Simio May 2019 Student Competition

Super Market Distribution Center Simulation

SUPERINTENSIVEMEGASTORE
With
INTEGRATED OPERATIONS

Simio
Forward Thinking

Overview

Super Intensive Megastore with Integrated Operations (S.I.M.I.O.) is a distribution center that utilizes cutting-edge technology and advanced analytics to minimize cost. Real-time information actively guides decision making and verification, optimization, and automation are a part of daily operation. Due to the complexity of the operation, it is difficult to predict how additional investment will function after implementation. Specifically, how orders should be prioritized and dispatched to minimize labor costs? The best way to answer system performance questions is to create a detailed digital twin of the system, to simulate activity, and to observe/quantify the outcomes. At the warehouse, there are 3 primary operations: Put-Away, Select, and Replenish. The Put-Away operation includes Receivers who unload delivery trucks and Put-Away Operators (PAOps) who transport pallets from the Receiving area and place them on racks. For the Select operation, Selectors handle outbound shipments and pull products from the racks to ship. Finally, for the Replenish operation, Replenish Operators take pallets stored on higher shelves to replenish the stock the Selectors picked for orders. The focus of this investigation will be the Put-Away operation. In the past year, robotic pallet jacks (i.e., RPJ or AGV) have been purchased to assist with Put-Away operations. Some of the incoming pallets are transported by RPJs, which have been loaded with pallets in the Receiving area and autonomously delivered by the vehicle to drop areas in the aisles. Replenish Operators will pick up pallets from the drop areas and place the pallets on racks.

Receiving

When a delivery truck arrives, the contents are unloaded into a Receiving area. The contents of a pallet are all the same SKU and pallets are arranged according to such when they are unloaded. The contents of the arrival are known and stored in the megastore's ERP system. Trucks are unloaded LIFO and there is no system to how the truck is loaded. There are always trucks ready to be unloaded. Each Receiver can unload Triangular(40,45,55) pallets per hour, and there are two Receivers per a shift. The Receivers unload the delivery trucks and stack pallets in the Receiving area. Only one Receiver unloads each truck because there is not enough room for their forklifts to work together. The Receiving and front-dock areas have a limited amount of space. The Receiving area in front of each dock door can hold about 30 pallet stacks (in a configuration of three pallets wide and ten pallets deep). A pallet stack is comprised of multiple pallets stacked on top of one another, such that the stacks are eight or less feet tall for safety reasons. The top pallet is typically 36 inches or shorter. Products from a single truck do not typically overflow into another truck's Receiving area. Pallets are 48x40x6 inches. The height of received pallets is included in the historic data. There are typically under 100 pallets waiting to be picked up by the Put Away Operators at the beginning of Shift1.

Put Away Operators

When a PAOp picks-up a pallet from Receiving, they scan it to let the system know they have taken the job. PAOps typically transport one pallet at a time. The pallet picked up is the next available pallet in the dock Receiving area. Automated routing information is communicated to the PAOps via headset. PAOps utilize high-reach forklifts. There are more forklifts than operators (i.e., if a forklift requires maintenance, the operator checks out a new one). The audio-provided routing specifies a rack location where the pallet is to be stored. Once a pallet is put away, the PAOp returns to the Receiving area for the next pallet to be put away. PAOps transport a single pallet at a time. For this investigation, it is not necessary to include the exact shelf the pallet is placed on, only the rack location. Details on the high-reach fork lifts is in Table 1 below. Accordingly, much of the operator's time is spent traveling back and forth from rack locations to the Receiving area. PAOps follow the direction of the arrows in the facility layout, but they can travel in the horizonal-middle aisle in either direction. Assume forklifts do not pass each other if going in the same direction.

Robotic Pallet Jacks

Put-Away Operators are currently supported by robotic pallet jacks (RPJ, which are automated guided vehicles (AGVs)). These AGVs are double pallet jacks; they can pick up two pallet stacks at a time. The stacks may contain pallets that do not have the same destination. On average, an AGV transports 2.5 pallets per trip. The purpose of the AGV is to minimize operator travel time. When an AGV arrives to the Receiving area, a Receiver manually operates the vehicle to position it under the pallet stacks and scans the pallets and the vehicle to associate them. Then, the AGV autonomously delivers all the pallets to a single drop location on the floor in the aisle near the rack location of the last scanned pallet (or closest drop location). Each downward aisle currently has two drop points; one in the middle of the racks above the horizontal-middle aisle and one below. Drop points should follow a pattern. The aisles are wide enough to have pallets dropped and forklifts drive around them. Replenish Operators, working in conjunction with AGVs, pick the pallet from the drop location and place the pallet in the specified rack location. Replenish Operators must often drive to other aisles to deliver pallets to their destination rack. They utilize a high-reach forklift to deliver one pallet at a time. This combination greatly reduces operator travel time, as the Replenish Operators can proceed immediately to the next pallet which needs put away at a drop location, rather than returning to Receiving. Therefore, the same amount of demand can be handled with fewer operators, minimizing cost. AGVs are currently handling about 25% (+/- 10%) of incoming demand, and there are plans to increase the load.

The main job of Replenish Operators is to ensure that Selectors always have SKUs available at Level 1 or Level 2 on a rack. As Selectors deplete stock at Levels 1 and 2 for outbound shipments, the computer system recognizes inventory levels and routes Replenish Operators to restock the picking area. Replenish operators also receive routing instructions via audio headsets. Assume that the Replenish Operators use at least 80% of their time replenishing stock at picking locations. However, transporting pallets from a drop area is a high priority, so Replenish Operators will put pallets away when pallets are dropped off, as soon as possible. The Replenish Operators divide the racks into zones and replenish in their zone. Assume the Replenish Operator in each zone transports pallets from a drop area in their zone to the final rack location (which may not be in their zone). If needed, Replenish Operators in nearby zones could help take the pallets from the drop areas to their final rack destination. The Replenish Operators follow the direction of the arrows as indicated in the layout, except if transporting a pallet within the same aisle as it was picked up.

The RPJ must follow the direction of the aisle as indicated in the layout, and it can only drop the pallets of a load at one location. The AGV can cross the horizontal-middle aisle if dropping in the bottom section of racks. Currently, the RPJ only travels up aisle 77 and descends in the aisle it will drop the pallets. This means that currently only downward aisles have drop points. Although this constraint exists in the current state, changing the design of the system is possible. Replenish Operators follow the same travel rules as PAOps. In the current state, RPJs are only capable of picking up pallets from dock doors 47-56, as shown in the historic data.

Table 1: Forklift Data

Description	Time
Load pallet on forklift/RPJ*	Uniform(0.3,0.38) minutes
Time to lift/lower to rack location	Triangular(0.13,0.17,0.24) minutes
Time to put a pallet on rack	Uniform(0.3,0.36) minutes
Unload pallet from forklift/RPJ	Uniform(0.3,0.38) minutes
RPJ speed**	Pert(300,350,400) feet per minute
High-Reach forklift speed**	Uniform (450,546) feet per minute

*Includes time to scan the pallet into the system

**The RPJ and forklift ground speed is based on average speed for each trip

Table 2: Resource Data

Resources	Count
PAOps per shift	4
Replenish Operators per shift	12
Receivers per shift	2
High-Reach Forklifts	32
Robotic pallet jacks	2

S.I.M.I.O has the following work schedule for all its resources:

- Shift 1: 7:00-15:00, breaks: 10:28-10:45, 12:28-13:00
- Shift2: 15:00-23:00, breaks: 18:28-18:45, 20:28-21:00
- Assume the warehouse operates everyday

Table 3: Resource Costs

Description	Cost
Operator (Put-Away, Receiver, Replenish)	$29/hour
High-Reach Forklift (capital cost)	$37,000
Robotic pallet jack (capital cost)	$150,000

Additional Files

Download the additional files here

- CAD drawing of the facility. This includes:
  - Arrows indicating the direction of travel for each aisle
  - Location of docks
  - Aisle number
  - Note: Layout Scale: The center on one aisle to the center of the next aisle is 19.5 feet
  - Hint: We do not recommend using a separate object for each individual rack
- Excel file of the historic data of when the products were received, put-away, and the locations of the racks. See Tables 4 and 5 below. The historic data provides 3 weeks of information on the pallets that

were put away. This is data based on a real warehouse, so it may have outliers that should be excluded from analysis. Analyze this historic data to understand the current system and to validate your model. Some examples of information from the historic data include: the frequency each dock is used for unloading, the number of pallets in the Receiving area at the start of every day, and the pallets received per hour.

Table 4: Historic Data Schema

Column Name	Description
CASE_NBR	Unique ID for each pallet received
HEIGHT	Height of the product on the pallet (inches), includes the height of the pallet
TASK_TYPE	Type of operator that picked up the pallet. Either a Put Away Operator (Operator) or Automated Robotic Pallet Jack (AGV)
PUTAWAY_TIME	Time the pallet is picked up from Receiving area to be stored
DOCK_DOOR	Dock Door at which the pallet is unloaded
DEST_LOCN	Destination Rack location of the pallet. The format is XXYYY*Z 7 characters XX -aisle YYY – bay (rack #) * -one letter character (but you can ignore) Z-vertical position in rack (you can ignore the shelf the pallet is placed on)
RCVD_SHPMT_NBR	Shipment ID of the delivery truck
RCVD_DATE	Time the pallet was unloaded from the truck by Receiving Operator
EQUIPMENT_ID	PAOp ID number or Replenish Operator ID who transports the pallet from the drop area

Table 5: Aisle Rack Data Schema

Column Name	Description
Aisle	Aisle number
Rack Number Start	The smallest rack number found in the aisle
Rack Number End	The largest rack number found in the aisle
Aisle Direction	The direction forklifts and AGVs can travel

- Note: The starting number is the first rack to the right of the entrance to the aisle (based on direction of aisle). This means that the 100 and 500 rack aisles start at the bottom and number up the aisle and the 300 and 700 racks start at the top and number down the aisle. Even numbers are on the right side of the entrance the rack and odd number are on the left. Not all rack numbers are used. Assume half the rack numbers are above the horizontal-middle aisle (about 100 above and 100 below).

Project Deliverables and Analysis

The key to increasing pallets per hour is intelligent order consolidation, prioritization, and dispatching. Specifically, looking at inbound shipments within a certain window (e.g., 30 minutes), searching the arriving SKUs to group pallets intelligently and optimize who delivers the pallets and where. Minimizing travel time for Replenish Operators, who move pallets from RPJ drop areas into the assigned rack

locations, is ideal. Currently the robot pallet jacks handle about 360 pallets per day, the goal is to handle 500 pallets per day (combined). We would also like to decrease the time a Replenish operators spends putting away a pallet to 1.5 minutes per trip, currently it is 2.2 minutes per round trip. This would be the time the Replenish operator picks up a pallet from the drop area, transports it to the rack, and returns. Put-Away Operators handle 20 pallets per hour each shift (about 3 minutes per trip from the Receiving area, put away the pallet, and return to the receiving area).

If this number could be achieved, it would justify additional investment in RPJ to handle more of the inbound demand. Project deliverables are as follow:

1. A Simio simulation model of S.I.M.I.O. that spans at least 30 days, including 3D animation of activity (.spfx format)
    a. A model of the current-state (FIFO dispatching method)
    b. A model (or models) to explore and experiment with alternatives
2. Result analysis (including, but not limited to, pallets per hour, utilization, travel time, travel distance, cost, time per trip)
3. How would you devise a prioritized dispatching method?
4. What additional resources are needed to reach the goal of 500 pallets delivered by the robotic pallet jacks? What is the cost-benefit of different resource combinations?
5. Currently the RPJs only pickup pallets from one side of the docks (see data). Is there a benefit of the RPJs being able to deliver pallets from more or all dock locations?
6. Currently the RPJs only have drop areas on every other aisle (aisles where direction of travel is downward). For each aisle that has a drop area, there are two drop areas: one in the middle of the racks above the horizontal-middle aisle and one below. Is there a better placement for the drop areas? Remember, the schema of the drop areas should follow a pattern.
7. Should the RPJs be able to travel up any Up aisle or continue to only drive up aisle 77 and then down any down aisle?
8. What is the benefit of having the PAOps take multiple pallets on one trip, while still respecting the safety standards?
9. Is the system able to handle a 10% increase in shipment arrivals? What about 20%? If the system is unable, what changes need to be made? Assume the Receivers also increase the rate they unload the pallets per hour.
10. Are there other changes you would recommend to reduce the cost or to increase the efficiency of the system?