ISYE 6202 Supply Chain Facilities

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Casework 3

YubWeng Factory Organization Testbed

Due at the latest on October 27th, 2024, at 23h55

To be realized solo or in teams of up to 6 students, with no impact on evaluation

Weight: 20%

A worksheet is provided with all Tables and Basic Layouts depicted in this document.

Deliverables should be well documented, with joined files as pertinent (software, spreadsheets, drawings, etc.), yet not forcing to rely on the joined files to evaluate the core of your deliverables.

Overall Context and Mission

YubWeng is a parts manufacturing service provider specialized in implementing factories near the assembly plants of their clients, robustly delivering demanded products in swift in-time fashion.

Up to now, YubWeng has considered its implemented factories mostly as job shops and has thus always designed them according to a function organization.

Recently, its leaders have been made aware that they may be restricting the capability and performance potential by designing its factories only as function organizations, as there are numerous other organizational options that may be more appropriate in specific cases.

YubWeng has selected the factory it has implemented for one of its current clients as a testbed for assessing the impact of alternative organizational designs. This factory is built on the lot adjacent to the lot of the client's assembly plant.

YubWeng is requesting your help to perform a rigorous assessment of the potentiality of leveraging alternative factory organization designs, using the testbed factory as exemplar. The leadership wants your team to provide a fresh look, untainted by YubWeng internal history and paradigms, so it will keep you at arm's length while you perform the study.

Therefore, your team is hereafter provided with key functional and technical specifications for the testbed factory, yet not a single information about the client itself and about the factory YubWeng's team has designed and implemented for the client two years ago.

2025 Demand Forecast and Performance Expectations from Client

Located in the U.S.A., YubWeng's testbed factory serves the client's assembly plant that produces five different products A1 to A5. The 2025 demand forecast provided by the client for its products during

the 12-month period from May 1st, 2025 to April 30st, 2026 is as follows. First, it provided the overall expected demand for each product. Second, as it recognizes there is uncertainty on the overall quantity to be assembled for each product over 2025, it provided its expected standard deviation of to-be-realized 2025 demand around the provided forecast for each product.

2025 Demand Forecast for Each Product						
Year	A1	A2	A3	A4	A5	Total
2025	50000	100000	130000	60000	80000	*420000*

Standard Deviation on 2025 Demand Forecast for Each Product						
Year	A1	A2	A3	A4	A5	Overall
2025	721	1442	2163	1442	721	*447*

Third, as it does not foresee any seasonal pattern in its assembly factory demand, it provided the expected average weekly demand forecast for each of its products over 2025, which is simply the annual demand forecast divided by 52. Fourth, as it knows there are to be actual fluctuation of assembly production around this weekly average expectation, it provides the expected 2025 coefficient of variation of weekly demand for each product. Fifth, as its daily assembly schedules within a week are highly smoothed, the client specified that the weekly demand is smoothed over the five days a week , two shifts a day, and 8 hours a shift operations.

2025 Weekly Demand Forecast for Each Product						
Year	A1	A2	A3	A4	A5	Total
2025	962	1923	2500	1154	1538	*8077*

Expected Coefficient of Variation of Weekly 2025 Demand for Each Product						
Year	A1	A2	A3	A4	A5	Average
2025	15%	20%	20%	12%	18%	*17%*

YubWeng's client assembles its five products from 20 parts provided by YubWeng's parts factory. Here is the Product-Parts matrix for these products.

Part	Number of Parts per Assembled Product Unit Demanded in 2025				
	A1	A2	A3	A4	A5
P1	4	2	4	4	1
P2	1		2	2	
P3				2	1
P4		1	2	2	
P5		1	2		
P6	1				1
P7		2			2
P8				4	
P9		1	2		
P10	1		1	1	
P11	2				4
P12	4				4
P13	2				2
P14		4	2	2	2
P15				2	
P16		1	4		
P17	2				2
P18	4	1			4
P19		3	3	3	1
P20		2	3	3	

The client requests that its assembly plant be replenished continuously from YubWeng's parts factory once an hour during operating shifts. The client keeps a four-hour buffer of each YubWeng's parts. The agreement between YubWeng and the client is for a 99.9% service level at the hourly level, meaning that no more than 0.1% of the hours in the year will YubWeng be late in supplying its parts, subject to financial penalties for exceeding this percentage and for stopping assembly of any of the client's products. So, the parts factory must be designed to robustly meet this service level agreement.

Testbed Factory Specifications

YubWeng's parts factory is to be operating according to two 8-hour/day shifts over 5 days a week, as its client's assembly plant. YubWeng knows that it can leverage overtime and extra shifts to compensate for major disruptions, yet it wants to make sure the factory is designed not to need extra working hours and days through its normal operations.

Hereafter are listed the parts manufactured by YubWeng with their X, Y and Z (height) dimensions, their weight and their materials cost.

Part	Dimensions				Materials
Identifier	X (in.)	Y (in.)	Z (in.)	Weight (lbs)	Price/unit
P1	2	6	6	2	$ 12
P2	8	8	4	14	$ 100
P3	6	6	6	6	$ 50
P4	12	6	4	16	$ 120
P5	8	4	6	5	$ 50
P6	2	8	6	3	$ 15
P7	2	2	12	1	$ 25
P8	4	4	4	1	$ 20
P9	2	4	12	2	$ 40
P10	4	4	4	1	$ 20
P11	4	6	4	2	$ 30
P12	6	6	4	2	$ 30
P13	2	2	12	1	$ 25
P14	2	4	6	1	$ 20
P15	4	6	4	2	$ 25
P16	4	4	4	1	$ 20
P17	12	2	2	4	$ 80
P18	12	2	2	4	$ 80
P19	12	2	2	4	$ 80
P20	12	2	2	4	$ 80

Materials for each part are to be brought to the parts factory in 100-part kits whose total weight and volume is 150% of the sum of the individual part weight and volume. The factory is inbound fed once a week for each part, through part-specific kit suppliers. The factory is aiming to maintain a 99.9% robust two-week materials inventory.

Making the parts portfolio requires YubWeng to be equipped to realize 13 processes A to M. The following Table provides the manufacturing process for each part, expressing at each step the type of operations to be performed. The part materials kit is brought as input to the first step of its manufacturing process and follows the parts through the process.

Part	Process						
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
P1	B	A	B	C	D	I	J
P2	A	C	D	H	J		
P3	B	D	C	I	J		
P4	A	B	D	G	H		
P5	B	C	D	I			
P6	A	B	C	D	H	I	J
P7	E	F	C	D	I	J	
P8	E	H	J	I			
P9	F	G	E	G	I	J	
P10	E	F	I	J			
P11	E	G	E	G	I		
P12	E	G	F	I	J		
P13	E	F	G	F	G	H	I
P14	E	F	G	H			
P15	E	G	F	H	J		
P16	F	H	I	J			
P17	K	L	M				
P18	K	L	K	M			
P19	L	M	L	M			
P20	L	K	M				

At each process step for each part, the following Table provides the process time in minutes per unit for performing the required operation. YubWeng requires you to assume 90% efficiency and 95% reliability of all equipment, with 100% quality at each operation.

Part	Process Time (minutes/unit)						
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
P1	2.5	1	2.5	0.5	2.5	1.25	2.5
P2	1.25	0.5	2.5	1	2.5		
P3	1.75	3	0.75	1.5	2.5		
P4	1	2	3	0.25	1.25		
P5	1.5	0.75	3.5	1.75			
P6	0.75	1.25	0.5	3	1	1.25	2.75
P7	1	1.5	0.75	3.5	1.25	2	
P8	1.25	2	0.5	1			
P9	1.75	0.75	1.25	0.5	1.25	3	
P10	1.5	1.75	1.25	2			
P11	1.25	0.5	1.25	0.25	0.75		
P12	1	0.5	1	1.25	2.25		
P13	1.25	1.25	0.5	1	0.25	2	1.25
P14	1	1.5	0.5	1.75			
P15	0.75	0.5	1.25	2.5	2.5		
P16	1.25	5	1.25	2.5			
P17	0.75	3	3.5				
P18	0.75	1.25	0.5	3.75			
P19	2.25	2.5	2	3.75			
P20	2	0.75	3				

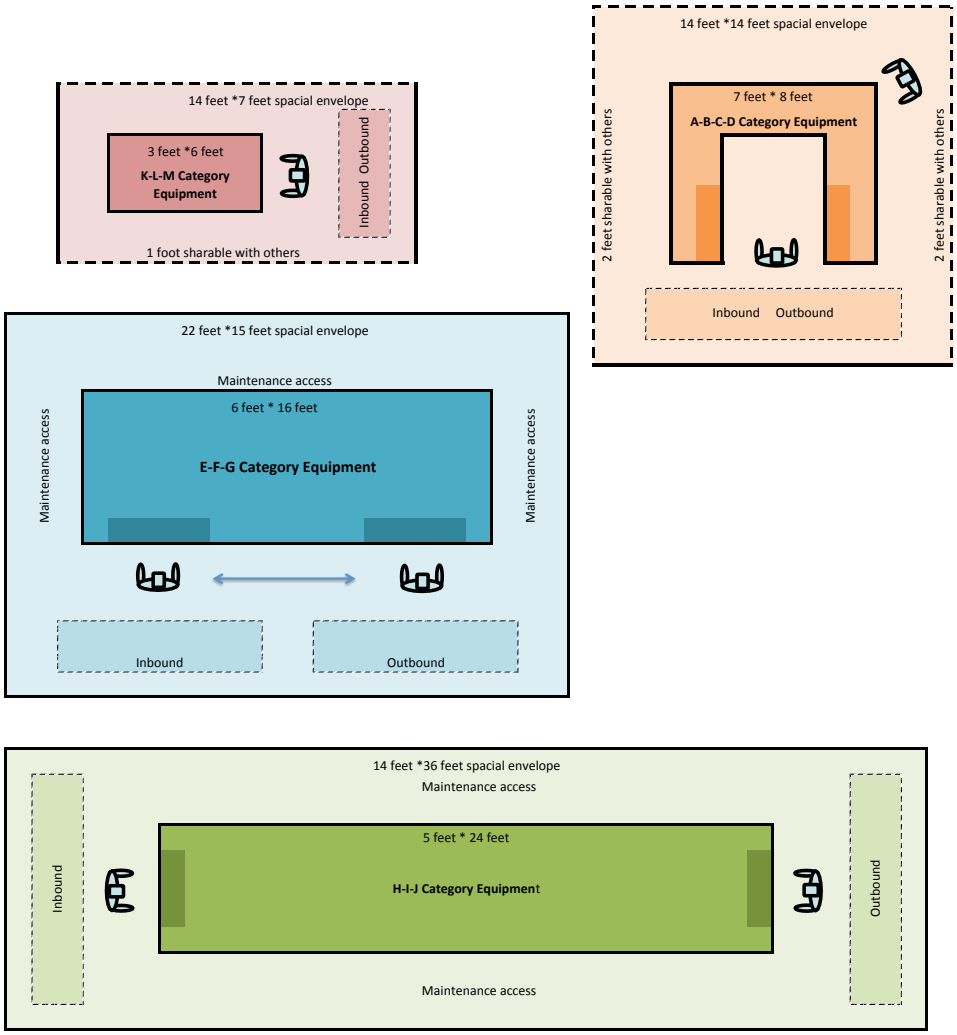
Each of these process operations requires specialized equipment that must be staffed by expert operators. The following Table provides a portfolio of equipment available on the market. Each is identified by a letter code expressing which process operations it can perform. For example, CD equipment can perform operations C and/or D on any part. The Table below provides for equipment type its installed price as well as the expected cost induced every time a unit of this equipment is to be later relocated within the factory. It also provides the expected equipment useful life, at which time the equipment would be discarded with negligible residual value.

Equipment	Installed price	Relocation cost	Useful life (years)	Number of operators
A	$ 150,000	$ 10,000	10	1 C1+1/4 C2
B	$ 200,000	$ 10,000	10	1 C1+1/4 C2
C	$ 250,000	$ 10,000	10	1 C1+1/4 C2
D	$ 300,000	$ 10,000	10	1 C1+1/4 C2
AB	$ 250,000	$ 10,000	10	1 C1+1/4 C2
AC	$ 280,000	$ 10,000	10	1 C1+1/4 C2
CD	$ 350,000	$ 10,000	10	1 C1+1/4 C2
ABC	$ 300,000	$ 10,000	10	1 C1+1/4 C2
ABCD	$ 400,000	$ 10,000	10	1 C1+1/4 C2
E	$ 400,000	$ 50,000	10	1 C1 + 1/2 C3
F	$ 400,000	$ 50,000	10	1 C1 + 1/2 C3
G	$ 400,000	$ 50,000	10	1 C1 + 1/2 C3
EF	$ 450,000	$ 50,000	10	1 C1 + 1/2 C3
EG	$ 450,000	$ 50,000	10	1 C1 + 1/2 C3
FG	$ 450,000	$ 50,000	10	1 C1 + 1/2 C3
EFG	$ 500,000	$ 50,000	10	1 C1 + 1/2 C3
H	$ 1,000,000	$ 100,000	15	2 C3
I	$ 500,000	$ 100,000	15	2 C3
J	$ 500,000	$ 100,000	15	2 C3
IJ	$ 750,000	$ 100,000	15	2 C3
K	$ 80,000	$ 2,000	8	1/2 C2
L	$ 100,000	$ 2,000	8	1/2 C2
M	$ 50,000	$ 2,000	8	1/2 C2
KL	$ 140,000	$ 2,000	8	1/2 C2
KM	$ 100,000	$ 2,000	8	1/2 C2
LM	$ 120,000	$ 2,000	8	1/2 C2
KLM	$ 150,000	$ 2,000	8	1/2 C2

Each equipment type requires a distinct staffing level. YubWeng has three types of operators, termed C1, C2 and C3. The Table provides the number of operators of each type required for each implemented equipment unit in a specific center. For example, equipment A requires the full-time presence of one C1 operator and one fourth of a C2 operator. Fractions of an operator may be shared within a center, but not between centers, except for small adjacent centers such in a holographic factory. Based on experience, workers are expected to work 49 weeks out of the 52 each year, accounting for holiday, sick days, and vacations. The following Table provides the hourly cost of each type of operator, including salary, benefits, and support.

Operator	Hourly Cost
C1	$40
C2	$75
C3	$100

Below are provided layout schematics for each category of equipment: A-B-C-D, E-F-G, H-I-J and K-L-M. Each one depicts the shape of the equipment unit itself, the typical position of an operator, zone-s for inbound materials or parts and outbound work-in-process or completed parts, and zone to be left open for maintenance purposes. These layouts are indicative and may be improved upon as desired.



Full lines are meant to state rigid boundaries not to be shared with other equipment units while dotted lines express areas sharable with adjacent equipment unit when pertinent. It is possible to alter these schematics as long as the proposed alterations are plausible.

All handling within the above zones, from inbound to outbound, is performed by the assigned operators. All handling of material kits and parts between centers and non-adjacent equipment zones is performed by handlers, costing 40 $/hour as the C1 operators. You are responsible for suggesting handling/storage units and means (vehicles, racking, etc.) and get documented rough-cut pricing for these.

Assume that the factory building implementation costs are 250 $/ft2, the equipment is to have negligible residual value at the end of its useful life, and YubWeng uses a 10% rate for its financial expenses, including inventory.

Task 1

Leveraging the client's information on demand forecast and service performance expectations, develop a demand fulfillment capacity plan for each part in the overall YubWeng factory over 2025 horizon.

Task 2

Consider the following eight alternative parts factories to satisfy the client's demand over the 2025 planning horizon:

a. ***Function organization****: A factory organized as a network of elementary-process-dedicated centers with a single center per process.*

b. ***Process organization****: A factory organized as a network of composite-process-dedicated centers with a single instance of each center.*

c. ***Parts organization****: A factory organized as a network of part-dedicated centers with a single center per part. You are allowed to include the receiving, storage, and shipping processes are included in each part center or to propose some other organization for these processes.*

d. ***Group organization****: A factory organized as a network of parts-group-dedicated production centers with each part assigned to a single group center. You are allowed to include the receiving, storage, and shipping processes are included in each group center or to propose some other organization for these processes.*

e. ***Product organization****: A factory organized as a network of product dedicated production centers, each making all parts required for its dedicated client product. You are allowed to include the receiving, storage, and shipping processes are included in each product center or to propose some other organization for these processes.*

f. ***Fractal organization****: A factory organized as a network of f fractal centers capable of making all products, with approximately 1/f of the overall demand satisfaction capacity required from the factory. You are allowed to include the receiving, storage, and shipping processes are included in each product center or to propose some other organization for these processes.*

g. ***Holographic organization****: A factory organized as a network of small, focused process centers (elementary or composite processes), most of these centers having several instances distributed throughout the factory, jointly capable of making all products at the required capacity.*

h. ***Free-style organization****: Learning from a to g, a factory organized as a network combining as you best prefer any of the types of center types used in a to g, or any other type using the framework introduced in class. This one is expected to be according to your assessment your best performing design, or at least be among the top three contenders.*

Select five factory organization types for which you will realize a factory design, respecting the following constraints:

- *Function organization-based factory (a) is mandatory*
- *At least one between the fractal and holographic factories (f, g)*
- *Free-style organization-based factory (h) is mandatory*

Justify your selection.

For each of the five factory designs, provide the following:

1. *Its network organization, including a network diagram and the mission of each center*
2. *Center-specific and overall resource requirements plan in terms of equipment and personnel for production, storage, and material handling*
3. *Layout of each center and of the overall factory, showing its relative position and connection points with the assembly factory*

4. *Estimated intra-center work and flow patterns and utilization profile in each center, clearly outlining how you proceeded, providing your results through both Table and Schematic formats overlaid on the layout*
5. *Estimated inter-center flows and travel distances and traffic, with graphical flow diagrams, heatmaps, and tabular results*
6. *Expected key factory performance indicators*
7. *Overall expected investment and direct operating costs, including those induced by production, storage, and material handling*

Systematically contrast and rank your generated alternative factory designs, then discuss your results, with emphasis on key insights to YubWeng and on your key learning.

2026-2029 Demand Forecast and Performance Expectations from Client

During the 2026-2029 planning horizon, YubWeng's testbed factory will have to make parts for three new products A6 to A8 of the client's assembly plant while continuing to meet parts demand for the five products A1 to A5 active in 2025.

The 2026-2029 demand forecast provided by the client for its products is as follows. First, it provided the overall expected demand for each product. Second, as it recognizes there is still uncertainty on the overall quantity to be assembled for each product from to 2026 to 2029, it provided its expected standard deviation of to-be-realized 2026-2029 demand around the provided forecast for each product.

Yearly Demand Forecast for Each Product in the 2026-2029 Horizon									
Year	A1	A2	A3	A4	A5	A6	A7	A8	Total
2026	78000	104000	140400	72800	93600	52000	26000	62400	629200
2027	62400	78000	150800	83200	109200	78000	52000	78000	691600
2028	46800	52000	161200	93600	124800	104000	78000	93600	754000
2029	26000	26000	171600	104000	140400	156000	104000	114400	842400

Standard Deviation on Each Year's Demand Forecast for Each Product in the 2026-2029 Horizon									
Year	A1	A2	A3	A4	A5	A6	A7	A8	Overall
2026	1442	1442	2884	1803	1082	1442	721	541	4449
2027	721	1082	3606	2163	1442	2163	1298	793	5333
2028	721	1082	4327	2884	1803	2884	1442	901	6572
2029	721	721	5048	3606	2163	3606	1586	1082	7803

Third, as it still does not foresee any seasonal pattern in its assembly factory demand, it provided the expected average weekly demand forecast for each of its products over 2026-2029 as done for 2025. Fourth, as it knows there are to be actual fluctuation of assembly production around this weekly average expectation, it provides the expected 2026-2029 coefficient of variation of weekly demand for each product. Fifth, as its daily assembly schedules within a week are highly smoothed, the client specified that the weekly demand will keep being smoothed over the five days a week, two shifts a day, and 8 hours a shift operation.

Expected Average Weekly Demand for Each Product in the 2026-2029 Horizon									
Year	A1	A2	A3	A4	A5	A6	A7	A8	Total
2026	1500	2000	2700	1400	1800	1000	500	1200	12100
2027	1200	1500	2900	1600	2100	1500	1000	1500	13300
2028	900	1000	3100	1800	2400	2000	1500	1800	14500
2029	500	500	3300	2000	2700	3000	2000	2200	16200

Expected Coefficient of Variation of Weekly Demand for Each Product in the 2026-2029 Horizon									
Year	A1	A2	A3	A4	A5	A6	A7	A8	Average
2025	15%	20%	20%	12%	18%	25%		8%	17%
2026	15%	20%	20%	12%	18%	25%	15%	8%	17%
2027	15%	20%	20%	12%	18%	25%	15%	8%	17%
2028	15%	20%	20%	12%	18%	25%	15%	8%	17%
2029	15%	20%	20%	12%	18%	25%	15%	8%	17%

YubWeng's client assembles its new three products using the same 20 parts provided by YubWeng's parts factory as in 2025. Here is the Product-Parts matrix for these products.

Part	Number of Parts per Assembled Product Unit Planned to be Demanded in 2026-2029							
	A1	A2	A3	A4	A5	A6	A7	A8
P1	4	2	4	4	1			2
P2	1		2	2				1
P3				2	1	2	4	1
P4		1	2	2				
P5		1	2			1	1	
P6	1				1			1
P7		2			2		2	3
P8				4		2	2	1
P9		1	2			1	1	
P10	1		1	1				1
P11	2				4	4	2	
P12	4				4	3	1	
P13	2				2	2	4	
P14		4	2	2	2			4
P15				2		2		1
P16		1	4					
P17	2				2	2	2	1
P18	4	1			4	1	3	
P19		3	3	3	1			3
P20		2	3	3				4

The client requests the same service performance in 2026-2029 as in 2025. So, the parts factory must be designed to robustly meet the same service level agreement.

Task 3

Consider the following designs realized in task 2:

i. *Function-organization-based factory design from task 2.a*
ii. *Top-ranked factory design among those produced in tasks 2.b to 2.g*
iii. *Free-style factory design from task 2.h*

a. *For each of these three designs, develop a proposal for evolving the organization (while respecting its type), the set of equipment and the pool of personnel, as well as the layout, to be ready as best as possible at the beginning of each year to satisfy the demand for that year. Specifically, you have to provide:*

    1. *Its network organization planned in each, including a network diagram and the mission of each center, providing clear depiction of its evolution (when pertinent)*
    2. *Yearly center-specific and overall resource requirements plan in terms of equipment and personnel for production, storage, and material handling*
    3. *Yearly layout of each center and of the overall factory, showing its relative position and connection points with the assembly factory*
    4. *Yearly relayout plan identifying all changes to be made in the factory to accommodate changing demand and the evolving sets of centers, equipment, and personnel; coupled with vivid graphical depiction of all relayout efforts*
    5. *For each year, estimated intra-center work and flow patterns and utilization profile in each center, providing your results through both Table and Schematic formats overlaid on the layout*
    6. *For each year, estimated inter-center flows and travel distances and traffic, with graphical flow diagrams, heatmaps, and tabular results*
    7. *For each year and overall, expected key factory performance indicators*
    8. *Yearly and overall expected investment and direct operating costs, including those induced by production, storage, and material handling*

b. *Systematically contrast and rank your generated alternative factory designs, then discuss your results,*

Task 4

Provide YubWeng an Executive Summary highlighting your overall assessments, insights, and recommendations, in a two-page-max format including compelling Figures and/or Tables.

Task 5

Synthesize your team's key learnings from performing this casework.

I hope this casework proves to be a challenging, stimulating, and worthwhile learning experience.

Professor Benoît Montreuil