

Simio Academic Case Studies

Simio Warehouse

Fall 2023

A. Introduction

This case study involves the development of model(s) for analyzing a warehouse that supports an e-commerce site for computer video cards used for advanced video processes and for AI and crypto currency applications. The facility handles three types of cards (*A*, *B*, and *C*) and Simio Warehouse orders the unpackaged cards in bulk-pack containers from three different suppliers¹. The warehouse has a packaging line that is used to test and package the video cards prior to fulfilling orders. The figure below shows an example video card along with its packaging and an example bulk-pack container.

Video Card and Packaging



Bulk-pack Container

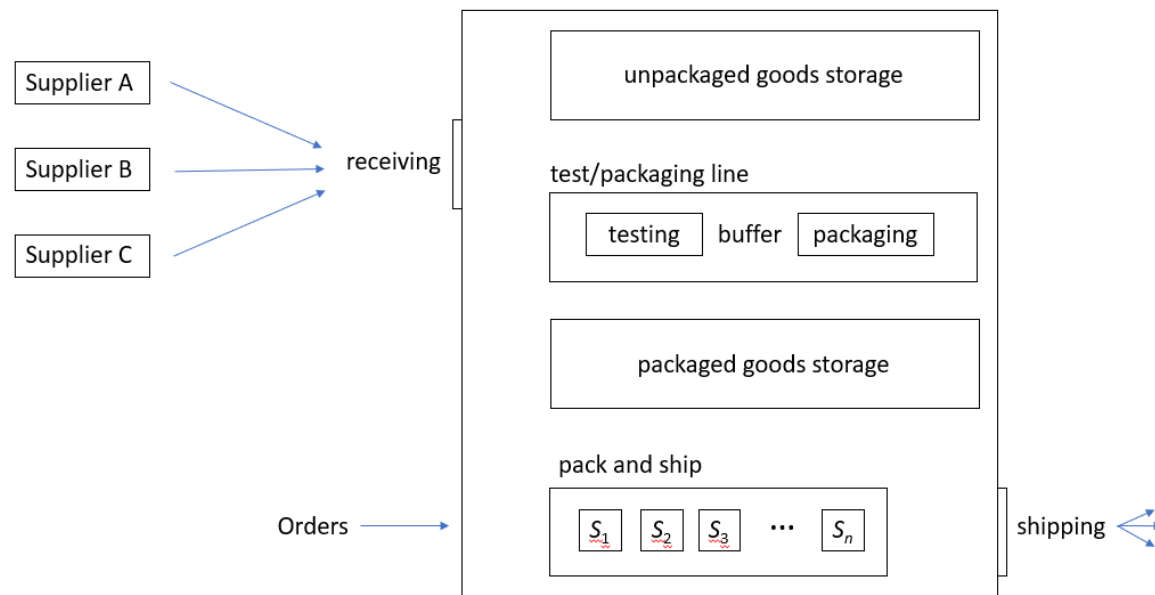
The case study assignment is to develop a Simio model of the warehouse operations and to use the model to help determine some of the parameters for the operating strategy along with the number of people required for the pick and pack operation.

B. System Description

The figure below shows the facility and its basic operations. Boards arrive from the three different suppliers (*Supplier A* for type *A* boards, *Supplier B* for type *B* boards, and *Supplier C* for type *C* boards). The boards are shipped (unpackaged) from the suppliers in bulk-pack containers and each order incurs a fixed order cost (independent of order size). When shipments arrive from the suppliers, the boards are stored in the unpackaged goods area (in the bulk-pack containers). Each bulk-pack container holds 60

¹ The facility encompasses many other storage and processing operations, but we are only interested in this small subset of the operations for this case study.

boards (regardless of type), and orders from suppliers are specified by number of bulk-pack containers (i.e., 60, 120, 180, 240, ... boards corresponding to 1, 2, 3, 4, ... bulk pack containers).



When boards are ready to be packaged, an operator moves the bulk-pack container from storage to the test/packaging line where the boards are removed from the bulk-pack container and individually tested and packaged, and the packaged boards are loaded back into a bulk-pack container (still 60 boards/bulk-pack container). Boards can only be tested/packaged in “full bulk-pack container” quantities. Once a batch is completed, an operator moves the bulk-pack container with the packaged boards to the packaged goods storage area. The test and packaging machines are both automated and are subject to random failures (the failure/repair processes are described below). The buffer between the two machines has capacity for five boards and when the buffer is full, the testing machine is blocked.

All orders fulfilled at this facility are internet-based and arrive 24x7 (the order file described below provides the order arrival data for the period July 1, 2022 – June 30, 2023). Simio Warehouse offers a shipping guarantee and orders that are not picked and packed (ready for shipment) within 6 hours of receipt are penalized (at a value of \$120 for each occurrence). Upon arrival, each order is picked from the packaged goods storage area and packed for shipment by a Pick and Pack operator. One case study objective is to determine the number of Pick and Pack operators that should be used. The facility operates 24x7 and order flow is fairly consistent throughout an individual day. The same number of operators are scheduled on each shift, so you do not need to consider individual work shifts. That is, you can assume that each unit of Pack and Ship capacity would be 3 individual operators – 1 for each shift – in reality. Assume that each unit of Pack and Ship capacity costs \$2,700 per week (i.e., \$900 per operator with 3 operators for each 24-hour period).

Operationally, Simio Warehouse uses a *reorder point/reorder quantity* inventory strategy to determine when and how much to order from suppliers and when and how much to package and move to packaged goods storage. For our facility, this involves 6 parameters – the reorder points and reorder quantities for unpackaged goods of type A, B, and C; and reorder points and reorder quantities for packaged goods of type A, B, and C. Determining good values for these parameters is an objective of the

case study. Inside the facility, there is much more room available for unpackaged goods storage than packaged goods storage, so you would like to minimize the space required from packaged goods storage.

C. System Details

The table below provides operational and ordering information about each board type.

	Board Cost (per board)		T&P Times (sec./board)		Supplier information		
Product	Unpackaged	Packaged	Test	Package	Supplier	Lead Time (days)	Order Cost
A	\$1,500	\$4,500	20	20	A	Uniform(1, 5)	\$4,000
B	\$2,050	\$6,150	22	24	B	Uniform(8, 16)	\$3,000
C	\$975	\$2,925	24	30	C	Uniform(3, 9)	\$6,500

The testing and packaging machines are automated and have random failures. Historical records show that the failure and repair processes are as shown in the table below:

	Boards between failures (count-based)	Time to repair (minutes)
Test	Uniform(150, 300)	Exponential(10)
Processing	Uniform(500, 1000)	Triangular(30, 60, 90)

In addition, when the test/packaging line changes from one board type to another, there is a 30-minute changeover time (the machines can be changed-over in parallel, so the total downtime for a changeover is 30 minutes).

In the Picking and Packing area, each order is picked and packed by an individual operator – the operator retrieves the order from the order queue, moves to the packaged goods storage area, removes the boards from the bulk-pack container, returns to the packing area, and packages the boards for shipping. The time required for picking and packing an order includes a fixed component and a variable component (proportional to the number of boards in an order), but the parameters are unknown. However, the sample order data includes the time required for pick and pack for each order. The order data is provided in the file “Order Data from July 2022 through June 2022.xlsx” – a sample is shown below. Note that an order includes only one board type, but orders can include different quantities of that board.

	A	B	C	D
1	Order Date/Time	Board Type	Quantity	Pick/Pack Time (minutes)
2	7/1/2022 0:00	C	4	5.2
3	7/1/2022 0:01	C	3	4.9
4	7/1/2022 0:06	A	9	7.37
5	7/1/2022 0:12	C	4	5.15
6	7/1/2022 0:15	C	1	3.67

Inventory costs at Simio Warehouse are based on a 12% cost of capital that is applied based on the total value of inventory over time. As such, the inventory cost components will be different for the different board types and packaged boards will be more expensive (from an inventory standpoint) than unpackaged boards.

D. Summary

To summarize, the operating parameters that need to be determined include:

1. The number of operators for the Pick and Pack area (remember, each “operator” works 24x7 and you do not need to explicitly consider work shifts).
2. The reorder points and reorder quantities for the six inventories (unpackaged A, B, and C boards and packaged A, B, and C boards).

The costs that you should use to determine “good” parameter values include:

1. Ordering cost
2. Inventory cost
3. Late order penalty costs

In addition to this document, the sample order data should provide the information that you need to determine order characteristics and pick/pack times. For things not specified in the document, you will need to make assumptions and these assumptions should be clearly stated in the submission document.

E. Hints/Suggestions

1. The easiest way to implement the Reorder Point/Reorder Quantity inventory policy is to use the Material and Inventory elements. See the Simio Help and related SimBits for details and examples.
2. Consider the use of referenced properties for the target inventory policy parameters – this will significantly simplify experimentation.

F. Challenge Questions

Simio Warehouse is considering changing the suppliers for the three boards. As part of this consideration, Simio Warehouse is currently negotiating with three “local” suppliers and is considering the following ideas:

1. Shorten the supplier lead times for all three boards to Uniform(2, 4) days per shipment?
2. The board packaging being done by the supplier – that is, boards arriving from the supplier would be pre-packaged and ready to ship.
3. Selecting/designing new bulk-pack containers with capacity 24 boards rather than 60 boards. The smaller bulk-pack containers would simplify the handling tasks at Simio Warehouse.

Since they are early in the negotiation process with the potential suppliers, Simio Warehouse does not have the costs associated with the three ideas and is requesting for you to use your simulation model to determine the approximate values of these options. These values would then serve as a starting point for the cost negotiations with the potential suppliers.