Final Project: Patient Transporter Facility

ISE 453: Design of PLS Systems **Fall 2018**

Assigned: Tue, 20 Nov (Groups of 4) Due: 11p Sun, 9 Dec

Background

A patient transporter is designed to assist in the transport and rescue of patients from areas that are difficult to access with traditional stretchers. A firm is considering importing transporters from a supplier in Aydin, a city in the southwestern part of Turkey, and then distributing them to its six customers located throughout the eastern U.S. Before entering into negotiations with the supplier, they would like to know the cost of producing and distributing the transporters if they build their own facility, as opposed to just distributing the transporters, so that they can use this information in their negotiations with the supplier. In order to facilitate shipping consolidated orders to customers, this facility is designed to perform dual functions: manufacturing transporters and purchasing other associated products to distribute to customers, which are mostly EMS equipment distributors. In the first function, the facility is a traditional manufacturing plant; in the second, it operates more like a distribution center. The advantage of the dual functionality is that it allows customers to order both transporters and a mix of related products from a single location and save on distribution costs. There are six associated products: A–F.

Your assignment is to develop a design for a facility that will fabricate a single type of transporter and distribute the transporter along with associated products. The main operations at this facility are shipping, receiving, loading, injection molding, drilling, painting, cleaning, and packaging and inspection. Once raw material (a special resin) is shipped to the facility, it is injected, drilled, and painted. Then, a cleaning operation is followed that will produce the finished transporter. Lastly, the finished transporter will be inspected, packaged, and shipped. Once the associated products (which the facility purchases from other suppliers) are received, they stay in their original packages and wait to be shipped out.

Assignment

We assume the associated products' unit demand is proportional to the transporter; the ratios are 0.20, 0.35, 1.25, 0.28, 2.32, and 0.70, which correspond to associated products A–F, respectively (e.g., the unit demand for associated product A is 20% of the transporter demand). Since the demand for the transporter has not yet been determined, but is likely to be between 12,000 and 20,000 units per year, each group will be assigned a target demand within this range.

The main results of your project, summarized in your report, should include the following:

1. Your estimate of the average production cost per unit produced at your facility (i.e., your total production cost, which does not include distribution cost or the cost of the associated products, divided by your assigned target demand) and the total distribution cost from your facility to customers.

2. The total investment cost of your facility and the annual operating costs (not including distribution costs)
3. The location of your facility and its nearest city.
4. A detailed design for your facility (including dimensions on all drawings).

The major criterion that you should use in your design is cost minimization, subject to meeting your assigned target demand with the throughput minimum number of machines for each workstation. Additional factors that should be considered in your design are flexibility, risk reduction, and meeting accepted and/or mandated facility design standards.

Demand

It will take at least a year to build the facility, and the expected economic life of the facility once it is operational is 20 years. The facility will operate for five eight-hour shifts per week, 50 weeks per year. This is a conservative estimate—a second shift can be added if demand exceeds expectations. Also, no information is available regarding the likely discount associated with any delay in delivery of an order, so at this time, the capacity of the facility can be determined without reference to any delays associated with the resulting cycle times, making it possible to design the facility so that it only satisfies the minimum throughput requirements.

The annual demand for the product is likely to remain the same throughout its life cycle and the demand pattern during each year is expected to be stable, with no marked seasonality; thus, you can assume an arrival SCV of one. Since the annual demand for the product has not yet been determined, each group will be assigned the following demand target based on last digit of the student ID number of the group member whose last name precedes the other group member in alphabetical order:

Last Digit of Student ID:	0,1	2,3	4,5	6,7	8,9
Annual Demand Target:	12,000	14,000	16,000	18,000	19,000

Distribution Costs

Both the transporter and associated products will be distributed P2P TL, with full truckloads shipped to each customer. The finished goods and associated products are shipped together on the same truck to each customer. Total distribution costs are determined by summing, for each customer, the estimated road distance in miles between the facility and the customer times the customer's demand times the transportation rate for TL. Customers 1–6 are in Tampa, FL, Winston-Salem, NC, Albany, NY, Warren, MI, Sharon, PA, and Ashby, MA, respectively, and receive 18, 11, 21, 9, 26, and 15%, respectively, of the total demand. Each unit of finished product is 52 × 32 × 12 inches and weighs 65 lbs, can be stacked up to six high. Although any location for your facility is feasible, its location should be chosen so that the sum of distribution costs to the customers and the procurement costs from the supplier are minimized. You only need to consider one-way costs.

Material Cost and Unit Load Design

Please refer to Table 1 for raw material and associated product shipping information. The supplier of your raw material is located in Savannah, GA. One unit of raw material is required for each unit of finished goods. Associated products are purchased from three suppliers, located in Houston, TX (supplies A, B), Richmond, VA (supplies C), and Ames, IA (supplies D–F). Full truckloads of the raw material and each associated product are shipped P2P to your facility. There are no significant costs associated with any other consumables. Loads can be rotated on the trucks with respect to their width and depth. Storage should be provided in your facility for at least two-week's demand of the raw material and each associated product and one week's demand of the finished product.

Table 1. Material Costs and Unit Load Information

Product	Width (in.)	Depth (in.)	Height (in.)	Weight (lb)	Cost ($/unit)	Stacking Level
Raw Material	40	42	36	125	150	6
A	42	48	36	145	73	6
B	42	48	36	100	54	6
C	40	42	36	86	103	6
D	36	48	36	54	46	6
E	36	48	36	31	136	6
F	36	48	36	107	79	6

Shipping and Receiving

You should estimate the number of shipping/receiving dock(s) needed so that, assuming the inbound and outbound trucks arrive at random times throughout the day, each truck does not have to wait on average more than 20 minutes for a dock. In addition, you should provide a truck waiting area twice what is needed for the average number of trucks waiting. All loading and unloading will be performed by your material handlers.

Equipment, Operations, and Routing

Each transporter is produced using the operations and machines listed in the routing shown in the table below. You should determine the minimum number of machines needed at each workstation to meet your throughput and cycle time requirements. The purchase cost of each machine (including installation) is listed along with its salvage percentage, its mean time to failure (MTTF), and its mean time to repair (MTTR). Each machine will have a salvage value equal to a percentage of its purchase cost at the end of 20 years. Listed for each operation is its natural process time (t_0), the SCV of its natural process time (c_0^2), yield fraction, and the time that the operator is required to attend the machine during processing (e.g., to load/unload the machine). (Note: each t_0 includes the time needed for machine loading/unloading; thus, the operator time is only needed to determine labor requirements.) Time permitting, a single operator can be attending multiple machines within a workstation as long as the machines not separated too far from each other. You can assume that the only sources of processing variability beyond c_0^2 are random failures, with the SCV of the repair times (c_r^2) equal to zero.

You should create a rectangle or block of the correct dimensions (see table) in your layout to represent these machines.

Table 2. Equipment, Operations, and Routing Data

W/S	Operation	Machine Dim.	Machine Cost ($)	Slvg (%)	Nat Proc Time (min)	Nat Proc Time SCV	MTTF (hr)	MTTR (hr)	Yield (%)	Oper Time (min)
1	Injection Molding	15' × 10'	120,000	20	8	0.25	—	—	95	2.00
2	Drilling	10' × 8'	50,000	50	12	0.10	60	1	98	2.00
3	Painting	8' × 6'	10,000	25	18	0.75	23	1.5	95	2.00
4	Cleaning	10' × 8'	20,000	30	6	0.25	30	3	98	6.00
5	Inspection	6' × 4'	2,000	40	4	0.20	—	—	92	4.00
6	Packaging	6' × 5'	35,000	30	3	0.50	—	—	100	3.00

Material Handling

You should selection the type of material handling equipment to transport raw material and finished goods. Material handlers will be used to operate any industrial trucks used to transport raw material and finished goods, while, between the machines, WIP will be transported by the machine operators using 4 × 4 ft floor hand trucks. Each hand truck can carry one unit. All trucks will have a salvage value equal to 15% of their purchase cost at the end of 20 years. The purchase cost of the trucks can be determined using Gross & Associates' *Rules of Thumb* (see course webpage for link). You should include enough space at each workstation to accommodate twice the workstation's expected WIP in queue. Beyond providing space for the hand trucks, details concerning in-process material handling can be ignored.

Building Requirements

In addition to the main manufacturing, storage, and shipping/receiving areas, your building should contain the following:

1. A lobby area for visitors.
2. Two offices: for a Plant Manager and, since there might be a need to add a second shift, an Assistant Plant Manager.
3. A small conference room adjacent to the offices.
4. A cafeteria located within 900 ft of every permanent workstation and able to seat an entire shift of employees. Assume vending machines will be used and allow approximately 20 ft^2 per person.
5. Restrooms located within 180 ft of every permanent workstation.
6. At least one employee entrance.
7. Emergency exits within 130 ft of any point in the building.

Additional Cost Data and Assumptions

The total cost to produce each unit of product is the sum of land, building, equipment, labor, material, supplies, utilities, and material handling costs. Taxes can be ignored.

- **Site Costs:** The perimeter of the site must front a road with a sewer connection. Land cost is $75,000 per acre, with a 100% salvage value after 20 years, plus a one-time sewer connection fee of $2000 per foot of road frontage. The total area for the site should be 8 times the area under-roof (i.e., the building area). The only site preparation cost that needs to be considered is $12 per ft^2 for the pavement used for parking lots, truck dock aprons and waiting areas, service roads, and driveways. You should include an employee parking lot (one space per employee per shift, with each space within 550 ft of the employee entrance) and eight visitor spaces. For both lots, each space should be 7.5×20 ft and there should be at least 5% handicapped spaces.
- **Building Costs:** Building costs are separated into high-bay (30-ft-high ceiling) and low-bay (15-ft-high ceiling) costs:

  High-bay: $68 per ft^2 of area and $2,740 per ft of perimeter (10 in. ext. and 8 in. int. walls);

  Low-bay: $39 per ft^2 of area and $1,050 per ft of perimeter (8 in. exterior and interior walls).

  The manufacturing, shipping and receiving, and storage areas in the facility should be high bay; everything else can be either high or low bay. High- and low-bay areas can be distinguished in your layout by wall thickness. You can assume a 100% salvage value after 20 years for these costs.
- **Labor Costs:** Direct labor costs for each machine operator is $24 per hour. In addition to the machine operators, the facility has on duty during all hours of operation a Plant Manager (at a salary of $148,000 per year), an administrative assistant/receptionist (at $18 per hour), material handlers (at $15 per hour), and a maintenance worker (at $18 per hour). All hourly employees are paid for eight hours of labor each shift, and all labor costs are fully burdened. You can ignore the cost to receive and stock up the associated product in your facility.
- **Maintenance and Utility Costs:** There are no significant maintenance costs beyond the labor cost of the maintenance worker. Utility costs (for HVAC, etc.) are $375 per hour of facility operation, independent of production throughput.
- **Breaks:** Production stops for breaks and lunch periods can be ignored.
- **Economic Analysis:** The real cost of capital is 4% with annual compounding; taxes can be ignored; and working capital costs (e.g., inventory) can be ignored.

Written Report

You should turn in a paper copy and submit an electronic copy (via Wolfware) of a written report that summarizes your results, along with any supporting files. The paper copy does not have to include appendices and can be turned in at the start of the Final Exam as long as the electronic version of your report was submitted by the deadline. Your report should include a title page addressed to the instructor of this course, an executive summary (maximum of one-page highlighting and summarizing your results), and the main body of your report, which should provide an explanation of the details of your design and support for all of the information requested. Additional assumptions used in your design should be numerically listed and justified. You should include citations for any material consulted (published or available on the Internet) beyond those provided in this handout, the textbook, and the lecture notes. Details in your layouts should be legible. If you are using 8½×11-inch paper for your layouts, then use multiple pages to show detailed views of selected areas of your facility design. Appendices should be used for information that supports the material in the main body of your report but is not essential to its basic understanding (e.g., detailed calculations). Each appendix should be cited in the main body of your report. The principal drawings of your facility should be in the main body of the report. Each drawing, figure, and table should be titled. Each drawing, figure, and table in the main body of your report should be cited in the text; those in appendices do not need to be cited in the main body of the report.

The quality of your write-up will be worth 20–30% of your grade for the project. The rest of your grade is largely based on your logic/strategy, and effective/appropriate use of the tools you've learned in class, so it's important to communicate that well.

- **Length:** Shoot for around 5 pages for the main body of the report (excluding appendices). Unless really necessary, try to keep it under 10 pages.
- **Executive summary:** This should be no more than one page, but should be more than a paragraph. Include your key findings for your four deliverables (include the actual numbers/results).
- **Content:** Write clearly and professionally. The report should be organized into sections. No need for gory details, but it should be clear what you did/how/why. Write as though the reader has taken ISE 453 before and is familiar with the content, but does not know about the project.
- **Supporting files:** All files used in your project (e.g., spreadsheets, Visio files) should be submitted, but they will not necessarily be reviewed unless you explicitly cite them in your report, where a file can be used in place of, or to supplement, detailed information provided in an appendix.