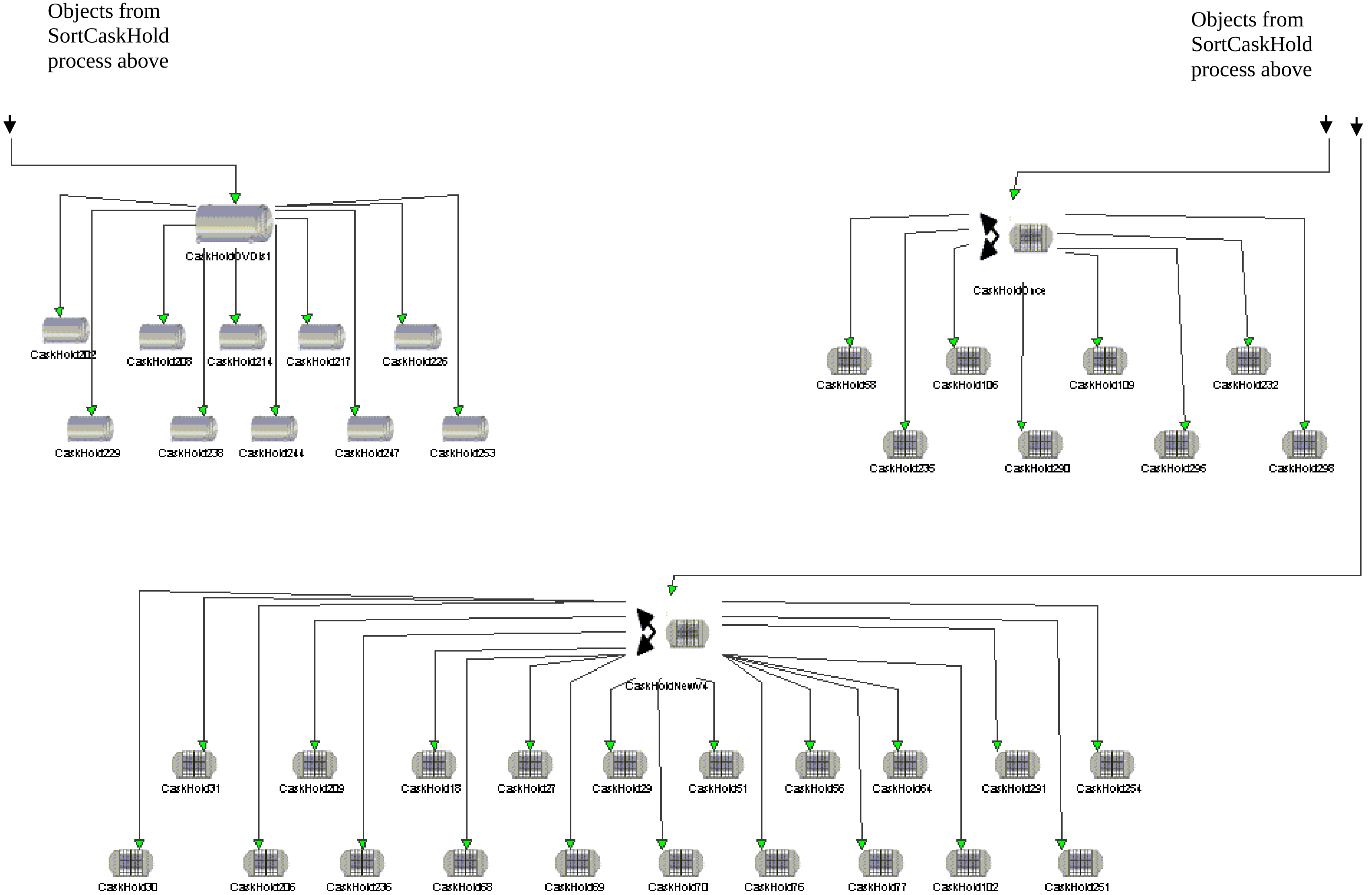


Figure 30. Repository Module: Rail Unbatch Department Continued

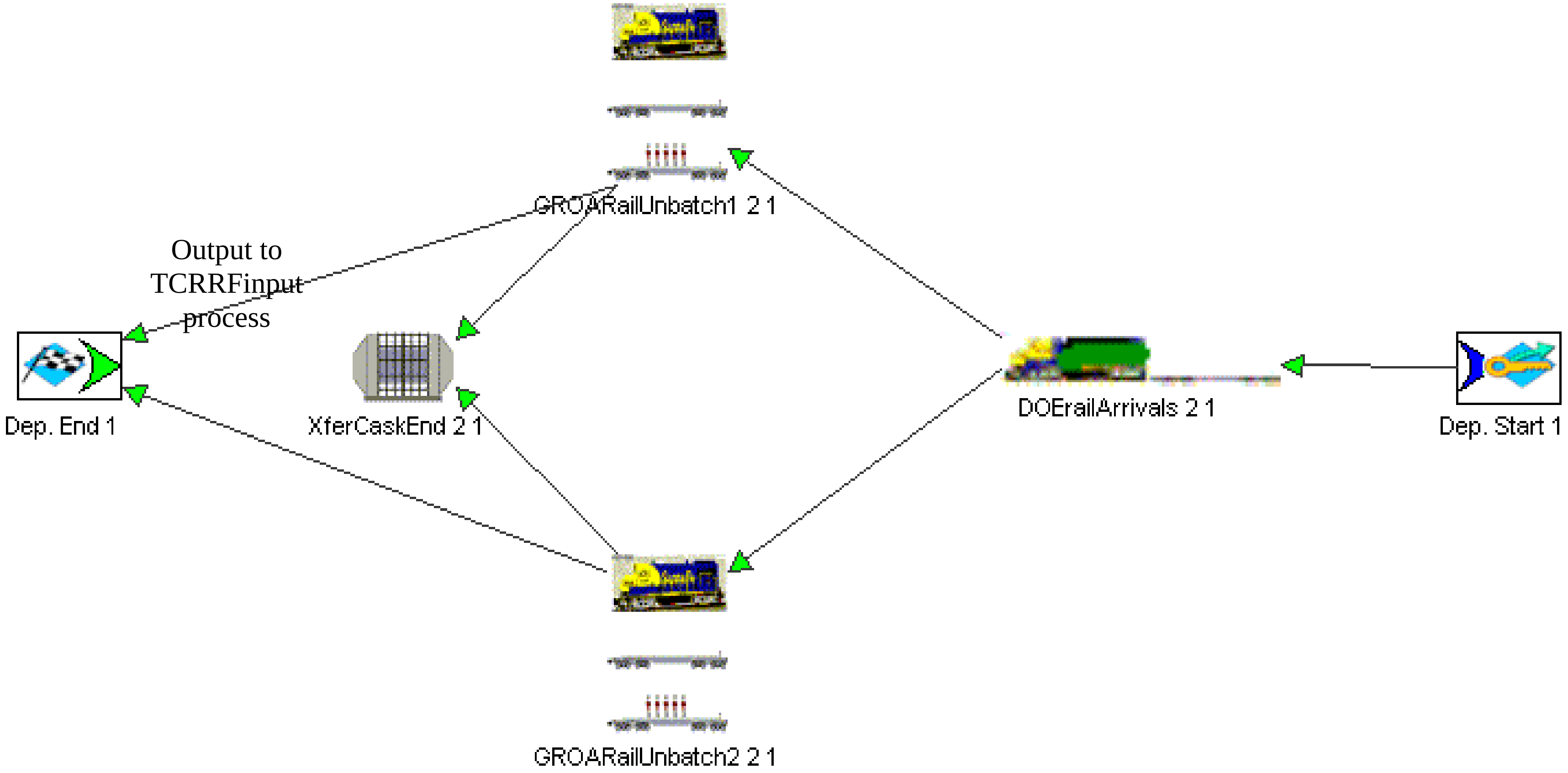


Figure 31. Repository Module: GROAUnbatchR Department

A second rail unbatch department is used to unbatch the “xfercask”, destroy the “xfercask” object, and send the waste cask load to the GROA via the InputtoGROA input process.

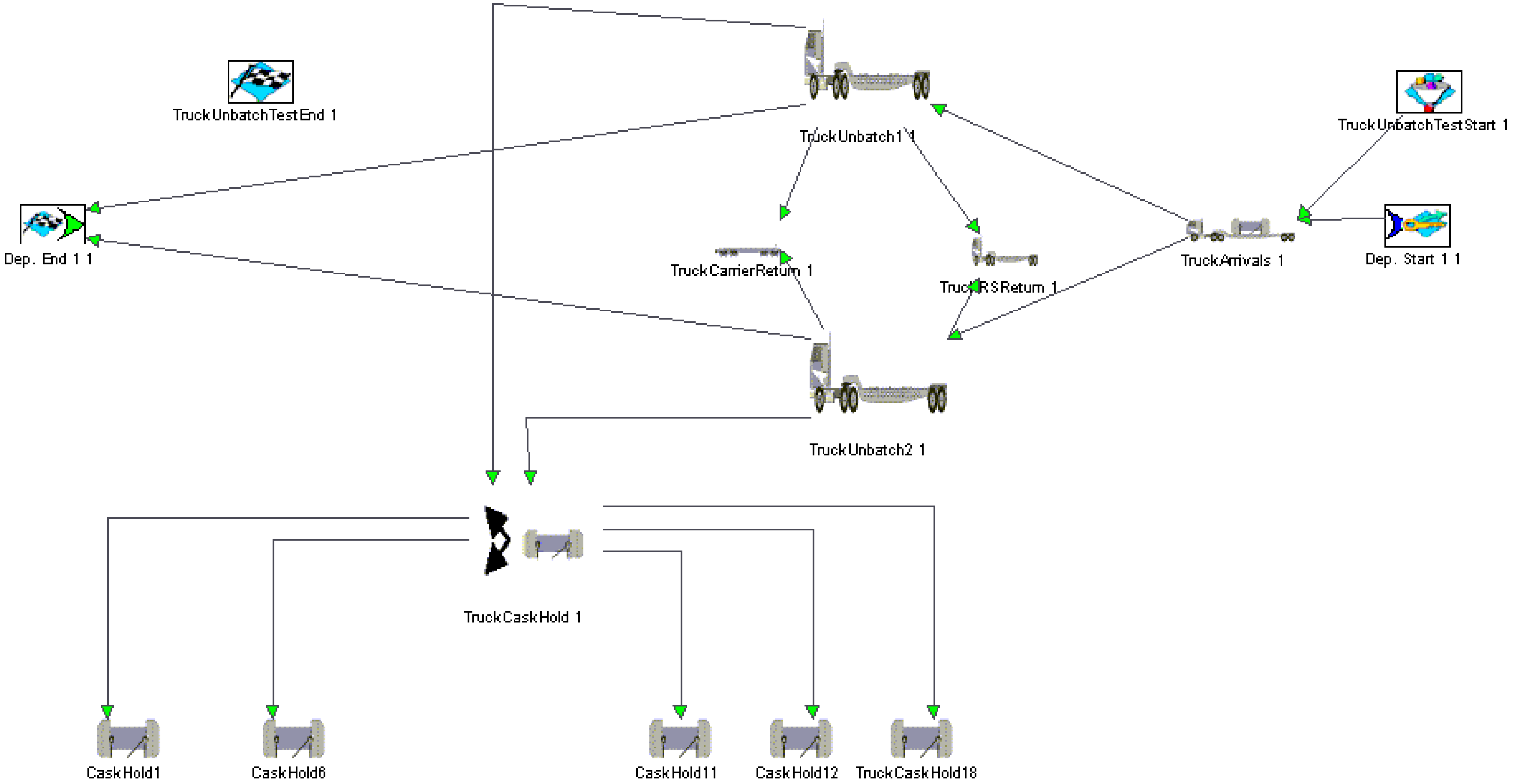


Figure 32. Repository Module: Truck Unbatch Department

After arrival at the repository, the truckshipment objects are unbatched and the constituents are appropriately routed. Rolling stock is returned via jumps; casks are placed in “caskhold” functions to await a trigger after the fuel is processed in the GROA; and the waste object is sent to the GROA department via the InputtoGROA process.

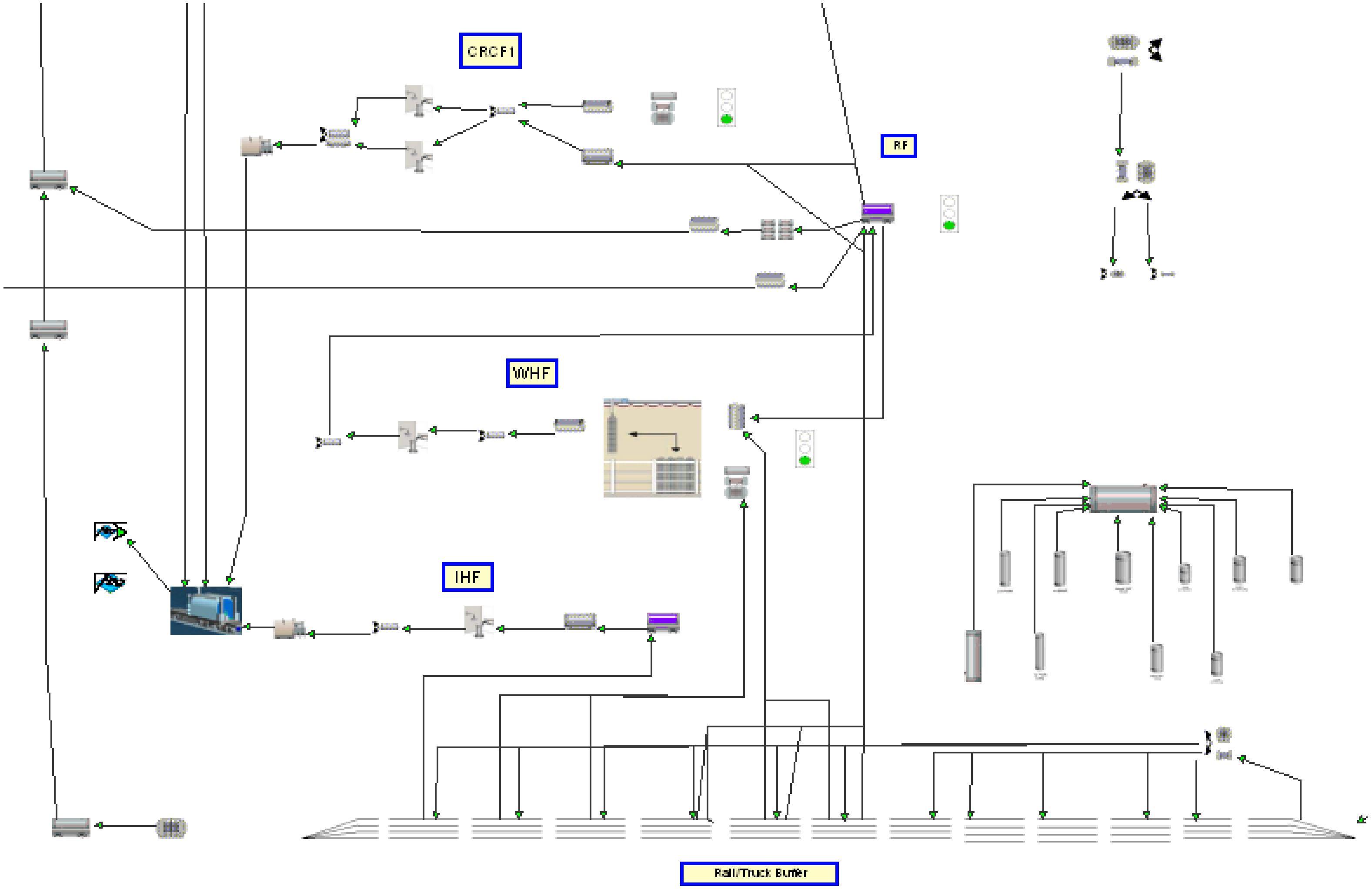


Figure 33. Repository GROA and Cask Return

The cask return in the revised GROA design does not pass through the SRTC that have been removed from the design. The cask return only involves the jump processes in the upper right. This reduces the cask cycle ties in Version 6.0.. (The TSM should be opened and viewed for more detail if needed).

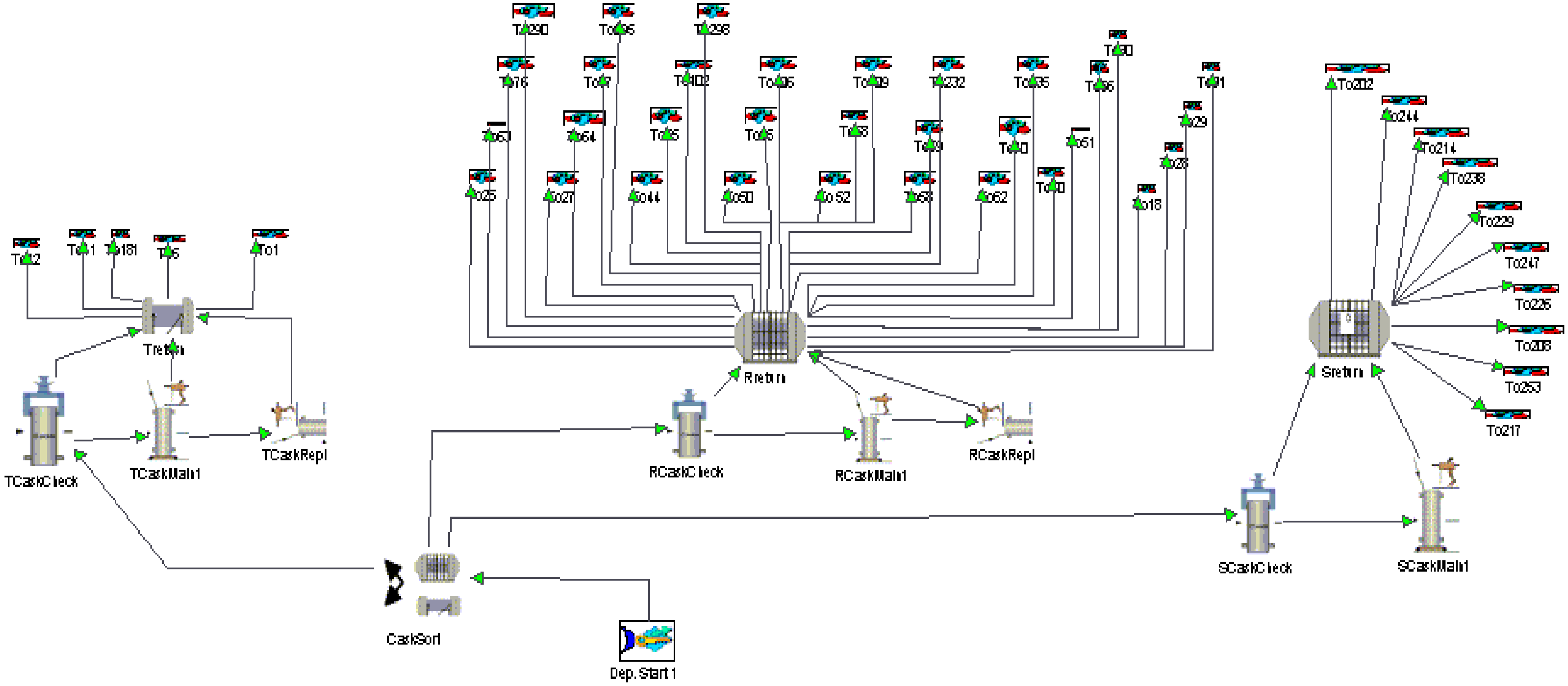


Figure 34. Cask Maintenance

Empty casks are returned from the GROA to the “Maintenance” department on the main GUI. Casks are sorted by truck (T), rail or basket (R) and shell/overpack (S). The need for cask maintenance (based on time or number of trips) is assessed in the “CaskCheck” processes. In the CaskMaint processes, T and R casks more than 25 years old are sent to a “CaskRepl” process for major overhaul. After maintenance, the casks are retuned to the “dist” processes in the cask allocation departments for reuse by the multiple jumps at the top of this department. The “dist” processes are shown in Figures 5-15.

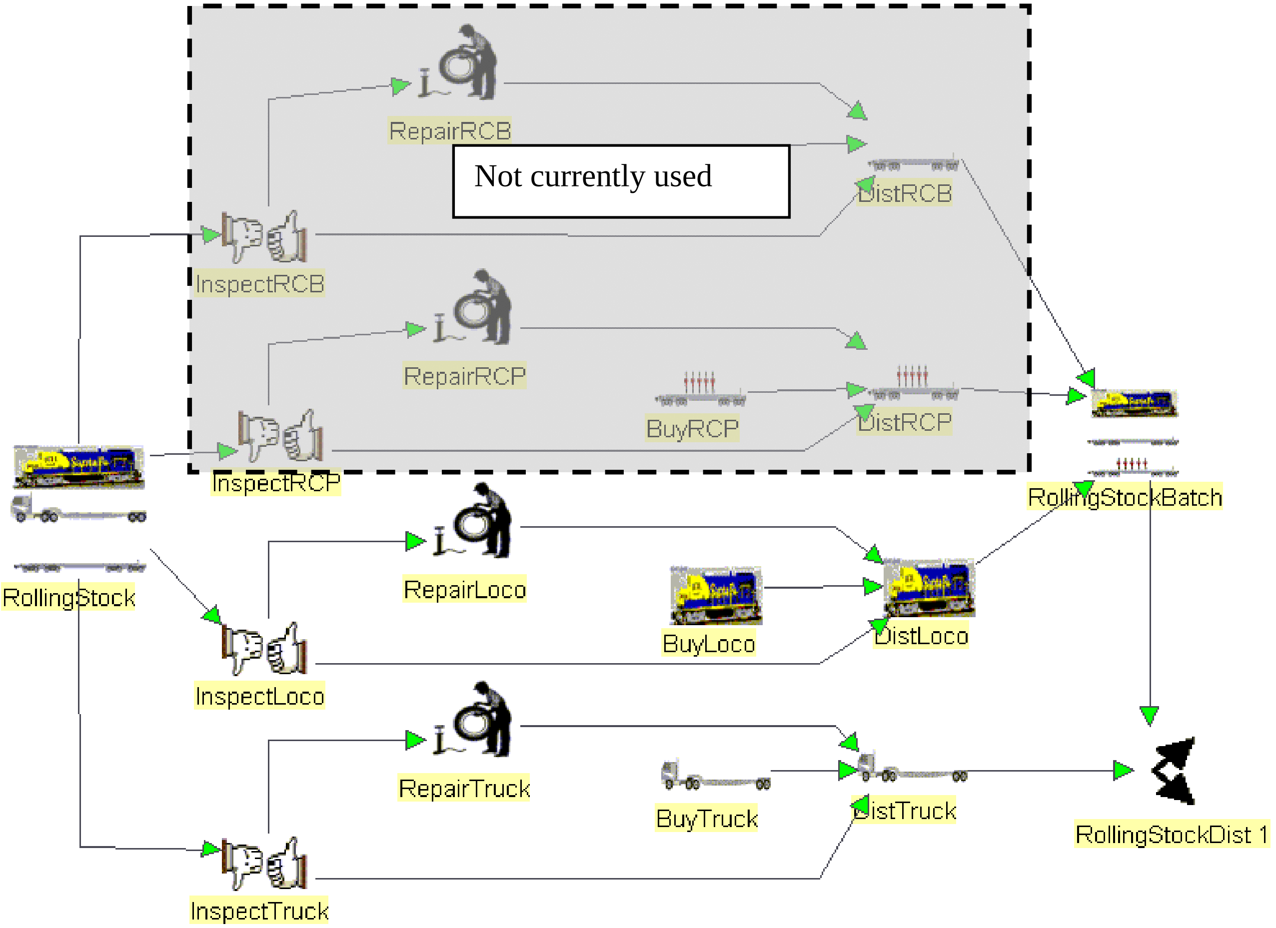


Figure 35. Rolling Stock Return and Maintenance

The transportation functions of rolling stock inspection, maintenance, purchase and distribution to the waste sites for shipments on demand is in this department. Rolling stock is returned from the “unbatch” departments shown in Figures 29 and 32. The DistTruck and RollingStockBatch send rolling stock to waste sites on demand. The need for maintenance or repair of the items is based on the number of trips assessed in the “Inspect” processes. The locomotives from (BuyLoco) are set with an “open” buy process. Trucks from the “Buy Truck” processes can be set to open buy or use a WO established by a TSMPP algorithm (see Section 2.7)

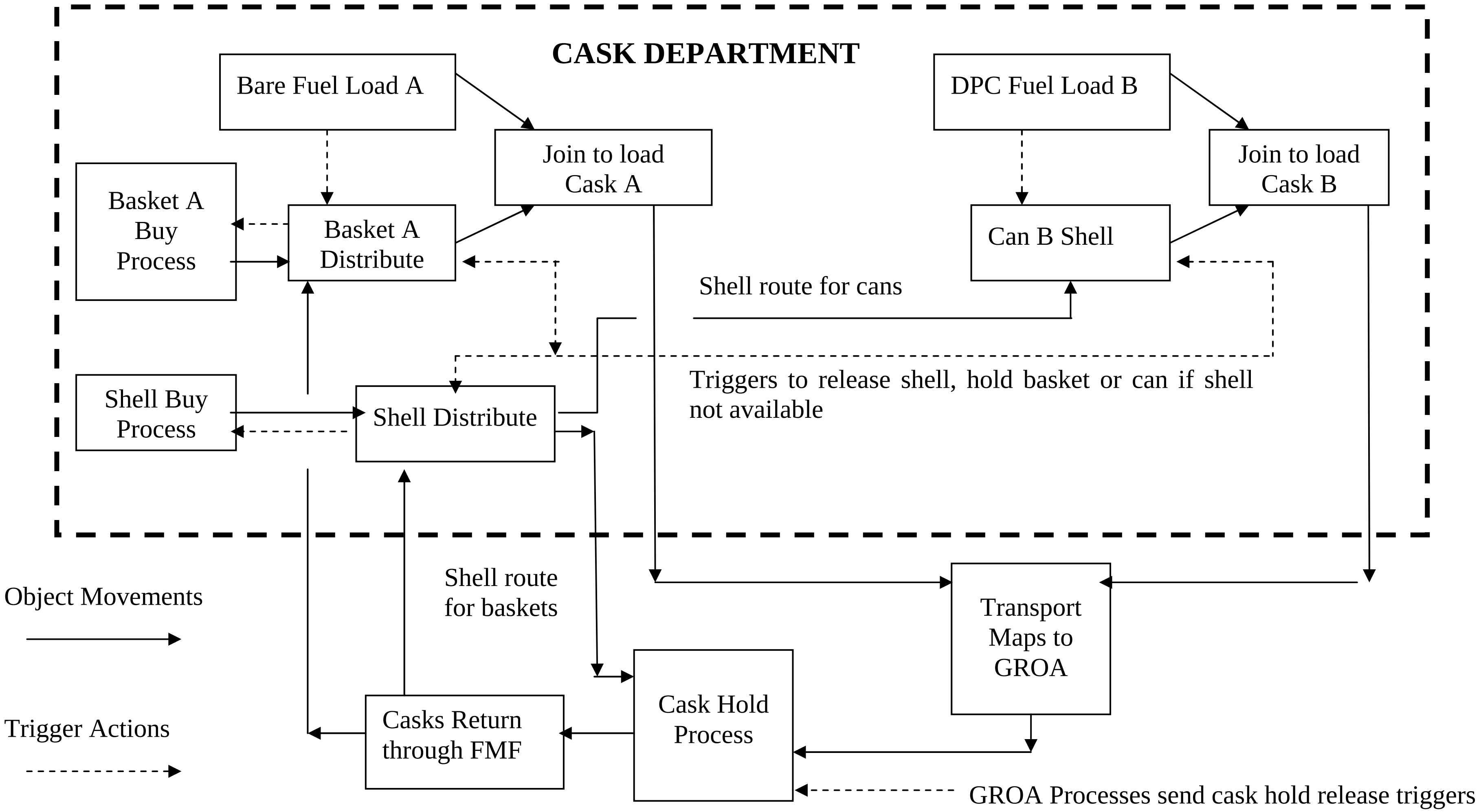


Figure 36. Cask Allocation Triggers

Cask allocation departments are used to house the cask allocation programming and logic and provide maximum flexibility for various cask allocation options such as using shells (overpacks) and bare fuel baskets as separate items.

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3. CASK TRANSIT TIME

To enable better understanding of the transportation module, this section discusses the time that a cask is in transit or being used by the various processes in the TSM. The total time that a cask spends in transit is a key driver to estimate the size of the casks fleet required for the simulation. For example, for simulations or cases with unlimited casks (see discussion in Section 2.6), a longer turn-around time at the waste sites, the GROA, or other places may cause a shortage of casks and will require a subsequent cask purchase to ensure the wastes are accepted and shipped when demanded by the IS file schedule. Long turn around times can cause very large cask fleets (>1,000 in cases with bounding assumptions).

The cask transit actions are shown in Table 5 and in Table 1 of Reference BSC 2007e. Similar tables and actions can be constructed for truck cask transit or other sites, but Table 5 provides an adequate example so as to understand transit actions. Table 5 includes the following information:

OCRWM/TSM Action	The general description of the OCRWM program element, action, or process
Process/Connectors	The process or connector in the TSM. In most cases, processes are abstractions of actual actions but in some cases, these are logistic processes used by TSM to implement a simulation action. Connectors typically represent flow paths for objects or routes for transportation but may also be included for TSM logistics modeling purposes.
Figure	Figure in this manual that shows the process, connector, or route.
TSM Programmed Steps	Number of 8-hour time steps specified in the programming of the process or connector.
TSM Simulation Steps	Number of 8-hour time steps from a typical TAD canister run (scenario 25B from the Phase 1 TAD Study, Reference BSC 2005). Usually not equal to the programmed process time because the system enablers such as resources or other needs may not be available, or the process capacity may be more than 1.
Discussion	Clarifications or important characteristics about the behavior of the action or TSM modeling of the action. Also indicates if the TSM action includes “model time” as discussed below.

“Model time” is composed of simulation processes/connectors required by the TSM to model the logistics where the process/connectors do not represent an actual OCRWM process or action. For example, the unbatching processes (Figures 29 - 32) have many logic elements that are not abstractions of actual processes. Table 5 shows how the transit of the casks through the TSM may include processes with “model time” that may cause the total simulated transit time to be overestimated if there are not TSM constructs to compensate for the elements that introduce model time. For example, some TSM processing elements have intentionally low programmed processing time to reduce the overall effect of additional model time added by nearby processes.

Notice that by using this method model times have minor impacts on overall transit time and simulation results.

Table 5. TSM Cask Transit Actions

OCRWM/TSM Action	Process	Figure	TSM Programmed Steps	TSM Simulation Steps	Discussion[1]
-1. Cask staging at FMF and transport from FHF to site	253Dist (TAD department)	9	0	3.6	TAD shell 253 is the cask in this example. Simulation time is 58.9 time steps and includes a 55.26 “queue wait” and 3.6 “waiting for next”.
-2. Cask Loading at site			0	0	This is for the TAD canister loading process and is typical for loading where a cask is always available.
	TADLargeB Bare and connector	9	4	6.61	Notice the downstream times cause the simulation time to be longer than the programmed time. Input point for cask load from IS file.
	251 load	9	1	1.56	TAD canister loading time.
-3. Waste Site	SUMR, SERail BFR-BFB, SERail PEAR-PEAHH, NERail	25 25 26	0 23 23	14 35 33	Typical rail, barge, HH sites that use TAD canisters are shown. Simulation time from BSC 2007e, Appendix G. See Note 2 for program time basis. Total steps at the sites depend on the time to make the 3-cask consist-not on programmed steps.
-4. Transit to Repository Transit from waste site to “ToNevIMF” jump in SWrail map	SUMR BFB PEAHH	Site map to SWRail, Figure 23	13 11 13	15 13.33 15.33	Programmed time is from BSC 2007e, Appendix B. Simulation time is from time testing, see BSC 2007e Appendix G, add 1 step for NVR to “ToNevIMF” connector.
-5. IMF Depot transfer to Nevada Rail	IMFDepot+connector	4, 28	0	0	Not included in cask cycle time since the NVR jump teleports objects to Arrivals 3 below.
	Rail Unbatch 3 Depart.	4, 28			Department Process, time set by each process below
	Arrivals3+connector	29	0	0.52	This is “model time”
	IMFUnbatch+connector	29	0	1.29	This is “model time”
	IMFrailshipment+ connector	29	1	1.87	This is “model time”. Cask load proceeds past this point, transport cask remains in the Rail Unbatch department waiting for trigger to return.
-6. Nevada/DOE Rail	DOERail including to/from connectors	28	0	0.51	Time is reduced in this process to compensate for model time in processes in Item 5.
	GROARailSecurity+ connector	28	1	2.04	Security inspection at gate.
	GROAUnbathcR2	31			Department Process, time set by each process below

OCRWM/TSM Action	Process	Figure	TSM Programmed Steps	TSM Simulation Steps	Discussion[1]
	DOErailArrivals 21+connector	31	3	3.52	This is “model time”
	GROARailUnbatch221+ connector	31	4	5.11	This is “model time”
	“InputtoGROA” including to/from connectors	31	1	2.18	This is “model time”
-7. GROA Operations to deliver cask load to unload in a process line.	GROA Department	28			The process sequence below is the GROA processing for a TAD cask load.
	Rail-TruckArrivalBuffer +connector	33	0	0.52	
	Parking	33	0	0.54	
	TADBuffer +connector	33	0	2.34	Logistics require that TAD canisters wait in queue for processing and this drives the simulation time.
	RF+connector	33	0	0.88	Receiving Facility (RF)
	TADxfertoWP	33	0	0.54	
-8. GROA Operations to return empty cask					These processes are the time to prep the cask for return.
	GROACaskReturn +connector	33	3	3.51	This represents part of the time at the GROA to prepare the cask to return. .
	CaskReturnJumptoTSM +connector	33	4	4.76	This represents part of the time at the GROA to prepare the cask to return. Process capacity is 5 so simulation time is lower than programmed time.
	RailCaskReturn	33	1	1.52	This is not a jump- it is a generic process that teleports. So, include the process time in the cask cycle time.
-9. Cask Transport from GROA to FHF					Time from the GROA to the FMF via DOE rail.
	GROARCaskReturn+ connector	28	0	0.53	The RailCaskReturn process n the GROA teleports to here in V6.0.
	IMFCaskreceive1+ connector	28	1	2.02	

OCRWM/TSM Action	Process	Figure	TSM Programmed Steps	TSM Simulation Steps	Discussion[1]
-10. Cask Maintenance at FHF		34			
	CaskSort+connector	34	3	3.52	This represents the routine inspection and arrival actions at the FMF.
	SCaskCheck+connector	34	1	1.67	If maintenance is needed add 6.6 steps. If major overall is needed add 13.2.
	SReturn+connector	34	1	1.59	Jump from here to cask distribute (Item 1) to repeat cycle.
TOTAL ALL ITEMS[3]	SUMR BFB PEAHH		48 69 71	67.64 86.97 86.97	Without FHF maintenance. Add 6.6 steps to include time for a cask that requires maintenance. If major overall is needed add 13.2. Totals are rounded up. See BSC 2007e.

Note 1. Results are from TAD canister Scenario 25B from run file in Section 8 of BSC 2007e for most results supplemented by BSC 2007e, Appendix B for route program times, and BSC 2007e Appendix G for some simulation times, as shown. The TAD canister scenario is reported since there are no cask shortages to impact the logistics. The TAD shells are set for an "open" buy to minimize cask delays and have no major impact on logistics.

Note 2. For Item 3, typical rail, barge, HH sites that use TAD canisters are shown. TSM programmed time is to complete the 3-cask consist and includes barge/HH transport cycles as follows:

Rail: Zero time steps programmed.

Barge Rsite then Rsite to Bsite then Bsite to Rsite then Rsite to BSite then BSite to Rsite then Rsite to Bsite. 0+4+1+4+0+4+1+4+0+4+1= 23

HH: RSite then Rsite to HHsite then HHsite to Rsite then Rsite to HHSite then HHSite to Rsite then Rsite to HHsite. 0+4+1+4+0+4+1+4+0+4+1=23

Note 3. Program time for all items in total. As discussed in BSC 2007e, the run to measure the TSM simulation steps includes an extra step for many processes that was included to correct for a SimCAD™ data recording bug. This step has been removed from the results shown here.

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4. FUTURE DEVELOPMENT

This section discusses the known limitations and areas for future development of the transportation module and associated algorithms. These items should be used as refinements to the current model capability. The present capability is adequate to reveal and evaluate the various system effects for various studies.

1. The rail routes are currently drawn as if all use the same railroad companies. In actuality, the routes use several different specific railroad companies and these details should be added to identify any transfers from railroad company to railroad company and refine the transportation routes to avoid transfers if required.

2. The waste sites use the same parameters for site cask operations and movements and assembly loading. Site-specific parameters can be added when data is available.

3. The TSM DOE rail system from the IMF rail process to the repository is a simple connection system. This can be modeled in other ways that account for other traffic on this route once information on the DOE rail logistics is available.

4. There may be seasonal restrictions on which transportation routes can be used in the summer or winter. These restrictions can be implemented to refine the results.

5. There may be “blackout” times for fuel shipments from various CSNF sites. These restrictions can be identified and implemented. Note that this change will be done in the TSMPP.

6. Cask-specific maintenance requirements based on time in service, number of trips, or other requirements should be enhanced once detailed data is available.

7. The sites and routes are hard-wired into the model and changes or additions to the sites and routes require building of new connectors and processes. Future models may incorporate options for various routes that can be selected by programming or by changes in existing drop-down menus.

8. As mentioned in Section 2.6.1, the cask allocation processes have set priorities. These priorities do not appear to have any major impact on the overall system response and behavior especially for TAD canister scenarios where there is less variety of baskets and shells. However, if any point design is eventually set by OCRWM, the impacts of the priorities should be studied in more details and the priority may need to be revised to provide higher fidelity.

9. As mentioned in Section 2.7, programming has been developed in the TSMPP to output WO for the rail rolling stock but this has not been implemented. The current batching method for the shipments at the waste sites does not allow for proper allocation of the rolling stock to support WOs. Because the batching includes a fixed maximum time to

complete the batch, there are situations where a batch (shipment) can depart without the rolling stock object. Currently, the buy processes for rolling stock must be “open buy” to ensure there is always a rolling stock object available for the waste site batching. If the batching method is re-designed to remove the maximum time, WO for rail rolling stock can be implemented.

5. REFERENCES

5.1 DOCUMENTS CITED

BSC 2005. *TSM System Study: Impact of a Canister-Based System on the CRWMS*, MIS-CRW-SE-000003 REV 00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: DOC.20051213.0001.

BSC 2006a. *Engineering Study: TSM Analysis of Alternative CD-1 GROA Configurations*. 000-00R-G000-00300-000-000. Washington, D.C.: BSC. ACC: ENG.20060912.0002.

BSC 2006b. *TSM Transportation Basis and Check*, 000-00C-G000-00900-000-00A. Bechtel SAIC Company, LLC, Washington, D.C. ACC: ENG.20061102.0002.

BSC 2007a. *User Manual for the Total System Model Version 6.0*, 50040-UM-01-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

BSC 2007b. *Total System Model Version 6.0 GROA Department Design and Bases*, 50040-DD-01-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

BSC 2007c. *Total System Model Version 6.0 Cost Estimating Routines Design and Bases*, 50040-DD-03-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

BSC 2007d. *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.

BSC 2007e. *Total System Model Version 6.0 Transportation Validation Report*, 50040-VAL-06-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

BSC 2007f. *Total System Model Version 6.0 TSM Validation*, 50040-DD-03-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC

BSC 2007g. *User Manual for the Total System Model Version 6.0 Preprocessor*, 50040-UM-02-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

BSC 2007h. *Total System Model Version 6.0 Preprocessor WO Algorithm Validation Report*, 50040-VAL-04-6.0-00, Bechtel SAIC Company, LLC, Washington, D.C. ACC: Submit to RPC.

CaS 2006. *SimCAD Process Simulator Users' Manual*, V 7.1, Create-a-Soft™, Chicago, Illinois, January 2006. ACC: MOV.20071016.0003.

DOE 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada,* Volume II, Appendixes A through O. DOE/EIS-0250, Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0316.

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.