Scheduling Discrete Part Production

General Description

The example uses Simio RPS Edition to schedule discrete part production. Simio RPS Edition is a simulation tool for developing applications in Risk-based Planning and Scheduling. RPS is the dual use of a simulation model to generate both a detailed resource constrained deterministic schedule as well as a probability-based risk analysis of that schedule to account for variation in the system. RPS is used to generate schedules that minimize risks and reduce costs in the presence of uncertainty. Although Simio RPS Edition is required to build this model, it may be viewed using Simio Design or Team Edition.

To understand the data schema and scheduling results in this example you should first read the *Planning and Scheduling with Simio* document in C:\Program Files (x86)\Simio. This problem description assumes that you are familiar with the standard data schema and scheduling concepts that are presented in that document.

The system to be scheduled in this example is a discrete part manufacturing facility. The facility is a job shop that produces finished goods. We wish to generate a 30-day production schedule for this facility that fully accounts for the limited resources in the system.

The facility consists of functionally grouped machine groups named *Cut*, *Weld*, *Shape*, and *Finish*, with two machines within each machine group. Each of these machines is modeled using a Server, with a TransferNode that is named for the machine group (e.g. Cut) and is used to dynamically route based on a scheduling rule to the selected machine (Cut1 or Cut2) within the group. The Cut and Weld Servers require a secondary resource that is that is modeled as a Worker. The Worker named Team 1 operates at Cut1 and Cut2 Servers while Team2 Worker operates at Weld1 and Weld2 Servers. The Cut Servers have a sequence dependent setup time where the setup time is specified in a changeover matrix based on material color. Possible material colors are defined in a string list named *MaterialColor* with values Other, Red, Green, and Blue.

There are three finished goods (*FinishedGoodA*, *FinishedGoodB*, and *FinishedGoodC*) that are produced in this facility, and each has its own routing and unique setup and processing time and material requirements at each Server within its routing. The B2MML-based data schema discussed in the *Planning and Scheduling with Simio* document is used to hold the production data for this example.

Although we are modeling the material consumption at each Server, in this example we are not explicitly modeling the material resupply logic. The consumed materials are defined in the Material Lots table and include *MaterialX* and *MaterialY*, and each has sufficient levels to supply production during the planning horizon. The Bicycle example model that is installed with Simio illustrates modeling of the material resupply based on a *Purchased Material* arrival table.

In this example, we are provided a set of CSV files for automatically generating the major components of the model, and populating the required data tables. This illustrates the concept of "data-generated" modeling where the model is created automatically by populating the object data into the Resource table. In this example, the objects that are created from this table are already mapped to the scheduling tables.

Detailed Description

For this example, we provide the following additional data files that we will use for building the model and populating the data tables:

File Name	Description
Resources.csv	A list of resources (objects) in the facility.
RoutingDestinations.csv	A list of node destinations from transfer node.
Manufacturing Orders.csv	A list of orders to be produced during this planning period.
Materials.csv	A list of materials that are defined in the system.
Material Lots.csv	A list of material lots that are consumed and may limit production.
Routings.csv	The routing that is required to produce each material.
BillOfMaterials.csv	The materials required at each routing step.
WorkInProcess.csv	The initial state of the work in process.
DispatchList.xml	An xml file of the dispatch dashboard schema for import.
Materials.xml	An xml file of the materials dashboard schema for import.
Orders.xml	An xml file of the orders detail dashboard schema for import.
Dispatch List Report.repx	A table report file for a dispatch list report for import.
Order Details.repx	A table report file for an order details report for import.

These files are in the DiscretePartProductionFiles folder that is in the same directory as this example.

To build this model we execute the following steps:

1) Click the File > New From Template option and select *ISA95 Schema Product Based Routings* template. This will create the tables and the subclass objects used for scheduling.
2) Import the Resources.csv into the Resources table. This will generate the objects for the model.
3) Import the remaining csv files into the data tables.
4) Add custom Dashboards and Reports.
5) Enhance the model logic as necessary (in this example no enhancements are made).

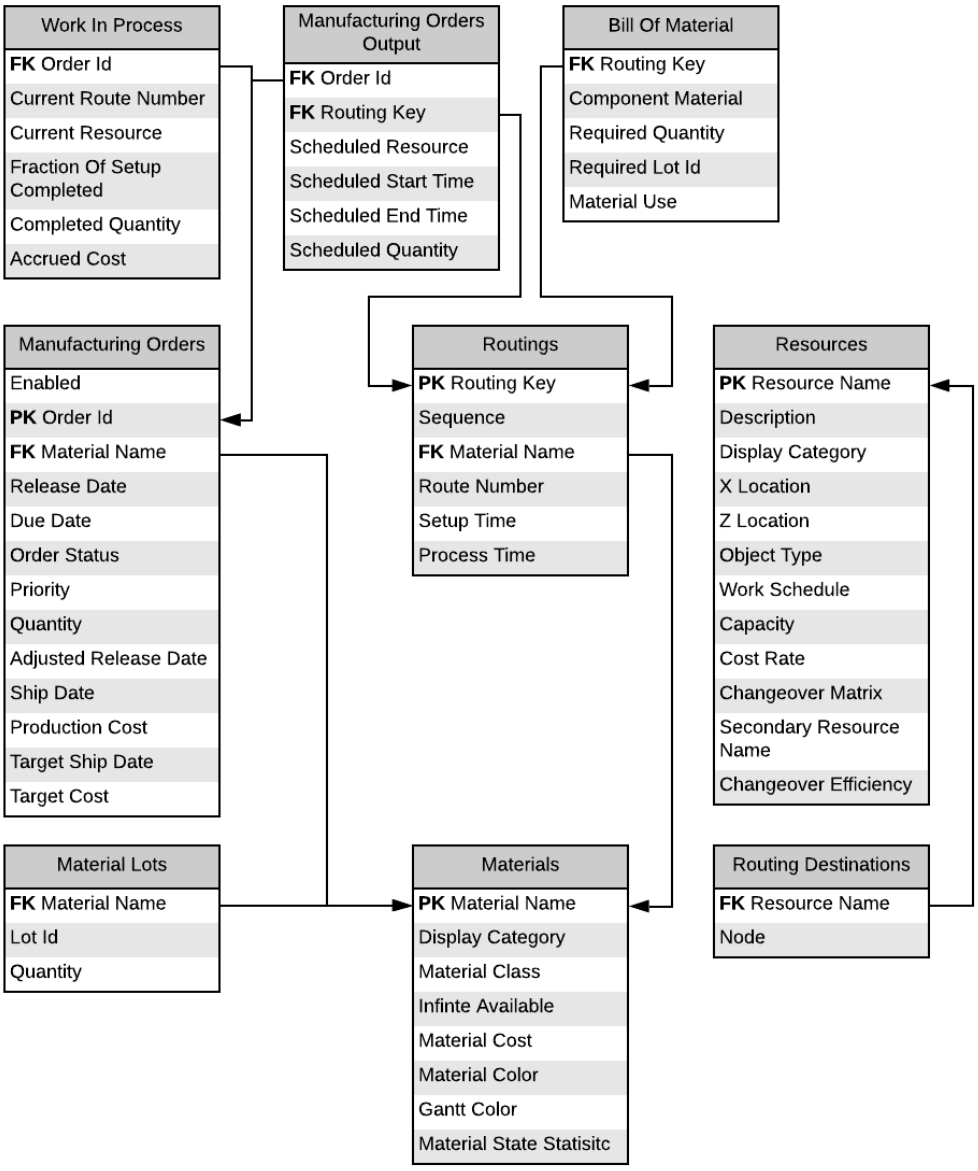
We will now describe each of these steps in detail.

Open the *ISA95 Schema Product Based Routings* Template

Our first step is to go to File > New From Template option and select the *ISA95 Schema Product Based Routings* template option. This will open a project that includes the *Resources, Routing Destinations, Materials, MaterialLots*, *Manufacturing Orders*, *Routings*, *Bill of Materials*, *Work In Process, and Manufacturing Orders Output* data tables; and the related string lists. These data tables will be populated at a later step by importing data from csv files. The *Order Status* string list is used to define orders as one of two types: *New* orders that are being released to the facility, and *WIP* orders that are currently in process. The Material Color string list is a default string list for use with change dependent setup times. In a typical application, this list would be renamed to size, part group, etc., based on the attribute that triggers a dependent setup change. In this example, we will use the default Material Color list to define the changeover attribute.

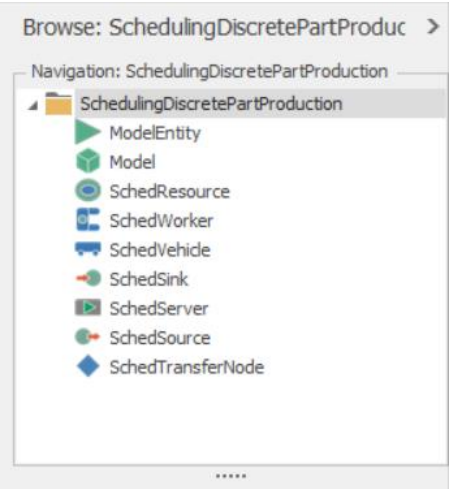
The following entity relationship diagram depicts the data tables that are used in this example, along with the relations between the tables (Note: see Appendix A – Data Tables for a detailed description of

the fields in each table). This data schema assumes a product-based routing where the routing is defined for each material that can be produced in the facility, and the manufacturing orders refer to each material being produced for that order. It is also possible to configure the tables where a unique routing is specified for each order. This later approach is useful in an engineered to order manufacturing environment.



Although the default Gantt display and Logs work fine for many applications, it is convenient to be able to extend the Logs with additional information, and to use this extra information to augment the Gantt display. This add-in will also add three new custom columns to the Resource Usage Log for this purpose. The first specifies the name of the material being produced on the resource. The second is the desired fill color for drawing bars on the Gantt. The third is the desired outline color for drawing these same bars.

In addition to creating the tables, the template includes the sub-classed objects that are used for scheduling. These objects are the same as their Standard Library objects except the default value for the object properties are mapped to the Scheduling tables. In the case of the Server, task sequences are also added to model the setup and processing phases of the server. As the objects are added to the model, they will already be mapped to use the data in the scheduling tables. All the objects in the Navigation window that start with "Sched" are the sub-classed scheduling objects.

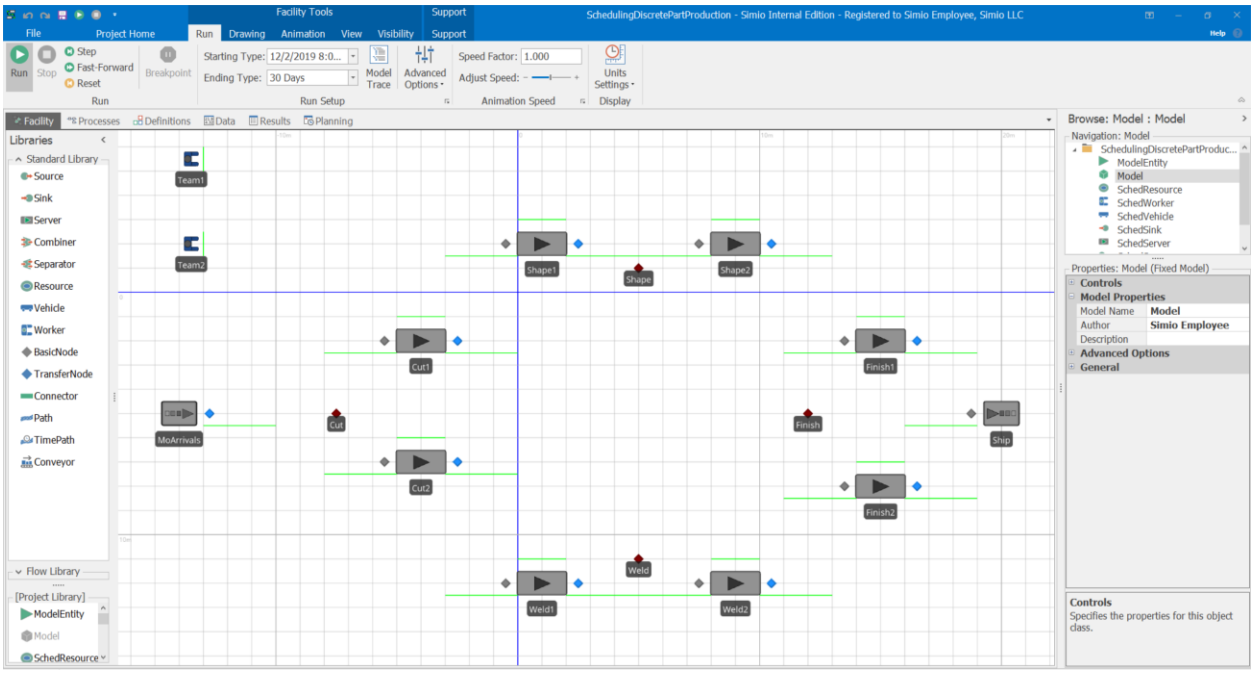


Import the Resources

Next, we will populate the Resources table by importing the data from the Resources.csv data file. To do so we first bind to the file by selecting Bind To CSV on the Content ribbon of the Data window, and then browse to and select the Resources.csv file in the Examples folder:

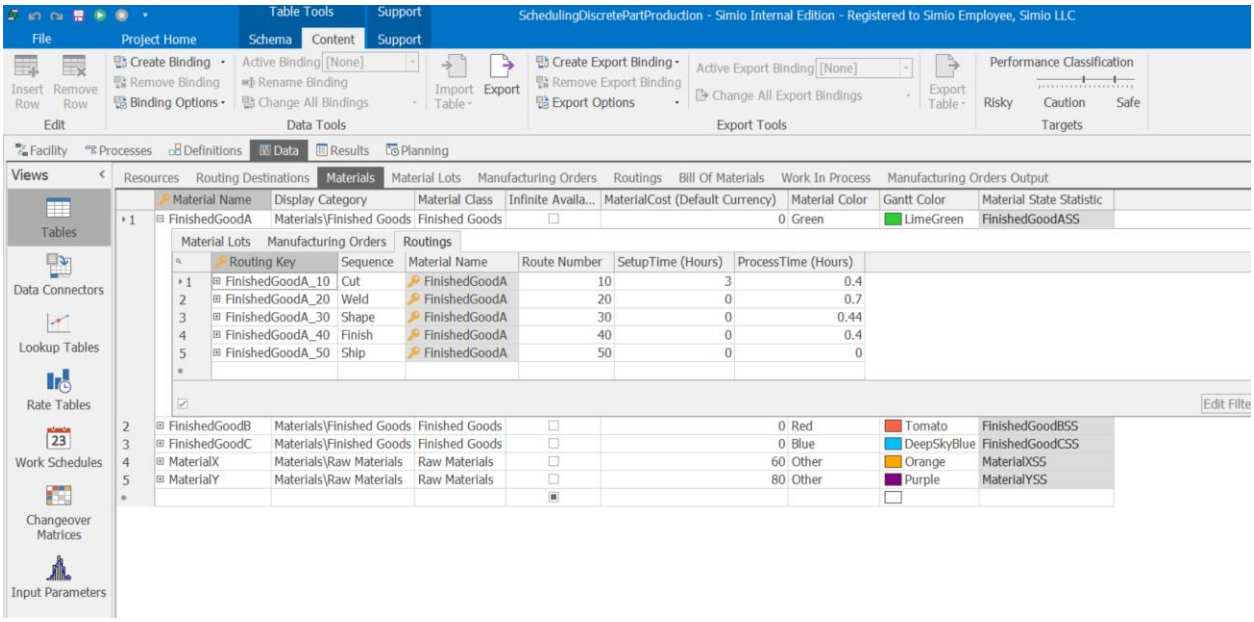
C:\Program Files\Simio LLC\Simio\Examples\DiscretePartProductionFiles.

We then set our binding option to manual, and then click on Import to import the resource data into the table. As the data is imported into the table, the objects are automatically added to the model. They are placed in the model at the XLocation and ZLocation coordinates in the Resources table. The resulting model is depicted below:



Import the remaining csv files

Next, we will import the remaining csv files to populate the remaining set of data tables. In each case, we bind to the appropriate csv file, select the binding option to manual, and then import the data. During this process, you may generate errors because of references to undefined items, but these errors will all be removed once all the data has been imported and the references are fully resolved. Also, note that the Manufacturing Orders Output table has no imported data rows; data is added to this table as the simulation executes. The following shows the imported relational data for the Material table.



Adding Custom Dashboards and Reports

Our next step is to enhance the model with some custom dashboards and table reports. We will import three standard dashboards to our model that are designed to work with the default data schema. These dashboards are saved in XML format and included in the DiscretePartProductionFiles folder that is saved with this example. These dashboards display material, order details, and a dispatch list for use by operators. We will also import a custom dispatch list table report and a customer orders details table report.

To import these dashboards, go to Dashboards Report view of the Results window and select the Dashboards ribbon. Click in the Import button and browse to the folder, and select the three dashboard xml files named Dispatch List, Materials, and Order Details. To import the two reports, go to the Table Reports view under the Results window and import the Dispatch List Report.repx for Manufacturing Orders Output table, and the Orders Details.repx for the Manufacturing Orders table.

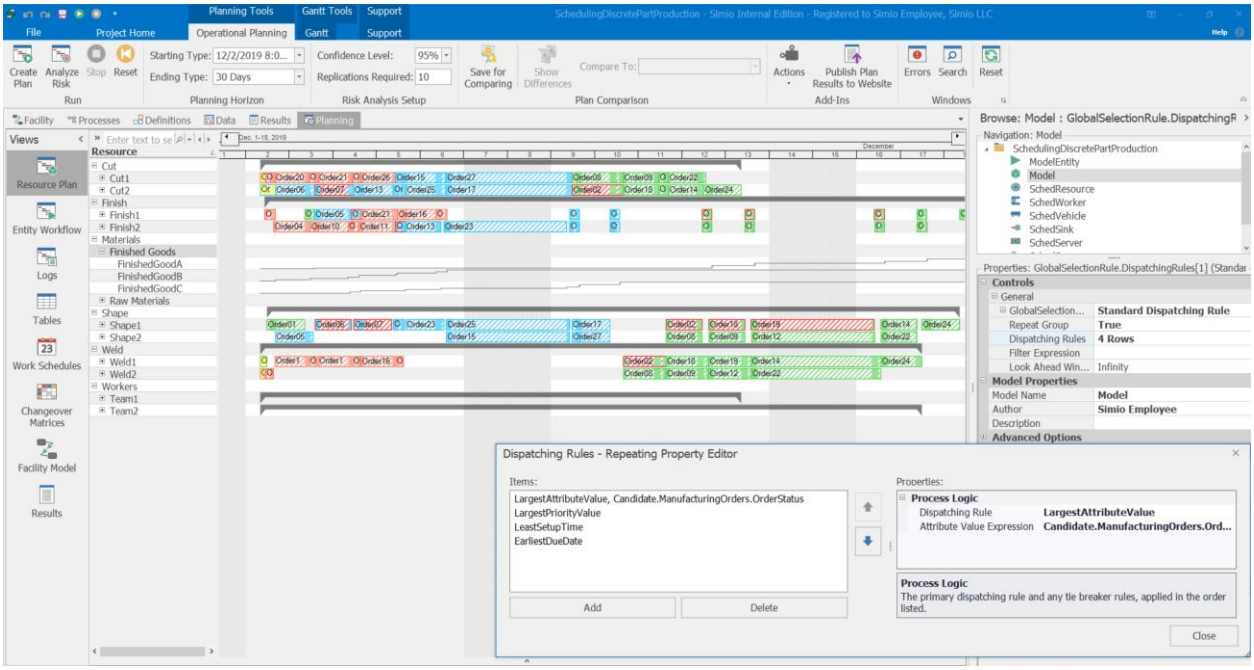
Enhancing the Model Logic

Although a default model can be rapidly built using the available add-ins, it's sometimes desirable to edit this default model to add additional logic or detail to the Facility model. Examples of possible enhancements include adding moving operators (using Worker objects) that travel between Servers, complex material handling devices such as AGVs or conveyor systems, as well as custom decision logic for selecting between orders or Servers. Note that the full modeling power of Simio is available to us to customize the model as needed. In this example, we will keep the basic model that is automatically created for us by the scheduling add-ins.

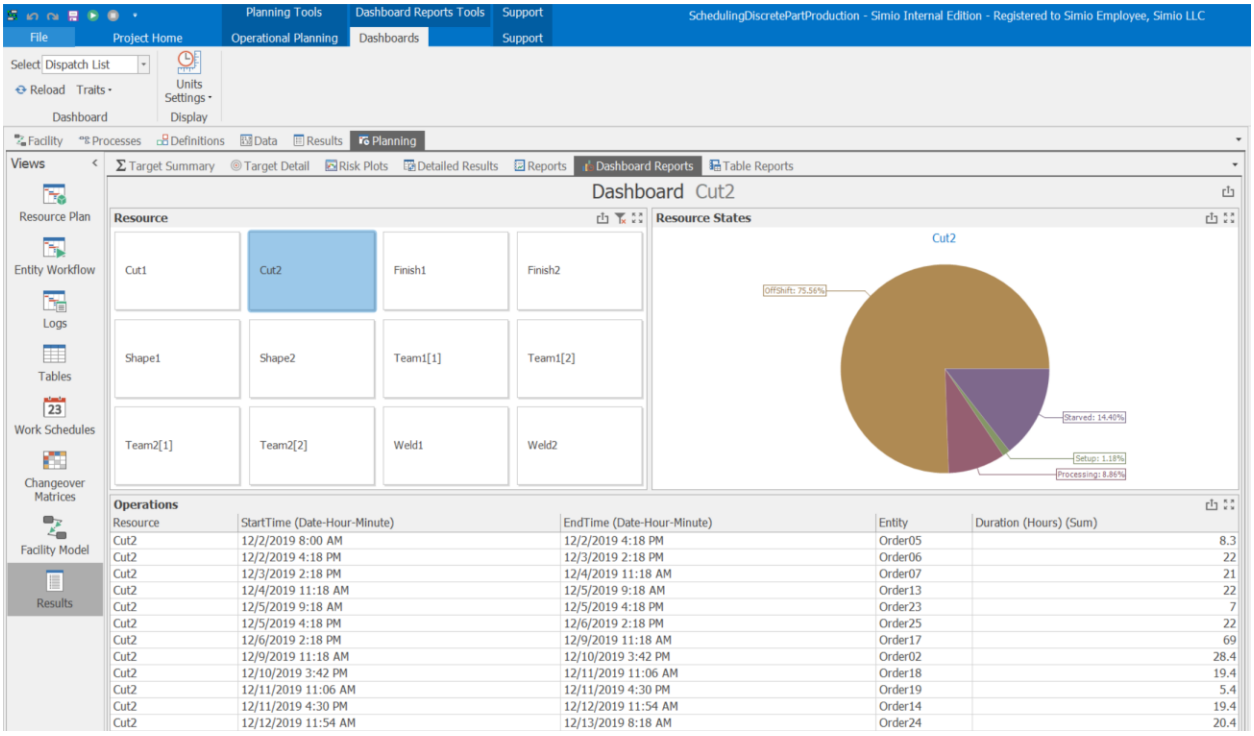
Generating the Schedule

Once our model is complete we can generate the schedule by clicking on Create Plan on the Operational Planning ribbon in the Planning window. This generates the deterministic schedule by automatically removing the randomness from the model. We can then generate the risk analysis for this schedule by clicking on the Analyze Risk button on the same ribbon.

Our model was created using a global scheduling rule that can be easily changed in the model properties. By default, orders are processed first-in-first-out, however this global rule can be easily changed to any of the standard dispatching rules supported by Simio. The following depicts a zoom-in portion of the Resource Plan for this example using the Largest AttributeValue rule.



As discussed in the *Planning and Scheduling with Simio* document there are many ways to view the schedule and the associated risk. For example, the following is dashboard for the dispatch list that we imported using the XML file. This dashboard shows the resource utilization and dispatch list for the currently selected resource (Cut2).



Data Tables

The following is a summary of the default tables that are based on the B2MML standard.

Resources:

A list of resources that are in the manufacturing facility.

Column Name	Description
Resource Name	The unique name of the resource. This is the object name.
Description	A description of this resource.
Display Category	The machine and worker groups.
Object Type	This reference an object type (sub-classed object) of the object.
XLocation	This is the X location of the object in the model.
ZLocation	This is the Z location of the object in the model.
Work Schedule	Work schedule assigned to the resource.
Capacity	The capacity of the resource.
Cost Rate	The hourly rate for the resource either idle or while being utilized.
Changeover Matrix	Changeover Matrix used by the resource.
Secondary Resource Name	This is the resource (object) that is seized by the primary resource while processing.
Changeover Efficiency	The calculated efficiency as it changes during the run.

Routing Destinations:

A list of each possible destination node for each resource. The entity is routed to one the nodes specified in this list based on the selection rule.

Column Name	Description
Resource Name	This is the transfer node used to route each entity to their destinations.
Node	Possible destination from this transfer node.

Materials:

A list of materials that can be produced at this manufacturing facility.

Column Name	Description
Material Name	The unique name of this material.
Display Category	The category of the material.
Material Class	A description of this material.
Infinite Available	Boolean for if the material is infinitely available.
Material Cost	The cost per unit of this material.
Material Color	The color index for computing color-dependent changeovers.
Gantt Color	The color used for drawing orders for this material in the Gantt.
Material State Statistic	State statistic used to plot material quantities over time on the Gantt.

Material Lots:

A list of material lots and quantities for materials in the facility.

Column Name	Description
Material Name	A foreign key reference to the Materials table for the material being produced.
Lot Id	This is a string determining what lot the material. This field is not required. If there is no lot control, just leave column blank.
Quantity	The initial quantity of material for the lot.

Manufacturing Orders:

A list of all production orders to be processed during this planning period.

Column Name	Description
Enabled	Boolean for if this order is enabled.
Order Id	A unique string name assigned to this manufacturing order.
Material Name	A foreign key reference to the Materials table for the material being manufactured.
Release Date	The date-time this order is released to production.
Due Date	The date-time this order is due.
Order Status	The order status specified as New or WIP (work in process).
Priority	The scheduling priority for this order.
Quantity	The material quantity to be produced for this order.
AdjustedReleaseDate	This field is an expression field used by the source to determine when to release orders. This expression is used to release the WIP orders slight before (Math.Eplison) before the NEW orders. It also handles when the release data is before the start of the model (e.g. Math.Max(ManufacturingOrders.ReleaseDate, Math.Epsilon)).
Ship Date	The ship date for this order (an output) based on the generated schedule.
Production Cost	The production cost for this order (an output) based on the generated schedule.
Target Ship Date-Value	The target ship date for this order.
Target Ship Date-Status	The target ship date status; OnTime, Late, or Incomplete.
Target Cost-Value	The target cost for this order.
Target Cost-Status	The target cost status: OnBudget, Overrun, or Incomplete.

Note that the *Ship Date* and *Production Cost* are both output columns in the Manufacturing Orders table; they are written from the simulation model to the table as the schedule is generated by the deterministic simulation run. Also note that the last four columns are targets.

Routings:

A list of job routings for each material specifying the resource and processing time for each task required to produce the material.

Column Name	Description
Routing Key	The unique name for this routing step.

Sequence	The transfer node (list of resources) or resource where this step is to be processed.
Material Name	A foreign key reference to the Materials table for the manufactured material.
Route Number	The routing number.
Setup Time	Discrete setup time for this step.
Process Time	Processing time for this step. In this example, the process time is multiplied by the ManufacturingOrders.Quantity.

Bill of Materials:

A list of component materials that are required at a specific routing sequence location to produce a material.

Column Name	Description
Routing Key	The material routing step where the material action takes place.
Component Material	The name of the material.
Required Quantity	The quantity of the material that is either consumed or produced. This value based on an order quantity = 1. The required quantity is multiplied by the ManufacturingOrders.Quantity.
Required Lot Id	Specified the lot id required for consumption and the lot id provide for production.
Material Use	Specifies if the material is to be consumed or produced.

Work In Process:

A list of current orders that are in the system, along with their current status.

Column Name	Description
Order Id	Foreign key reference to the Order Id in the Manufacturing Orders table.
Current Route Number	The current route number for this order.
Current Resource	The current resource that this order is being processed on.
FractionOfSetupCompleted	Percentage of setup completed (values between and including 0 and 1).
Completed Quantity	The number of material units that have been processed on this resource.
Accrued Cost	The activity-based cost accrued by this order at this point.

Manufacturing Orders Output:

An output table defining order start and end time on each resource used for creating table reports.

Column Name	Description
Order Id	Foreign key reference to the Order Id in the Manufacturing Orders table.
Routing Key	Foreign key reference to the Routing Key in the Routings table.
Scheduled Resource	The resource where this order is to be processed.
Scheduled Start Time	The start time at this resource for this order.

Scheduled End Time	The end time at this resource for this order.
Scheduled Quantity	The quantity schedule at the resource for this order.