Next-Generation System Analysis Model (NGSAM) Software Guide and Training Manual

(DRAFT - Release 0.9)

Fuel Cycle Research & Development

Prepared for
U.S. Department of Energy
Spent Fuel Disposition Campaign and
Integrated Waste Management Planning Project

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DOCUMENT REVISION HISTORY

Revision Number	*Effective Date*	*Description of Revision*
N/A	2/20/2015	Initial creation of Nuclear Fuel Storage and Transportation (NFST) / Next-Generation System Analysis Model (NGSAM) Training Manual (Release 0) -- FCRD-NFST-M4FT-15AN0902046
0.3	10/30/2015	Updated to reflect NGSAM Phase 2 – Prototype 2 (Milestone M4FT-15AN0902043) functionality and capabilities. The revised NGSAM Software Guide & Training Manual (Release 0.3) contains the "Blue Jean" tutorial/scenario demonstrated at the Oct 14-15, 2015 Boot Camp.
0.4	12/18/2015	Revisions made based on NFST Analysts feedback from initial benchmark testing activities
0.5	4/5/2016	Addition of Appendix B Transportation, Appendix C Allocation and Acceptance and Appendix D NFST Glossary. Moved installation information to Appendix E.
0.6	6/7/2016	Removed references to unused functionality – world map, sense events, etc. Section 2.2 updated with explanation of user defined distributions. Section 2.3 updated with current scenarios installed with the software. Appendix A updated with current reports. Appendix C updated with more context. New appendix F for quick edit. Previous appendix F now Appendix G and updated so that the tutorial is more generic. Updated figure numbers. Changes made throughout to reference Phase3Proto1 instead of previously referenced out of date scenario.
0.7	2/17/2017	Added section on NGSAM 2.2.1.0 Configuration notes, as well as integrating the appropriate information into section 2. Added Appendix F: Web Interface for Client/Server and Appendix G: Continuous Integration. Updated Appendix C: Allocation and Acceptance. Changes made throughout to reference Small scenario instead of previously referenced out of date scenario. Because of the FY2017 reorganization, changed references to Nuclear Fuel Storage & Transportation (NFST) to Integrated Waste Management (IWM).
0.8	4/14/2017	Removed references to map. Reduced references to limited edit and quick edit, but did not remove them entirely since the options are still in the GUI. Removed original Appendix H. Updated description of small scenario. Minor updates throughout. Added reports to Appendix A.
0.9	4/28/2017	Reinstated Appendix H – Quick Edit. Updated Appendix H with further quick edit functionality. Added reports to Appendix A.

NGSAM 2.2.1.0 UPDATES

Release Notes

- NGSAM Simulation Framework:
  - Stand-Alone System Requirements
    - 16GB RAM
    - 2GB Free Space, 10GB per scenario run
    - Solid State Hard Drive
  - Client/Server supports:
    - A "shared directory" for analysts to share selected scenario with results.
    - Multiple user accounts
    - Two simulation servers, running a total of four concurrent simulations.
    - 10 minute session timeout, based on activity

- Continuous Integration (CI) -- The CI process for published NGSAM releases is available to system analysts. Both NGSAM client and NGSAM server "builds" are generated on a nightly basis and accessible to analysts. These daily client and server builds are purged with milestone releases (e.g., NGSAM Version 2.2.1.0). Refer to APPENDIX A for details.

- The following NGSAM enhancements for Version 2.2.1.0 include:
  - Ability to start simulation from a "saved state" generated from a previous NGSAM run.

  - Simulation from a starting state for the GC859 data in the Unified DB snapshot (Revised UDB snapshot received in November from ORNL) with the following data enhancements:
    - Information regarding overpack storage orientation (horizontal and vertical)
    - Overpack to canister mapping
    - Transportation and storage thermal limits for every canister (i.e., zones loading maps) in the database.
    - Canister types (models) needed for the revised Allocation & Acceptance logic.
    - 19 Interim storage facility configurations
    - De-Aggregation data – UDB Version 3.0 contains reactor, pool and reactor-pool linkage data:
      - Package BWR / PWR data – types of canisters for each assembly type
      - Full Core Reserve (FCR) data for La Crosse
      - Horizontal / Vertical data
      - Complete thermal zone data.

  - Multiple JTOM modifications (8 identified issues discussed and distributed to users/analysts after the Dec 14-15 System Architecture & NGSAM team meetings held at Argonne). The JTOM library version that was distributed by ORNL on 19 December 2016 is integrated and included with this release.

  - A basic implementation of a Repackaging facility based on discussions with the System Architecture analysts. The Repackaging facility is co-located with the MGR in this version.

- De-aggregation of pools and reactor definition at reactor sites for the handling of bare spent nuclear fuel (SNF). Abstract use of pools and reactors has been hardened into actual pool and reactor entities that complete tasks during the run. The single pool per site logic was enhanced into "the actual number of pools per site and by type (PWR/BWR) for real world pools that contain both."

- Reactor-to-ISF Allocation & Acceptance – interaction between allocation planning and source sites to provide a more flexible allocation and acceptance process that will allow the user/analyst to specify particular package types accepted by different ISFs. NGSAM Version 2.2.1.0 default scenarios include three ISFs with the capability to add additional ISFs.

- ISF operation enhancements include "basic bare fuel handling at the federal ISF." Users can now define the destination (either pool or storage) for incoming Direct Transport packages, and what package type to use to pack out of the ISF pools.

Transportation routes from each reactor to the middle of Texas and to the middle of Tennessee are included. The three ISFs included in the default scenarios are defined as follows: Eastern ISF is the federal ISF and is located in Tennessee. ISF2 and ISF3 represent the private ISFs and are located in Texas by default. The user can change the state where each ISF is located to either Tennessee or Texas. To expand the set of states an ISF could be located, the developers will need routes from those ISFs to RPK/MGRs.

- A number of reporting changes:
  - Summary reports from the multiple ISFs are now aggregated into a single report.
  - A new transportation report showing final loaded and unloaded mileage for each railcar in the scenario.
  - A new transportation report showing the cumulative railcar mileage compiled over time for the scenario.
  - A new Repackaging facility summary report.
- A number of User Interface improvements, including:
  - The ability to use formatted dates as starting times for agent or resource generation.
  - An improved ability to change package types used at reactors over time using a new edit dialog.
- Multiple bug fixes including the "ability to change the total railcars available per scenario in Client-Server runs."

Configuration Notes

This section outlines the new configuration items included in NGSAM 2.2.1.0 and how to modify them.

Allocation/ISFs

- The Allocation constraints spreadsheet defines constraints for the system and for the ISFs. The system rate constraint has been moved from the allocation spreadsheet to this spreadsheet. The user can define constraints on rate, capacity, and acceptable package types at each ISF. These constraints may change over time.
- The allocation spreadsheet is now simpler. It has only a site name column and a site allocation column. After the allocation process has attempted to allocate all entries the user has defined in the allocation spreadsheet, it will continue with oldest fuel first allocation to all sites as rate and capacity constraints allow.

ISF

- Bare fuel packaging is controlled using the ISFPackageCreated.csv file. This file is available for editing in NGSAM by navigating: Edit -> ISF Package Created.
- Incoming package handling is defined using the ISFPackageIncoming.csv file. This file is available for editing by navigating: Edit -> ISF Incoming Packages.
- An ISF location can be changed by modifying the “LocationState” attribute on the “ISFDbDataAgent” generator for the particular ISF to be changed. Valid values are “Texas” or “Tennessee”.
- Initial Pool Capacity at the Eastern ISF can be modified by going to the “Generators” tab in the Eastern ISF installation, and editing the “capacityInitial” value in the attributes for the two pool agents (PWR and BWR) generated.

MGR

- The MGR input processing rate is controlled in the MGR installation with the “MGRPlanner” agent generator. The “packagesPerYear” attribute setting controls this.

Repackaging

- The Repackaging processing rate is controlled by the number of modules available at a given time as well as the processing rate for the online modules. Both are controlled in the Repackaging installation with the “ModuleController” agent generators. Each has a generation time (the date at which the module becomes active) and a processing rate that can be set here. These are accessed by navigating to the Repackaging installation, then to Generators->ModuleController. The “packagesPerYear” attribute sets the input rate of the module.
- The output package types used at each Repackaging module are also set as attributes on the ModuleController agents and can be changed in the generator settings. These attributes are “outputPackageTypeBWR” and “outputPackageTypePWR”.

Reactor Sites

- Packages used at reactor sites are set using the “Package Usage” editor. This defines what package types are in use at reactor sites over time by pool. This is accessed by navigating to: Edit->Package Usage.

- The number of days in the packing period before the pre-discharge shutdown at reactor sites can be modified by changing the “daysToPackBeforePredischargeShutdown” attribute value on the “SiteManager” agent generator in the Generators tab.

ACRONYMS

ABM	agent-based model
COA	course of action
DOE	U.S. Department of Energy
FIFO	first in/first out
FY	fiscal year
GT	group task
GTCC	greater than Class C
GUI	graphical user interface
HLW	high-level (nuclear) waste
IWM	Integrated Waste Management (formerly Nuclear Fuel Storage & Transportation)
ISF	interim storage facility
IT	individual task
JTOM	Java-based Transportation Operations Model (ORNL)
LIFO	last in/last out
LLW	low-level (radioactive) waste
MGR	mined geological repository
MTHM	metric ton(s) of heavy metal
NE	Office of Nuclear Energy (DOE)
NGSAM	Next-Generation System Analysis Model
ORNL	Oak Ridge National Laboratory
P2P2	Phase 2, Prototype 2
PAT	Process Analysis Tool (Argonne application)
SNF	spent nuclear fuel (also known as UNF)
START	Stakeholder Tool for Assessing Radioactive Transportation
TOM	Transportation Operations Model
TSL	TSL Transportation Storage Logistics (a.k.a. TSL-CALVIN)
UNF	used nuclear fuel (also known as SNF)
WM	waste management

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1 INTRODUCTION TO NGSAM

The U.S. Department of Energy, Office of Nuclear Energy (DOE-NE), in its Integrated Waste Management (IWM) Planning Project, has developed tools for analyzing waste management (WM) systems. The results of the analyses can inform future decisions on the development and deployment of an integrated nuclear WM system. This document provides a brief introduction and step-by-step instructions for using the Next-Generation System Analysis Model (NGSAM), an integrated systems analysis software tool that focuses on the WM process.

The management of (1) spent nuclear fuel (SNF) generated by the fleet of U.S. nuclear reactors, (2) greater than Class C (GTCC) low-level (radioactive) waste (LLW) generated during the decommissioning of commercial nuclear reactors, and (3) federal-government-owned SNF and high-level (nuclear) waste (HLW) is complex. Managing these wastes requires the use of integrated systems analysis software that can address all aspects of the process: waste generation, on-site storage at various locations, centralized or regional interim storage, transportation, and ultimate disposal.

Alternatives for managing commercial SNF are complicated by many factors, including the large number of different fuel assembly types generated at nuclear reactors, the number of reactor sites involved, the variety of dry storage systems in use, and the different approaches used to transport SNF from the reactor sites. Alternatives for managing federal-government-owned SNF and HLW are complex too, because of the variety of different materials that are in storage, being generated, or projected to be generated at different sites.

NGSAM is an agent-based, discrete-event model written in the Java programming language. Agent-based models, or ABMs, are a class of simulations used to study the complex interactions of individuals and/or organizations by defining the simple “rules” that they follow. Emergent behavior, or large-scale patterns, can be modeled in these simulations without having to explicitly code every interaction. Since the overall purpose of NGSAM is to be a logistics model, it combines discrete event simulation with agents (e.g., casks, canisters, railcars) that are following plans and executing tasks. The underlying NGSAM software is built from the Process Analysis Tool (PAT), an application developed by Argonne National Laboratory that lets users perform micro-level planning and analysis without having to write software code (i.e., “hard-code” the processing).

Because of PAT’s generic nature, scenarios can be tailored by the analyst to emulate scenario-specific and site-specific activities at installations for any domain (e.g., for NGSAM, they could be activities at a reactor, an interim storage facility [ISF], or a mined geological repository [MGR]). The analyst also defines the UNF WM transportation logistics and procedures to be performed at the locations through NGSAM’s graphical user interface (GUI). PAT is the framework for defining the agents, resources, activities, and events used to model the various scenarios to be studied. It defines the tasks that agents need to complete at a location, the durations of the tasks, and the specific resources required to accomplish each task (e.g., cranes, personnel) and results in items like graphs that show the resource usage or demands that could signify bottlenecks. The advantage of generic modeling tool PAT is that an analyst can easily add new types of resources, change or add activities at locations, or add new installations and thereby assemble scenarios without having to program in Java.

1.1 PAT Concepts and Definitions

PAT concepts and definitions are described below, with existing NGSAM-specific modeling concepts provided in <brackets>. Items related to IWM are defined in Appendix D:

- **Agent** – (aka. Entity or Entity Type). Agents are the simulation objects that complete the tasks within the scenario. Attributes are defined for types of agents, and these attributes are checked in the simulation to help the user decide which task to do next. They can be altered as the result of doing a task. Agents may also be resources for tasks when other agents are completing a task.

NGSAM models the assemblies, casks, railcars, trucks, barges, and transportation overpacks as agents. The agents are the entities that make the decisions and move through the plans and tasks.

- **Course of Action --** Logic flow of NGSAM tool
- **Distribution** – Distributions may be used to define the duration of a task, set an attribute of an agent, set a value for a resource within a task, and create (generate) agents within a simulation. The analyst is given a selection of the most common distributions (e.g., normal, uniform) and defines the properties that will shape the curve (e.g., mean, standard deviation). The analyst can also create custom distributions by providing a comma-separated value (.csv) file containing the data (e.g., assembly packing time)
- **Event** – Events provide a way for agents to alter their plan of action based on a number of different conditions. These conditions might be resource levels, the state of some other agents, or the state of the agent itself. Events may be defined to execute at a certain time, or they may be triggered conditionally based on a change in the value of an attribute of an agent or resource.
- **Generator** – Agents and resources can be generated during the simulation, either at the start or as the result of an agent finishing a task.
- **Groups** – Groups are used to combine agents that are related <For example, combine all the assemblies defined to go into canisters>
- **Installation** (aka. Location or Node) – An installation represents a location where agents follow plans and complete tasks (e.g., reactor sites, ISF, MGR, repackaging location, or railcar maintenance facility). It represents a container with groups of agents and activities.
- **Plan** – Plans define the overall flow through a series of tasks. They consist of groups of courses of action. There may be many plans in an installation. Agents flow through the tasks at an installation by checking the task's attributes against the conditions in the plan to decide which task in the plan should be completed next. < The plans organize the tasks for the casks, assemblies, etc. to execute.>
- **Planner** – A notional NGSAM installation that acts as the overall scenario Allocation manager. Unlike most PAT or NGSAM installations, the Planner does not represent a physical site, but is considered a notional location. This is an installation specific to the NGSAM scenarios and is not included in PAT.
- **Resource** – Resources are anything needed to complete a particular task (e.g., people, equipment, supplies). Resource quantities can be Continuous (fractional amounts) or Discrete (whole numbers), and can be constrained or unconstrained. <Many resources are being modeling in NGSAM: reactor pool capacity, empty casks, railcar availability, etc.>
- **Scenario** – A scenario consists of one or more installations (e.g. reactor site(s), ISF site(s), and MGR site) and notional installations (e.g., Planner and Transportation). The installations within a scenario contain the agents, resources, plans, tasks, events, and generators for each installation. <A scenario maps to the different WM cases that will be evaluated for NGSAM.>
- **Task** – Tasks are the basic building blocks of the simulation. Tasks can be done by an individual (an individual task [IT] executed by a single agent) or by a group task [GT] (executed by all members of a group). A task can be executed because it is triggered by an event or as part of the decision logic in an agent's plan. < All tasks are user-defined and as such, create the logic of the scenario run.>
- **Transportation** – A notional NGSAM installation that implements the transportation aspects of NGSAM. In FY15 Phase 2 - Prototype 2 tool, the Transportation installation uses the Java

Transportation Operations Model (JTOM) to schedule trips and calculate transportation costs. This is an installation specific to the NGSAM scenarios and is not included in PAT.

- **Unified Group** - A unified group is created from a group task [GT] when the user sets the "unified" flag to *true*, signifying that the agent moves forward to decide on the next task to do as a unified group. All members of the group (i.e., multiple agents) remain unified until the user sets the flag to *false* in a task that the group executes. <In NGSAM, examples would be assemblies in a cask, that once packed, move as a cask group. Then when the cask is loaded onto a railcar, it moves as a railcar group. The railcar group is disbanded, when the cask is unloaded, and the cask group is disbanded if/when the assemblies are removed from the cask.> All tasks that members perform as a group are recorded on their agenda as having executed the task, so that when viewing the agent traversal graph in the results, the analyst can graph the flow the agent took through the model.

1.2 Purpose of NGSAM User Manual

This report, an evolving NGSAM user manual with new tool functionality, is designed to help analysts (system analysis and decision support) navigate the tool and to support their decision-making process. The scope of this software guide / training manual report supports analyst training and benchmark testing activities for major releases of the NGSAM tool. It provides a brief overview of analyst "Quick Edit" and "Limited Edit" modes, as well as an in-depth tutorial for the Expert Edit mode (Appendix H).

NGSAM is based on requirements for the WM system analysis simulation tool provided in *Waste Management System Analysis Simulation Tool Requirements* (Nutt, Puig, and Fortner 2015). Additional enhancements are derived from periodic workshops, research, and ongoing benchmark comparison testing with legacy tools.

NGSAM's ongoing design and development started in FY2014, and analyst enhancements and functional capabilities are anticipated through FY2018. The current project plan (FY2014 through FY2018) is to build a standalone model (this task was completed in FY2014) and migrate to the client/server (in FY2015 through FY2017) that could be converted to Web-based application software (Phase 3 in FY2018). This report contains the initial analyst training materials that reflect the current implementation of NGSAM Phase 2+. Revisions to this evolving document have been completed to align with major software deployments completed during each fiscal year of NGSAM development and maintenance activities.

1.3 Modes of Execution

The NGSAM tool may be executed in standalone mode or client/server (C/S) mode. However, the C/S will be limited to the Argonne network until a hardware server upgrade is procured and configured for remote access. Until then, external users can VPN into the Argonne network in order to use the system. Appendix E explains how to install NGSAM on a computer. The same software is used for both modes; the execution is determined via the Simulation menu (see Section 2). Selecting Save and Run executes the scenario on the local machine where NGSAM is installed. The database is also stored on the machine. When the user selects Run on Server, the simulation will be executed on the NGSAM Simulation Server located at Argonne National Laboratory. The input and results are stored on the server and may be shared among users (user-defined sharing permissions).

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2 RUNNING A SCENARIO

Step 1. When the NGSAM tool is initially launched (Figure 1), the analyst can choose to edit the scenario in "Quick Edit," "Limited Edit," or "Expert Edit" mode. Currently neither Quick Edit nor Limited Edit is typically used by analysts.

- Quick Edit allows the analyst to change some of the key parameters via a pop-up form.
- Limited Edit allows the analyst to go into any task and edit duration times and resource usage but does not allow the analyst to create new installations or add/delete/modify plans and courses of action.
- Expert Edit allows the analyst to edit/add/delete anything in the scenario as well as to copy and create templates.

Figure 1 Launching NGSAM

Step 2. Currently the install does not include a scenario with a Quick Edit or Limited Edit configuration. For this manual, the Expert Edit mode with be used, but not covered in depth. To learn more about the Expert Edit mode, please see Appendix H for an in-depth tutorial exercise and example. Pressing on the Expert Edit button will bring up a dialog box to select a scenario (Figure 2). Select the "Small" scenario and press the Open button.

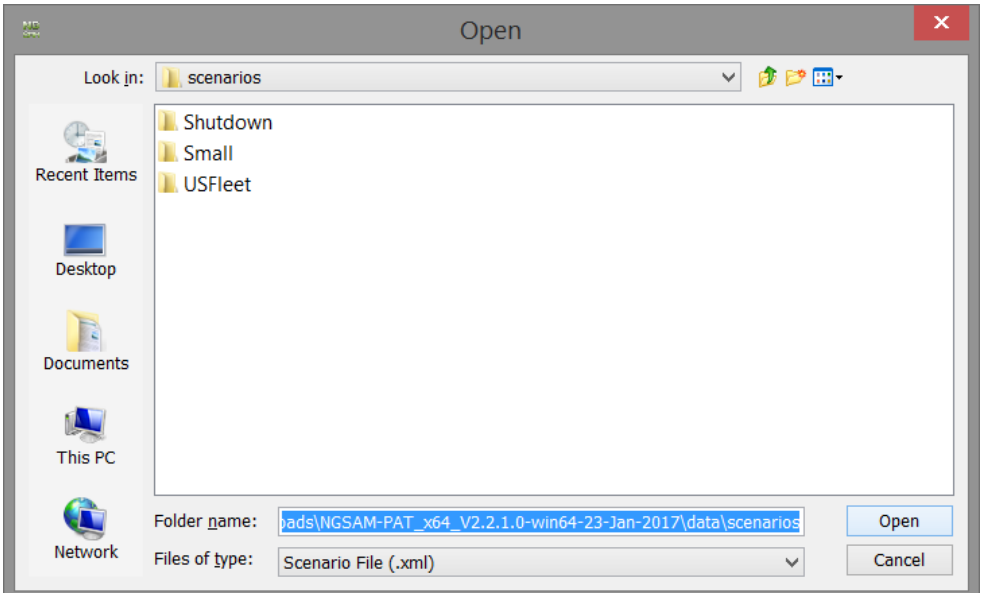


Figure 2 Selecting a Scenario

Step 3. In Expert Edit mode, the user will see a tree containing the scenario information. The top level is the name of the scenario with each installation listed below it. Under each installation will be areas for the various aspects of the installation within the scenario. The installations included within the Small scenario are: Braidwood, Byron, Dresdan, Eastern ISF, MGR, Planner, Transportation and Zion.

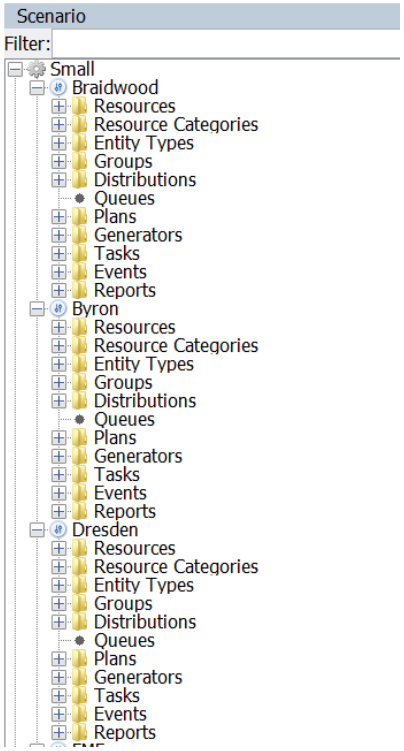


Figure 3 Expert Edit Scenario Tree

2.1 Menu Options

"File," "Edit," "Simulation," "Layout," and "Window" are the top level menus available in the NGSAM tool. Each of these menu items has submenu options, described in the following list.

File Menu

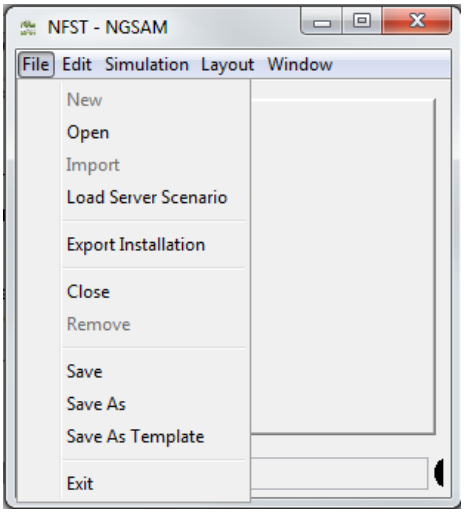


Figure 4 File Menu Options

- **File ⇨ New** enables an analyst to create a new scenario. This option is not available in Quick Edit mode.
- **File ⇨ Open** is used to open a different scenario.
- **File ⇨ Import** lets the user import an installation into the current scenario. This option is not available in Quick Edit mode.
- **File ⇨ Load Server Scenario.** Copy workstation scenario from standalone workstation to a directory on the server.
- **File ⇨ Export Installation** enables the user to export a report of the Plans/Courses of Action (COAs) and Tasks for an installation. The Select box will be displayed (Figure 5).

  Selecting the installation and pressing OK brings up the dialog in Figure 8. Select the desired options and the file name to export the installation to a file. The "Run All" option will export all of the plans of the installation; otherwise "Run Selected" will output just the selected items.

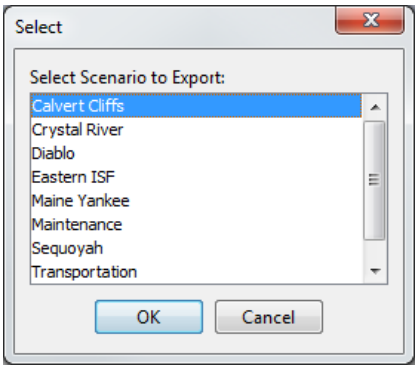


Figure 5 Export Installation

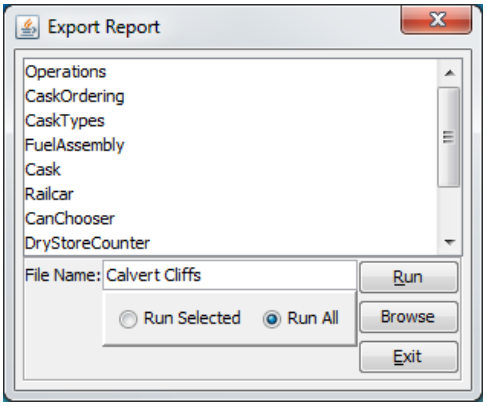


Figure 6 Export Report

- **File ⇨ Close** closes the current scenario.
- **File ⇨ Remove** can be used to remove a specific installation from the scenario. This option is not available in Quick Edit mode.
- **File ⇨ Save** saves the current scenario by overwriting it.
- **File ⇨ Save As** saves the scenario to a new folder.
- **File ⇨ Save As Template** saves an installation as a template, enabling it to be imported into another scenario.

Edit Menu

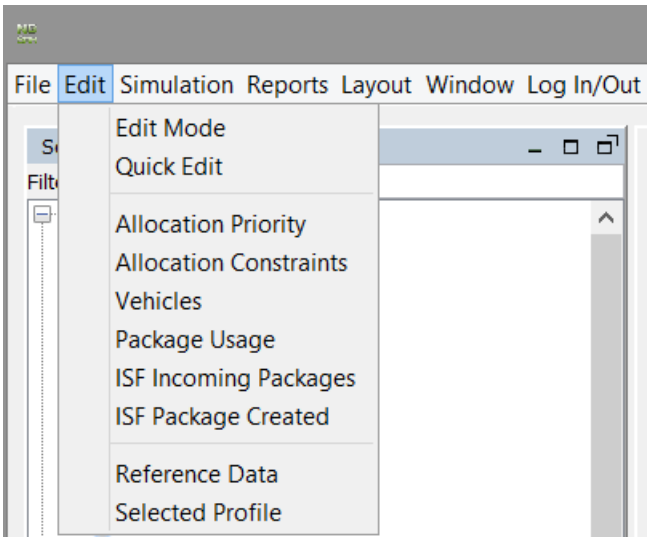


Figure 7 Edit Menu

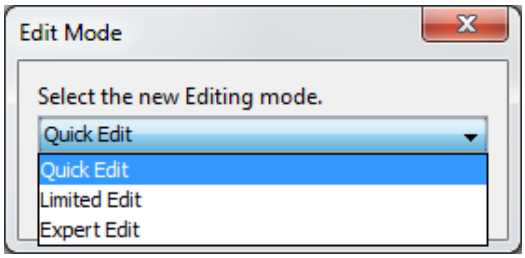


Figure 8 Edit Mode

- **Edit ⇨ Edit Mode** is used to switch between the three editing modes (Quick Edit, Limited Edit, and Expert Edit).
- **Edit ⇨ Quick Edit** brings up the dialog in Figure 3 that allows the analyst to change the bare fuel versus dry fuel options for the installations and other options as previously discussed.
- **Edit ⇨ Allocation Priority** brings up the Allocation Priority file to allow for editing. (See appendix C for further information)
- **Edit ⇨ Allocation Constraints** brings up the constraints file to allow for editing. (See appendix C for further information)
- **Edit ⇨ Vehicles** brings up the unf-vehicles.csv file for editing.
- **Edit ⇨ Package Usage** Packages used at reactor sites are set using the "Package Usage" editor. This defines what package types are in use at reactor sites over time by pool.
- **Edit ⇨ ISF Incoming Packages** allows editing of the `ISFPackageIncoming.csv` file. Incoming package handling is defined using this file.
- **Edit ⇨ ISF Package Created** allows editing of the `ISFPackageCreated.csv` file. Bare fuel packaging is controlled using this file.
- **Edit ⇨ Reference Data** enables the analyst to pull data from the database and edit it.
- **Edit ⇨ Selected Profile**. Brings up a dialog to allow for the user to change the selected profile or create a new one.

Simulation Menu

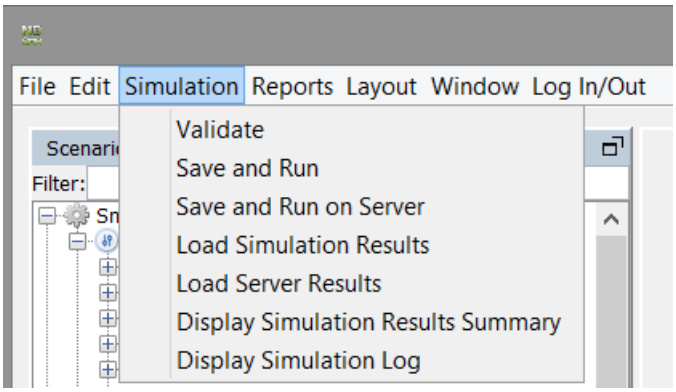


Figure 9 Simulation Menu

- **Simulation ⇨ Validate** will check for inconsistencies in the scenario that indicate common scenario development errors and will warn the user about any potential problems it finds. This option is most useful when using the "Expert Edit" mode.
- **Simulation ⇨ Save and Run** will save the current scenario and run the simulation from the standalone database. Simulation status is in the "PAT Simulation Control Manager" pop-up window (Figure 10). The simulation can be paused at any time by selecting the "Pause" button, and the results can be viewed. The simulation can be resumed by selecting the "Resume" button at any time, and it can be stopped by selecting the "Stop" button. Do not edit the scenario when in Pause mode; the changes will not be considered in the currently executing simulation.

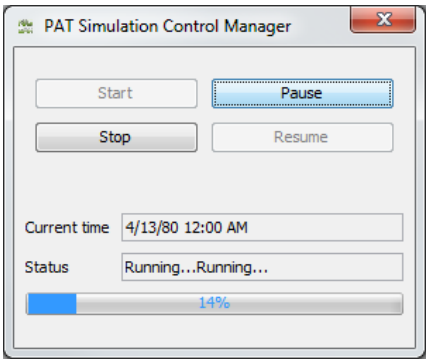


Figure 10 Simulation Control Manager

- **Simulation ⇨ Save and Run on Server** does exactly the same as Save and Run, except it runs from the server database.
- **Simulation ⇨ Load Simulation Results** will cause the "Select Results" pop-up window to display and will load the results of a selected simulation run. Figure 11 shows the different scenario runs from which the user can choose.

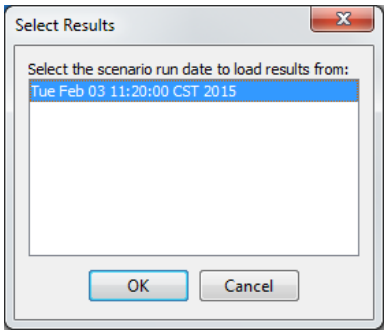


Figure 11 Select Scenario Run Date

- **Simulation ⇨ Load Server Results** does exactly the same as Load Simulation Results, except it loads the results from the server database.
- **Simulation ⇨ Load Simulation Results Summary** will display the simulation results report for a selected installation, as shown in Figure 12.

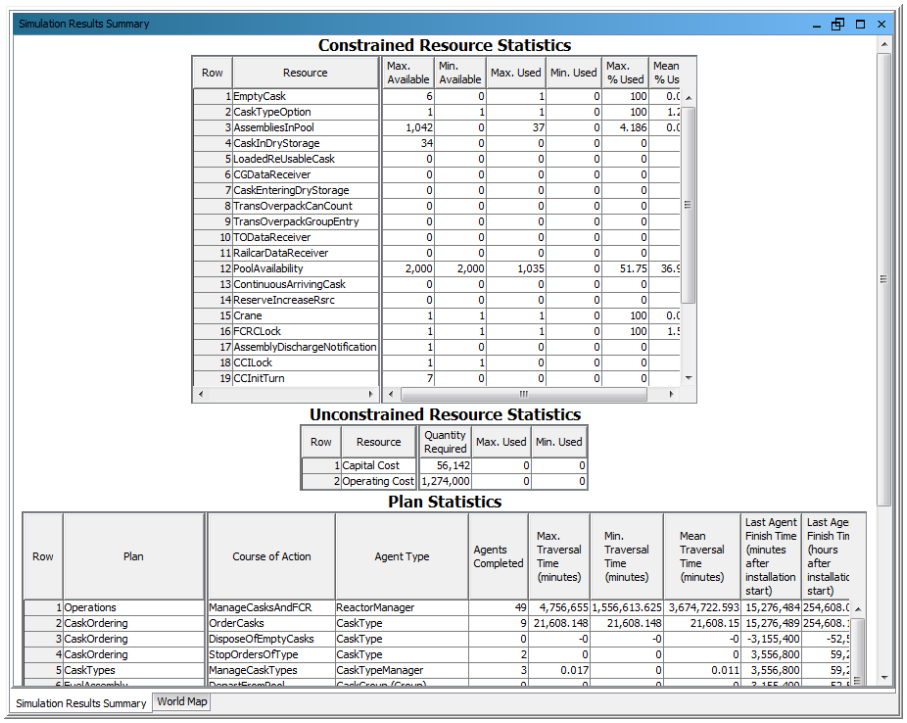


Figure 12 Simulation Results Summary

- **Simulation ⇨ Display Simulation Log** displays the logging window for the selected installation.

Layout Menu

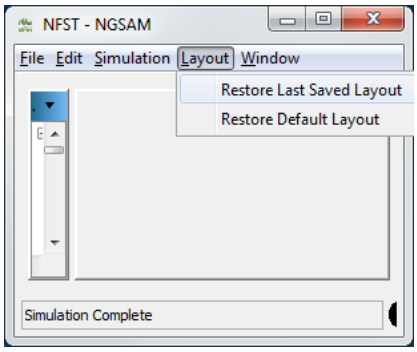


Figure 13 Layout Menu

- **Layout ⇨ Restore Last Saved Layout** restores the last saved window layout. Each time the application is closed, the current window layout is saved, and it is loaded upon restart. This option allows restoring the most recent saved layout.
- **Layout ⇨ Restore Default Layout** allows different display windows to be separated/externalized and docked by clicking on the externalize icon (Figure 14, circled in red). This enables the user to see different displays simultaneously. The user can restore the windows to their original layouts by selecting the Layout ⇨ Restore Default Layout menu.

Window Menu

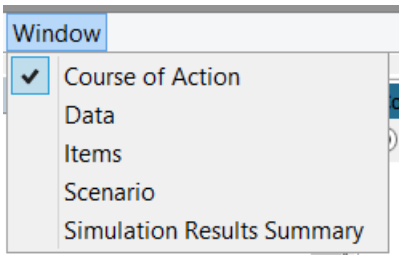


Figure 14 Window Menu

As the user opens up reports, more options will appear in the window menu. Here is a subset of some of the items that will appear in this menu.

- **Window ⇨ Scenario** will focus on the Scenario Window frame.
- **Window ⇨ Data** will focus on the data Window frame.
- **Window ⇨ Items** will focus on the Scenario Window frame.
- **Window ⇨ Course of Action** will focus on the Scenario Window frame.
- **Window ⇨ Simulation Results Summary** will focus on the Simulation Results Summary panel.

2.2 Scenario Elements

Clicking on the Scenario (Small) in the Scenario window to the top left of the tool will bring up the Simulation Time Frame window with simulation time frames, which show the start and end dates (Figure 16).

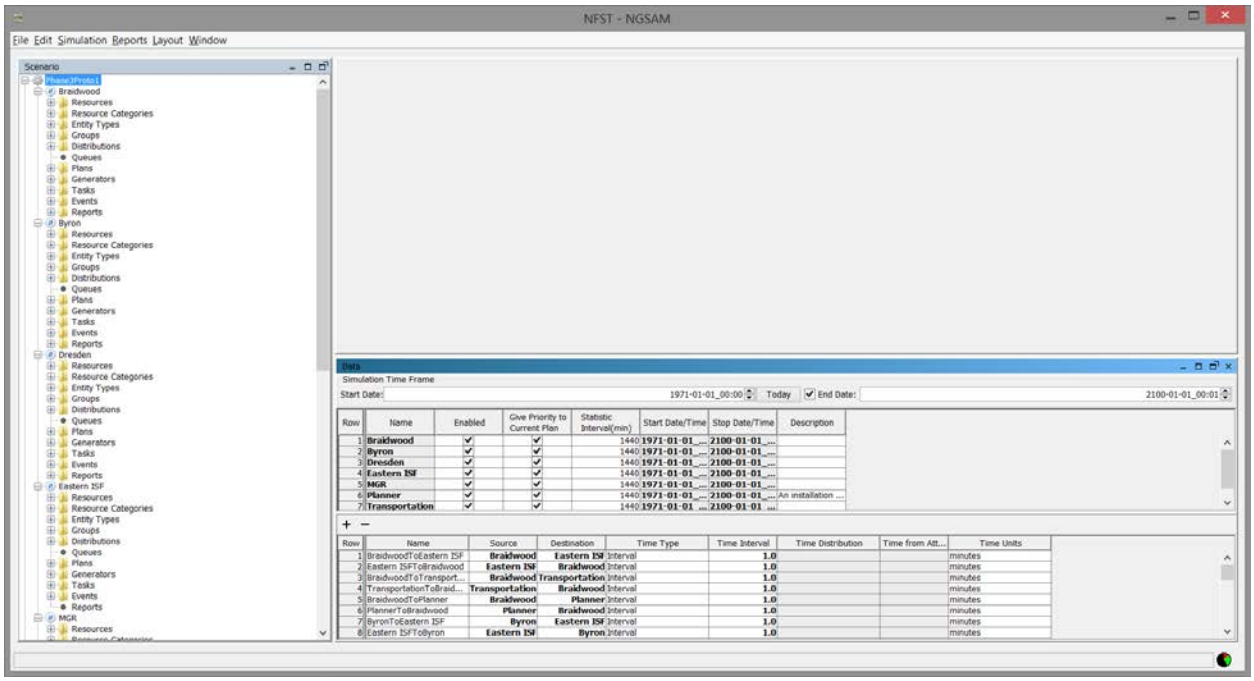
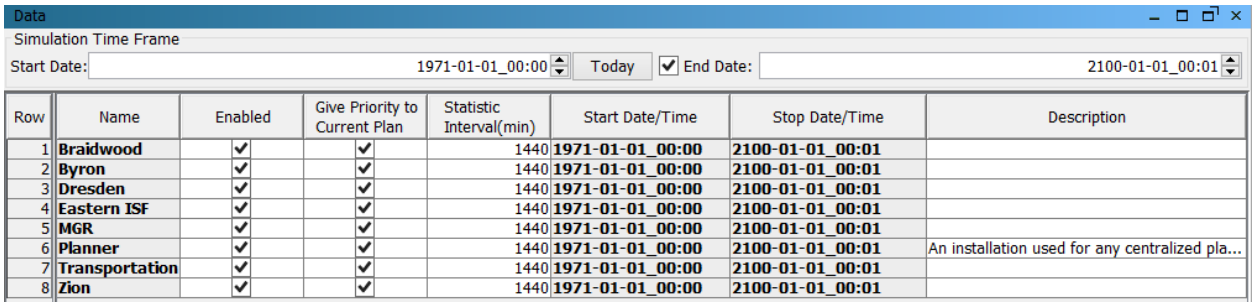


Figure 15 Scenario with Simulation Time Frame

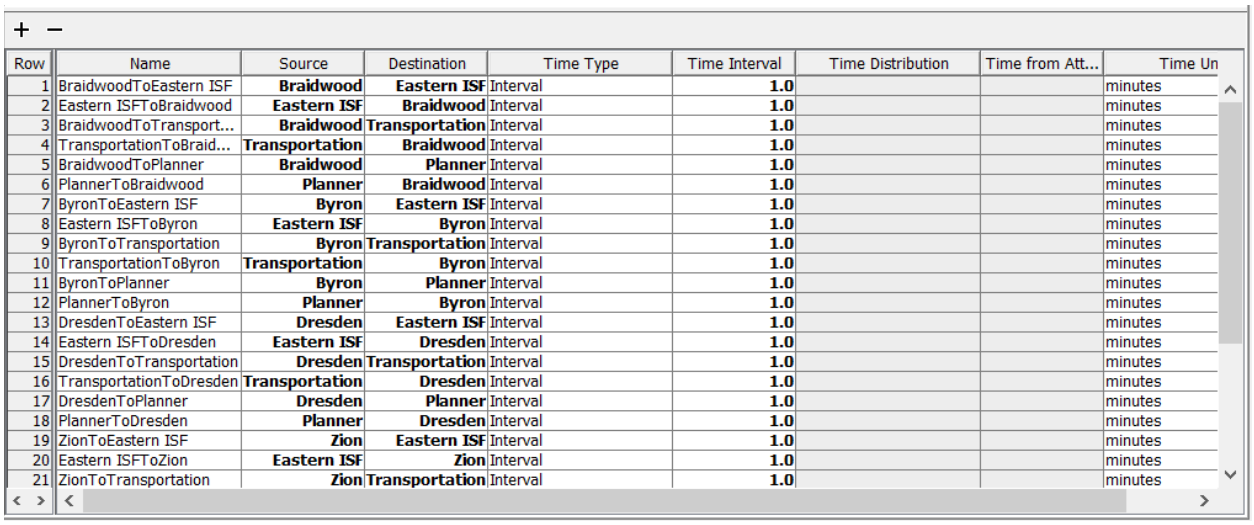
Figure 17 shows all the installations (Reactors, ISFs, and MGRs) listed under the start and end dates.



Row	Name	Enabled	Give Priority to Current Plan	Statistic Interval(min)	Start Date/Time	Stop Date/Time	Description
1	**Braidwood**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
2	**Byron**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
3	**Dresden**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
4	**Eastern ISF**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
5	**MGR**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
6	**Planner**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	An installation used for any centralized pla...
7	**Transportation**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	
8	**Zion**	✓	✓	1440	**1971-01-01_00:00**	**2100-01-01_00:01**	

Figure 16 Installations

Figure 18 shows the list of movements and the time it takes to move between the installations. Click on the plus sign (+) to add a new movement or select a movement. Click on the minus sign (–) to delete a selected movement.



Row	Name	Source	Destination	Time Type	Time Interval	Time Distribution	Time from Att...	Time Un
1	BraidwoodToEastern ISF	**Braidwood**	**Eastern ISF**	Interval	**1.0**			minutes
2	Eastern ISFToBraidwood	**Eastern ISF**	**Braidwood**	Interval	**1.0**			minutes
3	BraidwoodToTransport...	**Braidwood**	**Transportation**	Interval	**1.0**			minutes
4	TransportationToBraid...	**Transportation**	**Braidwood**	Interval	**1.0**			minutes
5	BraidwoodToPlanner	**Braidwood**	**Planner**	Interval	**1.0**			minutes
6	PlannerToBraidwood	**Planner**	**Braidwood**	Interval	**1.0**			minutes
7	ByronToEastern ISF	**Byron**	**Eastern ISF**	Interval	**1.0**			minutes
8	Eastern ISFToByron	**Eastern ISF**	**Byron**	Interval	**1.0**			minutes
9	ByronToTransportation	**Byron**	**Transportation**	Interval	**1.0**			minutes
10	TransportationToByron	**Transportation**	**Byron**	Interval	**1.0**			minutes
11	ByronToPlanner	**Byron**	**Planner**	Interval	**1.0**			minutes
12	PlannerToByron	**Planner**	**Byron**	Interval	**1.0**			minutes
13	DresdenToEastern ISF	**Dresden**	**Eastern ISF**	Interval	**1.0**			minutes
14	Eastern ISFToDresden	**Eastern ISF**	**Dresden**	Interval	**1.0**			minutes
15	DresdenToTransportation	**Dresden**	**Transportation**	Interval	**1.0**			minutes
16	TransportationToDresden	**Transportation**	**Dresden**	Interval	**1.0**			minutes
17	DresdenToPlanner	**Dresden**	**Planner**	Interval	**1.0**			minutes
18	PlannerToDresden	**Planner**	**Dresden**	Interval	**1.0**			minutes
19	ZionToEastern ISF	**Zion**	**Eastern ISF**	Interval	**1.0**			minutes
20	Eastern ISFToZion	**Eastern ISF**	**Zion**	Interval	**1.0**			minutes
21	ZionToTransportation	**Zion**	**Transportation**	Interval	**1.0**			minutes

Figure 17 Movements and Time Intervals between Installations

In the Small scenario, the reactors (Byron, Dresden, Braidwood, and Zion), ISFs (Eastern ISF), Transportation, Planner, and MGR (Western MGR) are represented as installations. The Transportation and Planner are NGSAM installation concepts. The reason that these are modeled as installations instead of simply relying on the installation movement panel is that what is being modeled is more than just the time it takes to move between reactors, ISF, and MGR. Within the Transportation and Maintenance installations, plans/COAs and tasks that the railcars (as agents) perform are defined, and decisions on where the railcar and its contents will travel to next are made.

Every installation contains the same set of 11 simulation elements: Resources, Resource Categories, Entity Types, Groups, Distributions, Queues, Plans, Generators, Tasks, Events, and Reports. These elements are shown as folders under the installation name (Figure 19). Each of them is described in detail in the text that follows.

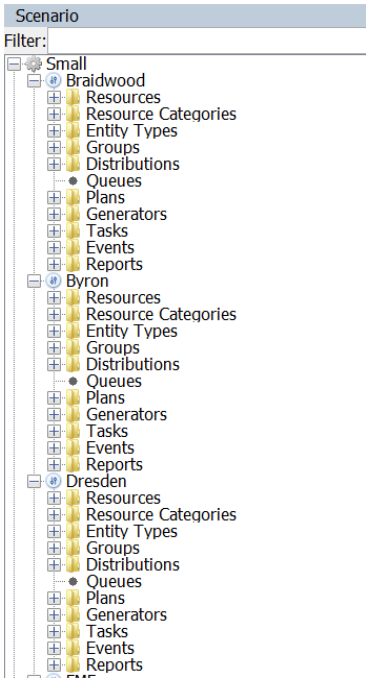


Figure 18 Simulation Elements in an Installation

Resources

Resources comprise anything needed to complete a particular task (e.g., people, equipment, supplies). Select the Resources folder within an installation to see all the contained resources, their availability, and their category in the Resource Table Editor (Figure 20). Additional resources can be generated during a simulation. The "Amount Available" is the amount of the resource available at the beginning of the simulation.

Resource Table Editor

Row	Name	Amount Available	Continuous	Constrained	Category
1	AssembliesInPool	0		✓	General
2	CaskConstraints	0		✓	General
3	CaskEnteringDryStorage	0		✓	General
4	CaskInDryStorage	0		✓	General
5	CaskTypeOption	1		✓	General
6	EmptyCask	0		✓	General
7	ISFShippingApproval	0		✓	ModelInternals
8	LoadChoiceLock	1		✓	ModelInternals
9	LoadedReUsableCask	0		✓	General
10	ReactorAllocation	0		✓	General
11	TransOverpackCanCount	0		✓	ModelInternals
12	TransOverpackGroupEntry	0		✓	ModelInternals
13	TransportOverpack	0		✓	General
14	WaitingRailcar	0		✓	General
15	CCILock	1	✓	✓	ModelInternals
16	CCInitTurn	0	✓	✓	ModelInternals
17	Capital Cost	0	✓		General
18	CaskLoadingLock	1	✓	✓	ModelInternals
19	ContinuousArrivingCask	0	✓	✓	General
20	Crane	0	✓	✓	General
21	DryStorageCost	0	✓	✓	DryStorage
22	DryStoragePad	4	✓	✓	DryStorage
23	EnterDryStoreLock	1	✓	✓	ModelInternals
24	FCRCLock	1	✓	✓	ModelInternals
25	LoadReady	0	✓	✓	ModelInternals
26	Operating Cost	0	✓		General
27	PoolAvailability	0	✓	✓	General
28	PoolHasShutdownFlag	0	✓	✓	ModelInternals
29	ProcessStartAllowance	0	✓	✓	General
30	RailcarLoadLock	1	✓	✓	ModelInternals
31	RailcarLoadedFlag	0	✓	✓	ModelInternals
32	RailcarPayloadLock	0	✓	✓	ModelInternals
33	TOGFLock	1	✓	✓	ModelInternals
34	TrainProcessLock	1	✓	✓	ModelInternals
35	TransportCollectorLock	1	✓	✓	ModelInternals

Figure 19 Resource Table Editor

Resource Category

Select the Resource Category folder to display the Resource Category Editor. All resources in the Small scenario are categorized as either "General" or "ModelInternals" (Figure 21). In Expert Edit mode, it is possible to create additional resource categories.

Data

Resource Category Editor

Row	Category
1	General
2	ModelInternals

Figure 20 Resource Category Editor

Entity Types

To view Entity Types, select that folder under the desired installation. The Entity Editor window will appear (Figure 22).

Entity Types are agents that complete the tasks within the scenario. Entity Types have Attributes (Figure 23) and Flow Attributes (Figure 24). Only Expert Edit mode allows attributes to be added or deleted, by clicking on the plus sign (+) to select an attribute or to add a new attribute and by clicking on the minus sign (–) to delete a selected attribute.

Flow attributes are created when the user creates a plan, since these attributes control the flow of the decision logic as it moves from one task to the next. The Flow attribute is initially set to *false*, and when the task is accomplished, it is set to *true* so that the agent does not repeat the task but instead moves on to check which task should be performed next.

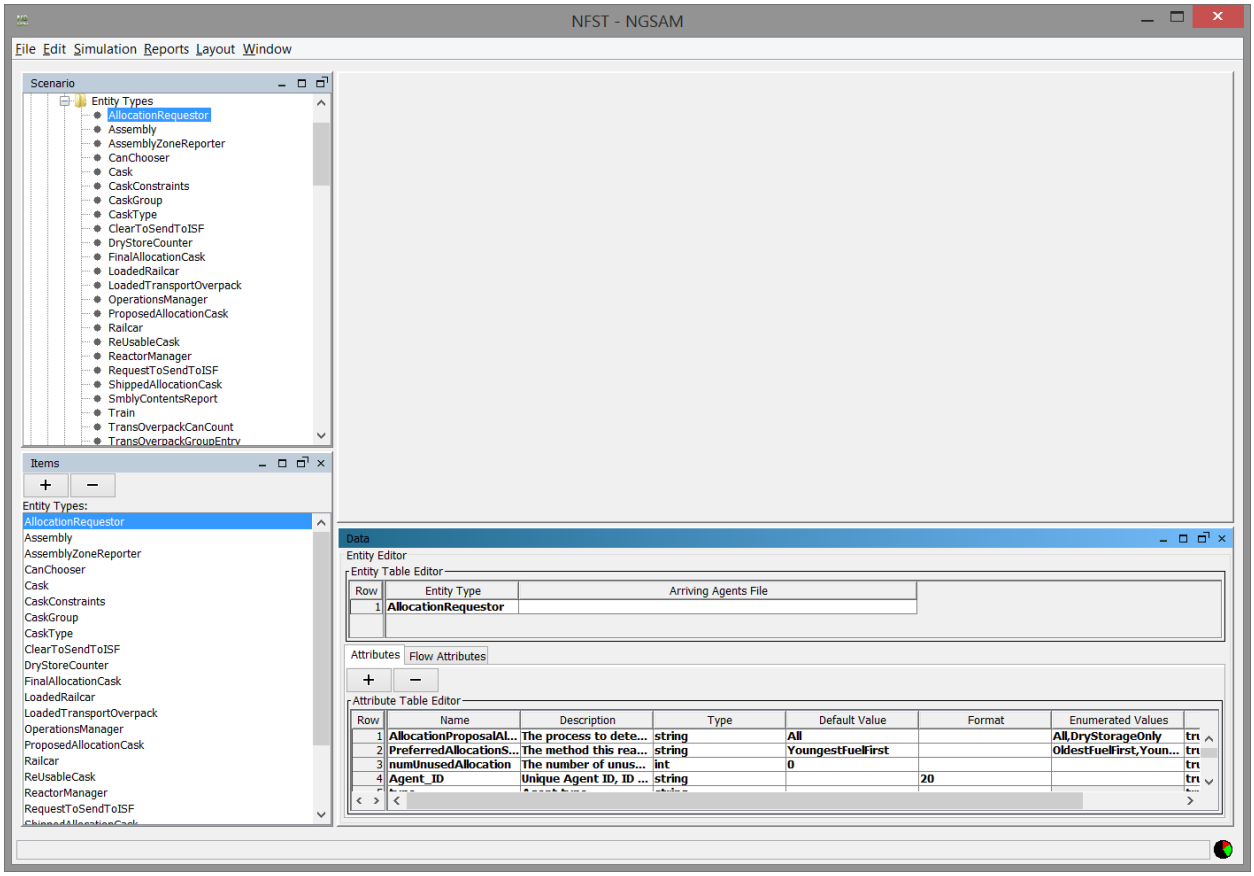
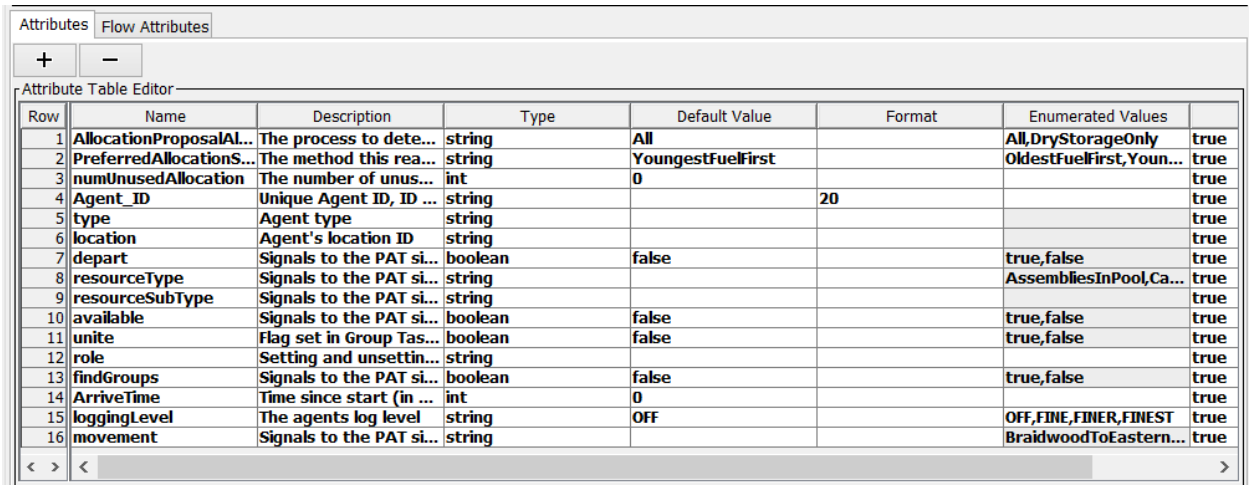
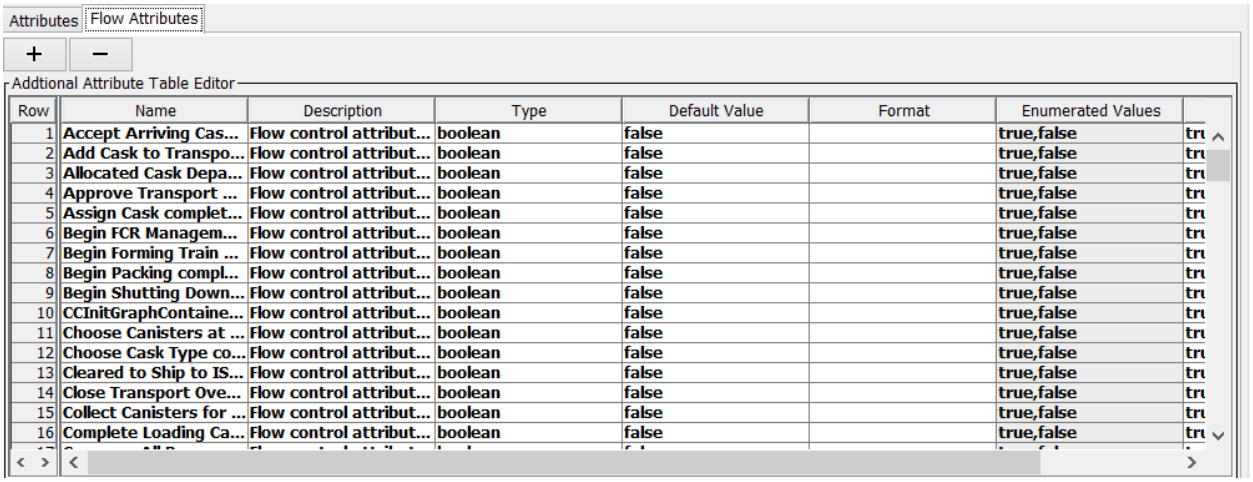


Figure 21 Entity Types and Entity Editor Window



Row	Name	Description	Type	Default Value	Format	Enumerated Values	
1	AllocationProposalAl...	The process to dete...	string	All		All,DryStorageOnly	true
2	PreferredAllocationS...	The method this rea...	string	YoungestFuelFirst		OldestFuelFirst,Youn...	true
3	numUnusedAllocation	The number of unus...	int	0			true
4	Agent_ID	Unique Agent ID, ID ...	string		20		true
5	type	Agent type	string				true
6	location	Agent's location ID	string				true
7	depart	Signals to the PAT si...	boolean	false		true,false	true
8	resourceType	Signals to the PAT si...	string			AssembliesInPool,Ca...	true
9	resourceSubType	Signals to the PAT si...	string				true
10	available	Signals to the PAT si...	boolean	false		true,false	true
11	unite	Flag set in Group Tas...	boolean	false		true,false	true
12	role	Setting and unsettin...	string				true
13	findGroups	Signals to the PAT si...	boolean	false		true,false	true
14	ArriveTime	Time since start (in ...	int	0			true
15	loggingLevel	The agents log level	string	OFF		OFF,FINE,FINER,FINEST	true
16	movement	Signals to the PAT si...	string			BraidwoodToEastern...	true

Figure 22 Attributes



Row	Name	Description	Type	Default Value	Format	Enumerated Values	
1	Accept Arriving Cas...	Flow control attribut...	boolean	false		true,false	tru
2	Add Cask to Transpo...	Flow control attribut...	boolean	false		true,false	tru
3	Allocated Cask Depa...	Flow control attribut...	boolean	false		true,false	tru
4	Approve Transport ...	Flow control attribut...	boolean	false		true,false	tru
5	Assign Cask complet...	Flow control attribut...	boolean	false		true,false	tru
6	Begin FCR Managem...	Flow control attribut...	boolean	false		true,false	tru
7	Begin Forming Train ...	Flow control attribut...	boolean	false		true,false	tru
8	Begin Packing compl...	Flow control attribut...	boolean	false		true,false	tru
9	Begin Shutting Down...	Flow control attribut...	boolean	false		true,false	tru
10	CCInitGraphContaine...	Flow control attribut...	boolean	false		true,false	tru
11	Choose Canisters at ...	Flow control attribut...	boolean	false		true,false	tru
12	Choose Cask Type co...	Flow control attribut...	boolean	false		true,false	tru
13	Cleared to Ship to IS...	Flow control attribut...	boolean	false		true,false	tru
14	Close Transport Ove...	Flow control attribut...	boolean	false		true,false	tru
15	Collect Canisters for ...	Flow control attribut...	boolean	false		true,false	tru
16	Complete Loading Ca...	Flow control attribut...	boolean	false		true,false	tru

Figure 23 Flow Attributes

Groups

Select the Groups folder for the desired installation. The folder expands to show all groups and the Group Table Editor (Figure 25). Groups are defined for agents that might need to do certain tasks together. The groups are defined by agent attribute and can be used to filter plans or COAs so that only certain types/groups of agents attempt to carry out the plan. (This narrows down the number of plans an agent must check when calculating what to do next during the simulation.) Agents come together for a Group Task (GT) (defined in the Tasks tab) during the simulation, for which all members of the group must be present before the task is executed. These groups usually disband into individuals to decide on their next tasks, unless the special “unite” attribute is set to *true* on the task. In this case, the members remain together and continue on as a Unified Group (e.g., assemblies that are packed in a cask or casks that are loaded onto a railcar).

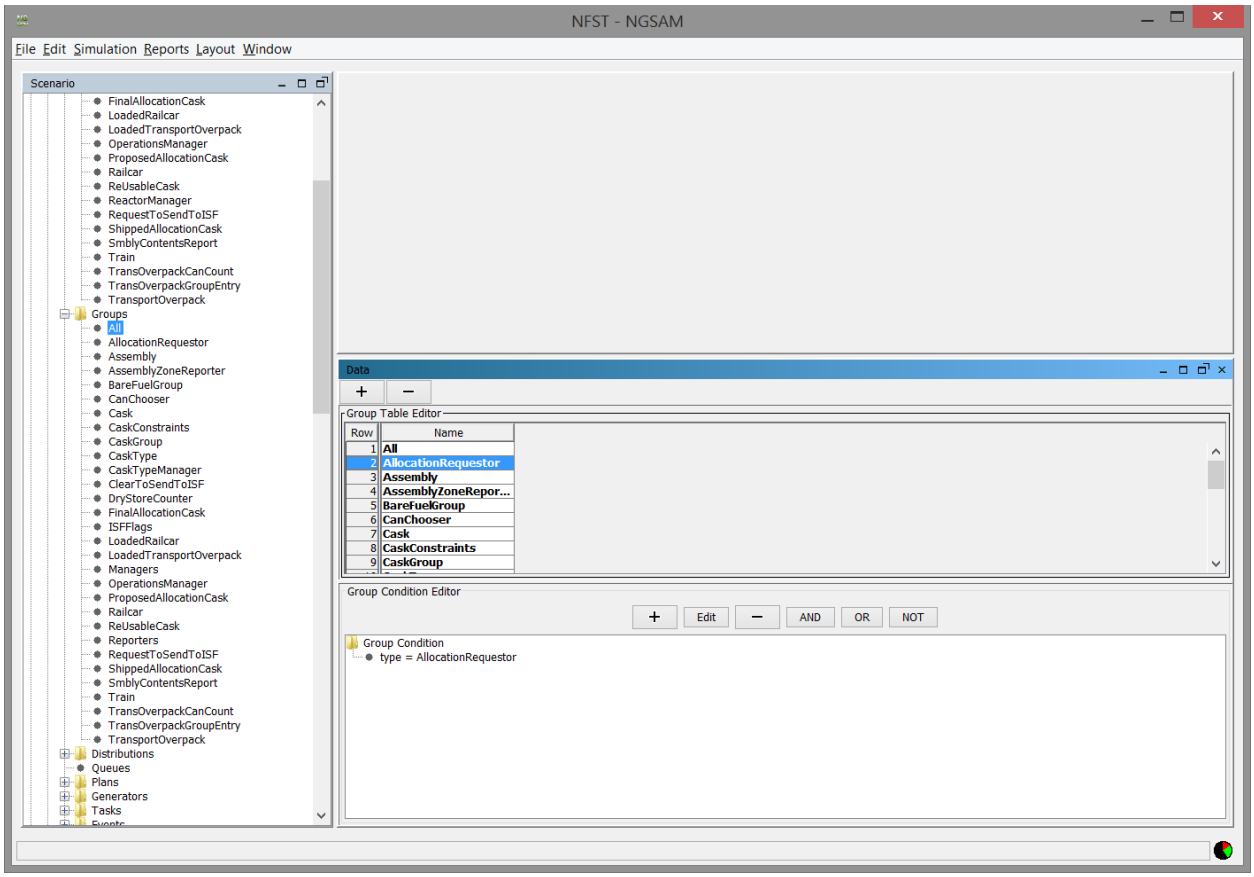


Figure 24 Groups and Group Table Editor

Distributions

Select the Distributions folder for the desired installation. The Task Distribution Editor is displayed (Figure 26). Distributions can be used to define the duration of a task, set an attribute for an agent, set a value for a resource within a task, and create (generate) agents within a simulation. The analyst is given a selection of the most common distributions (e.g., normal, triangular) and then defines the properties that will shape the curve (e.g., mean, standard deviation). The analyst can also create custom distributions by providing a comma-separated value (.csv) file containing the data (e.g., assembly packing time). The analyst can view the distribution curves or graphs (Figure 27) by clicking on the "View" button seen in Figure 26.

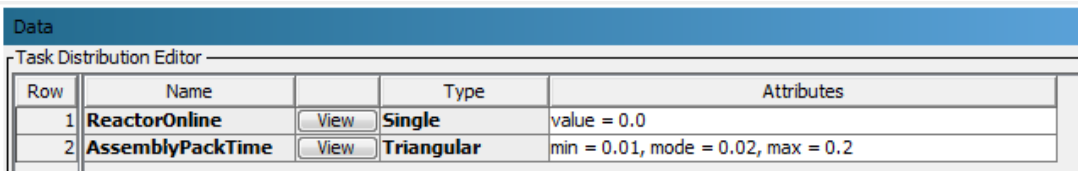


Figure 25 Distributions

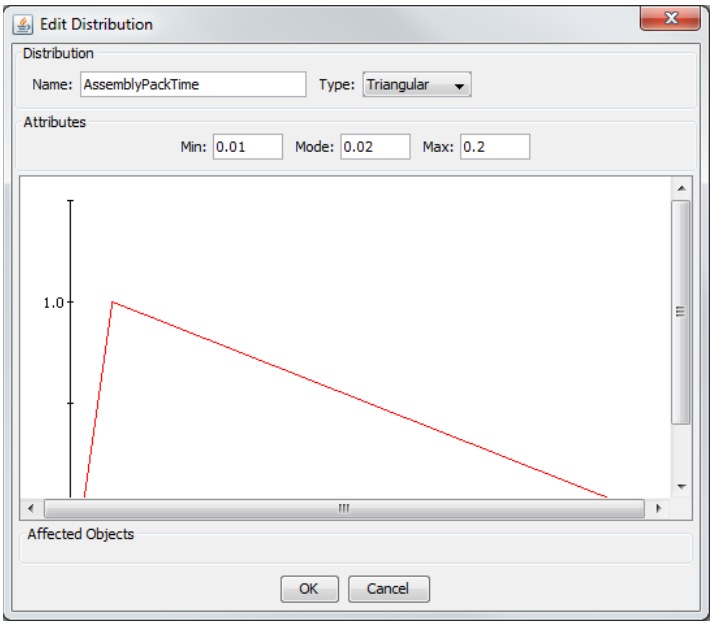


Figure 26 Distribution Curve

In order to create a user defined distribution from a CSV file, the user would choose "UserDefined" as the type of distribution. This will cause a CSV file selection button to appear. Once pressed, the user can choose a predefined CSV file. The file should contain two columns. The first column will specify values and the second column the percent probability that the value in the same row will be generated. The probability percentages must add up to 100 exactly in floating point arithmetic (using double values). There should be a header row that labels the two columns.

Queues

Queues definitions are found in the Distributions folder. Queues are used to add more control over the assignment of resources within a task. When a task requires a resource and that resource is unavailable at that time, the requesting agent doing the task will queue up for the resource and be notified when it becomes available. The default ordering is a first in/first out (FIFO) ordering of the agents waiting for a specific task, with a pseudo-random selection of which task will be notified when agents are waiting for multiple tasks for the same resource. If the user wishes to define a queue, the choices are FIFO, last in/last out (LIFO), or agent attribute-based (i.e., the queue priority can be based on the attribute of the agents queuing up for a resource).

Plans

Select the Plans folder for the desired installation, then select a plan. The Plan Canvas is displayed (Figure 28). Plans define the overall flow through a series of tasks. There may be many plans in an installation. Agents flow through the tasks at an installation by checking the task's attributes against the conditions in the plan to decide which task in the plan should be completed next. The plans organize the tasks to be executed by the casks, assemblies, etc.

The "Step Order" tab shows a list of tasks and the order in which they should be performed. The "Trigger Condition" tab displays the COA trigger.

The “Selected Time” slider at the bottom of the COA window can be used to see the plan at various “slices” of time. This slider is only available after a scenario has been run or when a previous run’s results have been loaded by using the “Load Simulation Results” menu option.

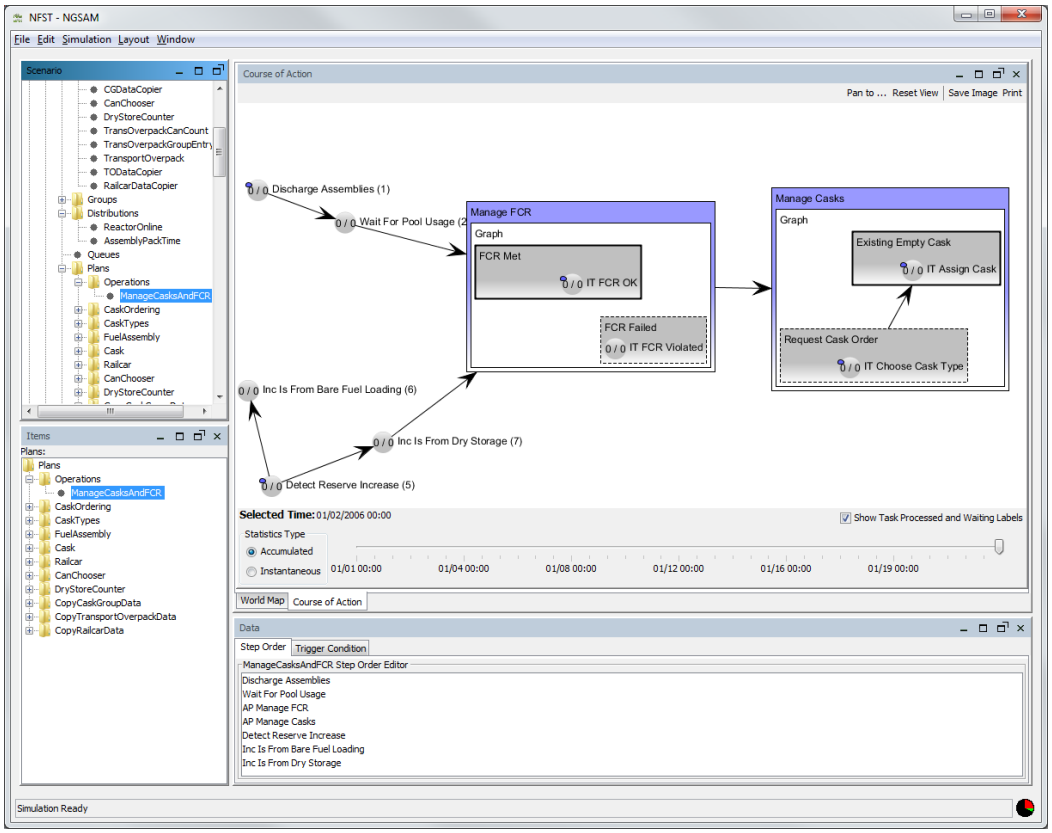
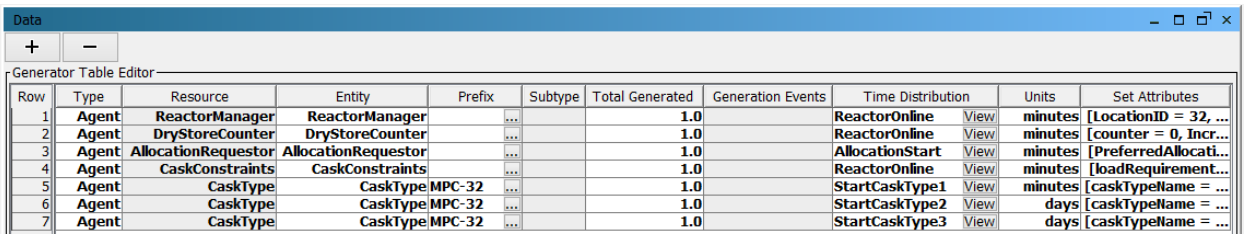


Figure 27 Plan Canvas

Generators

Select the Generators folder for the desired installation. The Generator Table Editor is displayed (Figure 29). Agents and resources can be generated during the simulation. Generators can be configured to execute at any time during the simulation by using the “Time Distribution.” In Expert Edit Mode, generators can be added or deleted by using the plus (+) and minus (–) buttons that will appear on top of the dialog window.



Row	Type	Resource	Entity	Prefix	Subtype	Total Generated	Generation Events	Time Distribution		Units	Set Attributes
1	Agent	ReactorManager	ReactorManager	...		1.0		ReactorOnline	View	minutes	[LocationID = 32, ...
2	Agent	DryStoreCounter	DryStoreCounter	...		1.0		ReactorOnline	View	minutes	[counter = 0, Incr...
3	Agent	AllocationRequestor	AllocationRequestor	...		1.0		AllocationStart	View	minutes	[PreferredAllocati...
4	Agent	CaskConstraints	CaskConstraints	...		1.0		ReactorOnline	View	minutes	[loadRequirement...
5	Agent	CaskType	CaskType	MPC-32 ...		1.0		StartCaskType1	View	minutes	[caskTypeName = ...
6	Agent	CaskType	CaskType	MPC-32 ...		1.0		StartCaskType2	View	days	[caskTypeName = ...
7	Agent	CaskType	CaskType	MPC-32 ...		1.0		StartCaskType3	View	days	[caskTypeName = ...

Figure 28 Generators

Tasks

View all tasks by selecting the Task folder for the desired installation. The Tasks and Task Editor windows will be displayed (Figure 30). Tasks are the basic building blocks of the simulation. Tasks can be done by an individual (an IT executed by a single agent) or by a group (a GT executed by all members of a group). A task can be executed because it is triggered by an event or as part of the decision logic in an agent's plan. All tasks are user-defined and, as such, create the logic of the scenario run.

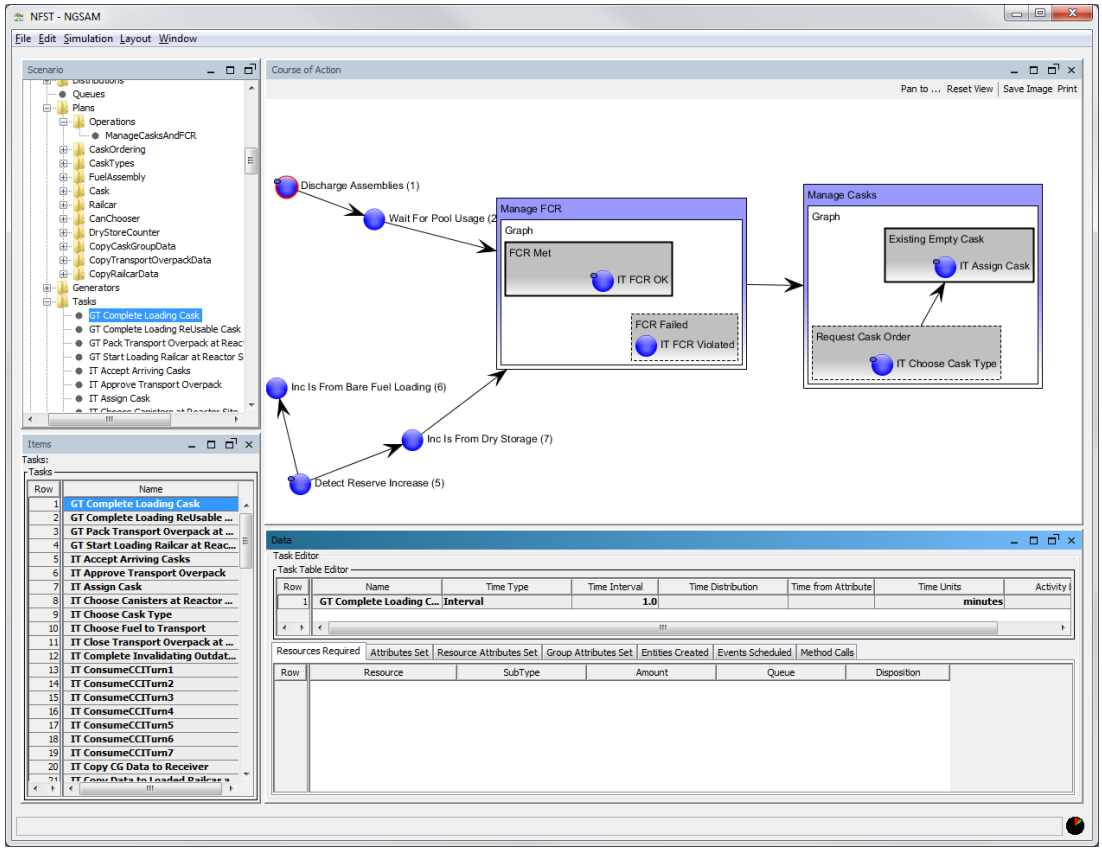


Figure 29 Tasks and Task Editor Windows

Tasks may require resources, configured in the "Resource Required" tab of the Tasks window (Figure 31). Users can also set attributes for the agent doing the task (Attributes Set, Figure 32), set attributes for some types of resources used in the task (Resource Attributes Set, Figure 33), or set attributes for a unified group from the members of the unified group (Group Attributes Set, Figure 34). Tasks can also generate agents or resources, and they are configured in the Entities Created tab (Figure 35). In addition, tasks can schedule events, which are configured in the Events Scheduled tab (Figure 36). The Method Calls tab (Figure 37) allows tasks to call custom Java code. In NGSAM, some tasks call special Java methods for doing calculations, such as creating the assembly discharge schedule for the reactors.

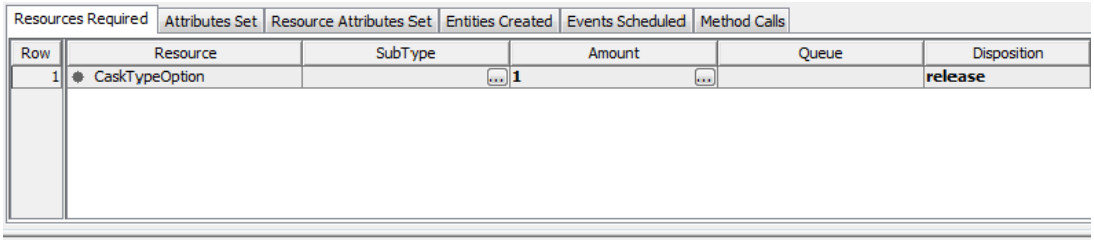


Figure 30 Resources Required

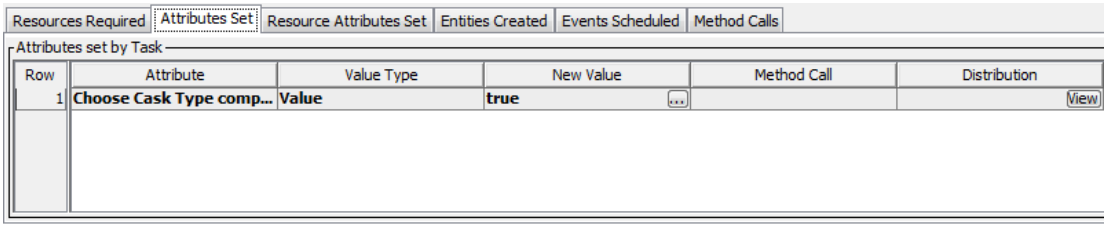


Figure 31 Attributes Set

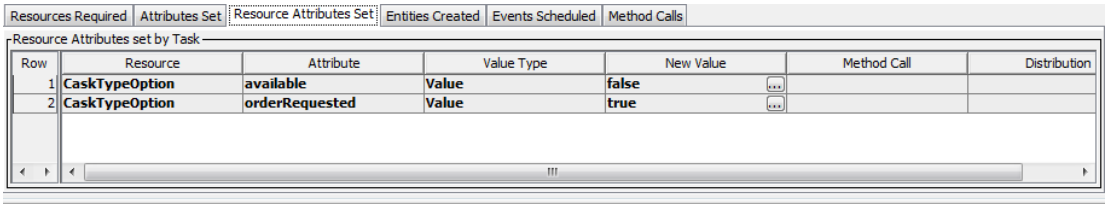


Figure 32 Resources Attributes Set

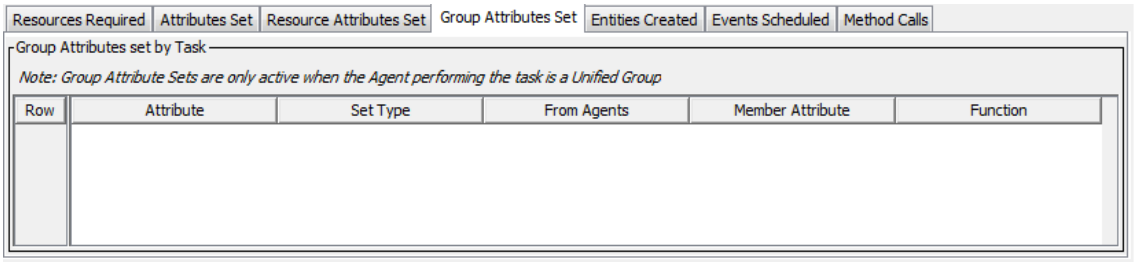


Figure 33 Group Attributes Set

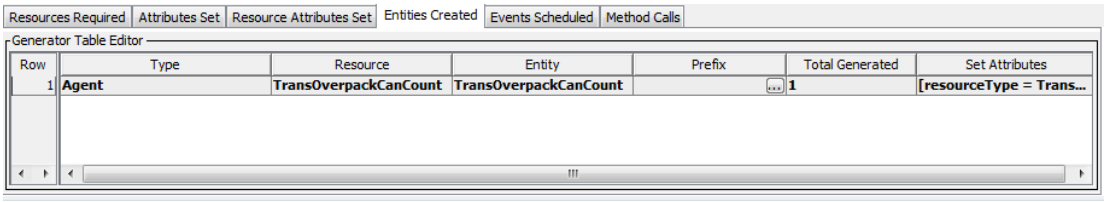


Figure 34 Entities Created

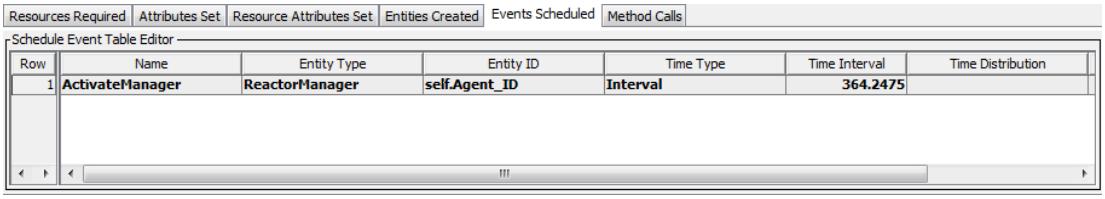


Figure 35 Events Scheduled

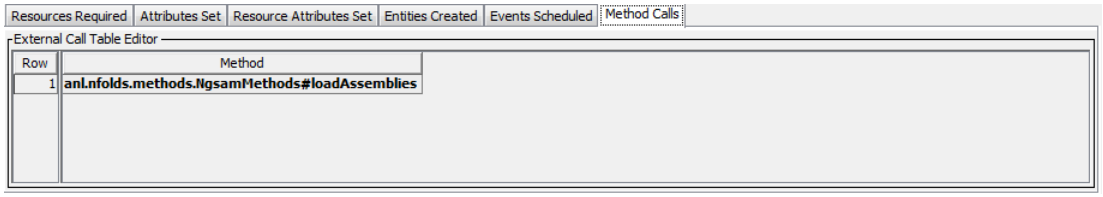


Figure 36 Method Calls

Events

Events provide a way for agents to alter their plan of action based on a number of different conditions. These conditions can be resource levels, the state of some other agents, or the state of the agent itself. Events may be defined to execute at a certain time, or they may be triggered conditionally based on a change in the value of an attribute of an agent or resource. There are two types of Events (External Events and Scheduled Events), as shown in Figure 38.

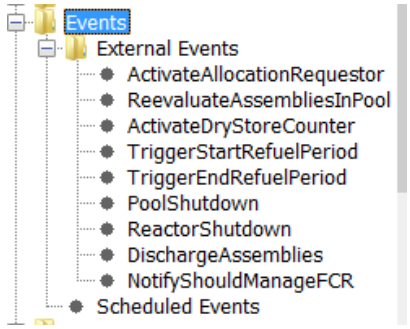


Figure 37 Events

External Events (Figure 39) may be used to set attributes in an agent (Entity Type). External Events can also schedule another event. In this way, the user can set up a recurring event during the simulation. In this example, the “ReactorManager” agent sets the flow attribute for its task “Discharge Assemblies” to *false*. This also triggers the agent to look at its plans to determine what to do next. The ReactorManager will redo the Discharge Assemblies task, which in this scenario, creates the assembly agents that will be discharged for the current year and adds them to the simulation to be processed. The Discharge Assemblies task schedules the “Activate Manager” event for the next year to initiate this process for each year in the simulation.

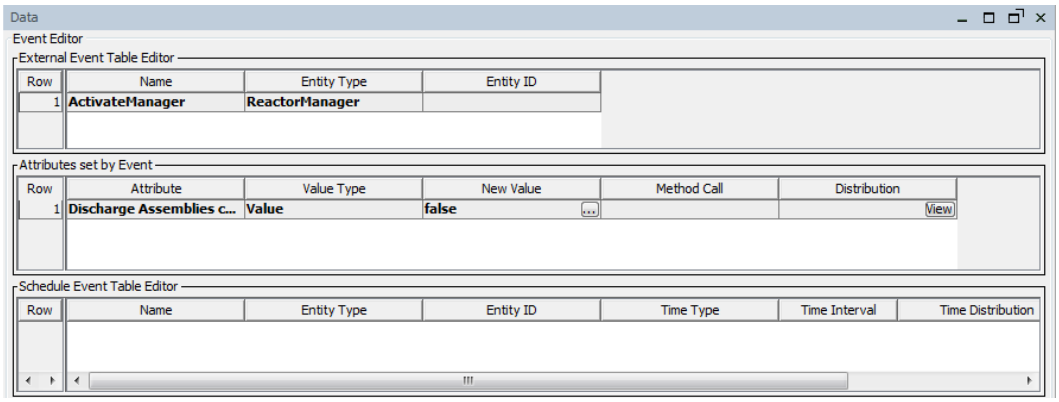


Figure 38 External Events

Scheduled Events (Figure 40) are used to specify a simulation time for an External Event to be initiated. The time could be an "Interval" (minutes or days from simulation start time) or chosen from a "Distribution."

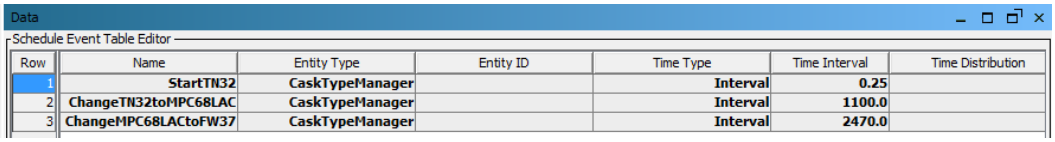


Figure 39 Scheduled Events

Reports

The Reports section is intended for users to create custom reports for a scenario installation and has been enhanced in current scenarios. The reports that can be generated currently are listed in Appendix A, and the Notes column has a description of how to generate each report.

In Expert Edit Mode, a user can add a new report or update existing reports. Add a new report by clicking on the plus sign (+) in the Items window and entering the name of a new report (Figure 41). To customize a report, select a report in the Items window and add/remove tasks (Figure 42) and attributes (Figure 43). Each time an agent performs one of the selected tasks, all of the selected attributes will be logged to the specified report file in .csv format.

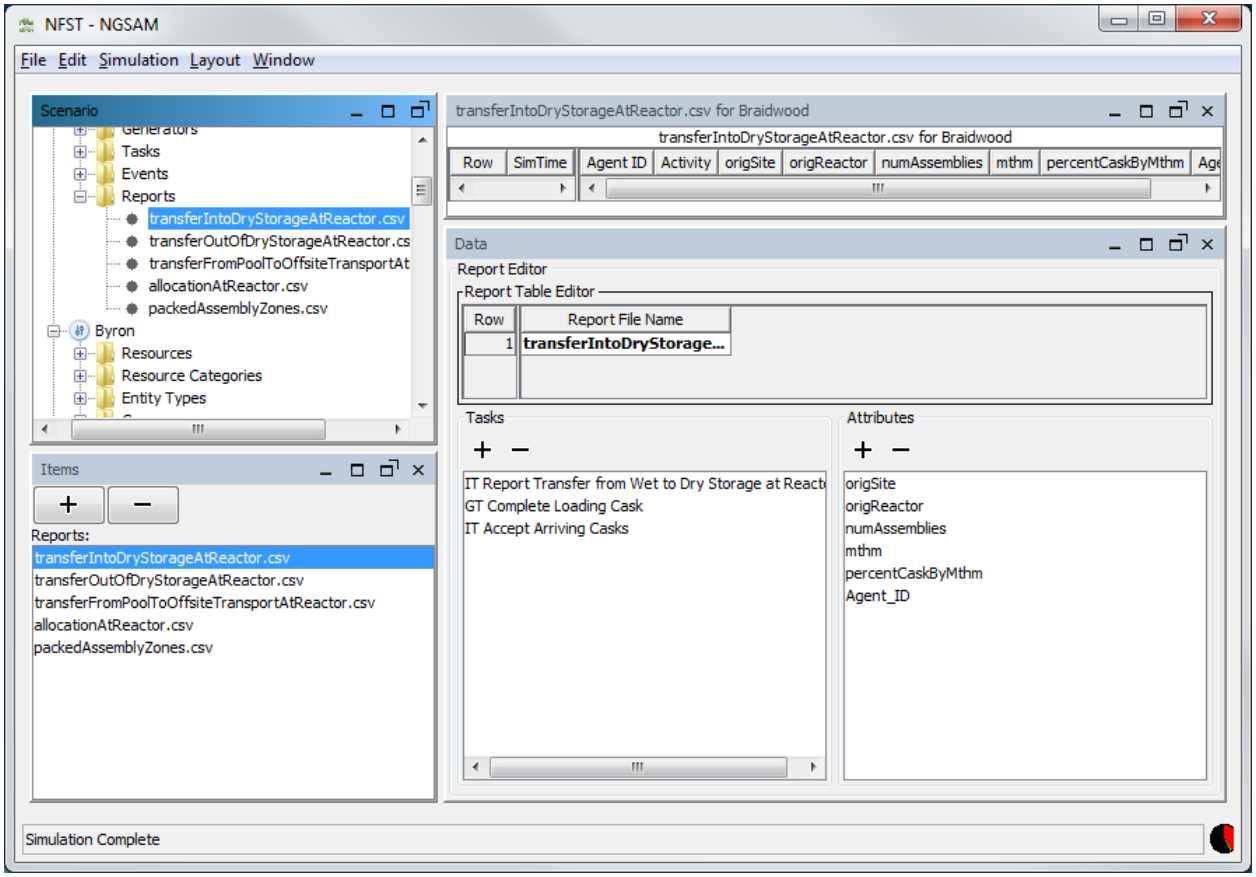


Figure 40 Creating Custom Reports

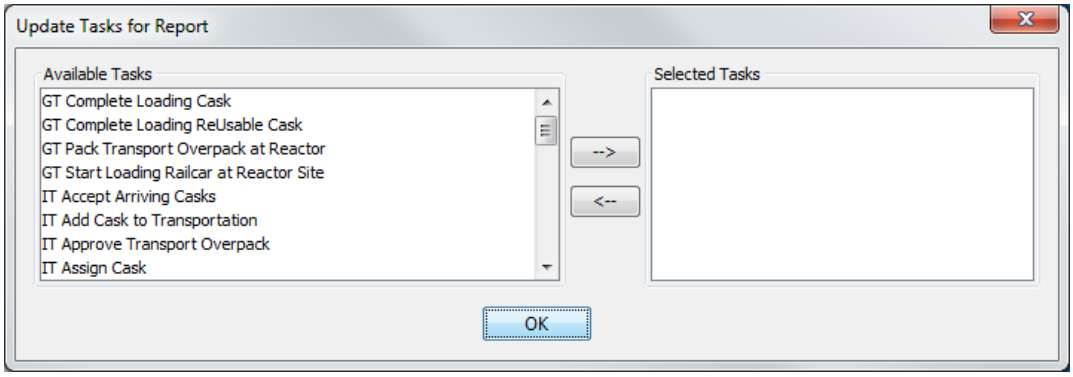


Figure 41 Update Tasks for Report

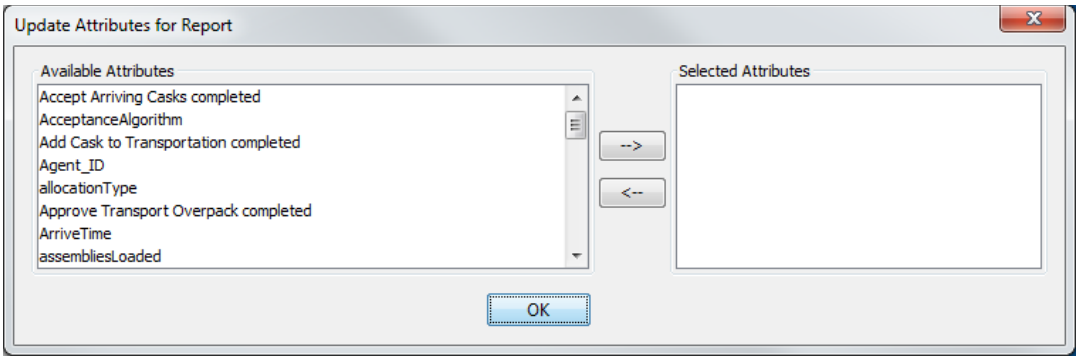


Figure 42 Update Attributes for Report

2.3 NGSAM Scenarios Installed with the Software

There are three full scenarios that come with NGSAM: the "Small" scenario, the "USFleet" scenario and the "Shutdown" scenario. The Small scenario models fuel movement from four selected reactor sites in Illinois, while the USFleet scenario models all reactor sites in the United States. Both scenarios have similar logic, but the USFleet scenario takes a significantly longer time to run due to the size. The Shutdown scenario contains reactor sites that have shutdown. The scenarios use identical allocation and acceptance logic (see Appendix C), dry storage cask loading logic, and transportation planning using JTOM (see Appendix A).

Small Scenario Overview

The Small scenario includes four reactor installations, three ISFs, one Repackaging facility, one FMF, and one MGR. In addition to these physically located installations, this scenario includes two additional notional installations that are related to modeling the (a) Transportation (see Appendix B) and (b) Planning installations. The Planning installation is primarily responsible for performing allocation among the reactors in the scenario.

The overall logistics in this scenario are defined such that the assemblies that are ready for packing and transport originate at one of the active reactor sites. Transportation assets are deployed to the reactors, where the assemblies or dry storage canisters are packed and loaded onto the railcar. Processing of the loaded asset then transfers back to the transportation installation; then by executing the plans and COAs at the transportation installation, the railcar is directed to one of the ISFs, which was pre-determined by allocation planning. After this, the railcar arrives at the physical destination installation and proceeds to execute plans and tasks at that installation. Packages are transferred from the ISFs to the Repackaging facility and from the Repackaging facility to the MGR in a similar fashion.

The main purpose of this scenario is to demonstrate the modeling concepts used in the USFleet scenario, but on a smaller scale so that runtimes are more manageable. The dates are defined such that the scenario begins at the beginning of A.D. 2013 and runs for 87 years, stopping at the beginning of A.D. 2100. Assemblies and Packages that pre-date 2013 are loaded in at the start of the simulation.

Transportation in the scenario is modeled by using itineraries and legs. An itinerary represents the path that will be taken by a particular asset when the asset is given a particular task. An itinerary is made up of legs. Each leg represents the asset traveling from one location to another location. For example, a railcar may be tasked to pick up UNF from Crystal River and bring that fuel to the ISF. Since the railcar is currently located at the maintenance facility, accomplishing the task might involve traveling from the maintenance facility to Crystal River (the first leg), traveling from Crystal River to the ISF (the second

leg), and returning to the maintenance facility (the final leg). These three legs make up the itinerary of the railcar for the task of bringing UNF from Crystal River to the ISF.

In all scenarios, the itineraries and legs are created automatically by the software through its use of JTOM. JTOM uses route data produced by the START tool to represent the transportation network. Currently, in NGSAM/JTOM, only rail routes are defined, and of those, only those between the reactors, ISFs and the MGR within this scenario are defined.

Scenario Components

The types of agents modeled in this scenario are the same as those in the Generalized Transport case. The NGSAM-specific agents that are modeled within and move between installations include:

- Fuel rod assemblies,
- Canisters,
- Transportation casks,
- Railcars, and
- Grouped agents:
    - Assemblies within canisters,
    - Canisters within transportation casks, and
    - Loaded railcar (cask with railcar).

Within the scenario, the dry storage cask models that are used are defined in the Generators tree. There are currently three types of casks that are defined, each being introduced at a different time. For example, the Braidwood reactor specifies that the MPC-32 package type be used. In this case, the same package is used for the entire scenario. The package is listed three times as a convenience for the user for if they would like to change the package type to be used at some point in the simulation.

To change the package type used at a given time in the simulation, simply change the package type to the desired value and the distribution value to the desired time. When the simulation reaches the desired time, then that reactor will switch over to using the new package type.

For bare fuel, the cask used is defined in the “Railcar Chose Bare Fuel at Reactor Site” task in the Railcar->ProcessRailcar course of action. These packages get their performance attributes from the database.

USFleet Scenario Overview

The USFleet scenario is the same as the Small scenario, except that it contains installations for all reactors in the U.S. nuclear reactor fleet. Because of this, the USFleet scenario takes a significantly longer time to run. This scenario is used for actual analysis, while the Small scenario is more appropriate for demonstrations, educational purposes, and debugging.

The agent types, resources, timeline, plans, courses of action, transportation network, and almost all other components are the same as in the Small scenario. The transportation fleet is larger.

Allocation and Acceptance

The current design of NGSAM allows for complete flexibility of allocation input. Allocation input to NGSAM consists of an excel worksheet defining which sites are allocated what amounts of metric tons of uranium (MTU) per year of the simulation along with a number of agent attribute settings. In addition, the report of acceptance (receipt) of SNF after a simulation has been completed is formatted in a way that closely resembles the allocation input worksheet. An analyst can easily modify the acceptance output of one simulation to serve as the allocation input of another simulation. This mirrors the functionality of current systems analysis tools (e.g., TSL-CALVIN) and allows complete freedom in defining system allocations.

There are three primary settings that control the operation of the allocation and acceptance process. First, each reactor has a setting for how it will propose fuel that it would like to ship. This setting is accessed in each reactor's AllocationRequestor agent Generator. The AllocationRequestor agent has an attribute called "AllocationProposalAlgorithm" which specifies what SNF will be proposed to the Planner for allocation.

Second, the Planner agent in the Planner installation has an attribute called "allocationAlgorithm" that specifies how the Planner will allocate fuel to ship from each reactor. The value of this attribute is set in the Planner agent Generator. There are a number of possible values for this attribute. The "Local" value causes the allocation spreadsheet to be used to determine allocation priority for each reactor. Reactors that are listed higher on the spreadsheet are given first priority in allocation. Reactors that are lower on the spreadsheet are given last priority.

The "Global…" values cause the Planner to ignore the allocation spreadsheet for allocation priority (but not for the allowed fleet and reactor maximums). These values cause the planner to evaluate all proposed allocations across all reactors and give priority in allocation according to the reactors that have fuel fitting the algorithm name. For example, "GlobalOldestFuelFirst" will cause the planner to give priority to reactors that house the oldest assemblies in the fleet of reactors.

Third, each reactor has a setting for how it will fulfill the given allocation it receives from the Planner. The "AcceptanceAlgorithm" attribute on the ReactorManager agent specifies how each reactor should choose fuel to ship to its destination. For example, "Dry Packages with oldest assemblies, then packable wet assemblies" will cause the reactor to choose to send its fuel that is in dry storage first, and only when that is exhausted will it send any fuel that is contained in the reactor's pool.

Refer to Appendix C for diagrams related to this topic.

Dry Storage Cask Loading

NGSAM software analyzes various alternative SNF management options and provides quantitative and qualitative merits for each of these options to inform decision-making. The current SNF management strategy relies on dry storage systems used at reactor sites to allow continued operation of the nation's nuclear fleet. Therefore, for integrated SNF management, NGSAM software requires a dry storage loading algorithm to simulate the loading of future dry storage casks at reactor sites according to dry

storage system requirements specified in the Certificates of Compliance (COCs). Dry storage loading logic/algorithm details can be found in (Banerjee and Jarrell, 2015).

JTOM Integration

In order to have transportation assets load and move casks between installations, the JTOM planner is integrated into the NGSAM simulation. All the inputs needed to initialize the JTOM engine come from the Unified database (stored within the NGSAM database), or from separate configuration files. In particular, the transportation network that JTOM uses and the transportation vehicle fleet that is modeled are defined in separate files. The transportation network is contained in the `routeData` folder of the NGSAM installation.

Another item of note is that the only mode of transport is railcars, since the START routes available to the simulation are only rail routes. JTOM uses the buffer and escort cars for scheduling and costing purposes, but only the rail cask cars are modeled as agents within the simulation. The railcar fleet is defined in the `unf-vehicles.csv` file of each scenario.

All the planning is done within the Transportation Installation. Figure 44 shows the Scheduling Plan with the Initialization COA. Clicking on the "Receive Transportation Init" task and then on "Method Calls" shows the Java method that is called whenever an agent executes this task. The JTOM engine is initialized with all the static data it needs between scheduling calls.

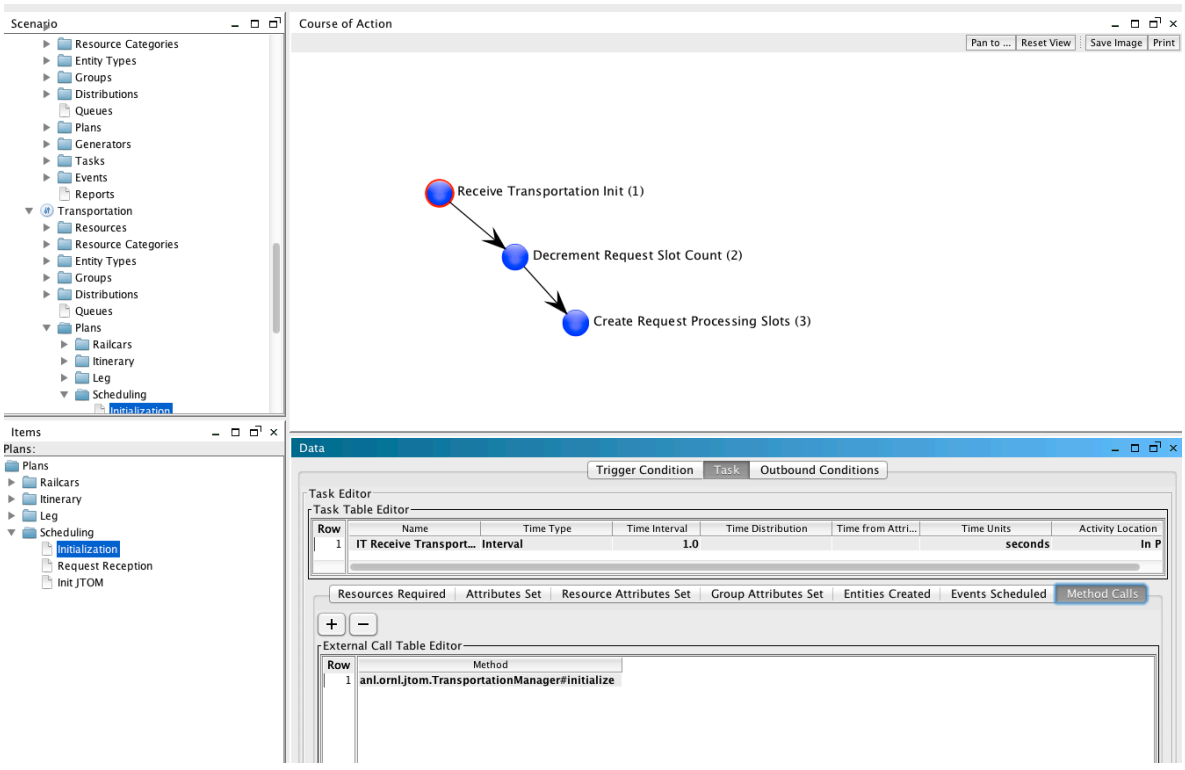


Figure 43 Initialization of JTOM

In Figure 45, the Request Reception COA is shown within the Scheduling Plan. The Transportation installation expects to receive transportation requests from every rector in the scenario for each transportation planning period. In order to know when all expected requests are received (one for each

reactor), “processing slot” resources are created. The number of processing slots available will equal the number of reactors that are in the simulation. In the Request Reception COA, if there is a processing slot available, then the transportation request is added to the JTOM module. If a transportation request is not available, this means that the request being processed is the final request that is to be expected during the planning period. In this case, the request is added to the JTOM module, *and* the JTOM scheduling process is run.

The current planning period for transportation is 1 year. Therefore, JTOM will be run every simulation year. It is called from the “Schedule Transportation” task in the Request Reception COA (see Figure 46). At this time, the simulation executes the JTOM module, which will attempt to schedule trips for the pending transportation requests in that time period. For trips that can be completed within the time period, itineraries and legs are created based on those trip plans and inserted into the NGSAM simulation as agents. These agents then start executing their appropriate plans (under Itinerary and Leg COAs, respectively).

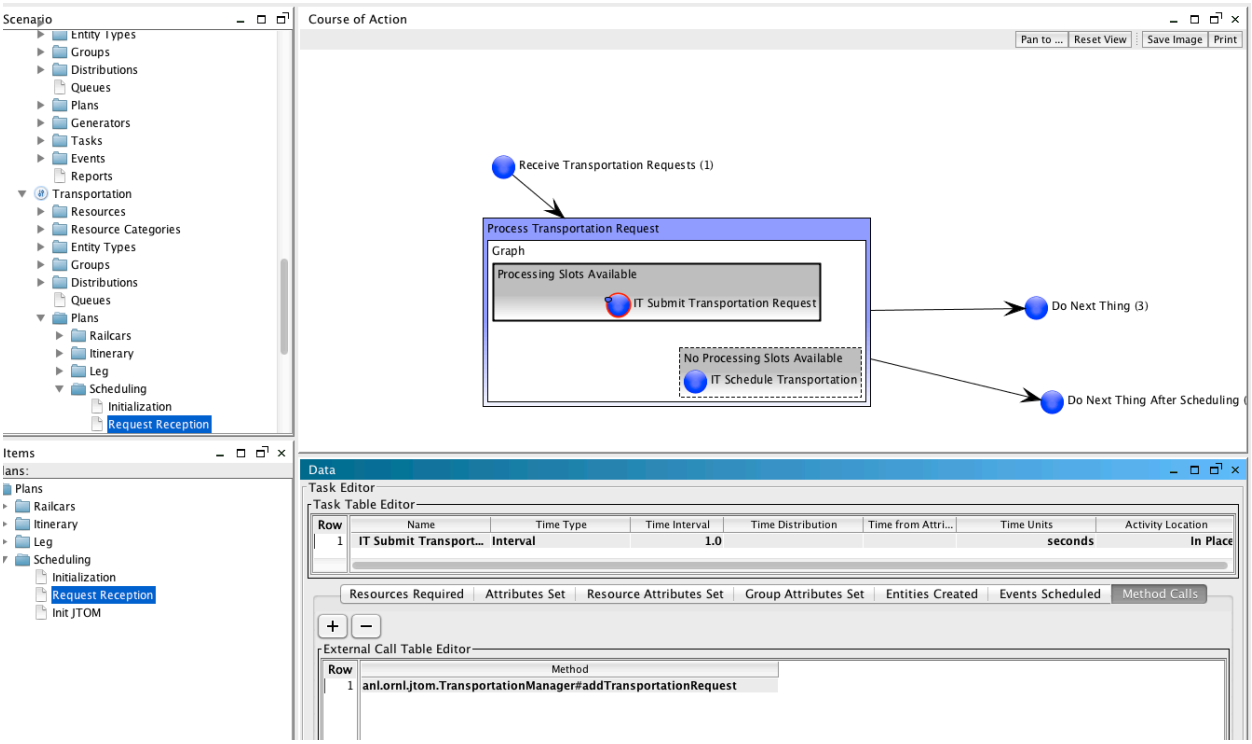


Figure 44 Adding Transportation Requests to JTOM

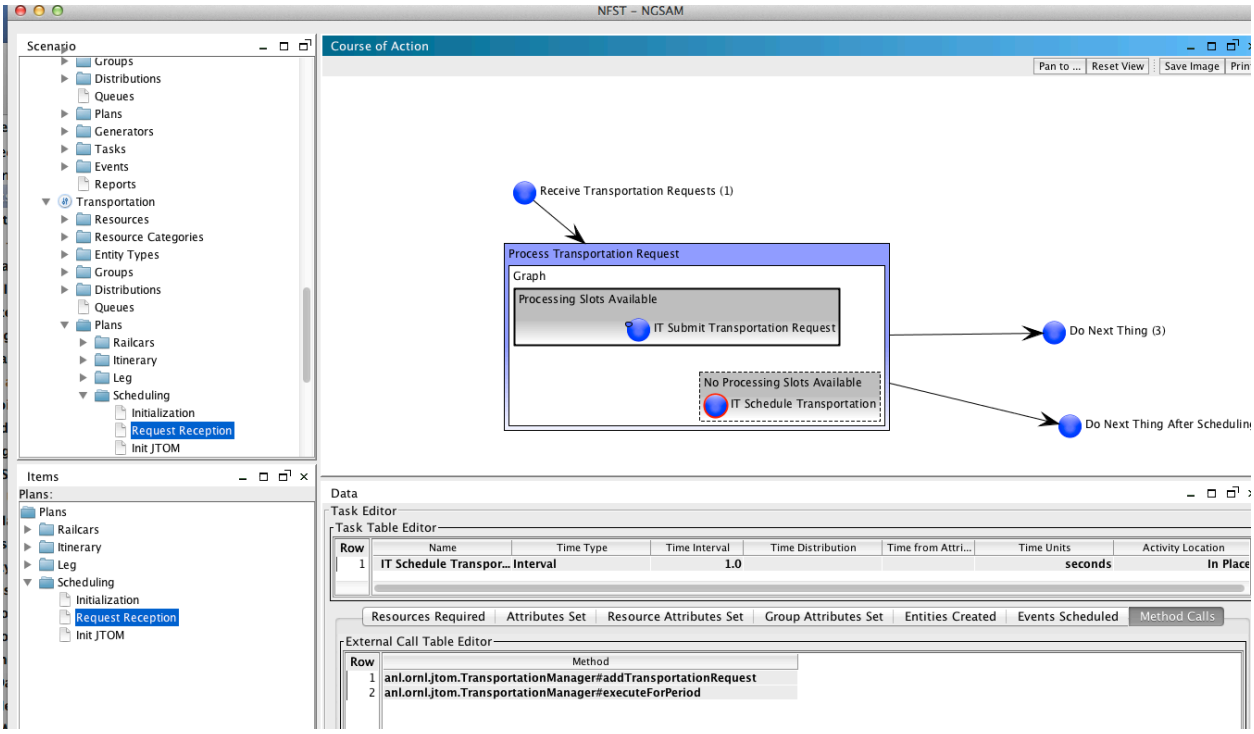


Figure 45 Schedule JTOM Execution

Appendix A provides a listing of new and existing reports in NGSAM Phase 2 – Prototype 2.

CONCLUSION

The NGSAM Software Guide and Training Manual reflects current functional and operational logic/algorithms existing in the NGSAM version 2.1.5.0 software. This evolving report can be referenced by System Analysts to assist their TSL-CALVIN vs. NGSAM Benchmark testing, as well as support their ongoing analyses reporting requirements.

3 REFERENCES

Nutt, M., and F. Puig, 2013, *Waste Management System Analysis Simulation Model Requirements, Fiscal Year 2014*. FCRD-NFST-2013-0000408, Rev. 0-DRAFT, Dec. 13.

Nutt, W., B. Craig, K.L. Simunich, E. Vander Zee, M. Kehrer, and J. St. Aubin, 2015, "Next-Generation System Analysis Model for Studying Alternative Courses of Action for Nuclear Fuel Logistics and Disposal – 15232," submitted to and accepted by WM2015 Conference, March 20.

St. Aubin, J., K. Simunich, and B. Craig, 2013, *Development Plan for Next-Generation Waste Management System Analysis Modeling Tool, Fiscal Year 2014,* FCRD-NFST-2014-0000346, Rev. 0-DRAFT, Dec. 13.

Banerjee, K., and J.J. Jarrell, 2015, *Dry Storage Loading Algorithm*, FCRD-NFST-2015-000642 (ORNL/SPR-2015/274), June.

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APPENDICES

Appendix A NGSAM Reports

#	Report Title	Report Format	Analyst Purpose/ Short Description of How Used	Notes
1	RX All	Table (exportable to .csv and .xls)	Shows shipping and storage activities, aggregated across all reactors, by year. This is output from one of the four TSL-CALVIN (TSL) reports via the Detailed Output and then the Facility Data buttons.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the TSL Reports submenu. Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
2	RX Detail	Table (exportable to .csv and .xls)	Shows shipping and storage activities, for each reactor, by year. This is output from one of the four CALVIN reports via the Detailed Output and then the Facility Data buttons.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu. Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
3	Shipment Summary	Table (exportable to .csv and .xls)	Shows number of truck and rail shipments of casks between all facilities. Typically used only to get transportation operations model (TOM) results.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
4	Final Inventory Summary	Table (exportable to .csv and .xls)	Shows the final number of dry packages, dry metric tons of heavy metal (MTHM), dry assemblies, wet MTHM, and wet assemblies for each installation.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
5	Final Assembly Disposition	Table (exportable to .csv and .xls)	Shows the DBID, reactor, package, package type, pool, discharge date, metric tons of heavy metal (MTHM), and heat for each assembly.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.

6	Site Shutdown Summary	Table (exportable to .csv and .xls)	Shows, for each reactor, the last discharge date, pool shutdown delay years, if the pool has shut down, and if the pool is empty.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
7	X ISF (e.g., Eastern ISF)	Table (exportable to .csv and .xls)	Shows shipping and storage activities, for this ISF, by year (basically the same as RX_DET). Used to examine cans/casks that are arriving, going into dry storage, coming out of dry storage, and being shipped from the ISF. This form is useful when repackaging is being done at the ISF; that is, the number of cans that arrive can differ from the number going into dry storage if repackaging is done upon ISF receipt (i.e., upon arrival). Similarly, the number coming out of dry storage can be different than the number being shipped if repackaging is being done at ISF shipping (i.e., on the way out the door). This is output from one of the four CALVIN reports via the Detailed Output and then the Facility Data buttons.	To display: Analyst can right-click on any part of a scenario, in the Table of Contents, and choose this report in the Calvin Reports submenu. Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
8	MGR	Table (exportable to .csv and .xls)	Shows shipping and storage activities, for the MGR, by year (basically the same as RX_DET). The activity called "Shipped" is really "disposal" (i.e., "bury it in the ground"). The MGR arrival report isn't typically used in analyses, but it is used sometimes and is good for some error checking. More important, at some point, it will be used a lot. For now, the focus has been on the logistics side (e.g., stuff coming into and going out of the different facilities). This is one of the four CALVIN reports output via the Detailed Output and then the Facility Data buttons.	To display: Analyst can choose it from the Reports->Calvin Reports menu

9	Cask Allocation for X (e.g., Cask Allocation for Zion, or Cask Allocation for All)	Graph/Table (exportable to .csv and .xls)	Shows how many casks were proposed (by the reactor to the planner), allocated (by the planner), and accepted (by the reactor—i.e., shipped). Can be generated for each installation or across all installations. This allows the analyst to determine, modify, and analyze alternative allocation strategies (by looking at the allocation, modifying it, and then running it again).	To display: Analyst can right-click on any part of an installation, in the Table of Contents, and choose this report for that installation. Or, choose Cask Allocation for All in the Scenario Results Reports submenu. Note: This report may need to be modified based on Casey's Macro calculation spreadsheet.
10	Dry Storage Inventory by Reactor	Graph/Table (exportable to .csv and .xls)	Shows the transfer of assemblies, metric tons of heavy metal (MTHM), and casks into dry storage, at a reactor, or out of dry storage. These are some things the system wants to monitor and try to control. For example, one of the alternative allocation strategies focuses on eliminating new dry storage after the ISF is up and running. There are three types for this report: assemblies, MTHM, or casks.	To display: Analyst can right-click on any part of the Table of Contents, and choose any of these reports in the Scenario Results Reports submenu.
10	Allocation Results	Excel file	Provides a workbook with a spreadsheet for each year of the simulation. Each sheet reports the cask allocation at each reactor.	To display: Analyst can right-click on any part of the Table of Contents, and choose this report in the Scenario Results Reports submenu.
11	Resources: Graph Instantaneous Resource Usage	Graph/Table (exportable to .csv and .xls)	Shows how much a resource was being used at a given time and how much of the resource was available during the run. Can be used to determine when a resource was used during the run and how much of the available resource was used.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
12	Resources: Graph Cumulative Resource Usage	Graph/Table (exportable to .csv and .xls)	Shows how much a resource was used over the course of the whole run and how much of the resource was available. Can be used to determine the total usage of the resource at a given time.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
13	Resources: Graph Hourly Resource Requested	Graph/Table (exportable to .csv and .xls)	Shows the amount of a resource requested by hour and the number of resource requests that cannot be filled per hour (number waiting). Can be used to	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).

			determine the demand for a resource at a given time.	
14	Resources: Graph Hourly Resource Usage	Graph/Table (exportable to .csv and .xls)	Shows the amount of a resource that was used per hour. Can be used to determine when the resource was most frequently used.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
15	Resources: Graph Hourly Resource Wait	Graph/Table (exportable to .csv and .xls)	Is similar to the Graph Hourly Resource Requested report, in that it shows when there is more demand for a resource than the amount that is available. Can be used to determine when there is high demand for a resource.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
16	Resources: Graph Daily Resource Requested	Graph/Table (exportable to .csv and .xls)	Is the daily version of Graph Hourly Resource Requested.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
17	Resources: Graph Daily Resource Usage	Graph/Table (exportable to .csv and .xls)	Is the daily version of Graph Hourly Resource Usage.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
18	Resources: Graph Daily Resource Wait	Graph/Table (exportable to .csv and .xls)	Is the daily version of Graph Hourly Resource Wait.	To display: Analyst can right-click on any resource listed in an installation's Resources list, in the Table of Contents, and choose this report (for that installation's resource).
19	Resource Categories: Graph Instantaneous Resource Category Usage	Graph/Table (exportable to .csv and .xls)	Shows the Instantaneous Resource Usage for each resource in the Resource Category on the same graph. Can be used to determine how the resources in a category that were used at a given time compare with one another.	To display: Analyst can right-click on any category listed in an installation's Resource Categories list, in the Table of Contents, and choose this report (for that installation's resource category).

20	Resource Categories: Graph Cumulative Resource Category Usage	Graph/Table (exportable to .csv and .xls)	Shows the Cumulative Resource Usage graph for each resource in the Resource Category on the same graph. Can be used to determine how the resources in a category that were used over the whole scenario compare with one another.	To display: Analyst can right-click on any category listed in an installation's Resource Categories list, in the Table of Contents, and choose this report (for that installation's resource category).
21	Entity Types: Agent Traversal	Table (exportable to .csv and .xls)	Displays information about each task completed by the selected agent, including Wait, Start, Stop, and Traversal times. Can be used to see what tasks were completed by an agent during the run and if the agent was used as a resource.	To display: Analyst can right-click on any entity type listed in an installation's Entity Types list, in the Table of Contents, and choose this report (for that installation's entity type).
22	Entity Types: Agent Traversal Graph	Graph (exportable to gif)	Provides a visual representation of the tasks completed by a selected agent during the run. Shows the plan under which the tasks were completed and the state that the agent was in while doing the task (Agent, Resource, Group, etc.). Can be used to see how the agent stepped through the run.	To display: Analyst can right-click on any entity type listed in an installation's Entity Types list, in the Table of Contents, and choose this report (for that installation's entity type).
23	Entity Types: Agent Timeflow	Timeline/ Calendar/List/ Graph/Table (exportable to .csv and .xls)	Provides a detailed visual representation of the agent's tasks completed during the run. Can be modified by the user to select a category. Can be used to see detailed information about task completion during the run.	To display: Analyst can right-click on any entity type listed in an installation's Entity Types list, in the Table of Contents, and choose this report (for that installation's entity type).
24	Plans Subtype: Agent Traversal for X	Table (exportable to .csv and .xls)	Shows the task traversal times through a plan taken by an agent. Can be used to determine what tasks in the given plan were completed by the agent and when they were completed.	To display: Analyst can right-click on any Plans subtype listed in an installation's Plans list, in the Table of Contents, and choose this report (for that installation's plan subtype).
25	Plans Subtype: Agent Traversal by COA for X	Table (exportable to .csv and .xls)	Shows Processing Wait and Processing Time taken by an agent by task.	To display: Analyst can right-click on any Plans subtype listed in an installation's Plans list, in the Table of Contents, and choose this report (for that installation's plan subtype).

26	Plans Subtype: Agent Traversal Graph by COA for X	Graph (exportable to .gif)	Provides a visual representation of the tasks in the plan that were completed by a selected agent during the run. Shows what state the agent was in for the task (Agent, Resource, Group, etc.). Can be used to see how the agent stepped through the plan.	To display: Analyst can right-click on any Plans subtype listed in an installation's Plans list, in the Table of Contents, and choose this report (for that installation's plan subtype).
27	Plans: Task Duration Report for COA	Table (exportable to .csv and .xls)	Shows the time spent in each task of the COA. Can be used to determine how long the plan was used.	To display: Analyst can right-click on any plan listed in an installation's Plans subtype list, in the Table of Contents, and choose this report (for that installation's plan).
28	Plans: Graph Traversal Time: X	Graph/Table (exportable to .csv and .xls)	Is a bar graph of traversal time through the COA. Shows the number of agents that took X amount of time to complete the COA. Can be used to determine common run times through the COA.	To display: Analyst can right-click on any plan listed in an installation's Plans subtype list, in the Table of Contents, and choose this report (for that installation's plan).
29	Plans: Show Agent Timeline Table: X	Table (exportable to .csv and .xls)	Shows the number of minutes spent on each task by each agent that entered the COA. Can be used to compare task completion times and traversal times of agents.	To display: Analyst can right-click on any plan listed in an installation's Plans subtype list, in the Table of Contents, and choose this report (for that installation's plan).
30	Task: Graph Processing Distribution: X	Graph/Table (exportable to .csv and .xls)	Shows a graph of the Processing time taken by each agent that completed the task. Can be particularly useful for seeing the completion times for tasks with variable Processing times.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
31	Task: Graph Wait Distribution: X	Graph/Table (exportable to .csv and .xls)	Shows a graph of the Wait time for each agent that waited in the task. Can be used to see how many agents waited in the task and how long Wait times were for the task.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
32	Task: Graph Traversal Distribution: X	Graph/Table (exportable to .csv and .xls)	Shows a graph of the Wait time plus Processing time for each agent in the task. Can be used to see how much total time that agents spent on the task.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
33	Task: Graph Traversal and Wait Distribution: X	Graph/Table (exportable to .csv and .xls)	Shows both the Graph Waiting Distribution: X and the Graph Traversal Distribution: X graphs on the same graph. Can be used	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose

			to compare Wait time to total Traversal time.	this report (for that installation's task).
34	Task: Graph Waiting	Graph/Table (exportable to .csv and .xls)	Shows a graph of the number of agents waiting in the task at a given time. Can be used to see how frequently agents were waiting in a task and how many agents remained waiting in the task at the end of the simulation.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
35	Task: Graph Processing	Graph/Table (exportable to .csv and .xls)	Shows a graph of the number of agents processing in a task at a given time. Can be used to see how often agents processed in the task and if any agents were still processing in the task at the end of the simulation.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
36	Task: Graph Completed	Graph/Table (exportable to .csv and .xls)	Shows a graph of the total number of agents that have completed the task at a given time. Can be used to determine how often a task was completed and how many agents completed the task.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
37	Task: Graph All	Graph/Table (exportable to .csv and .xls)	Shows a combination of the Graph Waiting, the Graph Processing, and the Graph Completed graphs on the same graph. Can be useful for comparing the number of agents that are waiting with the number that completed a task and seeing how a task was used throughout the simulation.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
38	Task: Graph All (Cumulative)	Graph/Table (exportable to .csv and .xls)	Shows a cumulative version of the Graph All graph. Can be used to see the cumulative amount of waiting done in a task during the simulation. Can also be used to compare the amount of waiting with the cumulative amount of agents that completed the task.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).

39	Task: Agents Processed Table	Table (exportable to .csv and .xls)	Shows a table with a row for each task completed during the simulation, with each row showing the name and type of agent, if the agent was a resource, and the timing of the agent's traversal. Can be used to see what agents completed the same task multiple times, how long specific agents waited in the task, and when the agents entered and exited the task.	To display: Analyst can right-click on any task listed in an installation's Tasks list, in the Table of Contents, and choose this report (for that installation's task).
40	COA Graph	Graph (exportable to .gif)	Shows the flow of tasks that are involved in the plan.	To display: Analyst can right-click on any Plans subtype listed in an installation's Plans list, in the Table of Contents (for that installation's plan subtype).
41	Transfer Into Dry Storage At Reactor	CSV file, displayed as a table (exportable to .xls)	Custom report: Shows a table of origin site, origin reactor, number of assemblies, metric tons of heavy metal (MTHM), and percent cask by MTHM for each cask being transferred from dry storage to offsite transport at the reactor. Can be generated for each installation or across all installations.	To display: Analyst can right-click on transferIntoDryStorageAtReactor.csv, listed in an installation's Reports list, in the Table of Contents.
42	Transfer Out Of Dry Storage At Reactor	CSV file, displayed as a table (exportable to .xls)	Custom report: Shows a table of origin site, origin reactor, number of assemblies, metric tons of heavy metal (MTHM), and percent cask by MTHM for each cask being transferred from wet to dry storage at the reactor. Can be generated for each installation or across all installations.	To display: Analyst can right-click on transferOutOfDryStorageAtReactor.csv, listed in an installation's Reports list, in the Table of Contents.
43	Transfer From Pool To Offsite Transport At Reactor	CSV file, displayed as a table (exportable to .xls)	Custom report: Shows a table of origin site, origin reactor, number of assemblies, metric tons of heavy metal (MTHM), and percent cask by MTHM for each cask being transferred from the pool to offsite transport at the reactor. Can be generated for each installation or across all installations.	To display: Analyst can right-click on transferFromPoolToOffsiteTransportAtReactor.csv, listed in an installation's Reports list, in the Table of Contents.

44	Allocation At Reactor	CSV file, displayed as a table (exportable to .xls)	Custom report: Shows the allocation type for each cask. Can be generated for each installation or across all installations.	To display: Analyst can right-click on allocationAtReactor.csv, listed in an installation's Reports list, in the Table of Contents.
45	Packed Assembly Zones	CSV file, displayed as a table (exportable to .xls)	Custom report: Shows a table of packed assembly zones, zone slot number, and cask ID for each packed cask. Can be generated for each installation or across all installations.	To display: Analyst can right-click on packedAssemblyZones.csv, listed in an installation's Reports list, in the Table of Contents.
46	Allocation	CSV file, displayed as a table (exportable to .xls)	Shows the current site allocation, cumulative allocation total, current site name, and current site index for planned allocation.	To display: Analyst can right-click on allocation.csv, listed in a Planner installation's Reports list, in the Table of Contents.
47	Transportation Costs	CSV file, displayed as a table (exportable to .xls)	Shows the traversal costs, miles, and days of each leg of each itinerary.	To display: Analyst can right-click on transportationCost.csv, listed in a Transportation installation's Reports list, in the Table of Contents.
48	Ad Hoc/ Custom Reports	CSV file, displayed as a table (exportable to .xls)	User-defined: Shows any available Attributes of any available Tasks (within a scenario).	Custom reports that can be defined for any of a scenario's Tasks. To display: Analyst can right-click on the defined report, listed in an installation's Reports list, in the Table of Contents.
49	Transportation Costs -- Rail	Graph/Table (exportable to .csv and .xls)	Shows various costs related to rail transportation.	To display: Analyst can select the report from the Reports->Scenario Results Reports->Transportation menu
50	Final Railcar Mileage by Railcar	Table (exportable to .csv and .xls)	Shows the miles traveled and number of trips by railcar.	To display: Analyst can select the report from the Reports->Scenario Results Reports->Transportation menu
51	Cumulative Railcar Mileage	Graph/Table (exportable to .csv and .xls)	Shows the cumulative loaded and unloaded miles by railcar.	To display: Analyst can select the report from the Reports->Scenario Results Reports->Transportation menu

52	Transportation Schedule - Unscheduled Casks	Graph/Table (exportable to .csv and .xls)	Displays unscheduled casks for all sites by year.	To display: Analyst can select the report from the Reports->Scenario Results Reports->Transportation menu
53	Transportation Schedule - Unscheduled Casks by Site	Graph/Table (exportable to .csv and .xls)	Displays unscheduled casks for each ISF by year.	To display: Analyst can select the report from the Reports->Scenario Results Reports->Transportation menu
54	Repackaging	Table (exportable to .csv and .xls)	Displays repackaging values by year/activity.	To display: Analyst can select the report from the Reports->Calvin Reports menu
55	Summary Info: Pools	Table (exportable to .csv and .xls)	Displays first and last shipment, discharge and dry storage dates for each pool.	To display: Analyst can select the report from the Reports->Calvin Reports menu
56	Summary Info: Reactor Units	Table (exportable to .csv and .xls)	Displays first and last discharge dates for each reactor.	To display: Analyst can select the report from the Reports->Calvin Reports menu
57	Summary Info: Sites	Table (exportable to .csv and .xls)	Summarizes activity at each site including: first and last discharge dates, first and last shipment dates from pool and dry storage, first and last shipments from site, first and last dry storage dates, years with fuel on site and the delay in years for pool shutdown.	To display: Analyst can select the report from the Reports->Calvin Reports menu

Appendix B Transportation

Overview

The NGSAM transportation logic integrates the Java Transportation Operations Model (JTOM) into NGSAM. The allocation logic of NGSAM generates input to JTOM consisting of requests that transportation be provided to transport the SNF that has been allocated. After JTOM has been run, NGSAM uses the output from JTOM to control the formation and scheduling of trains within the simulation.

Transportation in the simulation is modeled using the concept of an *itinerary* that consists of one or more *legs*. A leg represents travel from one physical location to another physical location. For example, traveling from a reactor to an intermediate storage facility (ISF) is one leg of travel. Travel from a railcar maintenance facility to a reactor is another leg of travel. An itinerary is a list of legs that transportation assets must execute in sequence, allowing for some processing time at each facility that is visited along the itinerary. Most itineraries are organized around some objective of SNF transportation. For example, in order to achieve the objective of picking up SNF from a reactor and bringing it to an ISF, a train might travel empty from the railcar maintenance facility to the reactor (the first leg), pick up the SNF at the reactor (processing after the first leg), travel loaded from the reactor to the ISF (the second leg), drop off the SNF at the reactor (processing after the second leg), travel empty back to the railcar maintenance facility (the third leg), and undergo railcar maintenance (processing after the third leg). Since JTOM models train travel as trips originating at and returning to the railcar maintenance facility, itineraries typically have two or three legs, depending on whether the railcar maintenance facility is co-located with the ISF.

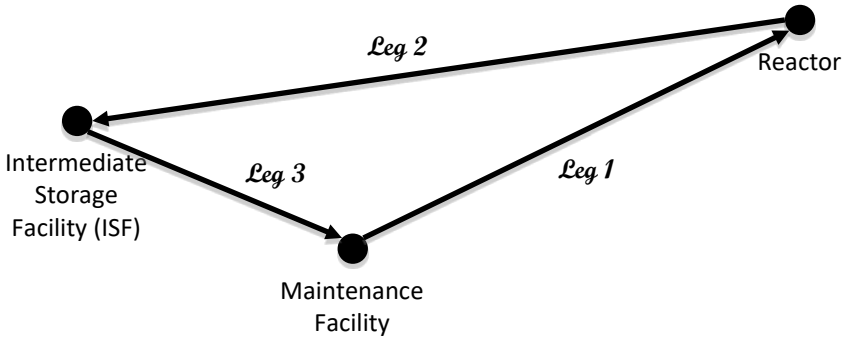


Figure 46 A typical Itinerary

An itinerary in NGSAM is responsible for managing its legs and for obtaining transportation assets. For instance, an itinerary for a three-cask-railcar train has the responsibility of obtaining three cask railcars and assembling them into a train. NGSAM does not explicitly model the movement of escort and buffer cars. The escort cars and buffer cars are passed to JTOM, and accounted for in the scheduling, but in the NGSAM model itself it is implicit that each assembled train includes the escort and buffer cars that it needs. After obtaining and assembling transportation assets, the itinerary manages handing off control of the transportation asset group to each leg in turn until all legs of travel are completed.

Itinerary legs are responsible for receiving a transportation asset group, such as a train, when it is handed off from an itinerary. After receiving the handoff, the leg is responsible for communicating with the asset group and sending the asset group from the leg's origin – which should be the current location of the asset group – to the leg's destination. When the transportation asset group has completed whatever processing

is necessary at the leg's destination, the itinerary itself regains control of the transportation assets and manages handing them off to the next leg, if any, or disassembles the transportation asset group into individual transportation assets if there are no more legs.

Scheduling (JTOM Integration)

The transportation scheduling logic appears in the Transportation installation under Plans->Scheduling. Transportation scheduling is initiated at the beginning of a simulation by a JTOMInitializer entity that is generated using a generator in the Transportation installation. The JTOMInitializer resets JTOM, preparing it for use in the current scenario. The task responsible for this is in the Init JTOM course of action in the Scheduling plan. It calls the Java method TransportationManager#reset.

Each transportation scheduling period, a round of transportation scheduling is initiated by a TransportationInit agent sent from the allocation process in the planner. This agent completes the tasks in the Initialization course of action in the Scheduling plan, calling the Java method TransportationManager#initialize and creating TransportationRequestProcessingSlot resources to pave the way for transportation requests from specific reactor sites.

Each reactor site as well as, in some cases, the monitored geologic repository (MGR) sends a TransportationRequest agent to the Transportation installation. These requests are handled by the Request Reception course of action in the Scheduling plan. Each request is recorded as input to JTOM by calling the Java method TransportationManager#addTransportationRequest. Each request that is recorded uses up a TransportationRequestProcessingSlot. When the resources run out, the Schedule Transportation task adds the last transportation request of the transportation scheduling period to JTOM and calls the Java method TransportationManager#executeForPeriod. This Java method tells JTOM to find a transportation solution for the current period that fulfills transportation requests that were added in the scheduling period. Then it reads the trips that JTOM chooses and converts them into Itinerary and Leg agents, scheduling those agents to appear in the transportation installation at the proper time.

Railcars and Trains

The number of cask cars, buffer cars, and escort cars in a scenario is defined as input in the unf-vehicles.csv file in the scenario input directory. The NGSAM GUI launches Excel to edit this file when the user clicks on Edit->Vehicles. In the scenario logic, the first time that the Java method TransportationManager#initialize is called, the unf-vehicles.csv file is read, and a VehicleGenerator agent is created that will execute the GenerateVehicles course of action in the VehicleGeneration plan. This plan creates Railcar agents that represent empty cask cars.

When cask cars are created and initialized, they become individual empty railcars that are available to become part of a train and complete an itinerary. A cask car in this state is an AvailableRailcar resource in the simulation. An itinerary that requires a train will acquire enough AvailableRailcar resources to form the train that it needs and will direct those railcars to become a train. After a train has completed an itinerary, the itinerary directs to train to disassemble itself. After the train has disassembled the cask cars once again become AvailableRailcar resources.

When a train is assembled in the NGSAM model, it does not know which installation it should go to. In order to communicate with a leg of the itinerary and receive direction on where to go, the train becomes an AssignableTransportation resource. The first leg of the itinerary uses the AssignableTransportation resource and tells the newly assembled train where it should go and all of the other trip details, such as the costs of the transportation. Each time that the train completes a leg and the processing at the destination of the leg, it returns to the Transportation installation and again becomes an AssignableTransportation

resource. As long as there is another leg in the itinerary, the next leg will update the train's transportation details, including telling it what the next destination is. After the last leg of the itinerary is complete, the itinerary itself will communicate with the train and instruct it to disassemble.

To run JTOM in acquisition mode (i.e. the simulation only buys the number of railcars it needs), edit the unf-vehicles.csv file from the Edit->Vehicles menu and set the numeric values to 0 and unconstrained to true.

Appendix C Allocation and Acceptance

Overview

NGSAM's allocation and acceptance process, often referred to as merely the *allocation process* in this document, controls decisions about which waste packages will be shipped from which reactor sites to which ISFs. In NGSAM, the allocation process runs at the beginning of each simulation year. It is initiated in and managed in the scenario's Planner installation but involves communication between installations.

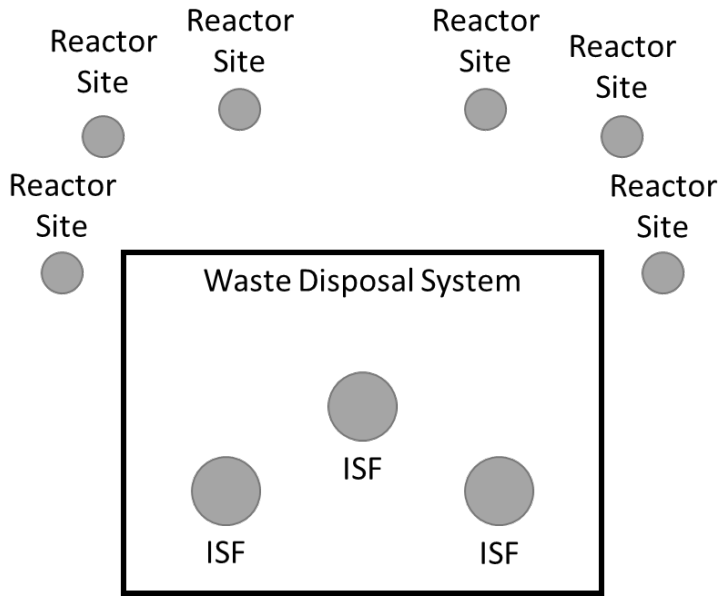


Figure 47 Allocation and Acceptance

The allocation process distinguishes between the Integrated Waste Management Systems (IWMS) as a whole and sites with the IWMS. In the current version of NGSAM, the only type of IWMS site included in the allocation process is an interim storage facility (ISF), and there can be up to three ISFs. The allocation process can model three different types of constraints related to the IWMS and its sites: package type constraints, rate constraints, and capacity constraints. Package type constraints can limit which types of waste packages a site within the IWMS can receive. Rate constraints can limit the number of canisters that a site within the IWMS or the IWMS as a whole can receive during a simulation year. Capacity constraints can limit the number of waste packages that an IWMS site may have in its inventory. Users define the applicable constraints and can change the constraint that applies each simulation year.

The allocation process had two components. The first component is an inventory component that can query the reactor sites to determine which assemblies have been discharged at the reactor site and remain in the inventory of the reactor site. The second component is an allocation negotiation component that queries the reactor sites to determine whether they can provide waste packages that satisfy various constraints.

The current version of NGSAM supports only one allocation algorithm. At the core, that algorithm is an oldest fuel first (OFF) allocation algorithm. In this algorithm, oldest fuel means the oldest assembly, that is, the assembly that was discharged from its reactor longest ago. Using the inventory component to determine which assemblies are discharged each year, the algorithm keeps a record of which assemblies would be in the inventory of each reactor site if the site had sent its oldest assemblies each time that it

shipped a package. This record, called the *OFF assumed inventory*, rarely agrees with the actual inventory; however, the algorithm uses the record to determine the oldest remaining assembly that each site would have on hand if all sites had been shipping their oldest assemblies each time they sent a shipment. Unless a user-specified site allocation overrides it, the algorithm gives the highest priority for allocating a waste package to the site that would have the oldest assembly according to the OFF assumed inventory.

The allocation algorithm uses the allocation negotiation component to negotiate with one reactor site at a time, determining whether that reactor site can provide a waste package that satisfies the current package type, rate, and capacity constraints. If the queried reactor site can provide a package, the allocation algorithm will choose which IWMS site will receive that package. Then it will update the constraints for that site and for the IWMS as a whole, reducing the remaining number of canisters that can be received and, if the site has reached its capacity or rate limit, updating the types of packages that the system is capable of receiving. If the queried reactor site cannot provide a waste package that satisfies current constraints, the allocation algorithm moves to the reactor site with the next highest priority and negotiates with that reactor site to determine whether that reactor site can provide a waste package that satisfies the constraints. This process continues until the system cannot receive any more packages or until no reactor site can provide a package that satisfies the package type constraints of the IWMS sites that have remaining rate and capacity.

In cases where the user has specified which reactor sites the allocation algorithm should use, the allocation algorithm negotiates with reactor sites in the order that the user has specified for the number of packages that the user has specified, skipping over sites when those sites cannot provide any more waste packages that satisfies the current constraints. The algorithm continues to maintain the OFF assumed inventory while negotiating the user-specified site allocation. If there is capacity remaining after user-specified site allocation has been completed, the algorithm will continue to allocate waste packages if possible, giving priority to sites according to the age of the oldest assembly that would remain at each reactor site according to the OFF assumed inventory.

Constraint Definition and Interpretation

The user-defined package type constraints, rate constraints, and capacity constraints are stored in a file named constraints.csv in the scenario directory. Users can access the file with the Edit->Allocation Constraints menu item. Users may also navigate to this file in the file system and edit it directly.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Year	Site	Constraint	Constraint	ConstraintValue														
2	2021	ISF 2	PkgType	L	MPC-24|MPC-24EEF|MPC-32|MPC-32F|MPC-37|MPC-68|MPC-68F (HI-STORM)|MPC-68FF|MPC-68M|MPC-89|MPC-HB|MPC24E|MPC24EF														
3	2021	ISF 2	Rate	C	10														
4	2021	ISF 2	Capacity	C	300														
5	2021	ISF 3	PkgType	L	NUHOMS FC-DSC|NUHOMS FF-DSC|NUHOMS FO-DSC|NUHOMS 24PT1|NUHOMS-61BT|NUHOMS-61BTH-Generic|NUHOMS 61BTH Type1|Yankee-MPC|CY-MPC26|T														
6	2021	ISF 3	Rate	C	10														
7	2021	ISF 3	Capacity	C	400														
8	2021	System	Rate	C	40														
9	2027	ISF 2	Rate	C	30														
10	2027	ISF 2	Capacity	C	600														
11	2027	ISF 3	Rate	C	30														
12	2040	Eastern ISI	PkgType	C	All														
13	2040	Eastern ISI	Rate	C	10														
14	2040	Eastern ISI	Capacity	U															
15																			

Figure 48 Example Constraints file as accessed via the Edit->Allocation Constraints Menu

The file contains five columns, named Year, Site, ConstraintCategory, ConstraintType, and ConstraintValue.

The “Year” column defines which year the constraint will take effect or change from its previous value, and the “Site” column defines which IWMS site the constraint applies to. Currently, valid values for the

"Site" column are "ISF 2", "ISF 3", "Eastern ISF", and "System". A value of "System" indicates that the constraint applies to the IWMS as a whole.
The "ConstraintCategory" column defines which category of constraint is defined in the remaining columns. Valid values are "PkgType", indicating a package type constraint, "Rate", indicating a rate constraint, and "Capacity", indicating a capacity constraint. At the level of the IWMS as a whole, the only valid constraint category is "Rate".

For rate constraints and capacity constraints, the value in the "ConstraintType" column must be either "U", which means unconstrained, or "C", which stands for constrained. If the value is "U", then any entry in the "ConstraintValue" column is ignored, and the capacity will be unconstrained. If the value is "C", then the "ConstraintValue" must contain an integer, which will be interpreted as a number of canisters. If the capacity at an IWMS site is constrained, the allocation process will check the inventory of that site at the beginning of the year, and the number of canisters sent to the site that year will not exceed the difference between the defined capacity constraint and its current inventory. This is enforced even if the IWMS site is planning to decrease its inventory during the year by sending waste packages to other IWMS sites. Although the capacity constraint at an IWMS site can change between years, the current implementation does not support decreasing the constraint. If the constraints input file defines a row that would decrease the capacity or make it a constrained capacity after it was previously set to unconstrained, that row of the constraints input file will be ignored.

If the capacity at a IWMS site or for the IWMS system as a whole is constrained, the allocation process will ensure that the number of canisters shipped from any source to that site or, for the system constraint, from reactor sites to any IWMS site within the system, does not exceed the number of canisters defined in the rate constraint.

For package type constraints, the value in the "ConstraintType" column must be either "L", which stands for list, or "C" which stands for category. If the value is "C", the "ConstraintValue" column must contain a value that identifies a category of package types. The only category supported in the current NGSAM implementation is the category "All", which is a convenient way to say that an IWMS site can accept any type of waste package. When the value in the "ConstraintType" column is "C", the "ConstraintValue" column must contain a list of canister model identifiers – basically names of canister types – separated by the vertical bar "|".

For package type constraints that give a list of package types, the allocation process will ensure that all packages shipped to the site where the constraint applies will be waste packages that have a canister model that matches one of the values in the list.

Constraints that are defined to apply in one year will apply to each subsequent year unless and until a year is reached where the user has defined a change to the constraint.

Here is the sample content of a constraints.csv file.

Year	Site	ConstraintCategory	ConstraintType	ConstraintValue
2021	ISF 2	PkgType	L	MPC-24|MPC-24EEF|MPC-32
2021	ISF 2	Rate	C	10
2021	ISF 2	Capacity	C	300
2021	ISF 3	PkgType	L	NUHOMS FC-DSC|NUHOMS FF-DSC
2021	ISF 3	Rate	C	10
2021	ISF 3	Capacity	C	400
2021	System	Rate	C	40

2027	ISF 2	Rate	C	30
2027	ISF 2	Capacity	C	600
2027	ISF 3	Rate	C	30
2040	Eastern ISF	PkgType	C	All
2040	Eastern ISF	Rate	C	10
2040	Eastern ISF	Capacity	U	

This sample input does not make much sense for use in an actual scenario, but it does illustrate most of the possible values that are supported in NGSAM.
There may be some features of the CSV format that are not supported in the current implementation of NGSAM when reading a constraints file; however, editing the file in Excel, as is the default editor when launching the editor for the constraints from the NGSAM interface, should work fine as long as the proper format for the constraints is observed. NOTE: Care should be taken when deleting lines in the file to ensure that the line is completely gone.

IWMS Site Choice

During the negotiation with a reactor site, the overview states that the allocation algorithm chooses which IWMS site will receive a package from a reactor site. This section gives a little more detail about how that IWMS site is chosen and what the user can do to influence that choice.

The IWMS sites are organized into allocation priority tiers. In the current implementation, the priority tiers apply to only ISFs, and the priority tier of an ISF is defined by the isfAllocPriorityTier attribute of the ISFDbDataAgent generated at the ISF. Lower numbers indicate higher priority, so the default scenario settings, which give a value of 1 to ISF 2 and ISF 3 and a value of 2 to Eastern ISF mean that ISF 2 and ISF 3 will be preferred over the Eastern ISF.

The negotiation process includes an allocation query for each allocation priority tier. If a package can be provided for a higher allocation priority tier, lower allocation priority tiers will not be attempted. Thus with the default scenario settings, the allocation algorithm will first ask a reactor site if it can provide a package that could be sent to either of ISF 2 or ISF 3. If that is impossible, then the allocation algorithm will follow up by asking whether the reactor site can provide a waste package that could be sent to Eastern ISF. If that is also impossible, then the negotiation is complete and the allocation will continue with the next reactor site, if any.

When there are multiple IWMS sites within the same allocation priority tier, the allocation algorithm has more flexibility in choosing which site will receive a waste package. In the current implementation, the algorithm first checks the site constraints to determine which of the sites can actually receive the waste package according to package type constraints, site rate constraints, and site capacity constraints. If there are multiple such sites, the current implementation makes the choice in a style that approximates a round robin choice, selecting the IWMS site which has least recently been allocated a waste package.

User-Defined Site Allocation

The user-defined site allocation is stored in a file named AllocationPriority.xlsx in the scenario directory. Users can access the file with the **Edit->Allocation Priority** menu item. Users may also navigate to this file in the file system and edit it directly.

The Excel workbook may contain multiple worksheets. The name of the worksheet indicates the year that the data from that worksheet will begin to apply. The data from that year will apply to any subsequent

years that do not have a worksheet in the Excel workbook. Each worksheet should have two columns named “Site” and “Site Allocation (Casks)”.

The “Site” column defines a reactor site to which the allocation process should allocate packages. The “Site Allocation (Casks)” defines the number of canisters that the allocation process should allocate to that site at that point during the allocation process. The site name must be an exact match for the name of reactor site installation in the NGSAM scenario. The allocation process will work from the top of the worksheet down to the bottom of the worksheet. A site may appear in multiple rows in the spreadsheet; the allocation process will attempt to allocate to the site each time that it appears.

If an analyst desires pure oldest fuel first allocation, the appropriate input, which is the default input for the USFleet scenario, is a workbook with a single spreadsheet that is blank except for the column headers. NGSAM writes out an allocation results file that matches the format of the allocation input file. This file, named AllocationResults.xlsx is written to the output directory that contains the other results of the NGSAM model run. Users can access it using the **Reports->Scenario Results Reports->Allocation Results** menu item. This file can be saved and tweaked to provide input to a subsequent model run and get similar but slightly different allocation.

Appendix D Glossary

- **Acceptance** – The stage at which spent nuclear fuel or high-level radioactive waste has been prepared for transportation by a waste generator and accepted for transportation in the waste management system. Traditionally, *acceptance* specifically implies a transfer of ownership from the generator to the disposing agency.
- **Acceptance Approach** – The approach waste generators use (i.e., oldest fuel first [OFF] or youngest fuel first [YFF]) to prioritize acceptance of spent nuclear fuel or high-level radioactive waste into the waste management system.
- **ALARA (as low as reasonably achievable)** – A radiation safety principle to minimize radiation doses by employing the methods of time, distance, or shielding. As defined in Title 10, Section 20.1003, of the Code of Federal Regulations, implementing the ALARA principle means that every reasonable effort is being made to maintain exposures to ionizing radiation as far below the dose limits as practical. This practice is consistent with the purpose for which the licensed activity is undertaken, taking into account (1) the state of the technology being used, (2) the economics of improvements in relation to the state of technology, (3) the economics of improvements in relation to benefits to the public's health and safety, (4) other societal and socioeconomic considerations, and (5) use of nuclear energy and licensed materials in accordance with the public interest.
- **Allocation** – The amount of spent nuclear fuel or high-level radioactive waste that a waste generator is allotted to have received into the waste management system. Allocation determines (1) which waste generators ship spent nuclear fuel or high-level radioactive waste, and (2) how much material is to be shipped from each waste generator or custodian in a given year.
- **Allocation Priority** – The approach used to define allocation. Allocation priority for commercial spent nuclear fuel is defined by the Standard Contract as oldest fuel first (OFF).
- **Argonne National Laboratory (ANL)** – National laboratory and contributor to the Nuclear Fuels Storage and Transportation Planning Project located in Lemont, Illinois.
- **Assembly** – see *fuel assembly*.
- **Bare Fuel Cask** – see *cask*.
- **Boiling Water Reactor (BWR)** – A light water moderated and cooled nuclear power reactor design in which water flows upward through the core, where it is heated by fission and allowed to boil in the reactor vessel. The resulting steam then drives turbines, which activate generators to produce electrical power. BWR assemblies are generally smaller (both in mass and number of rods) than pressurized water reactor assemblies.
- **Boiling Water Reactor (BWR) Assembly** – A nuclear fuel assembly used in a boiling water reactor. (See *fuel assembly*.)
- **Bolted Closure** – A method for closing and sealing a cask in which bolts are used to retain a lid; a metallic or elastomeric o-ring provides a seal between the body of the container and its lid. This type of closure is typically used on casks designed for reuse.
- **Buffer Car** – A rail car used to separate other rail cars transporting spent nuclear fuel from positions on the train occupied by personnel.
- **Burnup** – The degree to which the uranium in nuclear fuel has been consumed. Burnup is measured as the energy released by a spent nuclear fuel assembly divided by the mass of uranium initially loaded into the fuel assembly. Burnup is measured as either gigawatt-days per metric ton of initial uranium (GWd/MTU) or gigawatt-days per metric ton of initial heavy metal

(GWd/MTHM). The two measures are identical for spent nuclear fuel generated by the current fleet of US commercial nuclear reactors since they are all fueled solely by uranium rather than plutonium or other heavy metals.

- **Canister** – A welded metal enclosure that typically holds multiple spent nuclear fuel assemblies. The canister contains a basket that provides a metal lattice to hold the assemblies in place. Unlike casks, canisters are typically placed inside overpacks to ensure the necessary shielding, containment, and physical protection for storage, transportation, and disposal functions. Canisters are licensed either for storage only or for storage and transportation. No canisters are currently licensed for storage, transportation, and disposal.
- **Cask** – A thick-walled, bolted enclosure that holds multiple spent nuclear fuel assemblies that provides shielding and does not require the use of an overpack. The three primary types of casks are storage casks, transportation casks, and those licensed for both storage and transportation. No casks are currently licensed for storage, transportation, and disposal.
- **Cask Transporter** – Heavy machinery that lifts and moves casks (or canisters in transfer overpacks) between storage pads, marshalling yards, fuel handling buildings, or spent fuel pool buildings. Vertical and horizontal variations exist for the different canister systems.
- **Centralized Used Fuel Resource for Information Exchange (CURIE)** – Website that provides usable, collaborative document and data access, serving as a national resource for industry, vendor, federal, and laboratory partners.
- **Certificate of Compliance (CoC)** – The document issued by the US Nuclear Regulatory Commission (NRC) indicating that an item meets all applicable regulations and can legally be used for its proposed purpose. The CoC for a cask contains technical requirements and operating conditions for a specific cask design, and it specifies what the licensee is authorized to store in the cask system.
- **Civilian Radioactive Waste Management System (CRWMS) Analysis and Logistics Visually Interactive (CALVIN)** – Part of the Transportation-Storage Logistics (TSL) software that models packaging, storage and repackaging of spent nuclear fuel at all facilities. CALVIN establishes schedules for shipments between facilities that are entered into the Transportation Operations Model (TOM) software.
- **Consist** – A collection of railroad assets used for transportation of spent nuclear fuel or high-level radioactive waste. A complete consist typically includes an engine/locomotives, buffer cars, cask cars (for holding SNF casks or canisters in overpacks), and an escort car.
- **Damaged Fuel Can** – A thin-walled container for damaged fuel assemblies providing ventilated gross confinement of the fuel so that air, helium, or water can flow in and out. The can is only slightly larger than the fuel assembly to allow for handling, transportation, and storage similar to that for an undamaged assembly.
- **Disposal Overpack** – An overpack used to contain a canister so that it meets the requirements of a specific geologic disposal concept.
- **Dry Storage** – Storage of spent nuclear fuel outside the spent fuel pool (i.e., not in water), typically with spent nuclear fuel in a storage cask on a concrete pad or in a canister inside a storage overpack or horizontal storage module on a concrete pad. Several dry storage system concepts have been designed, including underground silos and above- or below-ground vaults. (See *storage overpack* and *storage cask* for more information.)

- **Dual Purpose Canister (DPC)** – A spent nuclear fuel canister that can be used for (1) storage inside a storage overpack, (2) transportation in a transportation overpack, or (3) dry storage loading operations with a transfer overpack.
- **Dual Purpose Cask** – A cask that can be used for transportation and storage of spent nuclear fuel.
- **Escort Car** – A car at the end of a convoy that is used for transporting personnel and equipment not involved with operating the train.
- **Execution Strategy Analysis (ESA) Tool** – A tool used for ongoing performance assessment of the evolving project plan/strategy, accounting for significant assumptions, risks, and uncertainties throughout the project life cycle. The ESA tool models institutional and management decisions rather than physical systems.
- **Fiscal Year (FY)** – A period ranging from October 1 of the prior year to September 30 of the current year. (For example, FY16 is from October 1, 2015 through September 30, 2016.)
- **Fuel Assembly** – A group of fuel rods, guide tubes, fuel rod spacers, and upper/lower end fittings for use in a nuclear reactor. The fuel rods in the assembly are bundled so that the entire collection can be moved as a single physical unit.
- **Fuel Cycle Research and Development (FCRD) Program** – A program within the US Department of Energy's Office of Nuclear Energy whose mission is to conduct research and development for sustainable fuel cycles as described in the Nuclear Energy Research and Development Roadmap.
- **Fuel Rod** – A long slender metal tube (typically made of Zircaloy) containing uranium dioxide fuel pellets; fuel rods are grouped together as fuel assemblies.
- **Greater-than-class C Low-level Radioactive Waste (GTCC LLW or GTCC)** – Waste in which the concentration of radionuclides exceeds the limits for class C low-level radioactive waste as established by the US Nuclear Regulatory Commission in 10 Code of Federal Regulations 61.55, "Waste Classification."
- **High-burnup Fuel** – Fuel with a burnup over the threshold of 45 GWd/MTHM as defined by the US Nuclear Regulatory Commission.
- **High-level Radioactive Waste (HLW)** – Highly radioactive waste material produced as a byproduct of reactions occurring inside nuclear reactors; HLW takes on two forms: (1) spent (used) reactor fuel that has been accepted for disposal, or (2) waste materials remaining after spent fuel is reprocessed.
- **Horizontal Storage Module** – A ventilated concrete structure used to store a canister in the horizontal orientation at an independent spent fuel storage installation or an interim storage facility.
- **Idaho National Laboratory (INL)** – National laboratory and contributor to the Nuclear Fuels Storage and Transportation Planning Project located in Idaho Falls, Idaho.
- **Impact Limiter** – A device made of energy-absorbing material (e.g., wood, foam, aluminum honeycomb) that reduces the acceleration of a transportation package during the impact of an accident. For some transportation packages, impact limiters provide thermal protection.
- **Independent Spent Fuel Storage Installation (ISFSI)** – A facility designed and constructed by a reactor site operator for the interim storage of spent nuclear fuel, solid reactor–related greater-

than-class-C waste, and other radioactive materials associated with spent nuclear fuel and reactor-related greater-than-class-C waste storage.

- **Interim Storage Facility (ISF)** – A centrally located facility, most likely away from a reactor's independent spent fuel storage installation, for temporarily storage of spent nuclear fuel from across the US reactor fleet. Spent nuclear fuel assemblies can be shipped from reactor sites to an ISF, stored, and ultimately shipped to a repository for final disposal.
- **Low-level Radioactive Waste (LLW)** – Nuclear waste that is not intermediate-level waste, high-level waste, spent nuclear fuel, or transuranic waste.
- **Metric Ton of Heavy Metal (MTHM)** – Unit of measure commonly used for the mass of spent nuclear fuel. (Note that a metric ton is 1,000 kilograms.)
- **Metric Ton of Uranium (MTU)** – Unit of measure commonly used for the mass of spent nuclear fuel. MTU is identical to *metric ton of heavy metal* for spent nuclear fuel generated by the current fleet of US commercial nuclear reactors since they are all fueled solely by uranium rather than plutonium or other heavy metals.
- **Mined Geological Repository (MGR)** – Location for final disposal of spent nuclear fuel and/or high-level radioactive waste. An MGR facility combines the waste form, waste package, engineered seals, and natural barriers to provide a high-level of long-term isolation and containment for spent nuclear fuel and/or high-level radioactive waste.
- **Next-Generation System Analysis Model (NGSAM)** – An advanced, agent-based system-level tool being developed to replace the Transportation-Storage Logistics (TSL) tool. NGSAM will be able to simulate scenarios for managing SNF, and it will support evaluation of several back-end SNF management scenarios for at-reactor storage, storage at an interim storage facility, and ultimate disposal using concepts specific to different geologic settings.
- **Integrated Waste Management (IWM) – formerly known as Nuclear Fuels Storage and Transportation Planning Project (NFST)** – An organization within the US Department of Energy Office of Nuclear Energy that is working to identify, plan, and conduct the activities required to achieve the Administration's Strategy milestones for interim storage and supporting transportation.
- **Nuclear Waste Policy Act (NWPA)** – A US Federal law that established a comprehensive national program for the safe, permanent disposal of high-level radioactive waste and spent nuclear fuel.
- **Oak Ridge National Laboratory (ORNL)** – National laboratory and contributor to the Nuclear Fuels Storage and Transportation Planning Project located in Oak Ridge, Tennessee.
- **Oldest Fuel First (OFF):**

  1. A commercial spent nuclear fuel priority approach in which the allocation queue is established based the oldest spent fuel discharged from a nuclear reactor having highest priority.

  2. A commercial spent fuel acceptance approach where the oldest spent fuel residing at a reactor has the highest priority to be received by the waste management system.

- **Overpack** – A thick container for canisters holding spent nuclear fuel. The overpack provides additional shielding and confinement to the canister. Each overpack is specific to the type of canister and its purpose (storage, transportation, or transfer).
- **Packaging:**

1. The process of loading a canister or cask with spent nuclear fuel assemblies from a spent fuel pool or a bare fuel cask (see *repackaging* for further information).
2. The container in which radioactive material is to be placed for transportation.

- **Pressurized Water Reactor (PWR)** – A light water moderated and cooled nuclear power reactor design in which very pure water is heated to a very high temperature by fission and kept under high pressure to prevent boiling. The water is then used to make to steam from another stream of water inside a steam generator. The resulting steam is used to drive turbines which activate generators to produce electrical power. PWR assemblies are generally larger (both in mass and number of rods) than boiling water reactor (BWR) assemblies.
- **Pressurized Water Reactor (PWR) Assembly** – A nuclear fuel assembly used in a pressurized water reactor. (See *fuel assembly.*).
- **Receipt** – The receiving of spent nuclear fuel at an interim storage facility or a repository.
- **Repackaging** – Loading a canister or cask with spent nuclear fuel assemblies after cutting open a welded canister.
- **Sandia National Laboratory (SNL)** – National laboratory and contributor to the Nuclear Fuels Storage and Transportation Planning Project located in Albuquerque, New Mexico.
- **Savannah River National Laboratory (SRNL)** – National laboratory and contributor to the Nuclear Fuels Storage and Transportation Planning Project located in Savannah River, South Carolina.
- **Site-specific Allocation (SSA)** – Alternative allocation priority strategies for commercial spent nuclear fuel that are based on a reactor's site conditions rather than the age of the spent nuclear fuel.
- **Spent Fuel Pool (SFP)** – Storage pools for spent nuclear fuel from nuclear reactors. SFPs are robust constructions made of reinforced concrete several feet thick with steel liners, and the water is typically about 40 feet deep and serves to shield the radiation and cool the spent nuclear fuel.
- **Spent Nuclear Fuel (SNF)** – Nuclear fuel (including fuel rods and fuel assemblies) that has been irradiated in a nuclear reactor.
- **Stack-up** – The process of transferring a canister into a vertical storage overpack by stacking a transfer overpack on a vertical storage overpack with a mating adapter in between. The mating adapter is used to remove the bottom lid of the transfer overpack, and the canister is transferred between the two overpacks.
- **Stakeholder Tool for Assessing Radioactive Transportation (START)** – A web-based decision support tool developed by the US Department of Energy as part of the Nuclear Fuels Storage and Transportation Planning Project for the purpose of evaluating routing options associated with the transportation of radioactive shipments.
- **Standard Contract** – A contractual agreement between the US Department of Energy and the utility operators of the reactor fleet that specifies the obligations and liabilities for the management of spent nuclear fuel and high-level radioactive waste under the Nuclear Waste Policy Act.
- **Standardized Canister** – A canister restricted to a standard set of designs that can be used for transportation, storage, and disposal when used in conjunction with the appropriate overpacks. (See *triple purpose canister*.)

- **Storage and Transportation Canister** – A canister licensed for both storage and transportation. (See *canister*.)
- **Storage and Transportation Cask (Dual Purpose Cask)** – A cask licensed for both storage and transportation. (See *cask*.)
- **Storage Canister** – A canister used specifically for storage of spent nuclear fuel. (See *canister*.)
- **Storage Cask** – A cask used specifically for storage of SNF. (See *cask*.)
- **Storage Overpack** – An overpack used for the storage of a spent nuclear fuel canister that provides shielding for the canister and ventilation to allow for cooling the fuel in the canister. Vertical storage systems and horizontal storage modules are the most prevalent storage overpack systems. Vertical storage systems store canisters upright so that they are taller and have a smaller footprint. Horizontal storage modules store canisters on their side so that they are shorter and have a larger footprint. Storage overpacks are typically reinforced concrete structures.
- **Storage Package** – A storage cask or canister in a storage overpack a container (separable or not) that holds spent nuclear fuel, provides shielding and containment, and allows for the cooling of the spent nuclear fuel in a dry storage configuration.
- **Thermal Limit** – Thermal limit refers to the regulatory thermal load limit allowed by a specific canister system design. Typically, there are separate limits for storage and transportation.
- **Transfer Cask** – A bolted-lid metal cask with lifting trunnions to provide for engagement with other components (cask transporter or handling crane lift yoke) used to provide temporary shielding and structural protection for a spent nuclear fuel canister during fuel loading into an spent fuel pool and during transfer of the loaded canister to or from the storage overpack or transport cask. (See *cask*.)
- **Transfer Overpack** – An overpack used to load and then transfer a canister from the spent fuel pool to dry storage. The transfer overpack provides shielding to reduce worker doses to levels that are as low as reasonably achievable (ALARA).
- **Transportation Cask** – A cask with bolted closures that is used specifically for transportation of spent nuclear fuel and that is typically designed for reuse. (See *cask* for more information.)
- **Transportation Operations Model (TOM)** – A component of the Transportation, Storage, and Logistics tool which assists the analyst in planning and evaluating scenarios for the transportation and storage of spent nuclear fuel. TOM provides detailed modeling of the transportation of spent nuclear fuel and the assets needed for transportation.
- **Transportation Overpack** – An overpack used for the transportation of a spent nuclear fuel canister. The transportation overpack provides shielding and containment of the fuel. The canister and its overpack are typically transported horizontally. Impact limiters are added to the ends of the overpack prior to transportation in order to protect the overpack, the canister, and the fuel in case of a transportation impact incident or drop of the container assembly.
- **Transportation Package** – The SNF and its packaging for the purpose of transportation: typically, a transportation cask with SNF or a canister with SNF in a transportation overpack, and the associated impact limiters. Effectively, it is the SNF and the container that holds SNF and provides shielding, containment, and physical protection of SNF throughout the transportation process.
- **Transportation-Storage Logistics (TSL)** – A system-level software tool for simulating scenarios for managing spent nuclear fuel and a range of back-end SNF management scenario

involving at-reactor storage, storage at an interim storage facility, and ultimate disposal using concepts specific to different geologic settings.

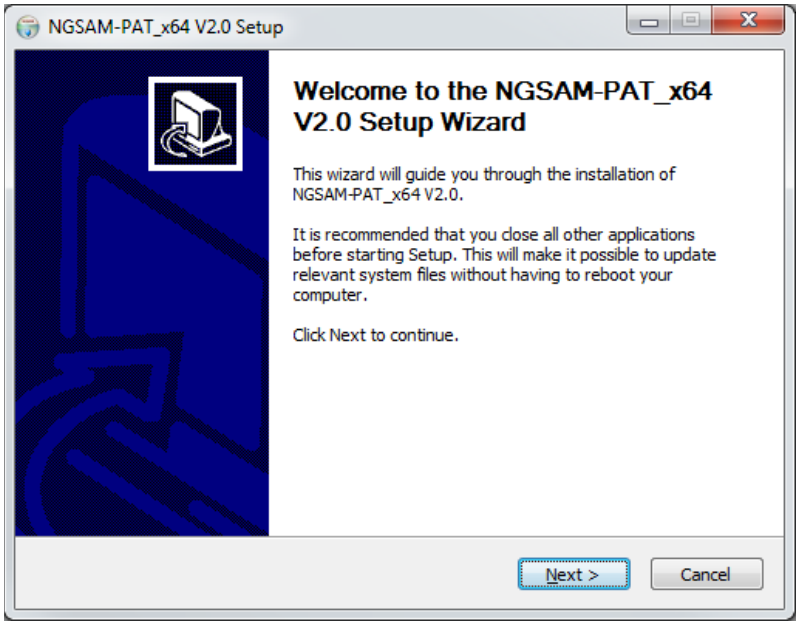
- **Triple Purpose Canister** – A canister that can be used to store, transport, and dispose of SNF. These canisters can store SNF when placed in a storage overpack. They can be used to transport SNF when placed in a transportation overpack. Finally, they can be used to dispose of spent nuclear fuel when placed in a waste package for emplacement in a repository. A Standardized transportation, aging, and disposal (STAD) canister is a standardized version of a triple purpose canister.
- **Trunnion** – An apparatus typically consisting of cylindrically shaped projections on a package that are attached by various means and used to lift, tie down, support, or tilt packages from horizontal and vertical modes.
- **Unified Database** – A controlled, unified domestic spent nuclear fuel system database integrated with nuclear analysis capabilities to support DOE waste management and fuel cycle-related objectives. It is contained in the UNF-ST&DARDS tool.
- **US Department of Energy Office of Nuclear Energy (DOE-NE)** – An organization whose primary mission is to advance nuclear power as a resource capable of meeting US energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration.
- **Used Nuclear Fuel (UNF)** – Nuclear fuel (including fuel rods and fuel assemblies) that has been irradiated in a nuclear reactor. Synonymous with *spent nuclear fuel*.
- **Used Nuclear Fuel–Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS)** – A database and associated analytical tools being developed as a foundational resource for DOE's Office of Nuclear Energy to streamline computational analysis capabilities for characterizing the input for the overall waste management system.
- **Vacuum Drying** – A process to remove the remaining water inside a canister or cask prior to dry storage or transportation by drawing a vacuum, causing the water inside the canister or cask to vaporize and be removed.
- **Vertical Storage Systems** – A ventilated concrete structure used to store a canister in the vertical orientation at an independent spent fuel storage installation or an interim storage facility.
- **Waste Package** – A combination of (1) packaging components used for disposal of spent nuclear fuel, and (2) the fuel itself.
- **Welded Closure** – A method for closing and sealing a spent nuclear fuel canister in which the weld is used around the lid of the container to create a seal. Redundant welds are typically used to ensure containment. This type of closure is commonly used on canisters and makes retrieval of the spent nuclear fuel more difficult than when bolted closure is used. Retrieving fuel from a welded canister involves cutting the canister open, usually rendering the canister unusable.
- **Youngest Fuel First (YFF):**

  1. An alternative commercial spent nuclear fuel allocation priority approach in which the allocation queue is established based the youngest spent fuel discharged from a nuclear reactor having the highest priority.
  2. A commercial spent fuel acceptance approach in which the youngest spent fuel residing at a reactor has the highest priority to be received by the waste management system.

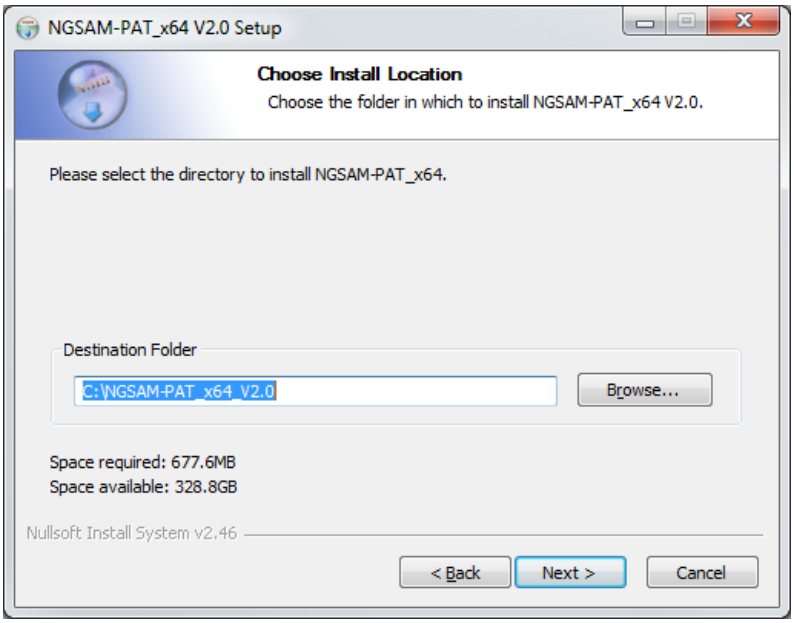
- **Youngest Fuel First-5 (YFF-5)** – Youngest fuel first, with a minimum spent nuclear fuel cooling time of five years out of the reactor.

Appendix E Installation Instructions

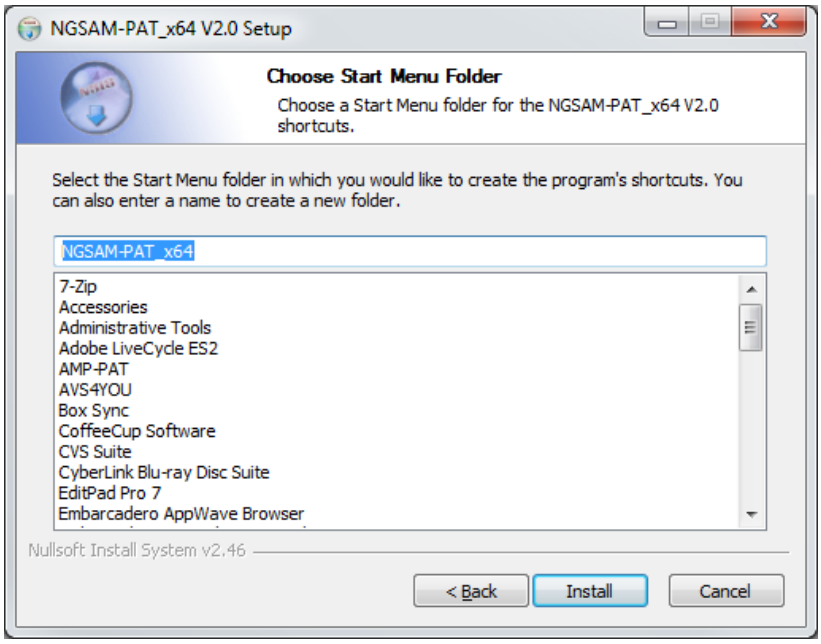
The NGSAM installer is fairly self-explanatory. Double click on NGSAM-PAT_x64_V2.0-win64_Installer.exe, and the image below appears if you have administrator privileges on the machine you are installing.



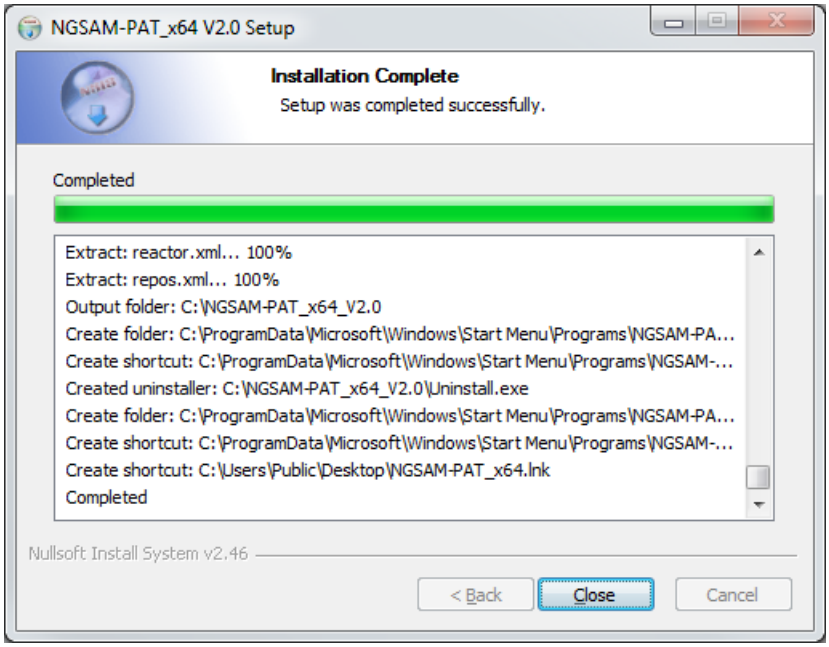
Click on the ‘Next’ button. Either change the installation location or keep the default location and click on the ‘Next’ button.



Click on the Install button to start the installation.



The installation complete dialog is displayed upon successful installation. Close the dialog box and you can find the 'NGSAM-PAT_x64' application in your programs.



Appendix F Web Interface for Client/Server

NGSAM Status page

The NGSAM Status page displays the status of the NGSAM cluster. The status can be accessed, from the Argonne network via the following URL: https://ngsamsrv0.gss.anl.gov/#status

The first table is the currently running simulations. The table lists the **server** for the simulation, the **slot** on the server, the **user**, and the **scenario**. The table also lists time statistics for the scenario, the current time of the **simulation**, the time the scenario was **submitted** to the cluster, the time the scenario **started** executing and the time the scenario **finished** running.

The Queue table shows the scenarios that are pending. The scenarios have been submitted but are waiting for node availability.

The History table shows the last 48 scenarios from each simulation node. The entries are copies of the status table once the scenario finishes.

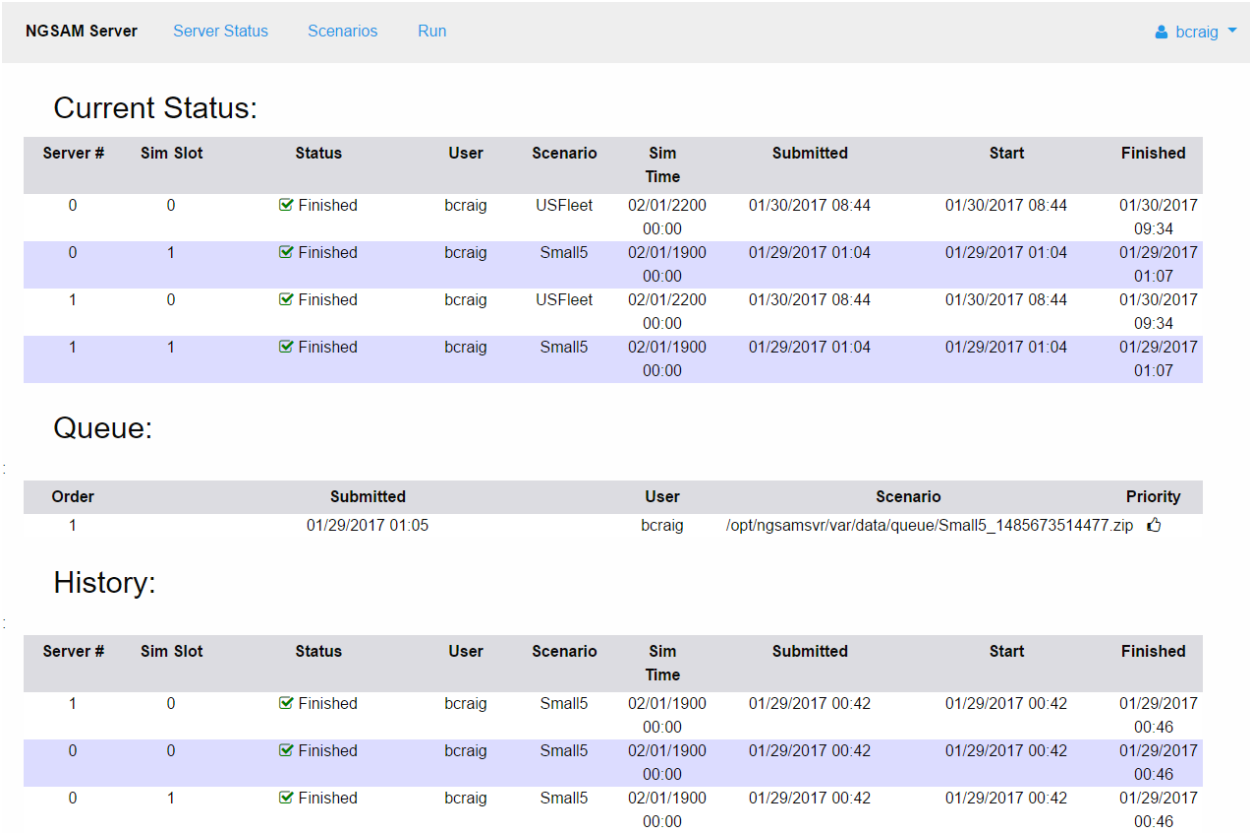


Figure 49 NGSAM Status Page

NGSAM Scenario Page

The NGSAM Scenario page displays a list of all scenarios in the user directory. It is located at the following URL: https://ngsamsrv0.gss.anl.gov/#scenarios . The listing includes information for the scenario **name**, the output **time**, and the **size** the scenario is using on the server. The Scenario page allows the user to perform for multiple actions for a given scenario.

The first action is the **Archive** action. This will compress the scenario and move it to the user's /.archive directory in their home folder. Please archive old runs that are no longer needed.

The second action is the **Calvin** Reports. Clicking the download icon for the **Calvin** Reports will download a zip file containing the contents of the calvinOutput directory.

The third action is the **Custom** Reports. The dropdown box under **Custom** has a list of the custom reports available in the output directory. Selecting a specific report will download a zip file containing the selected report. Selecting **All** will download a zip file containing all **Custom** Reports in the output directory.

The **Save** and **Browse** actions are not implemented at this time.

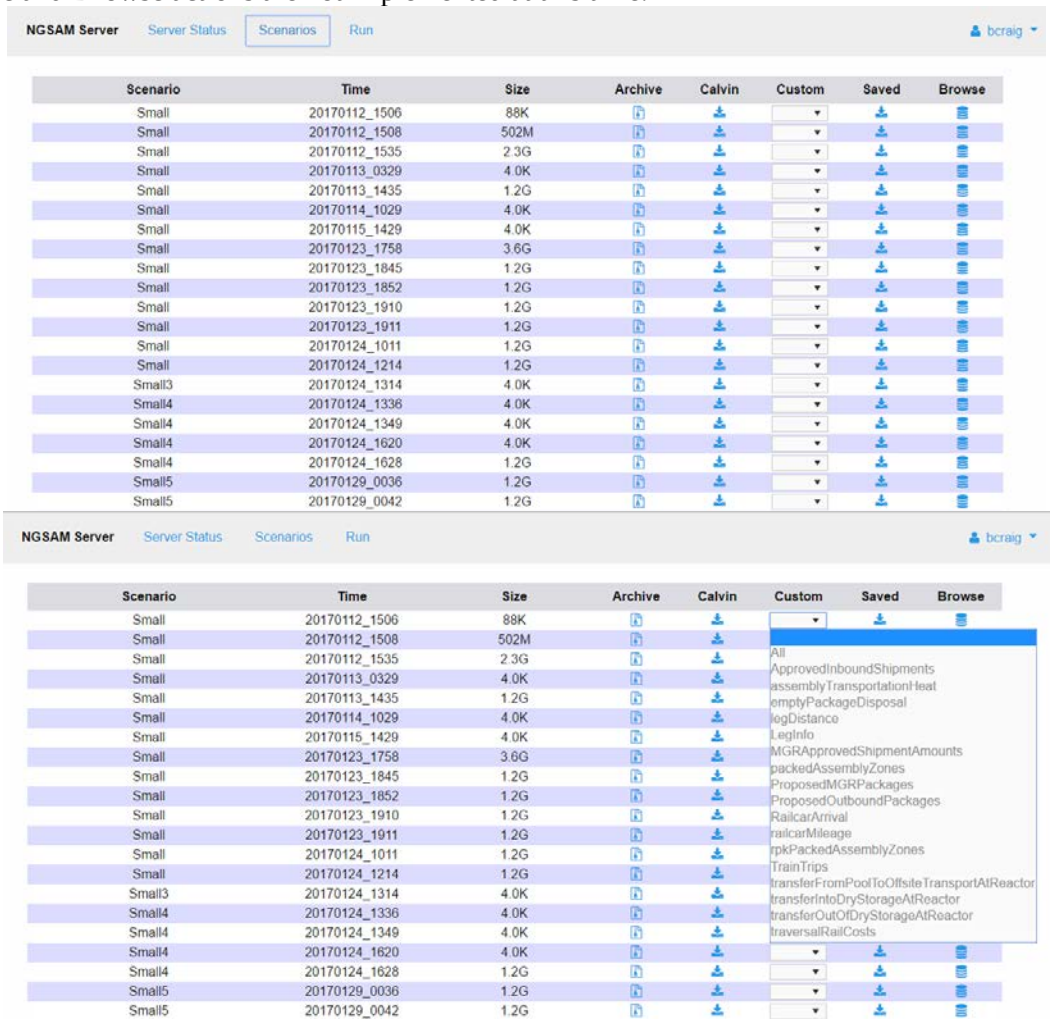


Figure 50 NGSAM Scenario Page

NGSAM Login form.

The login form is found at: https://ngsamsrv0.gss.anl.gov/#login Use your NGSAM Username and password to log into the website.

The website has a session timer of 10 minutes. After being inactive for 10 minutes, the server will expire your session and require you to log in again to view any server information.

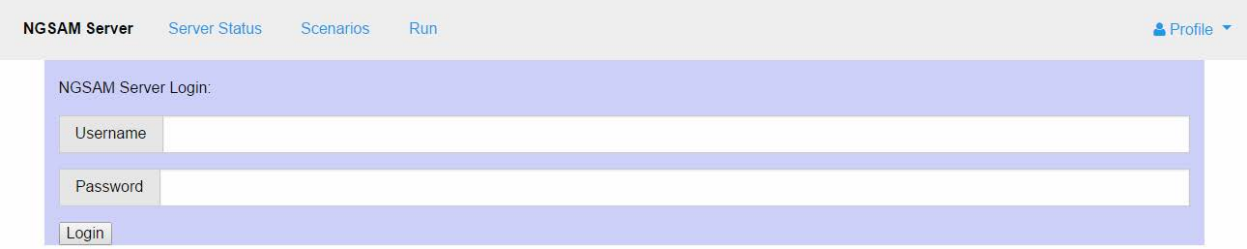


Figure 51 NGSAM Login Form

Once logged in, you will be able to see your session key through the profile menu. The session key can be used by scripting to perform actions in batch. Use the session key as the value of the HTTP Header Authorization when making batch requests to the server.

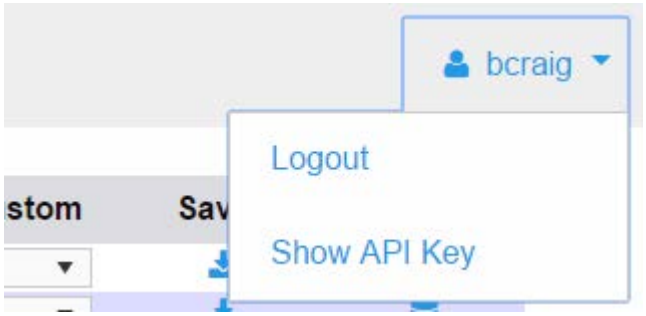


Figure 52 Profile Menu

Appendix G Continuous Integration

NGSAM currently utilizes a Continuous Integration (CI) framework, called Jenkins, to automate and modularize the build process of NGSAM Client / Server software. This has many benefits to end users of the NGSAM software, as it allows them to receive releases and new builds of the NGSAM client with a quick turnaround. This also allows developers to distribute new releases of the NGSAM client (including bug fixes after a major release) with the click of a button.

This guide will cover how end users can download releases of the NGSAM Client software distributed from the CI platform.

Accessing NGSAM CI Release Website

Releases of the NGSAM software can be found on the NGSAM CI webpage. To go there, follow these steps:

1) Using the Cisco AnyConnect VPN client, connect to vpn.anl.gov. If you do not have a VPN account with ANL, please contact Brian Craig or Brent Kolasinski.

2) In a web browser, go to http://ngsamci.gss.anl.gov. You will see a webpage like the following:

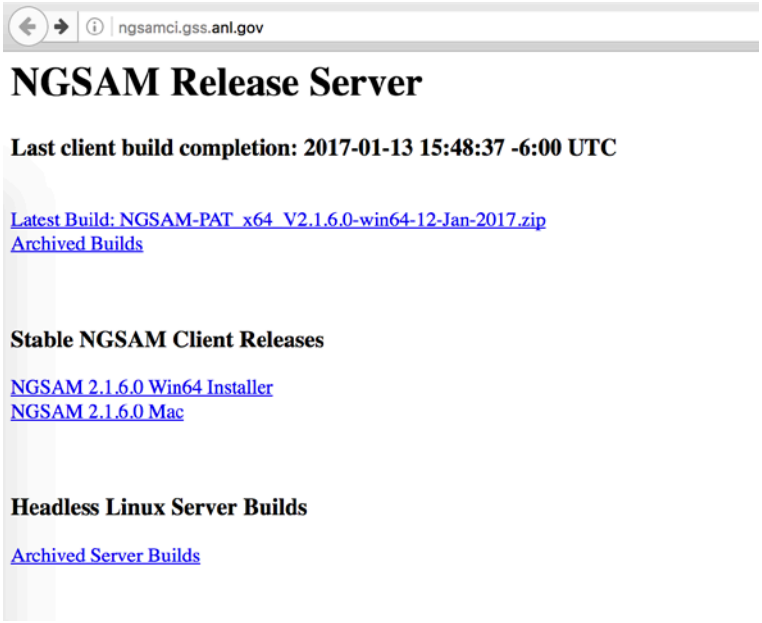


Figure 53 NGSAM CI Release Page

Downloading the Current Major Stable NGSAM Release

This section details the steps needed to follow for downloading the current major stable release of the NGSAM client software. The major stable release is what is recommended for analysts to be running.

1) Follow the steps in section I to access the NGSAM release webpage.

2) Under the "Stable NGSAM Client Releases" section, click a link that corresponds to your system type, Windows or Mac:

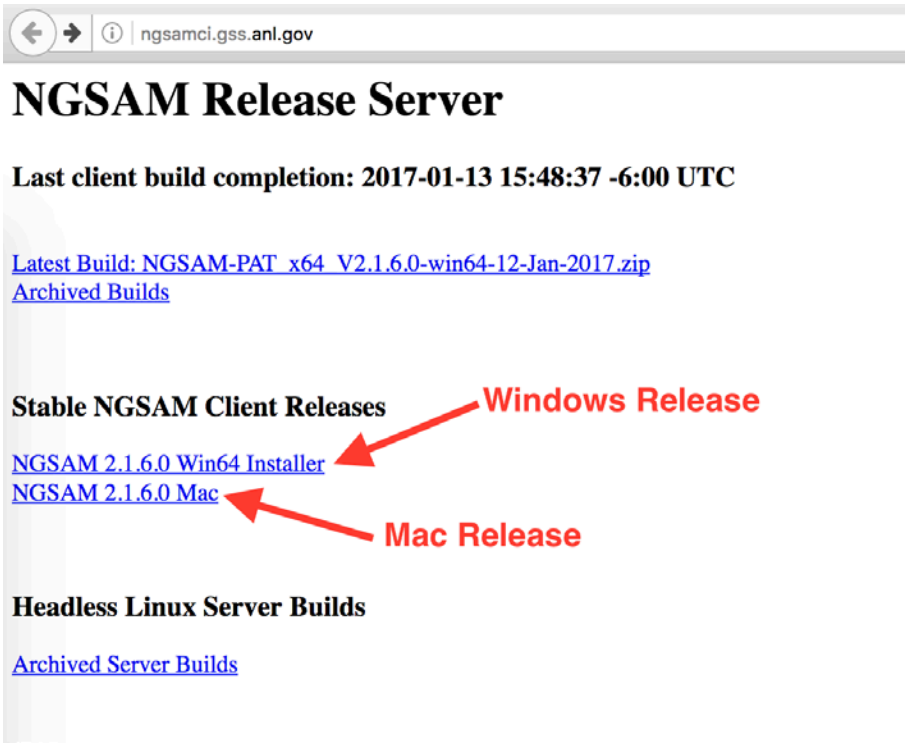


Figure 54 NGSAM Release Versions

Downloading the Latest NGSAM Build

The latest release of the NGSAM software is always accessible from a link on the NGSAM release website. Usually this link will point to the current nightly build, which takes place at 0200 UTC every night. However, a developer may also initiate a build of the NGSAM software ahead of the nightly build. In that case, the latest release link will point to the newest build. The timestamp at the top of the page gives information on when the last successful build of the NGSAM client was.

This latest release link will always point to newest build of the NGSAM software, regardless of whether the build was initiated automatically by the scheduled nightly build, or manually by a developer.

NGSAM end users should only be using the nightly builds under direction of an NGSAM developer or for testing new features or bug fixes in the client.

To download the latest build:

1) Follow the steps in section I to access the NGSAM release webpage.

2) Click the "Latest Build:" link near the top of the page. Note: The latest builds are built for Windows only. These will not run on Mac or Linux systems. If a Mac or Linux build is needed, please contact the NGSAM development team.

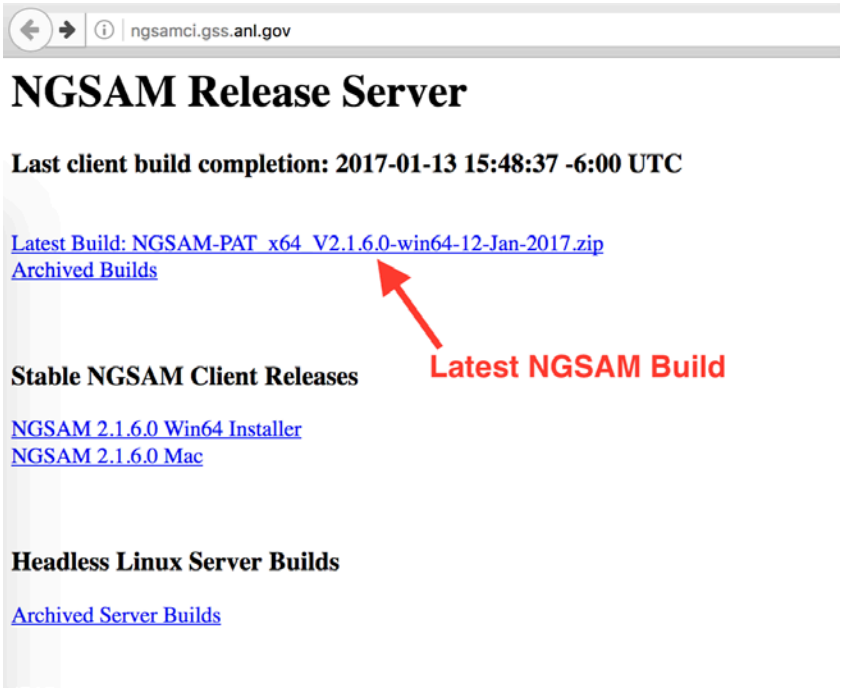


Figure 55 Link to Latest NGSAM Build

3) To run the software, extract the zip file, and double click the “runPAT.bat” file.

Accessing archived builds NGSAM releases

If an end user of the NGSAM software needs to access an older build of the NGSAM software, they will need to go into the NGSAM Archive on the NGSAM Release Server. Note that this will only need to be done under the direction of an NGSAM developer, for purposes of bug fixes or feature debugging.

1) Follow the steps in section I to access the NGSAM release webpage.

2) Click the “Archived Builds” link.

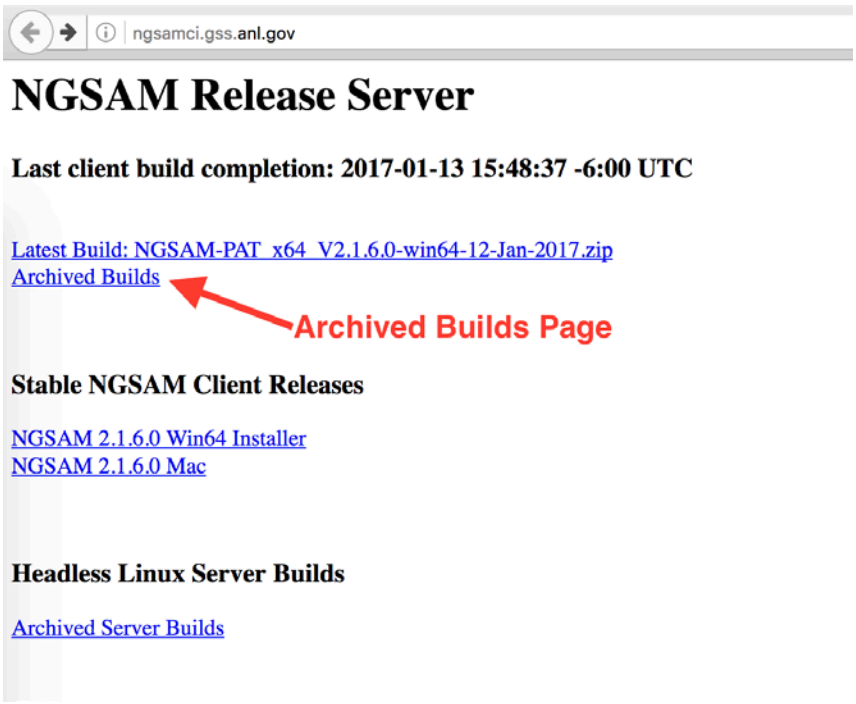
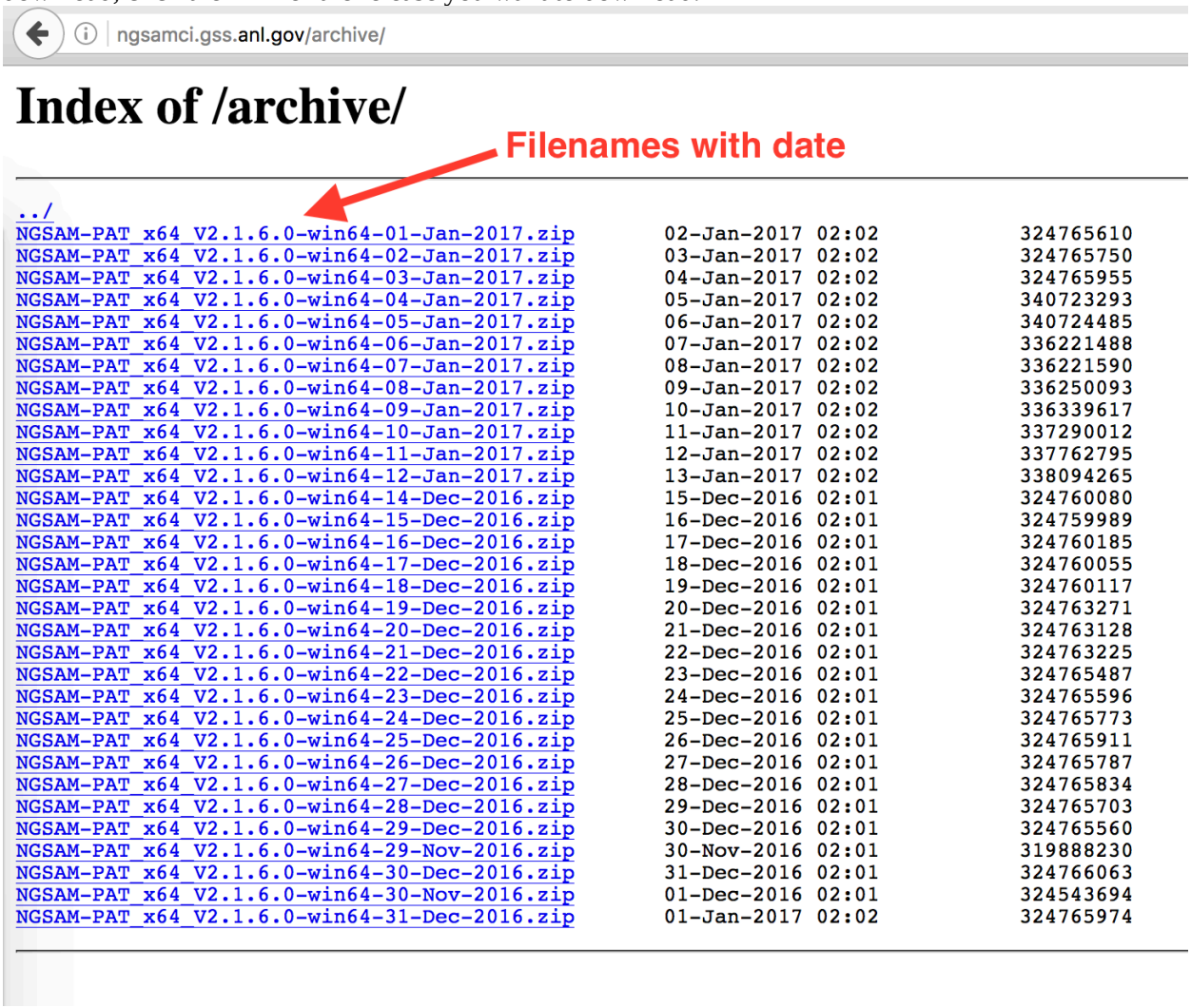


Figure 56 Link to Archived NGSAM Builds

3) A new page will open, with the last 30 days of archived builds. These are listed by date. When downloading a specific release from a date, attention should be made to look at the file name. To download, click the link for the release you want to download.



../
NGSAM-PAT_x64_V2.1.6.0-win64-01-Jan-2017.zip 02-Jan-2017 02:02 324765610
NGSAM-PAT_x64_V2.1.6.0-win64-02-Jan-2017.zip 03-Jan-2017 02:02 324765750
NGSAM-PAT_x64_V2.1.6.0-win64-03-Jan-2017.zip 04-Jan-2017 02:02 324765955
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NGSAM-PAT_x64_V2.1.6.0-win64-07-Jan-2017.zip 08-Jan-2017 02:02 336221590
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NGSAM-PAT_x64_V2.1.6.0-win64-17-Dec-2016.zip 18-Dec-2016 02:01 324760055
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NGSAM-PAT_x64_V2.1.6.0-win64-21-Dec-2016.zip 22-Dec-2016 02:01 324763225
NGSAM-PAT_x64_V2.1.6.0-win64-22-Dec-2016.zip 23-Dec-2016 02:01 324765487
NGSAM-PAT_x64_V2.1.6.0-win64-23-Dec-2016.zip 24-Dec-2016 02:01 324765596
NGSAM-PAT_x64_V2.1.6.0-win64-24-Dec-2016.zip 25-Dec-2016 02:01 324765773
NGSAM-PAT_x64_V2.1.6.0-win64-25-Dec-2016.zip 26-Dec-2016 02:01 324765911
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NGSAM-PAT_x64_V2.1.6.0-win64-27-Dec-2016.zip 28-Dec-2016 02:01 324765834
NGSAM-PAT_x64_V2.1.6.0-win64-28-Dec-2016.zip 29-Dec-2016 02:01 324765703
NGSAM-PAT_x64_V2.1.6.0-win64-29-Dec-2016.zip 30-Dec-2016 02:01 324765560
NGSAM-PAT_x64_V2.1.6.0-win64-29-Nov-2016.zip 30-Nov-2016 02:01 319888230
NGSAM-PAT_x64_V2.1.6.0-win64-30-Dec-2016.zip 31-Dec-2016 02:01 324766063
NGSAM-PAT_x64_V2.1.6.0-win64-30-Nov-2016.zip 01-Dec-2016 02:01 324543694
NGSAM-PAT_x64_V2.1.6.0-win64-31-Dec-2016.zip 01-Jan-2017 02:02 324765974

Figure 57 Links to Archived NGSAM Builds

4) To run the archived build, extract the zip file that is downloaded, and double click on the “runPAT.bat” file.

Appendix H Quick Edit

Figure 58 Launching NGSAM

In this appendix, the Quick Edit mode will be demonstrated. To learn more about the Expert Edit mode, please see Appendix I for an in-depth tutorial exercise and example. Pressing on the Quick Edit button will bring up a dialog box to select a scenario (Figure 2). Select a scenario that has a quick edit configuration and click on the Open button.

JTOM Configuration

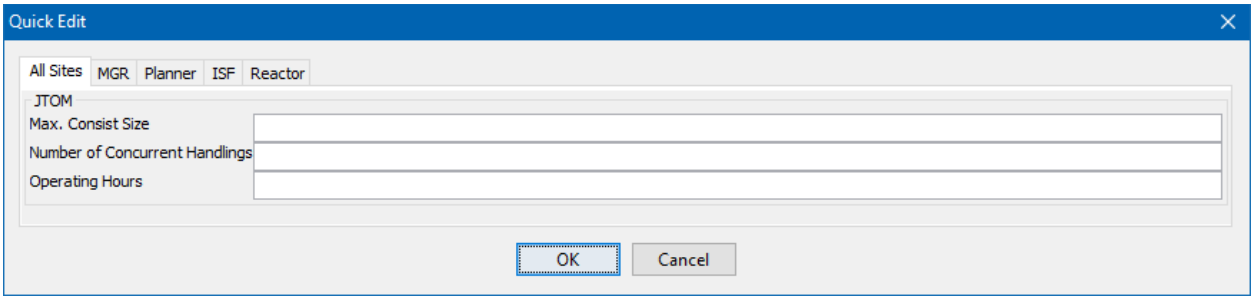


Figure 59 JTOM Configuration Options

- **Max. Consist Size -** the maximum number of casks that can be picked up at the site at once
- **Number of Concurrent Handlings -** the number of consists that can be simultaneously loaded or unloaded
- **Operating Hours** - hours available per day for loading and unloading operations

MGR Configuration

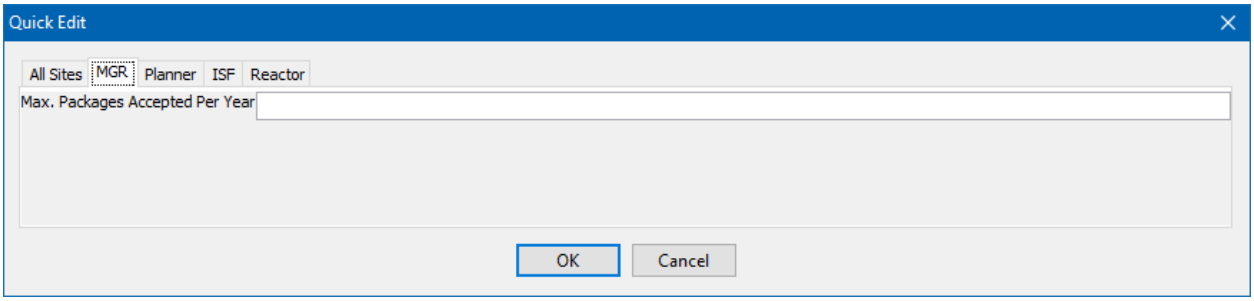


Figure 60 MGR Options

- **Max Packages Accepted Per Year –** The maximum number of packages the storage facility can accept each year.

Planner Configuration

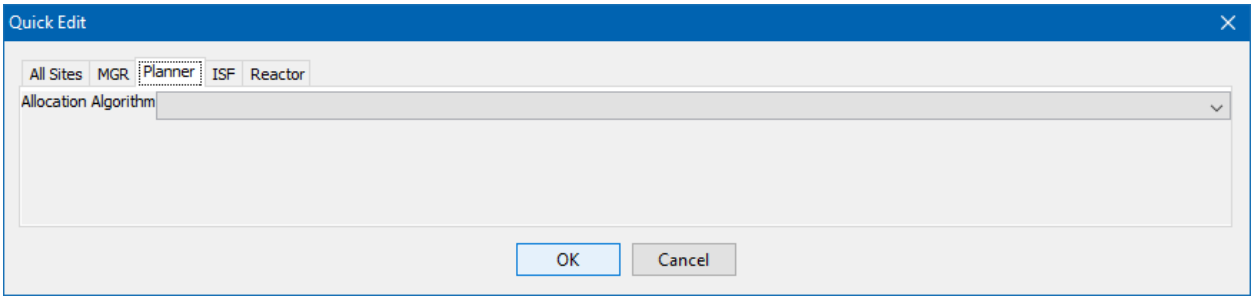


Figure 61 Planner Options

- **Allocation Algorithm –** Algorithm used by the planner to allocate resources.

ISF Configuration

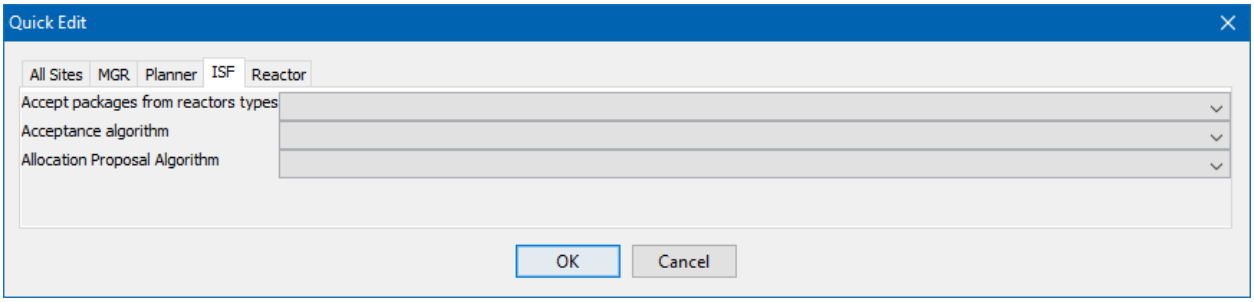


Figure 62 ISF Configuration Options

- **Accept packages from reactor types –** Types of reactors the interim facility can accept packages from.
- **Acceptance algorithm –** Algorithm for how the interim facility accepts packages.
- **Allocation Proposal Algorithm** – Algorithm for proposing allocation to the interim facility.

Reactor Configuration

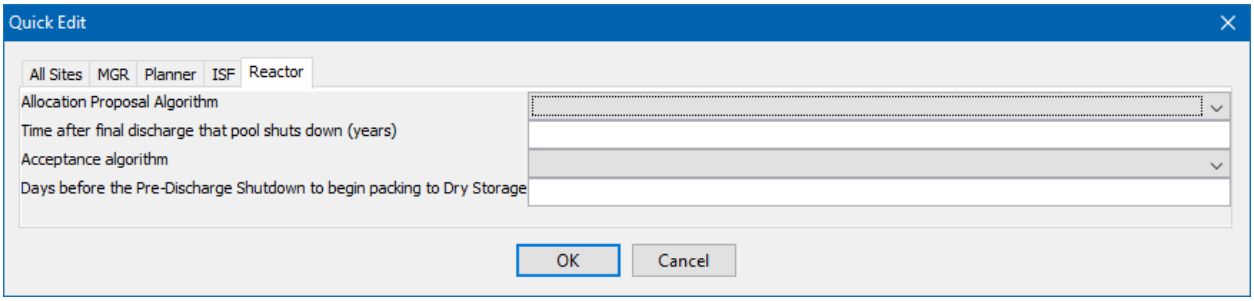


Figure 63 Reactor Configuration Options

- **Allocation Proposal Algorithm –** The algorithm used for proposing the allocation of resource.
- **Time after final discharge that the pool shuts down (years) –** The number of years after which the pool can shut down.
- **Acceptance algorithm –** The algorithm used for accepting packages.
- **Days before the Pre-Discharge Shutdown to begin packing to Dry Storage –** Time at which packing to dry storage can occur.

Appendix I Training Exercises

The following tutorials are intended as an example of how to use the functionality of the interface. They have been made generic to fit with any scenario. You will want to make a separate copy of any scenario used for the purposes of this tutorial. Assume any directions to open a node in the navigation tree refers to the first installation unless otherwise stated.
Note that the changes that will be made may not produce accurate or desired results. These exercises are meant to show functionality and are not meant as a representation of how actual data should be used.

Exercise 1: Looking at Results

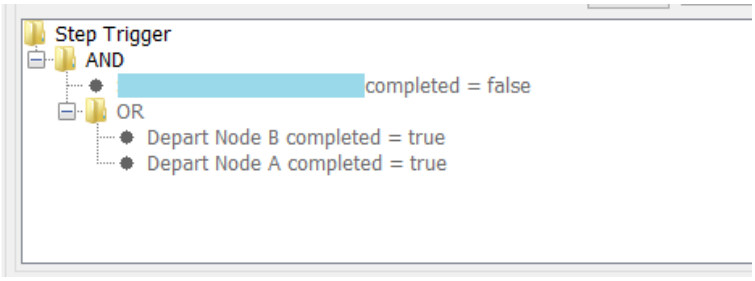
1. Open NGSAM
2. Click on the "Expert Edit" button
3. Choose one of the scenarios installed with the software and click Open. This will load in the scenario.
4. Do a File->Save As to save a copy of this scenario.
5. In the navigation tree on the left, expand the Entity Types node and a note the sub-nodes there.
6. Click on the Entity Types node. This will bring up a list of Entity types under the tree.
7. Click on the one of the items to bring up more information on the entity in the center area.
8. In the navigation tree on the left, expand the Resources node. Click on one of the nodes. This will bring up a table listing all resources.
9. Note the values under the "Amount Available" column.
10. Expand the Distribution node in the tree and note the items there.
11. Click on one of the Distribution sub-nodes to see a table listing task distributions. Note the type and attributes set for the distributions listed in the table.
12. Click on the name of the installation node. This will change the context to show the start and end dates of the simulation. Note that for any simulation time frame you **must set end time**.
13. Expand the Plans node. This will bring up a sub tree in the bottom left.
14. Click on one of the nodes in the sub tree.
15. For the chosen record, double click on the Group cell and set it to "All".
16. In the sub-tree, expand the chosen node and click on the first Course of Action node listed.
17. In the data area below the "Course of Action" diagram, click on the "Trigger Condition" tab.
18. Set the trigger condition of the COA to "true"
19. Note the tasks in the Course of Action diagram. Also note any arrows showing the flow between them.
20. Click on one of the nodes.
21. Select the Task tab in the lower area. Set the values as follows: Time interval is set to 1.0 second
22. Click on another node.
23. Select the Task tab in the lower area. Set the values as follows: Time interval is set to 3.0 days
24. Below that table, click on the "Resources Required" tab. Add a resource if there is none using the "+" button. Set the values as follows: Choose a resource from the dropdown seen when the cell is clicked. Amount is set to 0.01 and Disposition is set to "release"
25. Click on a third node.
26. Select the Task tab in the lower area. Set the values as follows: Time interval is set to 20.0 minutes
27. Below that table, click on the "Resources Required" tab. Note any Resources and add one if there isn't one. Amount is set to 1 and Disposition is set to "consume"

28. Click on the “Attribute Set” tab. Find a node with at least one attribute in table. Click on the “New Value” cell.
29. Select “Text value” and set the value to something that makes sense for that particular attribute. Click the OK button.
30. In the navigation tree on the left, click on the Generators node
31. Choose a generator in the table that appears. Change the “Total Generated” value and the “Time Distribution” to something different. Set the “Units” to days.
32. In the menu bar, click Simulation -> Validate. Note that there are no validation messages.
33. If you did not do so at the beginning of the tutorial, perform a File-Save As and save this scenario in a new location.
34. In the menu bar, click Simulation -> Save and Run
35. Once the run finishes, look at results as follows:
    a. Expand the task node. On each of the sub nodes, right click and choose the task name -> Results -> Graph All
    b. Expand the Resources node. For each of the sub-nodes, right click and select the resource name -> Graph Daily Resource usage.
36. Click on the “Resources” node.
37. Set the “Amount Available” for one of the resources used to 150.
38. Set the “Amount Available” for another resource used to 0.5001.
39. From the menu bar choose Simulation -> Save and Run.
40. Once the run finishes, investigate the results as follows:
    a. In the navigation tree on the left, click on Plans and choose a Course of Action. Note that in the Course of Action diagram, the circles have changed colors to reflect what happened during the simulation.
    b. Right click on one of the nodes and look at the various results.
    c. Close all of the open graphs and right click on the Resources-> <Resource used> node and select the <Resource used> -> Graph Cumulative Resource usage item.
    d. In the navigation tree on the left, right click on Plans-><Plan name> and select <Plan name> -> Agent Traversal for <Plan name>.
    e. In the pop up, choose an agent. Note the dates in the table that comes up.
41. Note that the arrows in the course of action diagram do not control the flow.
    a. Expand the Entity Types node in the navigation tree on the left. Choose one of the listed Entity types.
    b. Click on the “Flow Attributes” tab. Not the values there.
    c. Return to the Course of action diagram.
    d. Click on each task and choose the “Attributes Set” tab. Note the values there.
    e. For each task, observe the trigger conditions on the “Trigger Conditions” tab.

Exercise 2: Multiple Suppliers

1. If it is not already open, File-> Open the demo item from Tutorial 1.
2. Click on the Resources node in the navigation tree on the left.
3. Reset the “Amount Available” for the resources that were changed in the first exercise to their original values.

4. In the Course of Action diagram, select the first node in the process and press the “Delete” key on your keyboard.
5. A dialog asking to confirm the decision will appear. Confirm the delete.
6. In the navigation tree on the left, click the “Tasks” node.
7. In the lower table that appears, click the “+” button.
8. In the “New name” box enter: Depart Node A and click the OK button.
9. In the table, select the IT Depart Node A item.
10. In the table that appears in the center, set the “Time Interval” to 1.0 and the “Time Units” to seconds.
11. Return to the Tasks table in the lower left and click the “+” button.
12. In the “New name” box enter: Depart Node B and click the OK button.
13. In the table, select the IT Depart Node B item.
14. In the table that appears in the center, set the “Time Interval” to 1.0 and the “Time Units” to seconds.
15. In the Course of Action diagram, select “Create Step” from the top of the diagram.
16. Click anywhere in the diagram. This will bring up the “Create Step” dialog
17. From the “Use Existing Task” dropdown, choose “IT Depart Node A” and click “OK”. This will add the node to the diagram
18. Once more, click anywhere in the diagram. This will bring up the “Create Step” dialog
19. From the “Use Existing Task” dropdown, choose “IT Depart Node B” and click “OK”. This will add the node to the diagram.
20. In the Course of Action diagram, select “Create Links” from the top of the diagram.
21. Click on the “Depart Node A” node.
22. Click on one of the previously existing nodes in the course of action window (If there is no node, create one with a new task). This will create an arrow linking the two.
23. Click on the “Depart Node B” node.
24. Click on the node from step 22. This will create an arrow linking the two.
25. Above the Course of Action diagram, select the “Select and Move” option
26. Click on the node from step 22 to bring up its table of information.
27. Ensure that the “Trigger Condition” tab is selected.
28. In the “Step Conditions” editor, select the “AND” node.
29. Click on the “OR” button above the editor. This will add a new item to the tree.
30. Drag the condition “Depart Node B completed = true” to the “OR” node.
31. Drag the condition “Depart Node A completed = true” to the “OR” node.



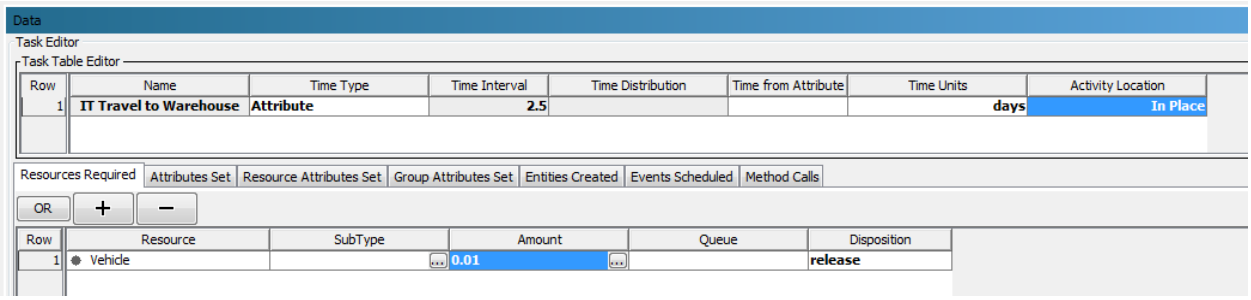
32. In the navigation tree on the left, click on the EntityType item
33. Click the “+” button above the list of entity types. In the popup, enter “TestEntity” and click the OK button.

34. Select TestEntity and click the "+" button above the Attribute Table Editor to add a new attribute to the bottom of the table.
35. Change the name of this new attribute to: manufacturer. Leave the attribute a string attribute.
36. In the navigation tree on the left, click on the Generators node
37. Add a generator by clicking on the "+" above the Generator Table Editor table. Name this generator "TestEntityGenerator".
38. In the TestEntityGenerator row, set the type to "Agent" and the Entity to "TestEntity"
39. In the TestEntityGenerator row, modify the row attributes by clicking on the right most cell in the table and then clicking on the "…" button that appears.
40. In the dialog that pops up, click the "+" button.
41. Click on the "Attribute" column and select manufacturer from the drop down.
42. Enter "NodeA" as the "New Value" and click close.
43. Set the "Total Generated" to 120.
44. Above the Generator Table Editor, click the "+" button. This will add another record to the bottom of the table.
45. In this new record, set the "Type" to Agent.
46. Set "Entity" to "TestEntity" and "Total Generated" to 80.
47. Set the "Time Distribution" to one of the existing distributions or create a new distribution and the "Units" to days.
48. Scroll to the right most column and click on the "Attributes" cell. And then click on the "…" button that appears in the cell.
49. In the dialog that pops up, click the "+" button.
50. Click on the "Attribute" column and select manufacturer from the drop down.
51. Enter NodeB as the "New Value" and click close.
52. Return to the "Course of Action" diagram and click on the "Depart Node A" node
53. In the Step Conditions Editor, click on the "Step Trigger" node in the tree.
54. Above the Step Conditions Editor, click on the "+" button.
55. In the dialog that pops up, ensure that the "Attribute Condition" item is the one selected.
56. From the "Attribute" drop down, select "manufacturer"
57. Leave the operator as "=" and enter "NodeA" as the value. Press the OK button.
58. Expand the tree in the Step Conditions Editor to see the added condition.
59. Return to the "Course of Action" diagram and click on the "Depart Node B" node
60. Above the Step Conditions Editor, click on the "+" button.
61. In the dialog that pops up, ensure that the "Attribute Condition" item is the one selected.
62. From the "Attribute" drop down, select "manufacturer"
63. Leave the operator as "=" and enter "NodeB" as the value. Press the OK button.
64. Expand the tree in the Step Conditions Editor to see the added condition.
65. In the menu bar, click Simulation -> Save and Run
66. View the various tables and graphs for results.

Exercise 3: Warehouse

1. If it is not already open, File-> Open the demo item from Tutorial 2.
2. In the navigation tree on the left, click on "Entity Types".

3. In the lower table, make sure that the “Attributes” tab is selected.
4. Click the “+” button to add a new attribute to the bottom of the table.
5. Give that attribute the name “goToWarehouse”
6. Set the “Type” of goToWarehouse to “Boolean”
7. Set the “Default Value” of goToWarehouse to false.
8. In the navigation tree on the left, click on “Resources”
9. Click on the “+” button above the lower table. This will pop up a creation dialog.
10. In the dialog, enter “Warehouse Storage” for the name. and click “OK”
11. For the new record, enter 20 as the Amount.
12. Ensure that the values for Continuous and Constrained are checked.
13. Click the “+” button above the table and add a resource called “Vehicle”.
14. Set the amount available to 1 and ensure that the values for Continuous and Constrained are checked.
15. In the navigation tree on the left, click on “Tasks”
16. Click the “+” button above the lower left Tasks table.
17. In the dialog that pops up, enter “Travel to Warehouse” as the name
18. Select “Travel to Warehouse” from the table.
19. In the central area’s upper Task Editor table, enter 2.5 as the “Time Interval”
20. Set the “Time unit” to days
21. Select the “Resources Required” tab for the lower table.
22. Above the tale there, click the “+” button to create a record
23. Set the “Resource” to be “Vehicle”, the “Amount” to be 0.01 and the “Disposition” to be “release”.



24. Click the “+” button above the lower left Tasks table.
25. In the dialog that pops up, enter “Store at Warehouse” as the name
26. Select “Store at Warehouse” from the table.
27. In the central area’s upper Task Editor table, enter 2 as the “Time Interval”
28. Set the “Time unit” to days
29. Above the “Resources Required” table, click the “+” button to create a record
30. Set the “Resource” to be “warehouseStorage”, the “Amount” to be 1and the “Disposition” to be “release”.
31. Click the “+” button above the lower left Tasks table.
32. In the dialog that pops up, enter “Warehouse to Nodes” as the name
33. Select “Warehouse to Nodes” from the table.
34. In the central area’s upper Task Editor table, enter 0.5 as the “Time Interval”
35. Set the “Time unit” to days

36. Above the “Resources Required” table, click the “+” button to create a record
37. Set the “Resource” to be “vehicle”, the “Amount” to be 0.01 and the “Disposition” to be “release”.
38. In the navigation tree on the left, click on “Distributions”
39. Above the “Task Distribution Editor” table, click on the “+” button.
40. In the dialog that pops up, enter EarlierManufacturing as the name.
41. Set the type to “Uniform”.
42. Set the Min value to 0 and the Max value to 5.
43. Click the OK button. The record appears in the “Task Distribution Editor” table.
44. Above the “Task Distribution Editor” table, click on the “+” button.
45. In the dialog that pops up, enter LaterManufacturing as the name.
46. Set the type to “Uniform”.
47. Set the Min value to 5 and the Max value to 10.
48. Click the OK button. The record appears in the “Task Distribution Editor” table.
49. In the navigation tree on the left, click on “Generators”
50. For each generator in the “Generator Table Editor” table, change all “Total Generated” values to be half of what they are. (i.e. if the value is 200, set the new value to be 100)
51. For each generator in the “Generator Table Editor” table, change all “Time Distribution” values to be “EarlierManufacturing”.
52. Use the “+” button to add two more similar generators that use LaterManufacturing as their distribution.
53. For the first new generator, double click on the “Set Attributes” cell to pop up a dialog.
54. In that dialog, click the “+” button.
55. Click on the “Attribute” value and choose goToWarehouse from the drop down. Set the “New Value” to be true.
56. Click ok
57. Repeat steps 51-54 for the second newly created generator. ,
58. Return to the Course of Action diagram. Click on one of the nodes in the middle of the process.
59. Highlight the “AND” node in the Step Conditions Editor and click the “+” button above it.
60. In the dialog that pops up, choose goToWarehouse for the “Attribute”. Set the “Value” to false.
61. Click the OK button.
62. Above the Course of Action diagram, click “Create Step”
63. Click somewhere in the diagram and choose “IT Travel to Warehouse” in the dialog that pops up. This will create a node in the diagram.
64. Above the Course of Action diagram, click “Create Links”
65. Click on “Go to Warehouse” and then click on one of the existing nodes.
66. Click on “Depart Node B” and then click on “Travel to Warehouse”
67. Click on “Depart Node A” and then click on “Travel to Warehouse”
68. Above the Course of Action diagram, click “Select and Move”
69. Click the “Travel to Warehouse” Node
70. Expand the top node in the Step Conditions Editor.
71. Highlight the “AND” node.
72. Click on the “OR” button above the editor. This will add a new item to the tree.
73. Drag the condition “Depart Node B completed = true” to the “OR” node.

74. Drag the condition “Depart Node A completed = true” to the “OR” node.
75. Highlight the “AND” node one more and click on the “+” button above the editor.
76. In the dialog that pops up, choose goToWarehouse for the “Attribute”. Set the “Value” to true.
77. Click the OK button.
78. In the Course of Action diagram, click on the node that was connected to “Go to Warehouse”.
79. In the Step Conditions Editor, highlight the “AND” node.
80. Click on the “OR” button above the editor. This will add a new item to the tree.
81. Drag the condition “<Selected node> completed = true” to the “OR” node.
82. Drag the condition “Go to Warehouse completed = true” to the “OR” node.
83. In the menu bar, click Simulation -> Save and Run
84. View the various tables and graphs for results.

Exercise 4: Separate Installations

1. If it is not already open, File-> Open the demo item from Tutorial 3.
2. In the navigation tree on the left, right click on the top installation node and choose “Create new installation by copying <Installation Name>”
3. In the dialog that pops up, enter NodeBManufacturer as the name and click OK. Note the new installation is added to the tree.
4. Right click on the first installation node once more and choose “Create new installation by copying <Installation Name>”
5. In the dialog that pops up, enter NodeAManufacturer as the name and click OK. Note the new installation is added to the tree.
6. In the navigation tree on the left, click on the top node.
7. Above the lowest table that appears, click the “+”
8. In the dialog, enter LeaveNodeB as the name.
9. For the “Source” choose NodeBManufacturer and click the OK button. A new record will appear in the table.
10. For this new record, set the “Time Interval” to 1.0 and the “Time Units” to seconds.
11. Click the “+” button once more.
12. In the dialog, enter LeaveNodeA as the name.
13. For the “Source” choose NodeAManufacturer and click the OK button. A new record will appear in the table.
14. For this new record, set the “Time Interval” to 1.0 and the “Time Units” to seconds.
15. In the navigation tree on the left, click on the Generators node under NodeBManufacturer.
16. In the Generator Table Editor, select the generator with the attribute “manufacturer = NodeA” Click the “-“button to delete that row.
17. In the navigation tree on the left, click on the NodeBManufacturer->Plans-><ProcessName>->Process to bring up the NodeBManufacturer Course of Action diagram.
18. Delete all nodes **EXCEPT** for the Depart Node B node. When prompted, agree to delete the associated task.
19. In the navigation tree on the left, click on the NodeBManufacturer->Tasks->IT Depart Node B node.
20. Above the lower table, select the “Attributes Set” tab.

21. Above the “Attributes set by task” table, click on the “+” button. This will add a row to the bottom of the table.
22. Set the “Attribute” of this new row to “movement”
23. Set the “New Value” to LeaveNodeB.
24. Above the “Attributes set by task” table, click on the “+” button once more. This will add a row to the bottom of the table.
25. Set the “Attribute” of this new row to “depart”
26. Set the “New Value” to true.
27. In the navigation tree on the left, click on the Generators node under NodeAManufacturer.
28. In the Generator Table Editor, select the generator with the attribute “manufacturer = NodeB” Click the “-“button to delete that row.
29. In the navigation tree on the left, click on the NodeAManufacturer->Plans-><ProcessName>->Process to bring up the NodeAManufacturer Course of Action diagram.
30. Delete all nodes **EXCEPT** for the Depart Node A node. When prompted, agree to delete the associated task.
31. In the navigation tree on the left, click on the NodeAManufacturer->Tasks->IT Depart Node A node.
32. Above the lower table, select the “Attributes Set” tab.
33. Above the “Attributes set by task” table, click on the “+” button. This will add a row to the bottom of the table.
34. Set the “Attribute” of this new row to “movement”
35. Set the “New Value” to LeaveNodeA.
36. Above the “Attributes set by task” table, click on the “+” button once more. This will add a row to the bottom of the table.
37. Set the “Attribute” of this new row to “depart”
38. Set the “New Value” to true.
39. In the navigation tree on the left, click on First installation->Generators
40. In the Generator Table Editor, highlight each generator in turn and click the “-“ button to delete it.
41. In the navigation tree on the left, click on First installation->Plans-><Plan name>->Process
42. In the course of action diagram, delete the “Depart Node A” node. When prompted, agree to delete the associated tasks.
43. In the course of action diagram, delete the “Depart Node B” node. When prompted, agree to delete the associated tasks.

NOTE: Steps 44-70 are intended as an exercise to show the use of the GUI. The contents of the steps will not affect the end simulation results and thusly are optional. Please skip to step 71 if you simply wish to review the results.

44. In the navigation tree on the left, click on First installation->Entity Types->TestEntity.
45. Select the “Flow Attributes” tab over the lower table.
46. Click the “+” button above the Additional Attribute Table Editor. This will add a new record to the bottom of the table.
47. Set the “Name” on this new record to: Depart Node B Completed. Set the “Type” to be Boolean. Set the “Default Value” to be false.

48. Click the “+” button above the Additional Attribute Table Editor. This will add a new record to the bottom of the table.
49. Set the “Name” on this new record to: Depart Node A Completed. Set the “Type” to be Boolean. Set the “Default Value” to be false.
50. In the navigation tree on the left, click on First installation->Plans-><Process Name>->Process
51. In the course of action diagram, click on one of the original nodes.
52. Click on the top level node in the Step Conditions Editor.
53. Click the “AND” button to add an AND node.
54. Highlight the “AND” node and click the “OR” button
55. Highlight the OR node and click the “+” button
56. In the popup, choose “Depart Node B Completed” as the “Attribute” and choose true as the value.
57. Click the OK button.
58. Highlight the OR node once more and click the “+” button
59. In the popup, choose “Depart Node A Completed” as the “Attribute” and choose true as the value.
60. Click the OK button.
61. In the course of action diagram, click on the “Go to Warehouse” node.
62. Click on the top level node in the Step Conditions Editor.
63. Click the “AND” button to add an AND node.
64. Highlight the “AND” node and click the “OR” button
65. Highlight the OR node and click the “+” button
66. In the popup, choose “Depart Node B Completed” as the “Attribute” and choose true as the value.
67. Click the OK button.
68. Highlight the OR node once more and click the “+” button
69. In the popup, choose “Depart Node A Completed” as the “Attribute” and choose true as the value.
70. Click the OK button.
71. In the menu bar, click Simulation -> Save and Run
72. View the various tables and graphs for results.