ISYE 6202 Supply Chain Facilities

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Casework 3

FeMoaSa Manufacturing & Warehousing Facility Design

Due at the latest on November 12th, 2025, 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, simulations, etc.), yet not forcing to rely on the joined files to evaluate the core of your deliverables.

Overall Context and Mission

FaMoaSa is a parts manufacturing service provider specialized in implementing factories and warehouses dedicated to its clients and implemented near the assembly plants of their clients, robustly delivering demanded products in swift in-time fashion.

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

Recently, FaMoaSa leaders have been made aware that they may be restricting its manufacturing and logistic capability and service performance potential by (1) designing its factories only as function organizations, as there are numerous other organizational options that may be more appropriate in specific cases and (2) factory organization has impact on its warehouses generally located adjacent to each specific client, notably their sizing and performance.

FaMoaSa has selected the factory and the warehouse it has implemented for two of its current clients A and B as a testbed for assessing the impact of alternative organizational designs. This factory is built along a North-South highway with the product assembly factories of clients A and B respectively 90 miles to the North and 110 miles to the South. Currently FaMoaSa operates two warehouses, respectively dedicated to clients A and B and located on a site adjacent to the client's factory.

FaMoaSa is requesting your help to perform a rigorous assessment of the potentiality of leveraging alternative facility organization designs, using the testbed as exemplar. The leadership wants your team to provide a fresh look, untainted by FaMoaSa 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, yet not a single information about FaMoaSa's clients A & B, and about the factory designed and implemented by FaMoaSa's team three years ago to serve these clients.

Year +1 Demand Forecast and Performance Expectations from Client

Located in the U.S.A., FaMoaSa's testbed factory produces parts for the plant of client A assembling products A1 to A3 and for the plant of client B that assembles products B1 and B2. The Year +1 demand forecast provided by the two clients for their products during the 12-month period from January 1st to December 21st. First, they provided the overall expected annual demand for each product. Second, as they both recognize there is uncertainty on the overall quantity to be assembled for each product over Year +1, they provided the expected standard deviation of to-be-realized Year +1 demand around the provided forecast for each product.

Year +1 Demand Forecast for Each Product of Clients A and B						
Year	A1	A2	A3	B1	B2	Total
+1	50000	100000	130000	60000	80000	*420000*

Standard Deviation on Year +1 Demand Forecast for Each Product of Clients A and B						
Year	A1	A2	A3	B1	B2	Overall
+1	721	1442	2163	1442	721	*447*

Third, as neither of them foresee any seasonal pattern in its assembly factory demand, they provided the expected average weekly demand forecast for each of their products over Year +1, which is simply the annual demand forecast divided by 52. Fourth, as they know there are to be actual fluctuation of assembly production around this weekly average expectation, they both provided the expected Year +1 coefficient of variation of weekly demand for each product. Fifth, as their daily assembly schedules within a week are highly smoothed, the two clients specified that the weekly demand is smoothed over the five days a week in two shifts of 8 hours a day.

Year +1 Weekly Demand Forecast for Each Product of Clients A and B						
Year	A1	A2	A3	B1	B2	Total
+1	962	1923	2500	1154	1538	*8077*

Expected Coefficient of Variation of Weekly Year +1 Demand for Each Product of Clients A and B						
Year	A1	A2	A3	B1	B2	Average
+1	15%	20%	20%	12%	18%	*17%*

FaMoaSa's clients A and B assemble their products, respectively A1 to A3 for A and B1 and B2 for B, from 20 parts provided by FaMoaSa's parts factory. Here is the Product-Parts matrix for these products.

Part	Parts per Assembled Product Unit Demanded in Year +1				
	A1	A2	A3	B1	B2
P1	1	2	4	4	1
P2	4		2	2	
P3				4	1
P4		1	2	2	
P5		1	2		
P6	1				2
P7		4			4
P8				4	
P9		2	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		2	4	4	1
P20		2	3	3	

Clients A and B respectively keep a buffer of each FaMoaSa's parts offering a 99% autonomy of four and 12 hours respectively. The clients request that their assembly plant be replenished continuously from FaMoaSa's parts factory during operating shifts, once an hour for client A and once every four hours for client B, with on-time in-full (OTIF) replenishment service level of 99.5%. subject to financial penalties for exceeding 0.5% of late replenishments 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

FaMoaSa's parts factory is to be operating according to one or two 8-hour/day shifts over 5 days a week while warehousing is to operate two 8-hour/day shifts over 5 days a week as the clients do.

FaMoaSa 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 operation.

Hereafter are listed the parts manufactured by FaMoaSa 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 from FaMoaSa's Materials Supply Center (MSC) 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. As several other factories of FaMoaSa, the testbed factory is inbound fed once a week for each part from the MSC located 250 miles away. The factory is aiming to maintain a 99.9% robust two-week materials inventory.

Making the parts portfolio requires FaMoaSa 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. FaMoaSa requires you to assume 90% efficiency and 98% 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				

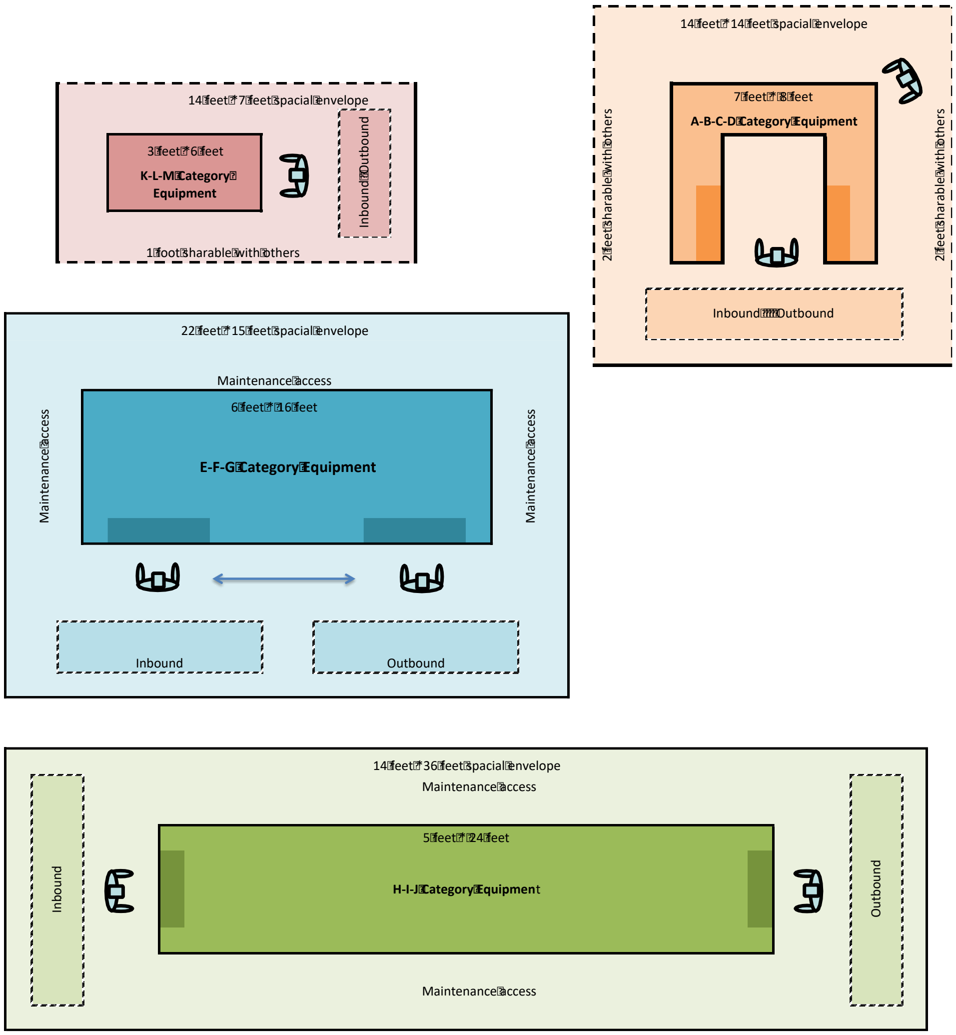
Each of these process operations requires specialized equipment that must be staffed by expert operators. The following Table provides a portfolio of equipment available on the market. Each is identified by a letter code expressing which process operations it can perform. For example, CD equipment can perform operations C and/or D on any part. The Table below provides for each 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	$200,000	15	2 C3
I	$500,000	$200,000	15	2 C3
J	$500,000	$200,000	15	2 C3
IJ	$750,000	$200,000	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. FaMoaSa has three types of operators, termed C1, C2 and C3. The Table above 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

Hereafter 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 FaMoaSa 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 FaMoaSa factory over the Year +1 horizon.

Task 2

Develop an overall finished storage capacity plan for each part for the Year +1 horizon, then propose how much storage of each part should be kept as outbound storage in the factory and how much should be kept in each of the two warehouses near clients A and B respectively, to ensure service level agreement is robustly respected.

Note that there is no obligation for you to use the three locations for parts storage.

Assume that parts are stored in standard racking without reliance on automated storage and handling equipment. Also assume that the near-client storage buildings, if used, have an internal usable height of 20 feet and are costing 200$ per square feet.

Task 3

Consider the following eight alternative parts factories to satisfy the client's demand over the Year +1 planning horizon:

- *a.* ***Function organization**: A factory organized as a network of elementary-process-dedicated centers with a single center per process, including centers dedicated to receiving, inbound storage, outbound storage, and shipping processes.*
- *b.* ***Process organization**: A factory organized as a network of composite-process-dedicated centers with a single instance of each center, including centers dedicated to receiving, inbound storage, outbound storage, and shipping processes.*
- *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, , inbound and outbound 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, inbound and outbound 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, inbound and outbound 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 facility designs, provide the following:

1. *Its network organization, including a network diagram and the mission of each center in the factory and used near-client warehouse-s*
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 and the near-client warehouse-s (if used)*
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 and warehouse 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 facility designs, then discuss your results, with emphasis on key insights to FaMoaSa and on your key learning.

Year +2 to +5 Demand Forecast and Performance Expectations from Client

During the planning horizon spanning years +2 to +5, FaMoaSa's testbed factory will have to extend its capacity to make parts for one new product A4 of client A and for two new products B3 and B4 of client B.

The demand forecast for years +2 to +5 provided by the clients for feeding assembly of their products is as follows. First, the clients provided the overall expected demand for each product. Second, as they both recognize there is still uncertainty on the overall quantity to be assembled for each product from to Year +2 to Year +5, they provided the expected standard deviation of to-be-realized Year +2 to +5 demand around the provided forecast for each product.

Yearly Demand Forecast for Each Product in the +2 to +5 Year Horizon									
Year	A1	A2	A3	B1	B2	A4	B3	B4	Total
+2	78000	104000	140400	72800	93600	52000	26000	62400	629200
+3	62400	78000	150800	83200	109200	78000	52000	78000	691600
+4	46800	52000	161200	93600	124800	104000	78000	93600	754000
+5	26000	26000	171600	104000	140400	156000	104000	114400	842400

Standard Deviation on Each Year's Demand Forecast for Each Product in the +2 to +5 Year Horizon									
Year	A1	A2	A3	B1	B2	A4	B3	B4	Overall
+2	1442	1442	2884	1803	1082	1442	721	541	4449
+3	721	1082	3606	2163	1442	2163	1298	793	5333
+4	721	1082	4327	2884	1803	2884	1442	901	6572
+5	721	721	5048	3606	2163	3606	1586	1082	7803

Third, as they still do not foresee any seasonal pattern in their assembly factory demand, they provided the expected average weekly demand forecast for each of their products over Year +2 to +5 as done for Year +1. Fourth, as they know there are to be actual fluctuation of assembly production around this weekly average expectation, they provided the expected Year +2 to +5 coefficient of variation of weekly demand for each product. Fifth, as their daily assembly schedules within a week are highly smoothed, the clients specified that the weekly demand will keep being smoothed over the five days a week, one or two shifts a day, and 8 hours a shift operation.

Expected Average Weekly Demand for Each Product in the +2 to +5 Year Horizon									
Year	A1	A2	A3	B1	B2	A4	B3	B4	Total
+2	1500	2000	2700	1400	1800	1000	500	1200	12100
+3	1200	1500	2900	1600	2100	1500	1000	1500	13300
+4	900	1000	3100	1800	2400	2000	1500	1800	14500
+5	500	500	3300	2000	2700	3000	2000	2200	16200

Expected Coefficient of Variation of Weekly Demand for Each Product in the +2 to +5 Year Horizon									
Year	A1	A2	A3	B1	B2	A4	B3	B4	Average
+2	15%	20%	20%	12%	18%	25%		8%	17%
+3	15%	20%	20%	12%	18%	25%	15%	8%	17%
+4	15%	20%	20%	12%	18%	25%	15%	8%	17%
+5	15%	20%	20%	12%	18%	25%	15%	8%	17%
2029	15%	20%	20%	12%	18%	25%	15%	8%	17%

Part	Number of Parts per Assembled Product Unit Planned to be Demanded in 2026-2029 by Clients A and B							
	A1	A2	A3	B1	B2	A4	B3	B4
P1	1	2	4	4	1			2
P2	4		2	2				1
P3				4	1	2	4	1
P4		1	2	2				
P5		1	2			1	1	
P6	1				2			3
P7		4			4		1	1
P8				4		2	2	3
P9		2	2			1	2	
P10	1		1	1				1
P11	2				4	4	2	
P12	4				4	3	4	
P13	2				2	2	1	
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		2	4	4	1			3
P20		2	3	3				4

FaMoaSa's clients assemble the new three products using the same 20 parts provided by FaMoaSa's parts factory as in Year +1. The Table above is the Product-Parts matrix for these products.

The clients request the same service performance in Year +2 to +5 as in Year +1. So, the parts factory and the warehouse-s must be designed to robustly meet the same service level agreement.

Task 4

Consider the following facility 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 and warehouse-s*
   4. *Yearly relayout plan identifying all changes to be made in the factory and warehouse-s 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 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 and warehouse 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 5

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

Task 6

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 Benoit Montreuil