Simio May 2020 Student Competition

Warehouse Picking Strategy

miebach
the supply chain engineers

Simio
Forward Thinking

Overview

The Miebach Distribution Center (MDC) is a warehouse that stores footwear and apparel items which are shipped out to fulfill customer orders. The MDC is noticing an increase in orders as well as a diversification of order types. Warehouse planners and mangers are looking to improve the picking operation strategy to meet their service level goals. They must determine how to balance the workload across the entire warehouse, starting with picking and then considering downstream processes like induction, packing and manifest. The scope of this project starts with picking units, from shelved storage, and ends with packing and shipping the orders.

Due to the uptick of orders, the MDC is transitioning to wave picking management methodology or "waving" to collect units from their storage locations. Orders are strategically grouped into waves that are individually released for picking based on their priority. Pickers in each warehouse zone receive information about the required units and SKU locations, for a given wave, through the warehouse management system (WMS). The zones are picked by workers who transport units primarily to a central staging area, with a few exceptions. Once all units from a wave reach the staging area, the wave is "inducted" to the packing area. The wave is then sorted into orders and shipped out.

MDC management is looking for recommendations to optimize labor utilization, and minimize missed customer delivery date goals, by improving the wave planning and picking strategies. The wave picking strategy should specify the preferred size of a wave based on order attributes and picking transporter requirements. The criteria that place orders in the same wave should also be critically investigated. Additionally, management would consider re-zoning the warehouse if measurable improvement were demonstrated along with the proposed wave planning strategy. Ideally a clear set of rules for wave planning can be identified as opposed to ad-hoc, subjective analyses of order data.

Problem Description

Warehouse Layout

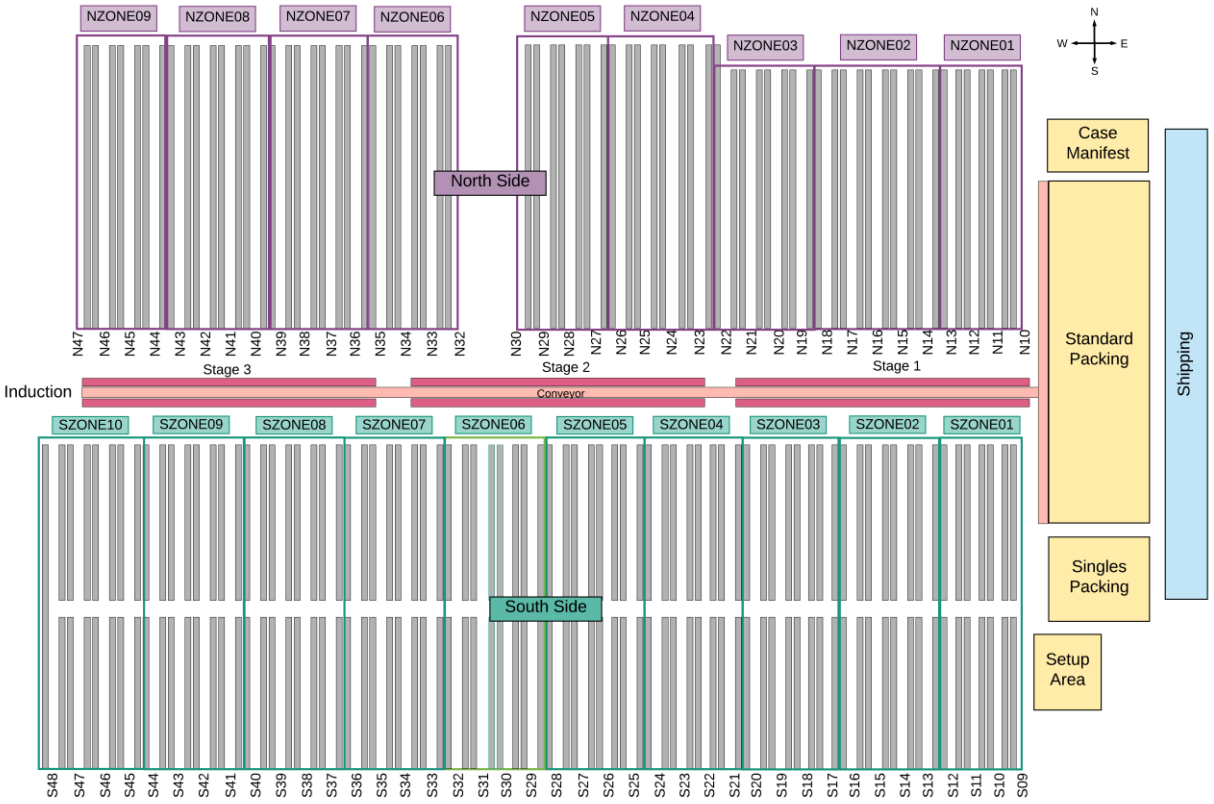
The MDC is a large warehouse that runs 24 hours per day, 5 days per week. The warehouse storage space is split into a north area and a south area, each comprised of shelving aisles that run perpendicular to the induction conveyor. The 550ft long induction conveyor feeds picked units to the packing areas.

The north area of the warehouse has 37 aisles. 25 of the north area aisles are slightly longer than the remaining 12. The length of a shelf is 8 ft and the longer aisles in the north area are approximately 176ft in length, while the shorter aisles are approximately 160ft in length. The south area of the warehouse has 40 aisles, that are equal in length, and perpendicularly bisected by a 15ft travel aisle for ease of transportation. This allows the workers to reduce their travel distance when there is no need to traverse an entire south aisle. Including the width of the travel aisle, the south aisles are approximately 200ft in length.

If a worker is walking down an aisle, they can pick from shelves on their left and their right. In the north area, every other row is used for replenishment. Thus, the Active SKU Locations data sheet contains only odd north aisles, up to aisle 32, then even north aisles for remainder. The south area, on the other hand,

is picked from all aisles as indicated by the data. The end aisles are unique as they only have shelves on one side, except for the southwest corner aisle which is two-sided.

Figure 1: The MDC warehouse layout



The east area of the MDC houses the packing, manifest, and shipping areas. The standard packing area is about 205’ x 95’. The induction conveyor branches into each packing area and ultimately feeds packed orders to the shipping area. The manifest area is about 55’ x 95’ and is located just above the packing area. The singles packing and staging area, just below the standard packing area, is 72’ x 95’. Manifest and singles packing feed directly into shipping. There is also a 90’ x 50’ setup area, in the south east corner, that is used to prepare certain picking transporters.

Unit Storage Location

The MDC warehouse uses random storage to stock its footwear and apparel products on the shelves. The active locations, shown in the warehouse layout diagram, are replenished from reserve locations during off-hours when open order volume is low. Regarding the wave planning and picking strategy, this project will assume infinite inventory for active locations and ignore reserve locations which are only picked for high volume case orders. The MDC has decided that the high volume case picks, from reserve locations, are already streamlined and do not need improvements at this time.

All active locations are specified in the data provided. Note that the ground floor shelves can be reached without special equipment whereas the higher shelves require an “air pick” performed by a lift truck. The Active SKU Locations data sheet indicates whether a SKU is “on the ground”, or “in the air” by an

alphabetical naming convention that increases vertically upward. Thus, any item that is stored in tier A can be ground picked while any units stored in tier B, or above, must be air picked.

The warehouse storage locations are divided into zones created by the MDC warehouse planners. All current zones are shown in the warehouse layout diagram. Aisle codes for the north and south areas (respectively) “N11, N13, S10, S11, etc.” are also included in the Active SKU Locations data sheet. Notice that a zone is comprised of a few aisles. Typically, a worker will pick from one zone at a time for one wave. However, there is no hard and fast rule that limits a zone to one worker at a time.

Orders

As orders arrive, they are classified by several attributes shown in the Open Orders data sheet provided. Orders are primarily categorized by sales channel. A channel could be a direct consumer web order or a wholesaler restock order. The sales channels are:

- Canada
- Direct
- Internal
- National (Retail)
- SRA (Special Retail Account)
- Ex-USA (International)

Orders are also categorized by order type which indicates whether an order should be fulfilled at once or in the future, along with some other characteristics like “bulk” or “B2B”. All order types that do not explicitly indicate “future” or “at once” should be treated as at once. In the data, each order is uniquely identified by Delivery Number. Notice that there may be several SKU’s, with variable quantities, required for one Delivery Number. Orders are also categorized by item type. The two main item types of merchandise in the warehouse are footwear and apparel. The item type will impact picking transporter capacity requirements.

The Order Quantity, for a given SKU, implicates the picking procedure, transporter requirement, and wave planning process. If an order (i.e. Delivery Number) requires *only* one unit, of a certain SKU, it is referred to as a “single”. For example (in the data) Delivery Number 13273127 is a single since there is only one SKU required and its Order Quantity is one. All other order quantities, excluding case quantities, are referred to as “multi-item” orders. Each case of footwear has 12 units and is the largest standalone unit of storage in the warehouse. Large footwear orders, whose quantity is a multiple of 12, may be collected as “case picks”. Only footwear items are case picked as the MDC has incentivized some big customers to order footwear in quantities that are multiples of 12. Demand for apparel items fluctuates too much for a similar proposition.

Due Date, shown in the Open Orders data sheet, is computed automatically by the WMS system which considers order type, delivery logistics, and time that the order was placed. The WMS also computes the Start Date for an order based on its Due Date and the availability of stock in the warehouse. On the Start Date, the order may be picked once the first shift of the day has begun. Orders are not available to the planners ahead of their Start Date. Planners can choose to hold an order, in hopes that similar ones will

arrive, to facilitate more efficient wave planning. But if orders are held too long, there is a risk of missing the due date.

The completed order must be at the shipping area by the Due Date to be considered on time. The MDC has a 99% service level goal, in other words, they would like to consistently ensure that 99% of orders are fulfilled on time. The MDC also has a same day shipping promise for Direct orders. During the transition to wave picking, the MDC estimates that they have been meeting this goal about 80%-90% of the time and would hope to improve going forward.

Wave Planning Current State

Recently, MDC management has decided to utilize wave picking or "waving" to collect units for orders. MDC management wants to use simulation to improve the wave planning process. They will consider alternative methods if the simulation model can demonstrate their measurable improvement(s). The current method is herein described.

First, a planner uses the WMS to analyze open orders and group them into waves based on several criteria – ultimately hoping to wave together orders that require similar work downstream, after picking. Once the wave is created it is released for picking in the WMS which notifies the pickers of all required SKUs, order quantities and their locations. Recall that each picker typically works in one zone at a time. The main criteria, considered by the planner, is sales channel. Each wave is comprised of orders from only one sales channel.

The Wave Frequency data sheet shows summary statistics from approximately three months' worth of historic MDC data that demonstrate the current decision-making criteria for wave planning. Estimates for the average unit volume and frequency of occurrence are provided for several wave types. Canada, Internal, and Ex-USA waves remain un-subdivided while waves for Direct, National and SRA are subdivided based on additional order attributes, priority, and picking procedure constraints.

For instance, an SRA wave may be dedicated to only air picks. Orders with *only* a single unit are always waved together as a dedicated singles wave. Orders with case picks are frequently waved together, as a dedicated case wave, but they may be waved with other multi-item orders. Ideally, the amount of case picks in a wave is maximized to increase picking efficiency. Therefore, orders should be grouped so that a given SKUs footwear quantity is a multiple of 12 as often as possible. Also, the planner often elects to wave orders with the same priority (at once vs. future).

Some waves in the data for Direct, SRA and National are not subdivided. These are waves that do not fit into just one subdivision. For instance, there may have been both case and tote picks waved together, or both floor and air picks. The Direct waves that are not subdivided are simply multi-item tote waves – since Direct orders never have cases. Due to downstream restrictions, waves cannot exceed 5,000 units. The planner creates and releases waves, by priority, as follows: Direct channel waves are always first, at once waves are second, and future waves are third. With the current system, on average, one wave is fully picked approximately every 4-5 hours.

Picking Items

Items are picked into containers that are transported on material handling equipment (MHE). All containers can be filled with a mix of apparel and/or footwear items. This excludes cases which are only footwear. Spatial unit requirements for apparel items are variable since apparel comes in different sizes and certain items require more space than others (jacket vs. t-shirt).

Table 1: Space Requirements for One Unit of the Item Type

Item Type	Spatial Units
Apparel	(5, 10, 25)
Footwear	40

Material Handling Equipment

The MDC currently has two types of MHE available for transporting units to their next destination. The MHE types and carrying capacities are shown below in Table 2. MHE vehicles are constrained to specific pick types. The pallet jacks are only available for use on the ground, since they cannot reach the upper shelves, and the lift trucks are reserved specifically for air picks. Time studies were performed across the warehouse to capture standard times for the various picking tasks for one worker. The outputs are shown below in Table 3.

Each MHE type can transport several containers which each have specific spatial unit capacities. The container types vary for singles, multi-Item, or case picks. For this problem, assume that containers do not need to be modeled independently, but rather they are filled and emptied while traveling with the MHE. Table 2 clarifies the maximum carrying spatial units per one MHE depending on wave picking type.

Table 2: Material Handling Equipment Specifications

MHE:	Quantity Available	Top Speed	Max Spatial Units		
			Singles Pick	Multi-Item Pick	Case Pick
Pallet Jack	20	3 mph	4,400	3,000	5,760
Lift Truck	8	3 mph	4,400	2,400	5,760

Table 3: Time Study Outputs

Activity	Standard Measure (UOM/Hr)
Multi-Item pick	20 units/hr
Singles pick	12 units/hr
Case pick	5 cases/hr

After pickers finish their route, either due to reaching capacity or completing all picking requirements for their zone, they deliver the units to their next destination. Singles wave picks are transported to the singles packing and staging area. Multi-item wave picks are transported to the induction staging area. Units in multi-item waves will ultimately travel down the induction conveyor to be sorted into the correct orders at the packing area.

Dedicated case waves are those comprised entirely of case picks, for which cases of footwear are stacked onto a pallet jack or lift truck. Table 2 shows the Max Spatial Capacity values for case picks on each MHE type. Cases, for dedicated case waves, are transported directly from picking to the case manifest area. When cases are picked as part of multi-item waves, one case has a spatial unit capacity of 480 and must adhere to the Max Spatial Capacity for a multi-item pick. Cases, that are part of a multi-item wave, are staged at induction with all other units for that wave.

When the warehouse is restocked, the footwear SKUs are stored as cases. When pickers need to collect an order quantity less than a case, they open the case packaging and grab the amount needed. It is assumed that opening a case is required for roughly 5% of non-case picks and requires about one to two minutes of work by the picker.

Induction

Units and cases picked in a multi-item wave are dropped off at the induction staging area. Units and cases are stacked on either side of the conveyor in one of three staging areas. Normally, there are only 3 waves at induction, one wave per staging area. Each staging area is approximately 175ft and they are spaced evenly along the distance of the conveyor.

Once all units required for a wave reach the induction staging area, the planner will call for the wave to be loaded onto the conveyor or “inducted”. Only one wave can be inducted at a time. Each induction worker will move units on the conveyor at an approximate rate of 2 units per minute. From its induction staging point, the units ride the rest of the conveyor length to packing and shipping. The conveyor is accumulating and moves at a rate of 150fpm (feet per minute).

As more waves are staged at induction, units become stacked up, and the induction workers incur a slight efficiency penalty. Wisdom of the organization has estimated that induction workers drop to 95% efficiency anytime there are more than 3000 units staged at induction and drop to 90% efficiency anytime there are more than 4000 units staged at induction.

Packing

The standard packing area is located at the end of the induction conveyor. Units are sorted into orders which are then placed into shipping boxes. Prior to packing, a small percentage of multi-item orders require value added services (VAS) like adding clothes hangers. It has been estimated that about 1.5% of units require VAS – these are always apparel (not footwear) ordered through the National channel. VAS processing time ranges from 10 to 30 seconds per unit.

The boxes are labeled and manifested at this packing area as well. The standard packing area can process approximately 360 units per hour on average. From packing, the boxes are sent to shipping. Singles waves are not sent to induction. Instead, they are staged directly at the singles packing area. Here, the individual units are placed in their shipping containers. The singles packing area can process approximately 150 units per hour on average.

Case Manifest

The dedicated case picks are staged at the case manifest area as shown in the layout. The manifest operators will check the cases to make sure all are present for the corresponding order. Labels are added to the cases and then sent to shipping. On average, manifest can handle 50 cases per hour.

Shipping

All packaged items are shipped through the localized shipping area. The shipping area will be the end of scope for this investigation. The MDC objective is that 99% of orders have been moved to shipping at or before their due date.

Workers

The distribution center functions with a few core teams. The largest team is picking, whose function is the transporting of units from shelves, to their next destination via the appropriate MHE. Besides picking, there are individual teams for each of the following areas: induction, manifest, singles packing, and regular packing. There are three shifts, but each team currently retains the same number of workers on each shift. Due to warehouse regulations, employees are only permitted to work in one area.

Table 4: Number of Workers per Team for All Shifts

Team:	Current Coverage
Pickers	15
Induction	3
Case Manifest	1
Singles Packing	2
Regular Packing	8

Analysis and Project Deliverables

The MDC is interested in keeping track of route productivity. One route is defined as a picker going into their zone, picking units, and transporting them to the next location. A picker might need to make multiple route trips to finish picking for a wave. The route productivity metric measures how many units were collected per route compared to the capacity of units that the picker could have picked with that MHE. The MDC recognizes that this metric may be skewed low if the remaining units required for a wave is less than the full capacity. However, they hope that the new wave planning strategy will improve this metric. The MDC also tracks picker productivity as measured by units (picked) per hour times distance traveled (in feet), i.e. units/hr*ft.

Create a current state model that processes the open orders with the ongoing waving strategy used. Also, as an expert simulationist, your models should include animation.

Consider metrics such as:

- Percent of orders completed on time

- Route productivity
- Picker productivity
- Worker utilization
- Same day shipping promise
- Order TIS

The MDC warehouse wants a set of rules that define the optimal picking strategy. Create an improved model with an updated strategy. Questions to answer include:

- What is the optimal size of a wave? Should the wave size depend on order attributes, unit locations, and/or picking MHE constraints?
- Are there order types that should be waved together for more efficient picking?
- What is the minimum number of workers on each team to ensure that at least 99% of orders are completed on time?
- What is the minimum number of each type of MHE that is needed to meet the 99% service level goal?

Optional Challenge Problem

The MDC has added a new MHE transporter, the shopper, into the warehouse. The MDC is looking for recommendation on how to effectively use this newer transporter. The shopper is strictly used for ground picks. Tables 5 & 6 are updated to include the shopper specifications and time study information.

Table 5: Material Handling Equipment Specifications with the Shopper

MHE:	Quantity Available	Top Speed	Max Spatial Units		
			Singles Pick	Multi-Item Pick	Case Pick
Pallet Jack	20	3 mph	4,400	3,000	5,760
Lift Truck	8	3 mph	4,400	2,400	5,760
Shopper	20	2 mph	-	9,600	-

Table 6: Time Study Outputs for the Shopper

Activity	Standard Measure (UOM/Hr)
Shopper – ground pick	25 units/hr
Shopper – setup time	7-8 shoppers/hr

Shoppers exclusively carry outbound shipping containers. Each outbound shipping container corresponds to an individual order. The shopper will not pick for orders that cannot fit into one outbound shipping container. One shipping container fits 480 max spatial units and 20 outbound shipping containers can fit on a shopper. Cases cannot be transported on the shopper and shoppers will not be used for singles. Shoppers require a setup which includes prepping and labeling the correct sized outbound shipping containers for the units they will be collecting. Idle pickers can set up shoppers for future waves at the rate specified in Table 6. The setup task is performed in the south east corner of the warehouse.

Shoppers also follow a unique picking strategy such that they are not constrained to one zone. Instead, pickers using a shopper will traverse through the entire warehouse starting at aisle S09 and ending at aisle N10. They will pick all the items for an order in a pass.

Once a picker finishes a route with the shopper, the outbound shipping containers are transported directly to the case manifest staging area. The shipping containers will be removed from the shopper and the shopper is returned to the setup area. On average, the case manifest team can process 60 outbound shipping containers per hour. After manifest the containers are sent to shipping.

The MDC is also considering re-zoning the warehouse and re-creating the staging areas at induction. They would like to know if this would be a help or hindrance to the picking strategy.

Questions to answer:

- Could the current MHE methodologies be improved? Should a mix of different MHE be used and if so, how many of each MHE is ideal? Should certain MHE be used for certain wave types?
- Would there be any benefit to re-zoning the warehouse? Should zones change based on any order attributes or MHE constraints?
- Does re-zoning, changing the induction staging area, or adding the shopper affect any staffing decisions or wave creation decisions?

Hints

- Consider using a data-driven approach to create entities which will enable you to access important information, about each entity, since they are created with a row reference to the corresponding table row.
- Think about approaching waving orders by channel, first, and then worry about the other special cases like singles, case pick, future vs at once, shopper cart etc.
- Contemplate what is the right level of fidelity to model the system. Ask questions like: do I need to model this physically, or can this be represented logically?

Data File

https://www.simio.com/StudentCompetition/May2020.zip

This section has been appended with additional help and clarification on the data provided

Open Orders

Contains orders from October 2019 through November 2019.

Table 5: Open Order data dictionary

Column Name	Data Description
Delivery Number	Unique identifier for a group of SKUs that are to be shipped together as one delivery.
Account Name and Number	Unique identifier for a customer.

Sales Channel	One of six codes to describe the means by which an order was placed.
Order Type	A secondary classification of an order that describes its fulfillment priority and whether it is bulk, or B2B, or neither.
Start Date	The date the picking of this order can be initiated.
Due Date	The date the order must be completed and at shipping.
Item Type	Indicates if this unit is a type of footwear or apparel.
SKU	The individual stock keeping unit (SKU) number for each item.
Order Quantity	The quantity of that SKU in that order.

In the Open Order data, there are two dates: Start Date and Due Date. Start Date is at the beginning of the day. Due Date is at the end of the day. The MDC works 24 hours a day, so there will be instances of orders that arrive and need to go out same day. For example, the order could come in 10/1/2019 12:00AM and need to be out by 10/1/2019 11:59PM. The dates in the data file are strictly Date type. However, Simio's Data Tables recognize DateTime type, so a time will automatically attach to the Dates when you import the data. Consider manipulating the data so Due Dates are recognized by Simio as end of day.

Active SKU Locations

Contains all the warehouse's storage locations, as well as a snapshot in time of the SKU that currently is allocated there.

Table 6: Active SKU Locations data dictionary

Column Name	Data Description
Aisle	Indicates whether a SKU is on the North (N) or South (S) side along with its aisle number.
Tier	Indicates the shelf height increasing vertically and alphabetically, i.e. 'A' is ground, 'B' is the next tier up, 'C' is above 'B', etc.
SKU	The individual stock keeping unit (SKU) number for each item.
Zone	The warehouse zone, all zones are shown in *Figure 1: The MDC warehouse layout.*

Wave Frequency

Contains summary information about the various wave types like average number of units, and frequency, over a three-month period.

Table 7: Wave Frequency data dictionary

Column Name	Data Description
Wave Type	The general wave types, as well as the breakdown of wave subgroups.
Avg. Units per Wave	The average number of units in a wave for that wave type.
No. of Waves	The count of that type of wave seen in the given time period.

In Table 7, the Wave Type column indicates how the MDC planner has historically partitioned the main wave types into smaller wave sub-types. There may be unfamiliar wave groups in the data, such as "SRA

PW", since the wave planning process has changed over time. Thus, "PW" has been omitted from the current state of wave planning description. It is not uncommon to find extraneous information, in data, which is why the "PW" sub-types were left in Table 7.

The Average Units per Wave column, in Table7, provides values that may guide your modeling of the current state of wave planning in terms of each Wave Type. Additionally, the Number of Waves column could be used to validate that the proportion of each wave type created in your current state model is representative of the current system. Remember, the Wave Frequency data is based on historic data, so it might not be identical to the new waves created from the current Open Orders data.

Base Model

We are sharing a base Simio model with all teams that demonstrates one method of the current state of wave creation. If you have already created your own method, you can disregard this example model, or compare it to your approach. As in most modeling problems, there is no single right way to approach this problem. The base model is meant to be just an example or candidate starting point. It includes Data Tables, Process logic, and Elements which are key to creating waves. Please investigate these features and consult the Support ribbon or the Simio Insiders forum for supplementary learning resources.

Download the project file here:
https://www.simio.com/StudentCompetition/BaseModel_May2020_StudentCompetition.zip

Base Model Notes

The purpose of this model is to show the creation of wave groups. In the MDC Warehouse waving process, consider this as the step where the Planner makes waves. This model does not include the wave being released into the warehouse and being picked or any other downstream process. This wave creation is also at a high level and only creates waves by the major Sales Channels. The wave creation does not take into consideration 'singles', sub-sales channel groupings, or other special cases.

One of the first steps was to prepare the data for this model. You will notice that the Data Tables, in the model, are not pulled directly from the data provided. In the Open Orders data, columns were added for the corresponding Active SKU Location data. A new Data Table, called Deliveries, holds the unique delivery numbers. It was created through manipulation of the Open Orders data. It serves as a record of each unique delivery and facilitates a table relationship to the required SKUs and their attributes – note the Table Key and Foreign Key relationship between the Open Orders and Deliveries tables.

Other columns in the Open Orders and Delivery Tables named WhichMonitor, WhichState and WhichDueDate are used in process logic and assignments throughout the model. These were created in the spreadsheets as strings, then the Change Type feature (Schema ribbon) is used to convert them to State Property columns in Simio. An alternative approach would be process logic that implements Decide step trees to identify each delivery entity as type "Canada", "Direct", etc. in order to determine which State Variable or Monitor is to be referenced. Remember, the Search window (ctrl+f) is a great tool to find where variables, assignments, references, etc. exist in a Simio model.

Two Output Tables were added to record information about the waves. The table called Wave Contents provides a breakdown of each wave into its delivery numbers and their quantities. The table called Wave Summary records when each wave was released along with other summary details. Note, the Release Time is when the Planner finished creating a given wave. Consider the Output Table results as the current state of waving planning at a high level.

While interpreting the process logic refer to the Process descriptions, next to each Process name in the Processes tab, and other documentation inside the model.

This model uses a few features available to certain Simio Editions. Depending on your Simio Academic Edition, you might not have full feature functionality. If you find this occurring, please fill out the form located here https://www.simio.com/large_model/, or contact us at licensing@simio.com and we will work with you to upgrade your Simio Edition for the duration of the competition.