2020 INFORMS O.R. & Analytics Student Team Competition

PRELIMINARY PROBLEM STATEMENT

The 2020 Title Sponsor, Bayer, has provided a challenging and multi-faceted problem for Competition teams to solve. In order to make the problem realistic, manageable, and instructive, the problem uses a fictitious company and product. However, this type of production planning and logistics problem is a common challenge for many types of industries.

The problem asks students to design a distribution network that involves determining product flows in the presence of resource capacity constraints at manufacturing facilities. Using realistic data, students will need to perform statistical analyses, develop simulation models and/or machine learning, design the distribution network using optimization, and conduct a quantitative assessment of their solution.

The Problem: Network Design & Facility Operations Modeling

Jelly Bean (JB) Manufacturing is headquartered in Chicago, IL with manufacturing facilities in five locations spread throughout the mid-western region of the United States as shown in Figure 1. These five manufacturing facilities supply both domestic and international orders for jelly beans. JB Manufacturing sells jelly beans in bulk that are of different colors, sizes, and flavors. JB Manufacturing locations operate each year from April 1st to the end of September or early October to fulfill seasonal demand for Halloween.
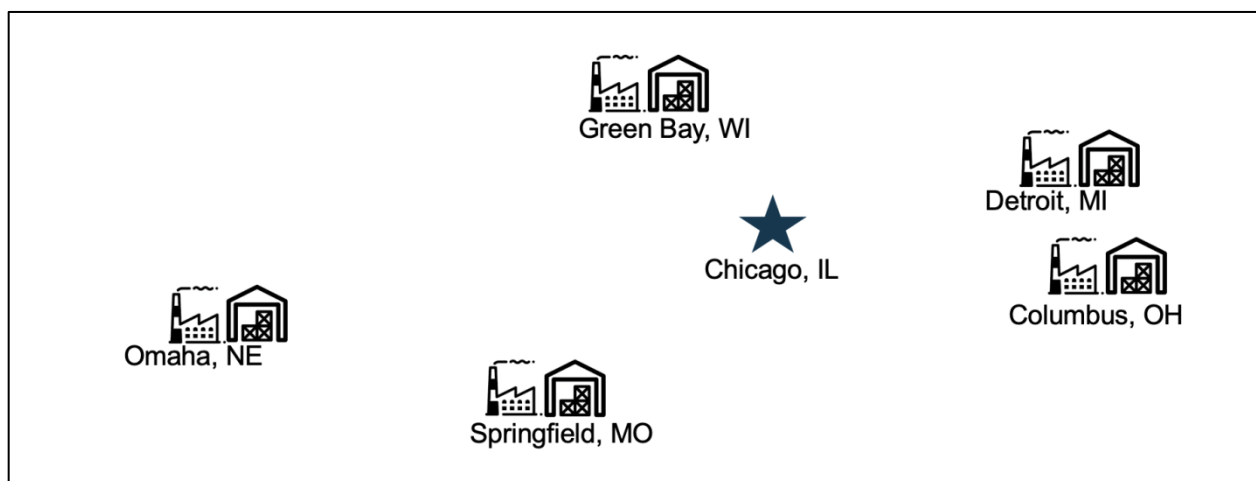

Figure 1: Locations of JB Manufacturing headquarters and manufacturing facilities.

The headquarters in Chicago, IL is home to the company's administrative, supply chain (planning, manufacturing, and logistics), process engineering, and commercial organizations. Each year, the orders for jelly beans from the wholesale retailers are received by the commercial organization and are passed on to the supply chain planning team. Competition teams will be provided with data showing the order bank comprising all orders received by the commercial team, specifying the quantity of a given color, size, flavor, and desired packaging.

Definition: Stock Keeping Unit (SKU) - Jelly beans that are of the same color, size and flavor packaged either in a bag or in a box constitute one SKU.

The supply chain planning team processes these orders and creates internal work orders for each manufacturing location specifying the quantity of jelly beans of a given color, size, and flavor that need to be packaged in bags and boxes at each site based on the initial inventory levels at start of the season at each site.

Jelly bean manufacturing is split into two phases--color coating & flavoring. For the scope of this competition, we assume that the coloring steps have been completed and the colored jelly beans are stored in the Raw Material Inventory Store and will pass through a series of operations before they are packaged. Figure 2 depicts both the process flow and the product differentiation at each processing step. Though the processing steps and stages for jelly bean manufacturing are similar, each of the locations has unique infrastructure with varying numbers of machines with different processing capabilities.

Process Steps:

Raw Material Inventory (RMI) Store: At each manufacturing facility, several drums act as an inventory store for the Raw Material. The number of drums and their capacities varies by site and the details by site are provided in the 'Facility Details' section below. Individual drums can hold jelly beans with a same color, however, jelly beans of a given color can occupy more than one drum.

Classifier: While each drum at the RMI stage holds jelly beans with the same color, the sizes of these jelly beans within a drum may vary. As the individual drums at the RMI step are emptied for further processing at the Classifier operation, the colored jelly beans are grouped into five different sizes. The percentage split for each of the sizes can be derived based on the historical data provided for each color.

Pre-Finish Inventory (PFI) Store: Once the colored jelly beans are sized and segregated, the beans are then stored in the PFI drums. To ensure contamination is avoided, each of the jelly bean sizes is assigned to a set of drums and great care is taken to ensure that at any given point in time, each drum is filled with similar color and sized jelly beans. The number of drums and their capacities varies by site and the details by site are provided in the 'Facility Details' section below.

Pre-Finish Operation: At the Pre-finish operation, the PFI drums are emptied into a tank where flavors are applied to the jelly beans. Currently, 12 flavors of jelly beans are offered and at a given time, jelly beans of a given color and size are processed in the tank. The number of tanks, tank capacity, and the processing rates are provided.

Pack Inventory (PI) Store: Once the Pre-finish operation is complete, the flavored jelly beans are staged at the PI drums. Each PI drum holds jelly beans grouped by color, size, and flavor to avoid contamination. The number of drums and their capacities vary by site and the details by site are provided in the 'Facility Details' section below.

Packaging: The PI drums are emptied for packaging either in a bag or a box. Typically, bags and boxes are processed at different packaging equipment; the number, capacity, and processing rate are provided later.
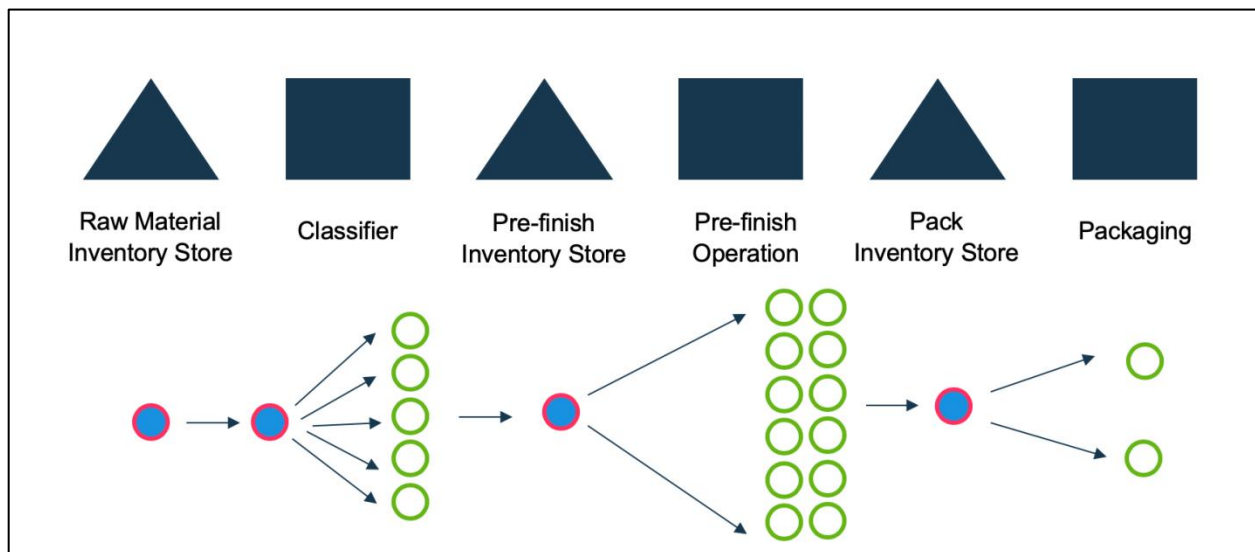

Figure 2: Process Flow and Product Differentiation.

In order to provide some flexibility and efficient capacity utilization at the network level, the planning team may coordinate with the logistics team to move some jelly beans from one

location to another provided sufficient storage drums are available at the other location's RMI store. Due to fleet capacity restrictions, limits exist on the number of colored jelly beans and the total quantity that can be moved from one location to the other. These moves of jelly beans between facilities are made at the start of the season before classifier operations begin for the year. Once the flavor stage operations begin at the facilities, the truck fleet is dedicated to moving the finished bags and boxes to the wholesalers. The move to the wholesalers is out of scope for this competition. The travel distances between facilities and the restrictions on the number of jelly bean varieties at RMI and the total quantity that can be transported from one site to the other will be provided.

Table 1 below provides the number of drums at various inventory stores along with the amount of equipment available for the Pre-finish & Packaging operations. Each manufacturing location has a single classifier. The equipment and drum capacities and processing rates at various operations and inventory stores are provided. In addition, the following information is provided:

1. Transfer times between each processing step.
2. Clean up times for each inventory drum and equipment.
3. Equipment layout for each of the five manufacturing facilities.
4. Historical downtimes for lunch breaks, weekends, machine failure, etc.

Table 1: Amount of equipment and drums at each operation and inventory store.

Manufacturing Facility	Number of RMI Drums	Number of PF Drums	Number of Pre-finish operation equipment	Number of PI Drums	Number of Packaging Machines
Detroit, MI	40	15	2	8	1 bag, 1 box
Columbus, OH	30	32	3	10	2 bag, 1 box
Springfield, MO	50	24	1	15	1 bag, 1 box
Green Bay, WI	20	17	2	17	1 bag,1 box
Omaha, NE	30	28	3	12	1 bag, 1 box

JB Manufacturing Executive Leadership team has retained you as their Decision Science Solutions consultant for developing strategies to reduce the total number of days the manufacturing facilities are operational so that jelly bean SKUs can be staged at the wholesaler locations to meet Halloween demand.

You have been asked to work with various organizations both at the headquarters and the manufacturing facilities to develop strategies for better planning and internal work order

creation, establishing the current manufacturing capabilities, and balancing the work load across each of the manufacturing locations. These organizations along with their objectives are as follows:

Process Engineering Team:
    a. Determine the statistical distribution of the processing rates for pre-finish and pack operations to establish current operational equipment capabilities at each manufacturing facility.
    b. Work closely with the process engineers to develop simulation models for the five manufacturing facilities to establish manufacturing capabilities for each facility.

Planning Team:
    a. Determine the distribution of sizes by performing statistical analysis for each color jelly bean in the RMI drum at each location (after the intra-site transfers are complete).
    b. Use the simulation models developed to evaluate the number of days it may take to process a given internal work order you will be designing in step c below.
    c. Process the order bank obtained by the commercial team and create the internal work orders for each manufacturing facility. Each internal work order for a manufacturing facility will comprise the quantity of jelly beans to be manufactured for a specified list of SKUs. You may develop optimization models in conjunction with machine learning and simulation models.
    d. Create a framework to analyze the complexity for each internal work order, in other words, develop a metric for comparing two internal work orders.

Logistics Team:
    a. Determine the number of jelly bean varieties along with the quantities that will be moved between facilities at the start of the season to balance the work load across the five manufacturing facilities based on the internal work orders created.

VP Manufacturing:
    a. Identify the bottleneck or rate-limiting steps at each of the manufacturing facilities.
    b. Determine if it is possible to balance the material flow by adjusting and designing optimal internal work orders.

Timeline

- October 11, 2019: Registration opens. Final problem statement, data and software available. Teams must register to receive access to the final problem, data and software. Registered teams will also be invited to attend webinars and other opportunities to ask questions and interact with Bayer staff.
- December 20, 2019: Deadline to register.
- January 27, 2020: Entry deadline.