Packaging Line Improvement using Arena Simulation Software at a Pharmaceutical Plant (Under NDA)

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Background

According to a Regulatory Education for Industry (REdI) report, one of the top reasons pharmaceutical products are recalled is due to packaging defects (1). Automation increases the speed at which products are packaged while negating the risks associated with human error (3). Creating a flexible, engineering solution allows for future optimization tools to be easily implemented in addition to the primary proposed solution.

BE Design Team #13 was asked to work alongside Perrigo Pharmaceuticals to analyze the packaging line efficiency in building ALC at Allegan, Michigan facility.

Figure 1: Part of Perrigo's production line

Problem Statement

Perrigo Pharmaceuticals has an opportunity to increase the current production flow efficiency of their packaging lines by implementing a solution to track the input and output of the product at various stages of production to optimize their packaging. The goal of the project is to review issues such as e-stops, automation problems, lack of data, and find the cause of the problems to help eliminate the frequency of such problems.

Constraints

These are the constraints the project had to stay within:
- Able to be used for multiple configurations on one product on one specific line
- Easily managed and altered for future configurations
- Accounts for bottle size of 12 oz
- Consistent use of bottle size and different configurations
- Keep equipment speeds between their qualified range
- Payback period of 5 years
- Complete by May 2022
- Legal Constraints:
  - ❖ Code of Federal Regulations Title 21 (6)
  - ❖ International Organization of Standards 9001:2015 (2)

Objectives

These are the objectives and goals that the team ideally wanted to meet for the project:
- Optimize the line speed
- Lessen bottlenecks occurrences
- Increase efficiency of production by 5%
- Justify prices based on higher efficiency levels

Design Alternatives

These are the three Design Alternatives discussed when deciding the best approach for the problem statement:
1. Creating a simulation model using the Arena Simulation software
   a) The simulation will test different configurations to provide a better understanding of the packaging line and provide data to determine the parameters that affect the overall efficiency the most
2. Installing robotic assistance in the packaging line
   b) The robot would automate repetitive processes that would otherwise involve human operators. This would lead to a decrease in human error, leading to decreased down time and fewer emergency stops
3. Installing in-line sensors within the packaging line
   c) These sensors track product input and output at the distinct locations. They consist of a set of speed, tilt, and pressure sensors to verify that the product is not being damaged and that the processing line is running optimally

Below is the decision matrix that aided in the determination that the simulation model using the Arena software was the best design.

Table 1: Decision Matrix

Criteria	Weighting (%)	Simulation model in Arena	Automation Robot	Smart Inline Sensors
Cost	15	12	10	13
Efficiency	15	12	14	11
Ease of installation	15	11	9	10
Safety	15	13	10	11
Time taken	10	7	5	8
Technology readiness	10	8	5	8
Waste of product	10	9	4	8
Maintenance	10	8	5	7
Total	100	80	62	76

Selected Design

Arena software was determined to be the best design solution is to create a simulation model. The simulation model could achieve each objective while staying within all the constraints as well. The Arena simulation is the best solution to accommodate the complexity of the packaging line in the pharmaceutical plant, and the variety of machines that run at their individual speeds.

- Simulating the packaging line allows to have a clear understanding of the systems components and their interdependencies, as well as, showing where bottlenecks occur.
- The simulation allows engineers to manipulate data inputs effectively and gain an understanding of how these inputs affect the overall output before implementing the new design.
- Using the simulation to theoretically mode a design first before an actual experimental data analysis helps save time.
- Taking an engineering approach, with the simulation, instead of a just an experimental scientific approach allows Perrigo to ensure packaging accuracy, expand the market, and meet more consumers' needs with ease.

Arena Simulation

Figure 2: Loose/Single bottle simulation
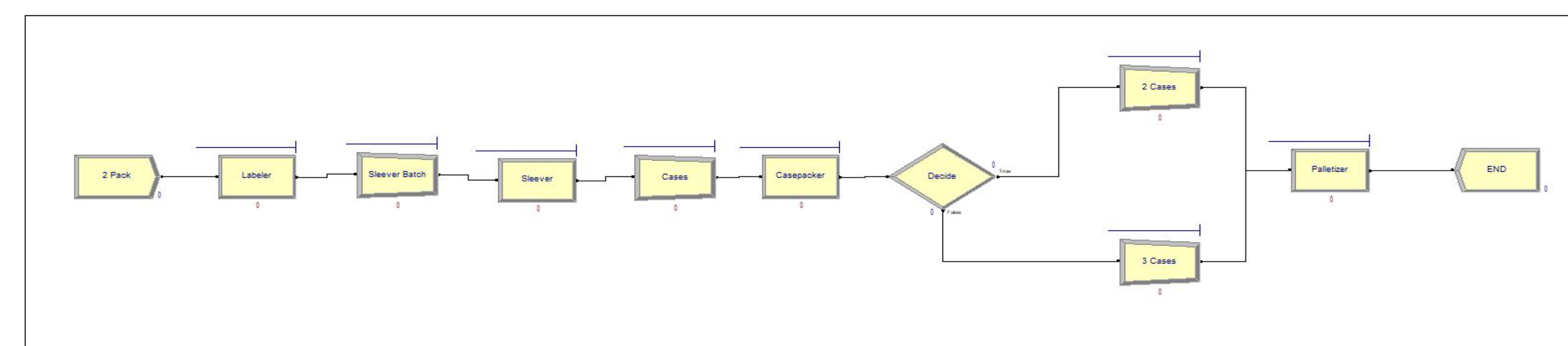
Figure 3: Sleeved 2 pack simulation

Figure 4: Bundled 3 pack simulation

Data Analysis

The simulation outputs a set of reports on multiple aspects of the simulation. We focused on the outputted statistics that relate to the bottlenecks. A generated report with arbitrary values can be seen below.

Figure 5: Arena simulation outputted report, using arbitrary values

This graph shows the relationship between bottleneck occurrences and the throughput of the bottles for all 3 of the configurations (loose bottles, 2 pack, and 3 pack).
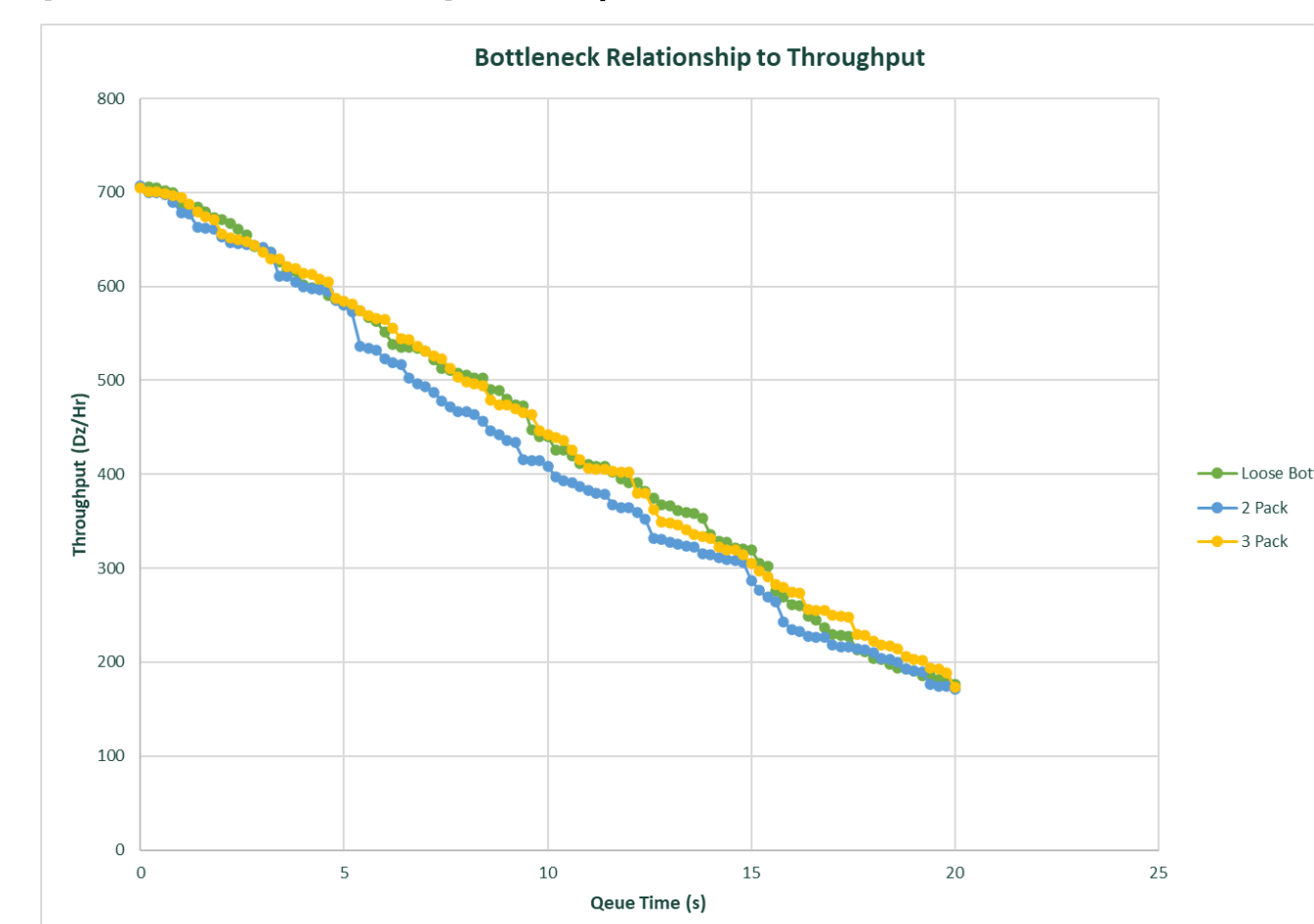

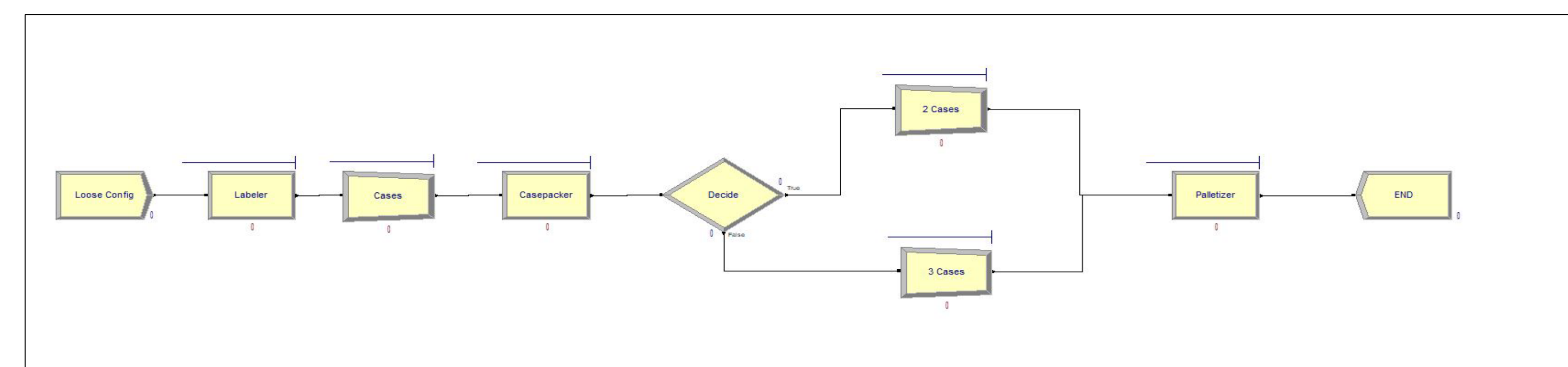*Figure 6: Graph of the bottleneck and throughput relationship*

Justification/ Economics

ARENA software will allow:
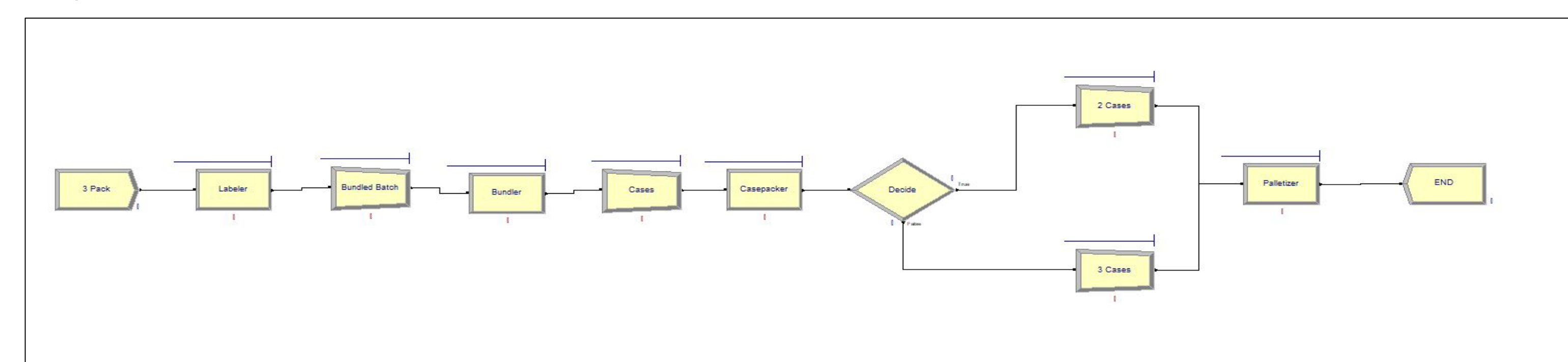- Predictions of the capabilities of production lines as uncertainty is reduced.
- Provide a relationship between the throughput and the final product.
- Machines to run smoother since it is preventing bottlenecks from occurring.
- Give a virtual representation of the production line.
- provide a chance for Perrigo to assess pricing based on customization choices.

Pricing for ARENA software and training - $10,500 (5)

For <5 years of payback period to be achieved the company's revenue for that fiscal year should account for $2100/year. For a company as widespread as Perrigo, the payback should be achieved within 2 years.

Recommendations

- Buy Arena Software to have a more inclusive version
- Arena simulation courses
- Other software options:
  - ❖ Tecnomatrix from Siemens (4)

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