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Subject: Deliverable Number 0014, Multi-Modal Terminal Model Documentation

Reference: Strategic Mobility 21 Contract N00014-06-C-0060

Dear Paul,

In accordance with the requirements of referenced contract, we are pleased to submit this Multi-Modal Terminal Model Documentation for your review.

Your comments on this document are welcomed.

Regards,

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Strategic Mobility 21

Multi-Modal Terminal Model Documentation

Contractor Report 0014

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This manual documents the Strategic Mobility 21 (SM21) Multi-Modal Terminal Model capabilities and functions. SM21 is an operational level concept that merges planning and execution of both commercial freight operations and the deployment and sustainment of joint military forces within a single construct of a Joint Power Projection Support Platform (JPPSP). The JPPSP can be described as a single transportation node that will be developed to seamlessly integrate with and support the end-to-end military and commercial distribution network. The inland multi-modal transfer facility, a key component of the JPPSP, can be described as a central node on a dual use regional agile distribution network. The JPPSP multi-modal transfer facility presents a capability to achieve rapid military deployment and responsive commercial support and will be designed for replication in other geographic regions of the US. The model includes four sub-models: the Highway Activity Sub-model, the Airlift Activity Sub-model, the Rail Activity Sub-model, & the Storage Activity Sub-model.

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ABSTRACT

This manual documents the Strategic Mobility 21[1] Multi-Modal Terminal Model capabilities and functions. The Model was created using Arena Basic version 10.00 from Rockwell Software, Inc. and extended using Visual Basic for Applications (VBA). Strategic Mobility 21 (SM21) is an operational level concept that merges planning and execution of both commercial freight operations and the deployment and sustainment of joint military forces within a single construct of a Joint Power Projection Support Platform (JPPSP). The JPPSP can be described as a single transportation node that will be developed to seamlessly integrate with and support the end-to-end military and commercial distribution network. The inland multi-modal transfer facility, a key component of the JPPSP, can be described as a central node on a dual use[2] regional agile distribution network. The JPPSP multi-modal transfer facility presents a capability to achieve rapid military deployment and responsive commercial support and will be designed for replication in other geographic regions of the US. In the model *Entities* represent the objects moving through the simulation. Each entity has its own characteristics, referred to as *attributes*. *Resources* are included as elements of the simulation that can be allocated to entities. Resources have a specified *capacity* and a set of *states* that they transition between during a simulation run. The model includes four sub-models: The *Highway Activity Sub-model* simulates a gate process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. The *Airlift Activity Sub-model* simulates an airlift process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. The *Rail Activity Sub-model* simulates a rail process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. Finally, the *Storage Activity Sub-model* simulates a storage process which will receive and release equipment inventory to a highway tractor or yard hostler at a multi-modal terminal.

[1] Strategic Mobility 21 is a Congressionally mandated and independently funded applied research program through the Office of Naval Research. The program is conducted under the auspices of the Center for the Commercial Deployment of Transportation Technologies (CCDOTT), a government-industry academic collaborative enterprise.
[2] Dual-use technology serves as a basis for both commercial and military products.

1.0 INTRODUCTION

Strategic Mobility 21[3] (SM21) is an operational level concept that merges planning and execution of both commercial freight operations and the deployment and sustainment of joint military forces within a single construct of a Joint Power Projection Support Platform (JPPSP). The JPPSP can be described as a single transportation node that will be developed to seamlessly integrate with and support the end-to-end military and commercial distribution network. The inland multi-modal transfer facility, a key component of the JPPSP, can be described as a central node on a dual use[4] regional agile distribution network. The JPPSP multi-modal transfer facility presents a capability to achieve rapid military deployment and responsive commercial support and will be designed for replication in other geographic regions of the US. SM21 is being managed as a four-year advanced technology development and demonstration program.

1.1 The Multi-Modal Terminal Model

This manual documents the capabilities and functions of the SM21 Multi-Modal Terminal Model. The Model was created using Arena Basic v 10.00 from Rockwell Software, Inc. (http://www.arenasimulation.com) and extended using Visual Basic for Applications (VBA). *SIMAN* is the underlying simulation engine that controls the execution of Arena simulation models. There are two (2) files that are needed to run the Model: *SM21 Terminal Model vX_XX.doe* and *SM21 Terminal Model vX_XX.xls*. The *.doe* file is the Arena Model including the VBA code and the *.xls* file is the data input to the Model for scheduled arrivals and resource capacities. The Excel data file by default is the Model file name and can be redirected to another input file at run-time as needed.

2.0 THE MODEL

Entities represent the objects moving through the simulation. Each entity has its own characteristics, referred to as *attributes*. There are two (2) types of entities in the Model: *entMission* and *entBatchMission*. A mission is a conceptual goal that needs to be accomplished within the simulation which could represent a container pickup from a storage area originating from a highway gate or an inter-yard repark storage work order. A batched mission is a collection of missions that may represent an inbound consist or a highway convoy arrival. A batched mission will move the collection of missions together through the simulation until separated by the Model (e.g. railcar unloading).

Resources are elements of the simulation that can be allocated to entities. They have a specified *capacity* and a set of *states* that they transition between during a simulation run. There are nine (9) types of resources in the Model: *resLanes*, *resStackedRows*, *resWheeledRows*, *resRunways*, *resTracks*, *resHostlers*, *resStackers*, *resAirMHEs* and *resRailMHEs*.

2.1 Highway Activity Submodel

The *Highway Activity Submodel* simulates a gate process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. Single highway missions are created at

[3] Strategic Mobility 21 is a Congressionally mandated and independently funded applied research program through the Office of Naval Research. The program is conducted under the auspices of the Center for the Commercial Deployment of Transportation Technologies (CCDOTT), a government-industry academic collaborative enterprise.
[4] Dual-use technology serves as a basis for both commercial and military products.

a user-defined random interval while batched missions are created for scheduled convoy arrivals. Scheduled arrivals may become delayed. Gate arrivals have a higher priority over departures in order to meet potential cut-off times and help reduce potential traffic at he entrance of the terminal. Highway missions may go directly to terminal storage, airlift marshalling or rail marshalling areas and are transported by the highway tractor. The Model has the ability to account for highway inspections. The *Gate Capacity* sheet from the Excel input file accounts for the degree of parallelism for each gate lane. Typically this value would be either 0 or 1 representing a gate clerk on-duty, however if handheld devices can be used or talk-backs installed routing to the gate house this number could possibly be larger. During animation, highway missions are represented as green dots.

2.2 Airlift Activity Submodel

The *Airlift Activity Submodel* simulates an airlift process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. Batched missions are created for scheduled sortie arrivals. An airlift mission should represent an equivalent container load unit of measure (TEU/FEU) as airlift mission transport 463L pallets. Scheduled arrivals may become delayed. General servicing delays which account for any service action including nitrogen, oxygen and minor repairs should be included in the *Activity-*Block-in Delay (minutes)* values. Air MHEs are used for loading or unloading missions. Loading activities have a higher priority for Air MHE requests. Airlift missions will request a yard hostler to perform the specific mission activity outside of the airfield and will only travel between the marshalling area and the terminal storage area. Airlift holster requests have a higher priority over Rail. The Model has the ability to account for airlift refueling, de-icing and cargo inspections. Departure runway requests have a higher priority over arrivals. During animation, highway missions are represented as blue dots.

2.3 Rail Activity Submodel

The *Rail Activity Submodel* simulates a rail process which will create missions to pickup or drop-off equipment inventory at a multi-modal terminal. Batched missions are created for scheduled inbound consist arrivals. Scheduled arrivals may become delayed. The Model will use the number defined missions to create per arrival as the capacity for each track. For example, if a double stacked unit train contains 640 TEUs and each arrival track can hold 64 TEUs (roughly occupying 8,000 feet of track) then 10 ramp tracks will be required to drop the entire train on the multi-modal ramp and 64 would be entered in the *Missions (per consist arrival)*: prompt and 10 would be entered son the *Rail Arrivals* Excel Worksheet. Rail MHEs are used for loading or unloading missions. Loading activities have a higher priority for Rail MHE requests. Rail missions will request a yard hostler to perform the specific mission activity outside of the rail spur and will only travel between the marshalling area and the terminal storage area. The Model has the ability to account for U.S. Customs for an inland port consist move and rail inspections. Departure track requests have a higher priority over arrivals. During animation, highway missions are represented as red dots.

2.4 Storage Activity Submodel

The *Storage Activity Submodel* simulates a storage process which will receive and release equipment inventory to a highway tractor or yard hostler at a multi-modal terminal. Storage missions are created at a user-defined random interval to account for reparking orders. Stackers are used for picking or placing containers. The Model has the ability to segregate equipment by wheeled or stacked rows. During animation, highway missions are represented as yellow dots.

3.0 GETTING STARTED

After loading the Model, you should see four (4) sub models: Highway Gate Activity, Storage Activity, Rail Activity and Airlift Activity as shown in Figure 1. To traverse the Model, use the *Navigate Panel* on the Arena *Project Bar* and click on the desired outline item or use the right mouse button on the *Model Canvas View* (main Window) and select *Open Submodel* or *Close Submodel* from the Action Popup Menu.

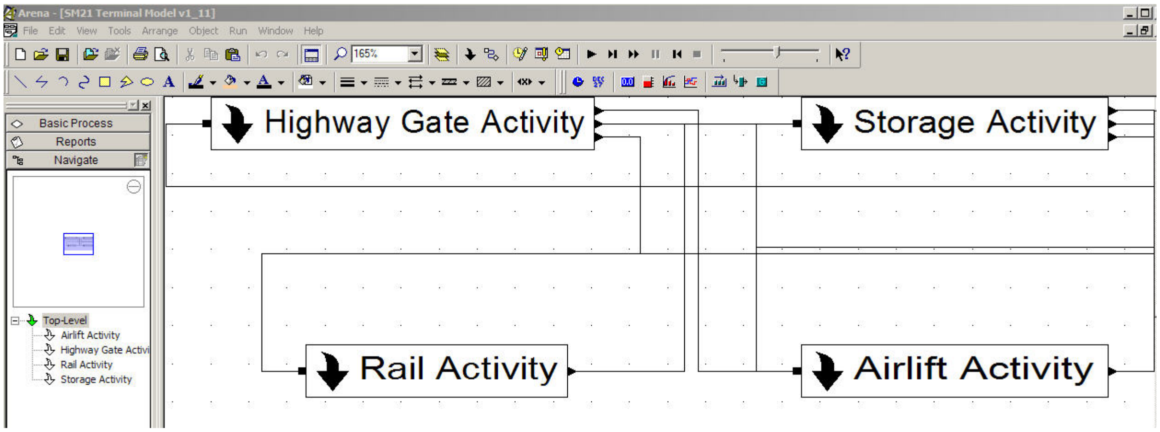

Figure 1: Arena Top-Level Model

Before running the Model, you'll need to verify that the appropriate VBA Excel Object Reference is loaded for your system. If you have Microsoft Office 2003 loaded on the machine you should be able to skip this step. Go to the Arena menu and select *Tools* > *Macro* > *Show Visual Basic Editor*, or simply use the shortcut key combination of *ALT-F11*. After the Visual Basic Editor is loaded, go to the VB menu and select *Tools* > *References*, you should see a screen similar to Figure 2. Now select the appropriate *Microsoft Excel XX.X Object Library* which is installed on the machine and click the *OK* command button. Save the VBA configuration by selecting *File* > *Save SM21 Terminal Model vX_XX* from the VB menu and finally *File* > *Close and Return to Arena* to close the Visual Basic Editor.

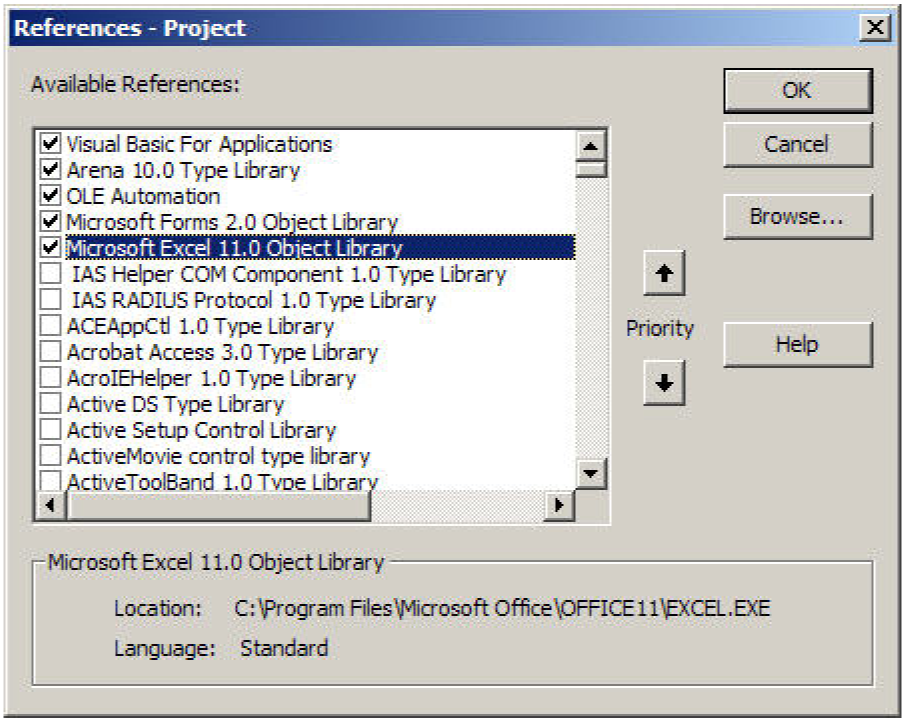

Figure 2: Visual Basic Editor Reference

The Model can be controlled either by the Run Toolbar (Figure 3), the Arena Run Menu or the assigned shortcut keys (Go *F5*, Pause *ESC*, End *ALT+F5*). When the Model is started a series of VBA screens will be displayed to capture user defined changes to the Model (i.e. number of resources available) and associated runtime variables (i.e. activity delay times). These configuration screens can be suppressed by setting the Area Model variable *varUserPrompt* to "0" via the *Variable* module located in the *Basic Process Panel* on the Arena *Project Bar*.

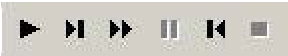

Figure 3: Arena Run Toolbar

4.0 MODEL CONFIGURATION SCREEN

The *Model Configuration Screen* (Figure 4) allows the user to make any structural changes to the Model such as changing the number of resources available in the simulation. Clicking the *OK* command button will upload any changes to the model, validate the model and then initializes the simulation to a run state. The *Cancel* command button will ignore any changes to the model and initialize the simulation to a run state.

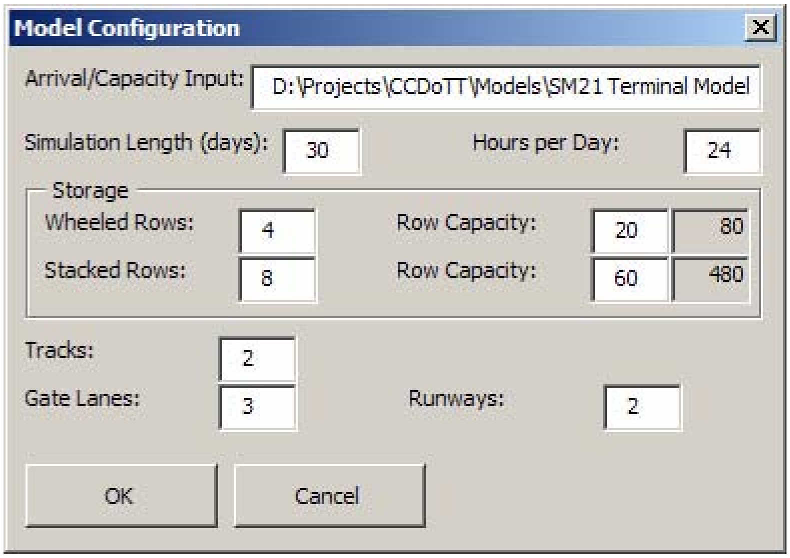

Figure 4: Model Configuration VBA Screen

PROMPT	DESCRIPTION
Arrival/Capacity Input:	Fully qualified location of the Excel input data file. This input file defines the scheduled arrivals and resource capacity for the simulation.
Simulation Length (days):	Number of days to simulate.
Hours per Day:	Number of hours in a day to simulate.
Storage-Wheeled Rows:	Number of wheeled rows available.
Storage-Row Capacity:	The individual capacity of each wheeled row (i.e. slots).
Storage-Stacked Rows:	Number of stacked rows available.
Storage-Row Capacity:	The individual capacity of each stacked row (i.e. slots).
Tracks:	Number of tracks available.
Gate Lanes:	Number of gate lanes available.
Runways:	Number of runways available.

The Excel data file which defines the model's resource scheduled arrivals and work capacity is based on a 24 hour schedule. Named ranges (Figure 5) are setup on each of the tabs (*Convoy Arrival*; *Gate Capacity*; *Air Arrivals*; *AirMHE Capacity*; *Rail Arrivals*; *Rail Departures*; *RailMHE Capacity*; *Stacker Capacity*; *Hostler Capacity*) which allows the Model to easily query the data. The *Time Slot* column indicates the hour of a day and it is used for reference and should not be changed. The *Arrival*, *Departure* and *Capacity* columns can be edited to reflect the appropriate scheduled arrivals/departures or resource capacity for the simulation.

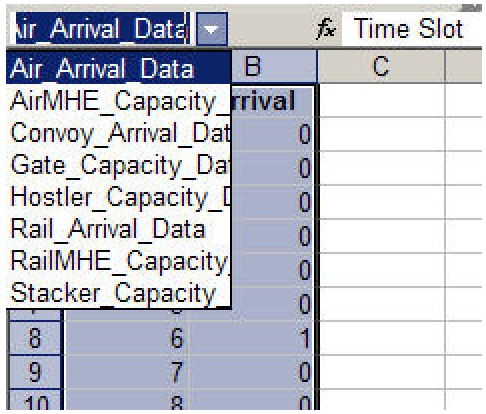

Figure 5: Excel Named Ranges

5.0 RUNTIME CONFIGURATION SCREEN

The *Runtime Configuration Screen* allows the user to make changes to the simulation runtime variables for that specific instance. This screen contains four (4) tabs organized by each sub model: *Highway*, *Airlift*, *Rail* and *Storage*. To modify these values so that they are saved along with the Model you must manually change the *Initial Value* of the corresponding Arena *Variable* using the Arena *Project Bar*.

5.1 Highway Tab

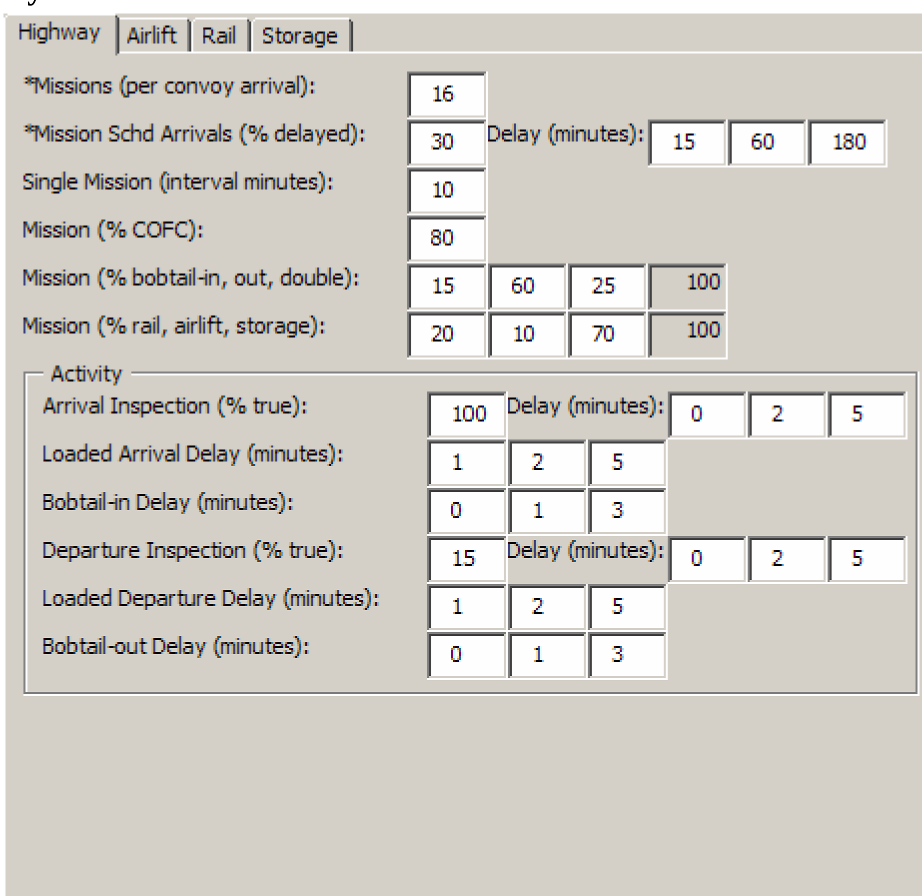

Figure 6: Runtime Highway Tab

PROMPT	DESCRIPTION	VARIABLE
***Missions (per convoy arrival):**	Number of missions to create for each scheduled convoy arrival.	varConvoyArrivalMissions
***Mission Schd Arrivals (% delayed):**	Value used to determine the percentage of delayed convoys.	varConvoyArrivalDelay
Delay (minutes):	Minimum, mean and maximum arrival delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varConvoyArrivalDelayMin, varConvoyArrivalDelayLikely, varConvoyArrivalDelayMax
Single Mission (interval minutes):	Random value using an Exponential Distribution to determine a highway mission arrival.	varGateArrivalInterval
Mission (% COFC):	Value used to determine the percentage of highway COFC missions.	varHighwayCOFC
Mission (% bobtail-in, out, double):	Distribution of cumulative probabilities to determine a bobtail-in (pickup), bobtail-out (drop-off) or a double move mission. The cumulative probabilities must add up to 100.	varHighwayPickup, varHighwayDropOff
Mission (% rail, airlift, storage):	Distribution of cumulative probabilities to determine a direct highway move to rail, airlift or a storage area. The cumulative probabilities must add up to 100.	varHighwayDirectRail, varHighwayDirectAirlift
Activity-Arrival Inspection (% true):	Value used to determine the percentage of arrival missions to be inspected.	varGateArrivalInsp
Delay (minutes):	Minimum, mean and maximum arrival inspection delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateArrivalInspDelayMin, varGateArrivalInspDelayLikely, varGateArrivalInspDelayMax
Activity-Loaded Arrival Delay (minutes):	Minimum, mean and maximum loaded arrival delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateArrivalDelayMin, varGateArrivalDelayLikely, varGateArrivalDelayMax
Activity-Bobtail-in Delay (minutes):	Minimum, mean and maximum bobtail-in delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateBobTailInDelayMin, varGateBobTailInDelayLikely, varGateBobTailInDelayMax
Activity-Departure Inspection (% true):	Value used to determine the percentage of departure missions to be inspected.	varGateDepartureInsp
Delay (minutes):	Minimum, mean and maximum departure inspection delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateDepartureInspDelayMin, varGateDepartureInspDelayLikely, varGateDepartureInspDelayMax
Activity-Loaded Departure Delay (minutes):	Minimum, mean and maximum loaded departure delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateDepartureDelayMin, varGateDepartureDelayLikely, varGateDepartureDelayMax
Activity-Bobtail-out	Minimum, mean and maximum bobtail-out	varGateBobTailOutDelayMin,

Delay (minutes):	delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varGateBobTailOutDelayLikely, varGateBobTailOutDelayMax

5.2 Airlift Tab

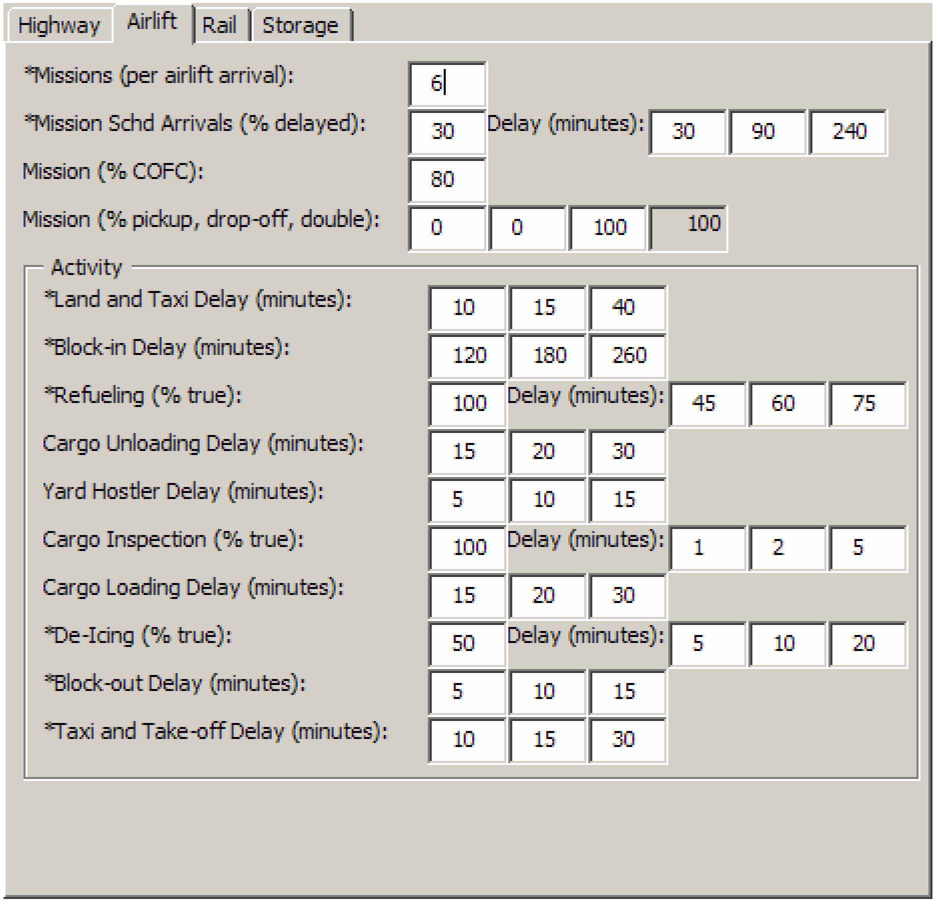

Figure 7: Runtime Airlift Tab

PROMPT	DESCRIPTION	VARIABLE
***Missions (per airlift arrival):**	Number of missions to create for each scheduled airlift arrival.	varAirArrivalMissions
***Mission Schd Arrivals (% delayed):**	Value used to determine the percentage of delayed airlift arrivals.	varAirArrivalDelay
Delay (minutes):	Minimum, mean and maximum scheduled arrival delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirArrivalDelayMin, varAirArrivalDelayLikely, varAirArrivalDelayMax
Mission (% COFC):	Value used to determine the percentage of airlift COFC missions.	varAirliftCOFC
Mission (% pickup, drop-off, double):	Distribution of cumulative probabilities to determine a pickup, drop-off or a double move mission.	varAirliftPickup, varAirliftDropOff

	The cumulative probabilities must add up to 100	
Activity-*Land and Taxi Delay (minutes):	Minimum, mean and maximum land and taxi delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirLandDelayMin, varAirLandDelayLikely, varAirLandDelayMax
Activity-*Block-in Delay (minutes):	Minimum, mean and maximum block-in and general servicing delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirBlockInDelayMin, varAirBlockInDelayLikely, varAirBlockInDelayMax
Activity-*Refueling (% true):	Value used to determine the percentage of airlifts where refueling is needed.	varAirRefueling
Delay (minutes):	Minimum, mean and maximum refueling delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirFuelDelayMin, varAirFuelDelayLikely, varAirFuelDelayMax
Activity-Cargo Unloading Delay (minutes):	Minimum, mean and maximum cargo unloading delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirUnloadDelayMin, varAirUnloadDelayLikely, varAirUnloadDelayMax
Activity-Yard Hostler Delay (minutes):	Minimum, mean and maximum yard hostler request delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirHostlerDelayMin, varAirHostlerDelayLikely, varAirHostlerDelayMax
Activity-Cargo Inspection (% true):	Value used to determine the percentage of airlift cargo inspections.	varAirCargoInsp
Delay (minutes):	Minimum, mean and maximum cargo inspection delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirInspDelayMin, varAirInspDelayLikely, varAirInspDelayMax
Activity-Cargo Loading Delay (minutes):	Minimum, mean and maximum cargo loading delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirLoadDelayMin, varAirLoadDelayLikely, varAirLoadDelayMax

Activity-*De-Icing (% true):	Value used to determine the percentage of airlifts where de-icing is needed.	varAirDeIcing
Delay (minutes):	Minimum, mean and maximum de-icing delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirDeIcingDelayMin, varAirDeIcingDelayLikely, varAirDeIcingDelayMax
Activity-*Block-out Delay (minutes):	Minimum, mean and maximum block-out delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirBlockOutDelayMin, varAirBlockOutDelayLikely, varAirBlockOutDelayMax
Activity-*Taxi and Take-off Delay (minutes):	Minimum, mean and maximum taxi and take-off delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varAirTakeOffDelayMin, varAirTakeOffDelayLikely, varAirTakeOffDelayMax

5.3 Rail Tab

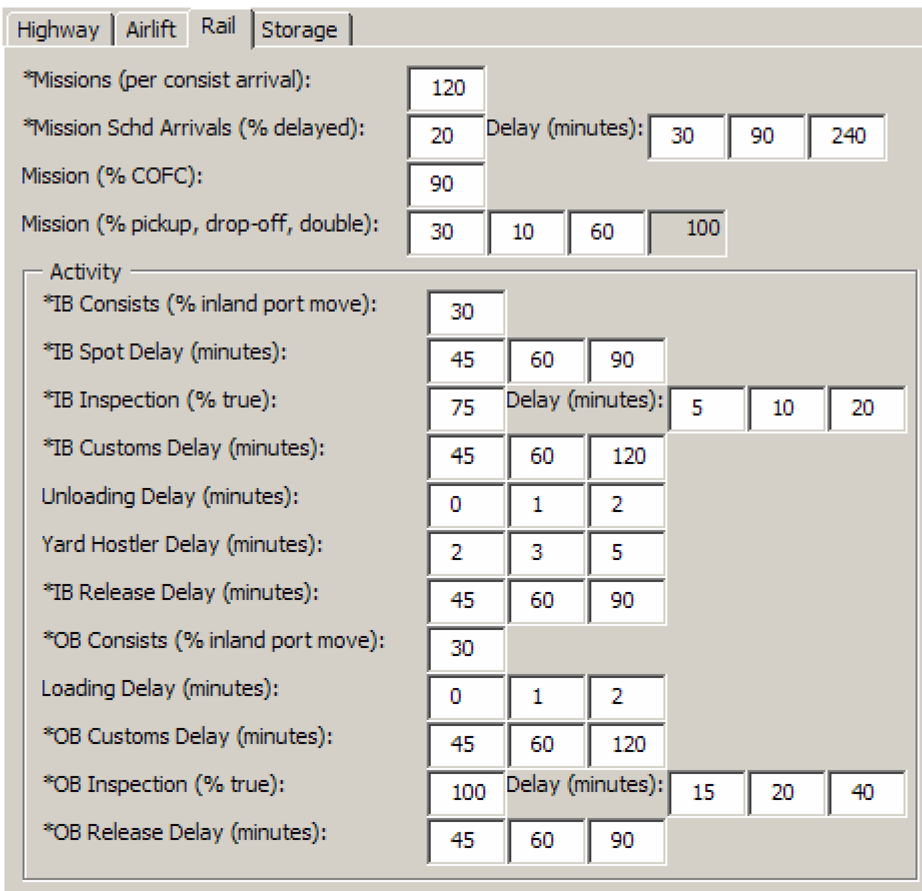

Figure 8: Runtime Rail Tab

PROMPT	DESCRIPTION	VARIABLE
***Missions (per consist arrival):**	Number of missions to create for each scheduled consist cut arrival.	varRailArrivalMissions
***Mission Schd Arrivals (% delayed):**	Value used to determine the percentage of delayed consist arrivals.	varRailArrivalDelay
Delay (minutes):	Minimum, mean and maximum scheduled arrival delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailArrivalDelayMin, varRailArrivalDelayLikely, varRailArrivalDelayMax
Mission (% COFC):	Value used to determine the percentage of rail COFC missions.	varRailCOFC
Mission (% pickup, drop-off, double):	Distribution of cumulative probabilities to determine a pickup, drop-off or a double move mission. The cumulative probabilities must add up to 100	varRailPickup, varRailDropOff
Activity-*IB Missions (% inland port move):	Value used to determine the percentage of inbound consists originated from a port.	varRailIBInlandPort
Activity-*IB Spot Delay (minutes):	Minimum, mean and maximum inbound consist spot delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailSpotDelayMin, varRailSpotDelayLikely, varRailSpotDelayMax
Activity-*IB Inspection (% true):	Value used to determine the percentage of inbound consists to be inspected.	varRailIBInsp
Delay (minutes):	Minimum, mean and maximum inbound inspection delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailIBInspDelayMin, varRailIBInspDelayLikely, varRailIBInspDelayMax
Activity-*IB Customs Delay (minutes):	Minimum, mean and maximum inbound customs delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailIBCustomsDelayMin, varRailIBCustomsDelayLikely, varRailIBCustomsDelayMax
Activity-Unloading Delay (minutes):	Minimum, mean and maximum railcar unloading delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailUnloadDelayMin, varRailUnloadDelayLikely, varRailUnloadDelayMax

Activity-Yard Hostler Delay (minutes):	Minimum, mean and maximum yard hostler request delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailHostlerDelayMin, varRailHostlerDelayLikely, varRailHostlerDelayMax
Activity-*IB Release Delay (minutes):	Minimum, mean and maximum inbound consist release delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailIBReleaseDelayMin, varRailIBReleaseDelayLikely, varRailIBReleaseDelayMax
Activity-*OB Missions (% inland port move):	Value used to determine the percentage of outbound consists destined to a port.	varRailOBInlandPort
Activity-Loading Delay (minutes):	Minimum, mean and maximum railcar loading delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailLoadDelayMin, varRailLoadDelayLikely, varRailLoadDelayMax
Activity-*OB Customs Delay (minutes):	Minimum, mean and maximum outbound customs delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailOBCustomsDelayMin, varRailOBCustomsDelayLikely, varRailOBCustomsDelayMax
Activity-*OB Inspection (% true):	Value used to determine the percentage of outbound consists to be inspected.	varRailOBInsp
Delay (minutes):	Minimum, mean and maximum outbound inspection delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailOBInspDelayMin, varRailOBInspDelayLikely, varRailOBInspDelayMax
Activity-*OB Release Delay (minutes):	Minimum, mean and maximum outbound consist release delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varRailOBReleaseDelayMin, varRailOBReleaseDelayLikely, varRailOBReleaseDelayMax

5.4 Storage Tab

Figure 9: Runtime Storage Tab

PROMPT	DESCRIPTION	VARIABLE
***RePark Work Orders (interval minutes):**	Random value using an Exponential Distribution to determine a repark mission.	varStorageReParkInterval
***ReParks per Interval:**	Number of repark missions to create per interval.	varStorageReParkNumber
Activity-Wheeled Receipt Delay (minutes):	Minimum, mean and maximum wheeled receipt to storage delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varWheeledReceiptDelayMin, varWheeledReceiptDelayLikely, varWheeledReceiptDelayMax
Activity-Wheeled Release Delay (minutes):	Minimum, mean and maximum wheeled release from storage delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varWheeledReleaseDelayMin, varWheeledReleaseDelayLikely, varWheeledReleaseDelayMax
Activity-Yard Stacker Delay (minutes):	Minimum, mean and maximum yard stacker request delay values in minutes. Model uses a triangular	varStorageStackerDelayMin, varStorageStackerDelayLikely, varStorageStackerDelayMax

	distribution to return a value between minimum and maximum with the most likely values centered around the mean.	
Activity-Stacked Receipt Delay (minutes):	Minimum, mean and maximum stacked receipt to storage delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varStackedReceiptDelayMin, varStackedReceiptDelayLikely, varStackedReceiptDelayMax
Activity-Stacked Release Delay (minutes):	Minimum, mean and maximum stacked release from storage delay values in minutes. Model uses a triangular distribution to return a value between minimum and maximum with the most likely values centered around the mean.	varStackedReleaseDelayMin, varStackedReleaseDelayLikely, varStackedReleaseDelayMax

6.0 SIMULATION REPORTS

Arena provides various drill-down reports located on the *Reports Panel* of the Arena *Project Bar*. Those that are applicable to this Model are: *Entities, Processes, Queues, Resources* and *User Specified*. Once the Model is successfully run you are able to run any of the reports to review the simulation outcome.

6.1 Resource Summary Report

Resource Detail Summary

Usage

	Inst Util	Num Busy	Num Sched	Num Seized	Sched Util
resAirMHE	0.21	0.86	4.00	1,713.00	0.21
resHostler	0.13	3.93	30.00	8,136.00	0.13
resLane1	0.47	0.47	1.00	6,473.00	0.47
resLane2	0.29	0.29	1.00	3,899.00	0.29
resLane3	0.18	0.18	1.00	2,501.00	0.18
resRailMHE	0.06	0.25	4.00	10,837.00	0.06
resRunway1	0.12	0.12	1.00	267.00	0.12
resRunway2	0.01	0.01	1.00	18.00	0.01
resStackedRo	0.07	4.43	60.00	811.00	0.07
resStackedRo	0.07	4.19	60.00	1,069.00	0.07
resStackedRo	0.07	4.09	60.00	998.00	0.07
resStackedRo	0.07	3.95	60.00	1,020.00	0.07
resStackedRo	0.06	3.82	60.00	944.00	0.06
resStackedRo	0.06	3.72	60.00	926.00	0.06
resStackedRo	0.06	3.59	60.00	890.00	0.06
resStackedRo	0.06	3.60	60.00	570.00	0.06
resStacker	0.26	1.03	4.00	17,160.00	0.26
resTrack1	0.15	0.15	1.00	66.00	0.15
resTrack2	0.07	0.07	1.00	34.00	0.07
resWheeledR	0.19	3.85	20.00	358.00	0.19
resWheeledR	0.16	3.23	20.00	487.00	0.16
resWheeledR	0.15	3.03	20.00	416.00	0.15
resWheeledR	0.15	2.96	20.00	239.00	0.15

Figure 10: Resource Summary Report

Instantaneous Utilization: The resource's utilization (*Number Busy*/*Number Scheduled*) at each instance of time during the simulation run. This may include times that the resource was not scheduled in the system.

Number Busy: The number of busy resource units.

Number Scheduled: The number of scheduled resource units.

Number Seized: The total number of seized resource units.

Scheduled Utilization: The cumulative average utilization over the time period that the resource was actually scheduled in the system.

6.2 Queue Summary Report

Queue Detail Summary

Time

	Waiting Time
Batch Airlift Loading.Queue	1.56
Batch Inbound Release.Queue	0.35
Batch Outbound Release.Queue	0.25
Batch Rail Loading.Queue	5.43
Process Airlift Loading.Queue	0.03
Process Airlift Unloading.Queue	0.31
Process Arrival.Queue	0.05
Process BobTail In.Queue	0.03
Process BobTail Out.Queue	0.08
Process Departure.Queue	0.11
Process Rail Loading.Queue	0.24
Process Rail Unloading.Queue	0.28
Process Stacked Receipt.Queue	0.00
Process Wheeled Receipt.Queue	0.00
Request Arrival Runway.Queue	0.00
Request Arrival Track.Queue	0.12
Request Departure Runway.Queue	0.00
Request DepartureTrack.Queue	0.02
Request Stacker.Queue	0.12
Request Yard Hostler Airlift.Queue	0.00
Request Yard Hostler Rail.Queue	0.62

Figure 11: Queue Summary Report

Waiting Time: The period of time from when the entity (*mission*) enters a queue until the entity exits the queue.

7.0 QUICK MODEL EXAMPLE

If we look at the *Queue Summary Report* (Figure 11), specifically the *Request Yard Hostler.Rail Queue*, we'll see that the average wait time is 0.62 of an hour or 37.2 minutes. If we wanted to reduce the average wait time for that process, one thing we can do is allocate additional hostlers around the rail activity schedule from the Excel file. Adding an additional 5 yard hostlers to the schedule from 0600 to 1000 on the *Rail Arrivals* worksheet and 1800 to 2200, we are able to reduce the waiting time to 0.53 of an hour or 31.8 minutes.

APPENDIX A - LITERATURE REVIEW AND SOFTWARE SELECTION

The Multi-Modal Terminal Model was created using Arena Basic v 10.00 from Rockwell Software, Inc. (http://www.arenasimulation.com) (Arena) and extended using Visual Basic for Applications (VBA). *SIMAN* is the underlying simulation engine that controls the execution of Arena simulation models. The decision to develop a multi-modal terminal model as a part of SM21 and to use Arena as the modeling tool was reached after completing an appropriate literature search.

Literature associated with existing models did not indicate the flexibility and ease of use required by the SM21 program. Therefore a decision was made to develop a model specifically designed to meet the demanding requirement of the SM21 program. The SM21 Multi-Modal Terminal Model will be used to model a large number of different terminal environments found in the Southern California region. This modeling effort is required to provide input data on terminal capacity and flow rates for the SM21 Southern California Agile Supply Network (SCASN) Model – a regional network model. The Multi-Model Terminal Model will be required to evaluate all modes of transportation including air cargo.

Since the decision was made to develop a model specifically for the SM21 program, a review of existing simulation software was conducted to find the one most capable software for quickly developing process modeling and simulation applications. SM21 requires a simulation development tool to support a breadth of applications, scaled to fit different needs throughout the SM21 project life cycle, and the tool must integrate with other SM21, government, and commercial terminal stakeholder's modeling and database systems. The Extend simulation software developed by Imagine That, Inc. was also considered a viable option for use in modeling the Multi-Modal Terminal. Extend was found to have many of the same features as Arena and is being used by the United States Navy, OPNAV-42 staff for evaluation of certain aspects of the Sea-basing concept. However, taking all the SM21 requirements into consideration, the reviews indicated that Arena from Rockwell Automation better fulfills the SM21 requirements through the following advantages:

- Preferred by United States Transportation Command for like simulations
- Useable by business analysts
- Use of sub-models provides "infinite" granularity
- Low Cost ($800)
- Visual
- Object oriented
- Can import from various sources (e.g. Excel)
- Can export to various formats
- Can create UML as an output
- Custom features can be created via VBA or Visual Basic

GLOSSARY

Terminology	Definition
AIRLIFT	The performance or procurement of air transportation and services incident thereto required for the movement of persons, cargo, mail, or other goods.
BOBTAIL	A tractor operating without a trailer or chassis.
CHASSIS	The wheels and frame assembly that supports the container.
COFC	Container on flatcar. A container that moves on a flatcar without a chassis.
CONTAINER	A piece of equipment that has a removable chassis. Usually used in ocean carriage or on stack trains. Comes in various sizes: 20, 40, 45, 48 and 53 foot.
DEICING	Deicing is a procedure by which frost, ice, slush or snow is removed from an aircraft to render it free of contamination.
DISCRETE DISTRIBUTION	The user-defined cumulative probability distribution is searched until a probability larger than a generated random number is found. The value associated with that probability is chosen.
EXPONENTIAL DISTRIBUTION	A continuous probability distribution with a mean 'λ': $f(x;\lambda) = \begin{cases} \frac{1}{\lambda}e^{-x/\lambda} & , \ x \geq 0, \\ 0 & , \ x < 0. \end{cases}$
FLATCAR	A railcar, which a trailer/container is placed on to move via the railroad. A car without roof or walls.
GATE	A point at an intermodal terminal where a clerk checks in and out all containers and trailer. All reservations and paperwork are checked at the gatehouse.
HAZMAT	Hazardous Material. Product that is determined to be harmful and requires special handling as set forth by government agencies and the intermodal companies.
HOSTLER	An individual employed to move containers and trailers within a terminal or warehouse yard area.
INBOUND	Cargo moving from a rail terminal towards its destination. Generally used for cargo coming off a train and heading for final delivery to consignee.
IN-GATE	The transaction or interchange that occurs at the time a container is received by a rail terminal, container yard, or water terminal from another carrier.
MHE	Materials-Handling Equipment. Mechanical devices for handling cargo.
OUTBOUND	Cargo moving from a shipper to rail ramp. Generally refers to cargo going onto a stack or conventional train.
OUT-GATE	The transaction or interchange that occurs at the time a container is delivered from a rail terminal, CY, or water terminal to another carrier.
OVER-THE-ROAD (OTR)	An all truck freight shipment, used in lieu of rail service, at a premium charge.

PALLET	A wooden, paper or plastic platform usually with a top and bottom, on which packaged goods are placed to facilitate movement by some type of freight handling equipment.
PICK-UP	The act of calling for freight by truck at the consignors shipping platform.
PICK-UP APPOINTMENT	Scheduled time for pick-up or loading of a container from a shipper or consignee.
RAMP	A technical rail ramp not serviced by an actual train.
SLOT	A single storage/placement location which accommodates an asset.
TERMINAL	An assigned area in which containers are prepared for loading onto a train or are stored after discharge from a train.
TEU	Twenty-foot Equivalent Unit. A standard container size used for comparative measuring purposes. Normally applied to containers used by steamship lines (20, 40 and 45 foot containers)
TOFC	Trailer On Flat Car. A trailer that moves on a flat car with the chassis attached.
TRAILER	A freight vehicle equipped with a permanent wheel assembly and a device for attaching to a tractor for movement.
TRAIN ID	A system to identify the trains origin and destination points, the day of the week for departure and the week of the year it moved.
TRIANGULAR DISTRIBUTION	A continuous probability distribution with a lower limit ‘a’, a mean ‘c’ and an upper limit ‘b’: $f(x \mid a,b,c) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)} & \text{for } a \le x \le c \\ \frac{2(b-x)}{(b-a)(b-c)} & \text{for } c < x \le b \end{cases}$
WHEELED ROW	A physical storage location which handles an asset with wheels such as a trailer, a bare chassis or a container married to a chassis.
YARD	A classification, storage or switching area.

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