EPFL School of Engineering

Continuous Improvement (CIP23)

Module 3 – Process

Facility Layout

Amin Kaboli

Week 8, Session 1-3, April 11th, 2025

Course Framework

Change Plan
Strategic plan

Continuous Improvement (ME-498)

Module 1

Introduction

Feb 23rd

CIP Foundations
CIP case studies

Module 2

People

March-May

Managing Change
Emotional Intelligence
Managing Oneself
Connection & Bonding
Effective Change Comm.
Managing Conflict

Module 3

Process

March-May

Capacity Planning
Constraint Management
Managing waiting lines
Quality Planning
Quality Control
Quality Improvement
Process selection
Facility Layout
Lean Management

Module 4

Technology

March-May

AI for CIP
Data Analytics, ML&AI
Digital Ecosystems
Best case practices

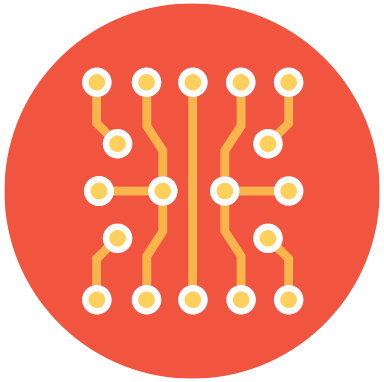
Final

May 31st

Final presentation & solid understanding of the course

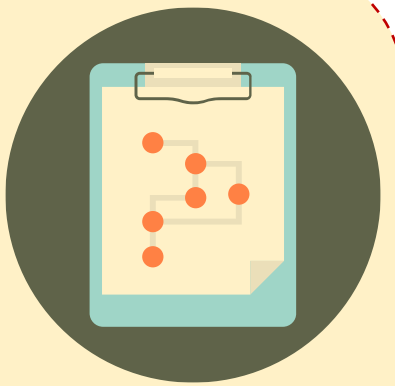
Facility Layout – Questions

1. What is production process strategy?



2. What is facility layout?

3. What are the common types of facility layout?

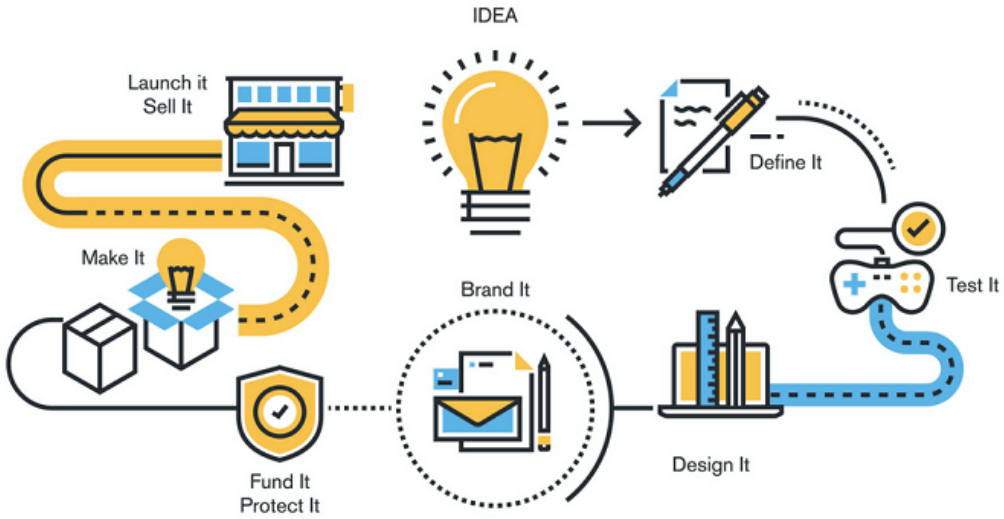


4. How to improve facility layout?

Question 1:

What is Production Process Strategy? Why it is Important?

Production Process Strategy – Definition & Necessity



Definition: Company's overall approach for manufacturing and/or producing goods or services.

Why? An indicator of flexibility and capital requirements of a production process.

Production Process – Types


Continuous production

(Steel, drinks, paints, chemicals, …)


Batch production

(Luxury watches, bakeries)


Mass production

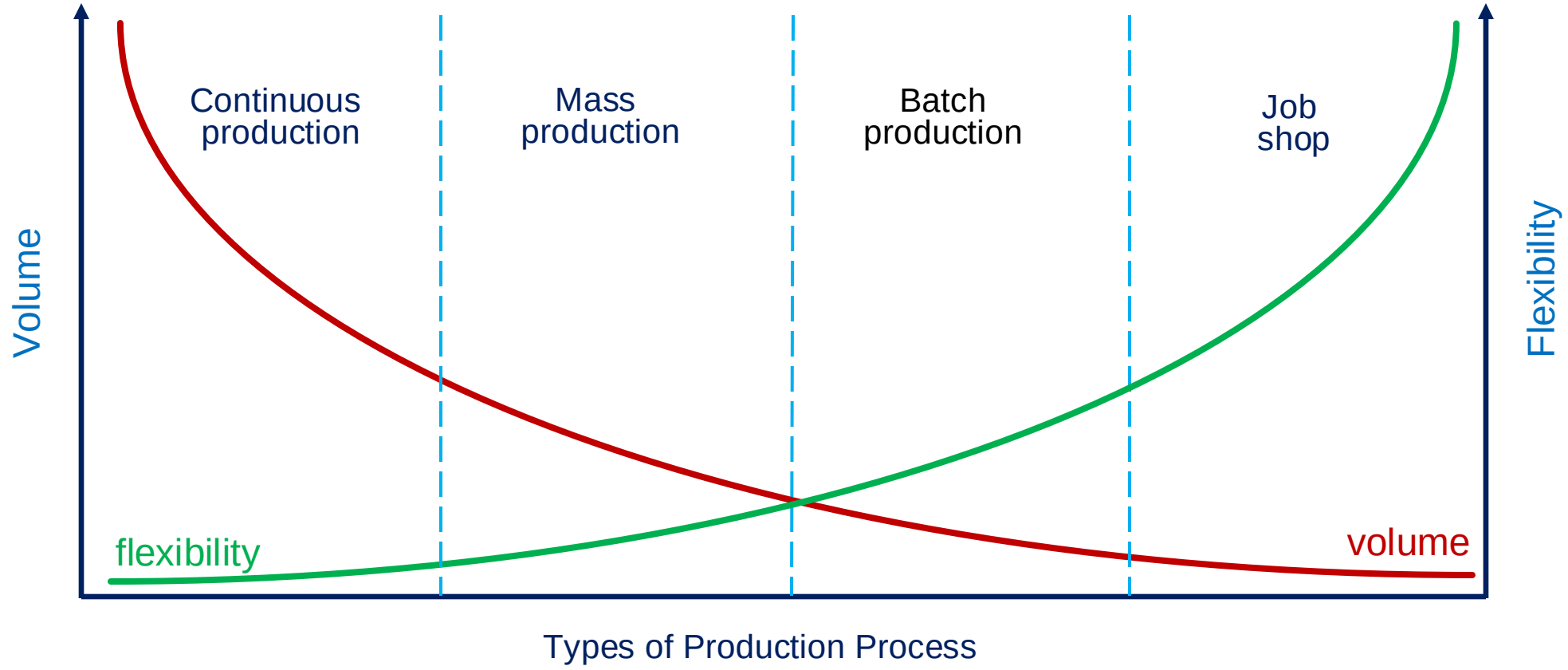
(Automobiles, most consumer goods)


Job shop

(Airplane, ship-making)

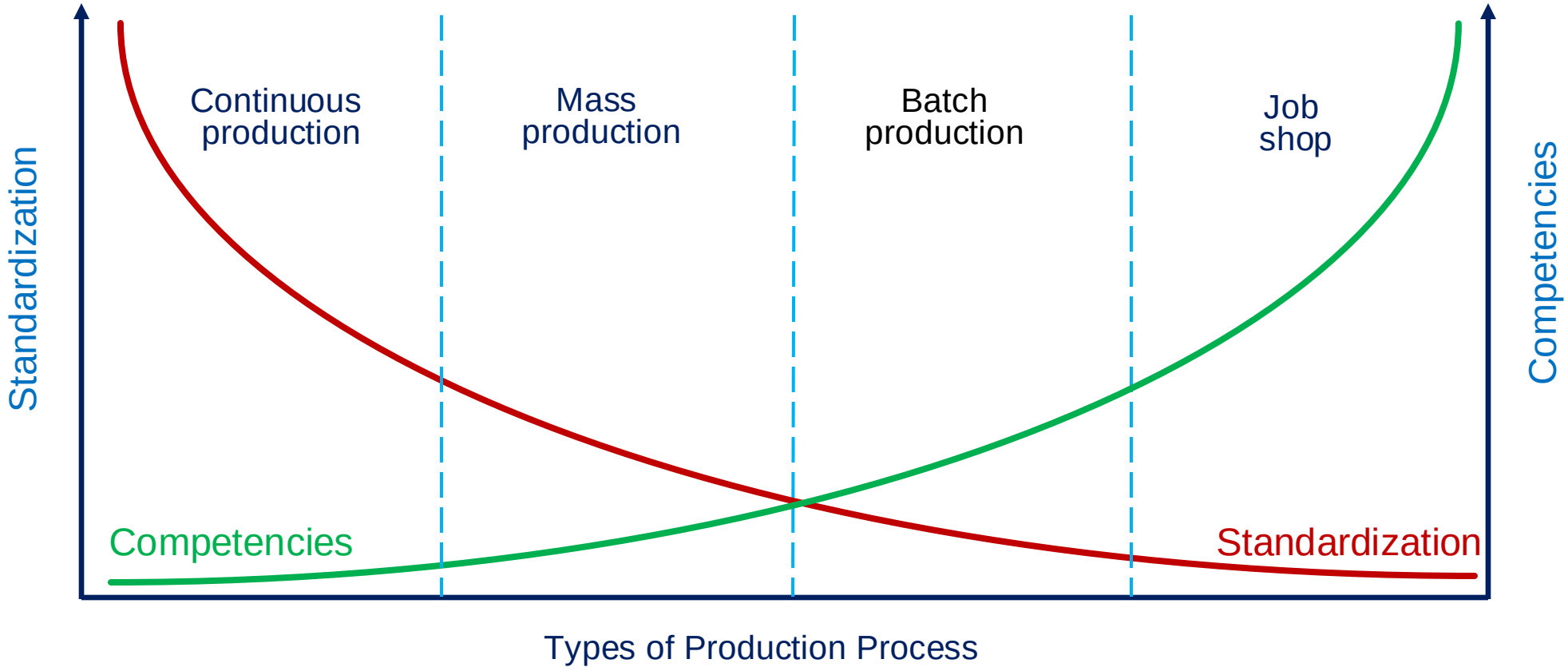
Production Process – Volume *vs.* Flexibility



Production Process – Standardization *vs.* Competence



Exercise 1 – Types of Production Process

3 min

What is/are related production process for each product/industry:

- Smart phones
- Cement
- Soft drink
- Refinery
- Airlines
- Automatic car wash
- Hospital operations room
- Movie theaters
- New product/service launch

Assignment 9 – Tasks are

5 min

Reflect, share and collect ideas of your group members and answer the following question in your work;

- Briefly describe the production strategy of your case study.
- What are the related production processes in your case study?

Question 2:

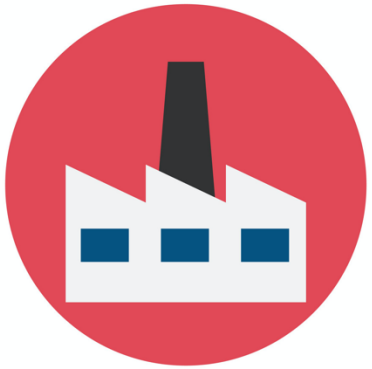
What is Facility Layout?
Why it is Important?

Facility Layout – Definition & Necessity

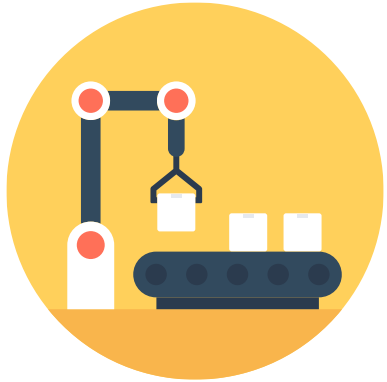
Definition: Configuration of departments, work centers, and equipment, with particular focus on smooth flow (products or customers) through a system.

Why? Facility Layout decisions requires investments of money and effort, involve long term commitments, have an impact on cost and efficiency of a system.

Facility Layout – When & Where?



Designing
new facilities



Redesigning
existing facilities

Exercise 2 – Production Process & Facility Layout

2 min

How would you design/re-design the facility layout of McDonalds's?

Exercise 3 – Facility Layout

2 min

Why do we need facility layout design/redesign?

Facility Layout – Summary of Reasons

Demand volume change

New product or service launches

Inefficient operations
(high costs, bottlenecks)

Safety hazards or accident

Changes in design regulations,
methods, equipment

Assignment 9 – Tasks are

3 min

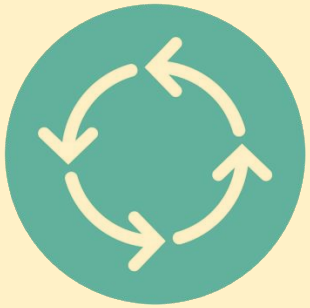
Reflect, share and collect ideas of your group members and answer the following question in your work;

- Briefly describe the production strategy of your case study.
- What are the related production processes in your case study?
- Why is facility layout important in your case study?

Question 3:

What are the common types of Facility Layout?

Facility Layout – Types



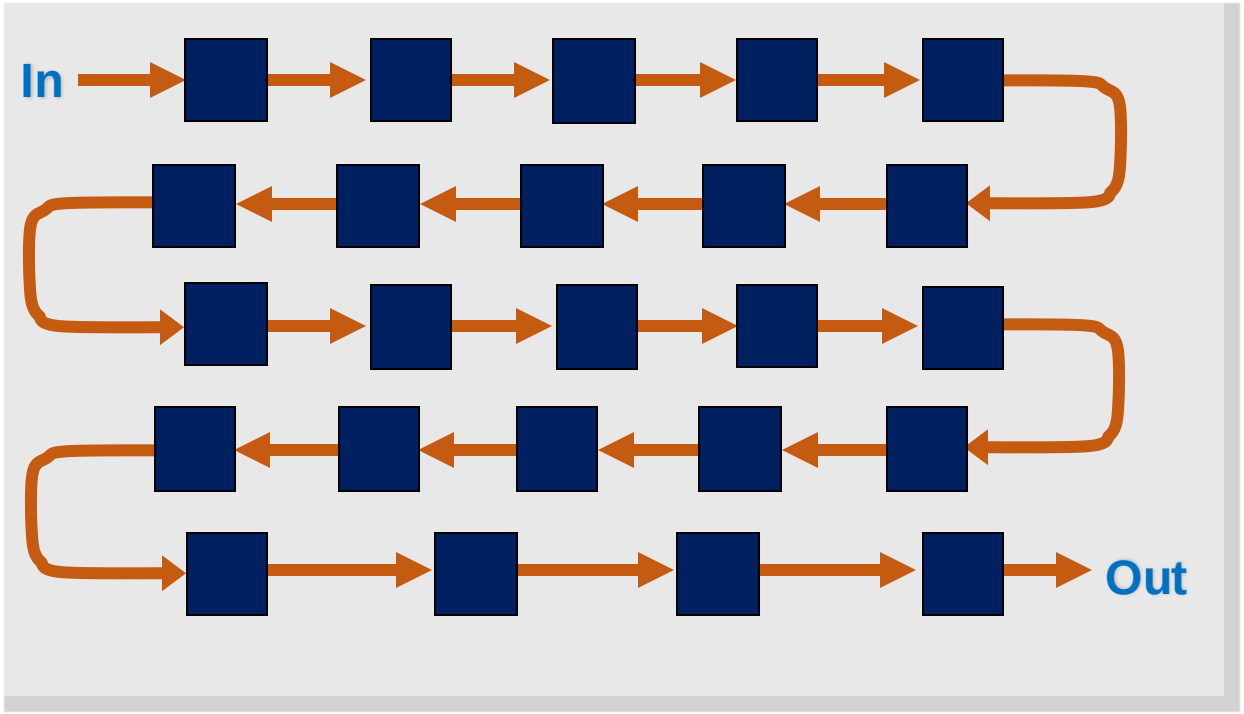
Product Layout
Repetitive processing

Process Layout
Nonrepetitive processing

Fixed-position Layout
Projects

Hybrid Layout
Mixed

Product Layout – Repetitive Processing



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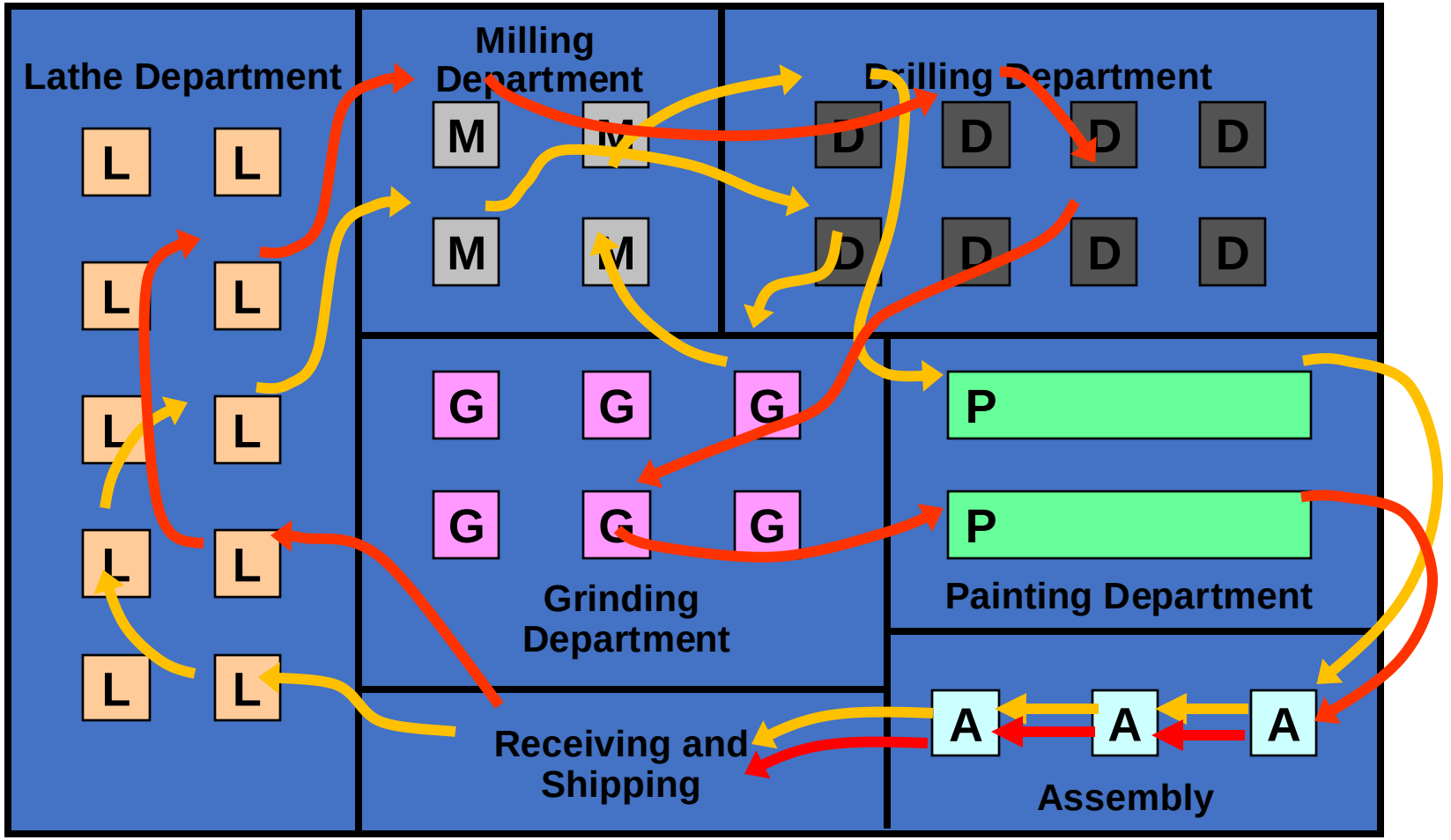
Product Layout – Repetitive Processing Examples

Process Layout – Nonrepetitive Processing



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Process Layout – Nonrepetitive Processing Examples

Assignment 9 – Tasks are

5 min

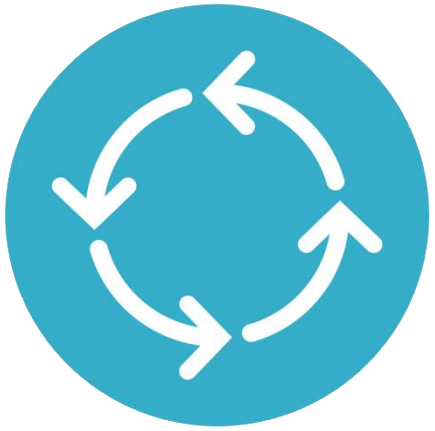
Reflect, share and collect ideas of your group members and answer the following question in your work;

- Briefly describe the production strategy of your case study.
- What are the related production processes in your case study?
- Why is facility layout important in your case study?
- What type(s) of facility layout are used in your case study?

Question 4:

How to improve Facility Layout?

Facility Layout – Improvement



Product Layout
Repetitive processing

Line Balancing

Process Layout
Nonrepetitive processing

Minimizing Transportation Costs/Distances

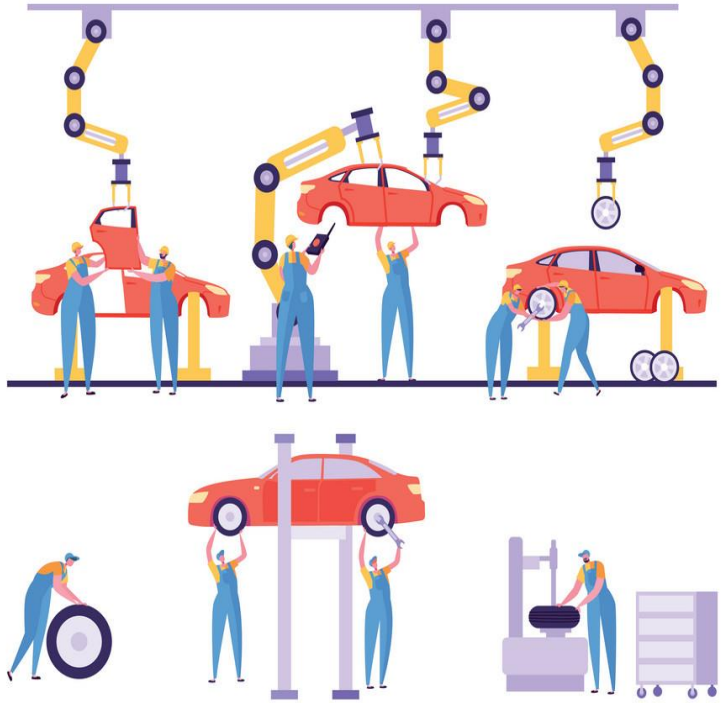
Assignment 9 – Tasks are

5 min

Reflect, share and collect ideas of your group members and answer the following question in your work;

- Briefly describe the production strategy of your case study.
- What are the related production processes in your case study?
- Why is facility layout important in your case study?
- What type(s) of facility layout are used in your case study?
- What improvements do you propose for the facility layout? What specific changes should be implemented?

Product Layout Improvement – Line Balancing



Line Balancing: The process of assigning tasks to workstations in a product layout in order to achieve a desired output and balance the workload among stations.

Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks) .
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Line Balancing – Step 1

- Identify tasks and their immediate predecessors (draw a precedence diagram)

Task	Immediate Predecessor	Task Time (in minutes)
a	–	0.2
b	a	0.2
c	–	0.8
d	c	0.6
e	b	0.3
f	d, e	1.0
g	f	0.4
h	g	0.3
		Σt = 3.8

Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
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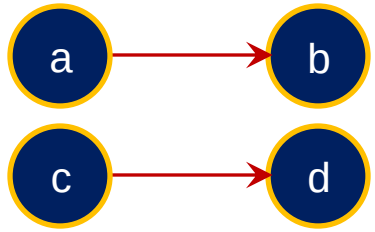
Line Balancing – Step 2

- Determine the criteria (Tiebreaker: most following tasks).

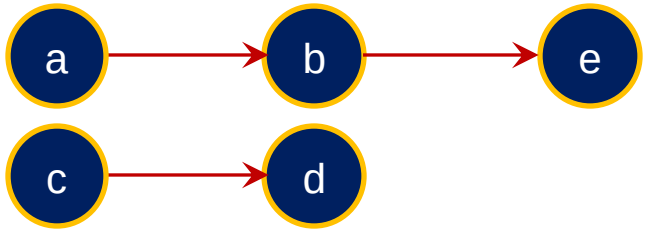
Task	Immediate Predecessor	Task Time (in minutes)
a	–	0.2
b	a	0.2
c	–	0.8
d	c	0.6
e	b	0.3
f	d, e	1.0
g	f	0.4
h	g	0.3
		$\Sigma t = 3.8$

Step 1:

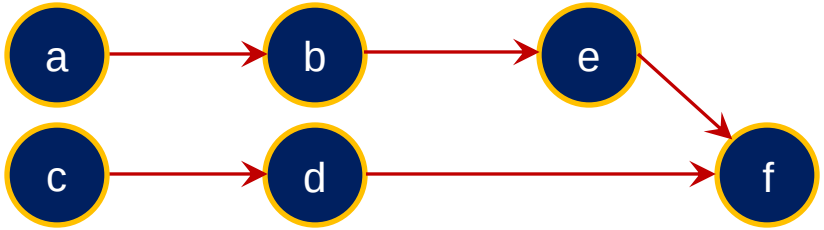
Step 2:
Task *b* follows *a*,
Task d follows *c*.



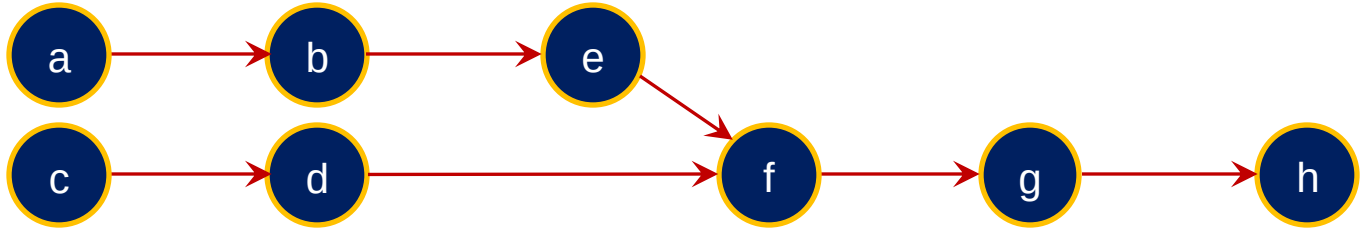
Step 3: Task *e* follows *b*.



Step 4: Task *f* follows *e*, and *d*.



Step 5: Task *g* follows *f*, and *h* follows *g*.



Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks)
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Line Balancing – Step 3

- Determine Cycle Time

$$\text{Cycle time} = \frac{\text{Operating time per day}}{\text{Desired output rate}}$$

$$\text{Cycle time} = \frac{480 \text{ minutes per day}}{400 \text{ units per day}} = 1.2 \text{ minutes per cycle}$$

Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks)
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Line Balancing – Step 4

- Compute the theoretical minimum number of stations.

Task	Immediate Predecessor	Task Time (in minutes)
a	–	0.2
b	a	0.2
c	–	0.8
d	c	0.6
e	b	0.3
f	d, e	1.0
g	f	0.4
h	g	0.3
		$\Sigma t = 3.8$

$$N_{min} = \frac{\Sigma t}{\text{Cycle time}}$$

Where

N_{min} = Theoretical minimum number of stations
Σt = Sum of task times

$$N_{min} = \frac{3.8 \text{ minutes per unit}}{1.2 \text{ minutes per cycle per station}} = 3.17 \text{ stations (Round to 4)}$$

Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks)
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Line Balancing – Step 5

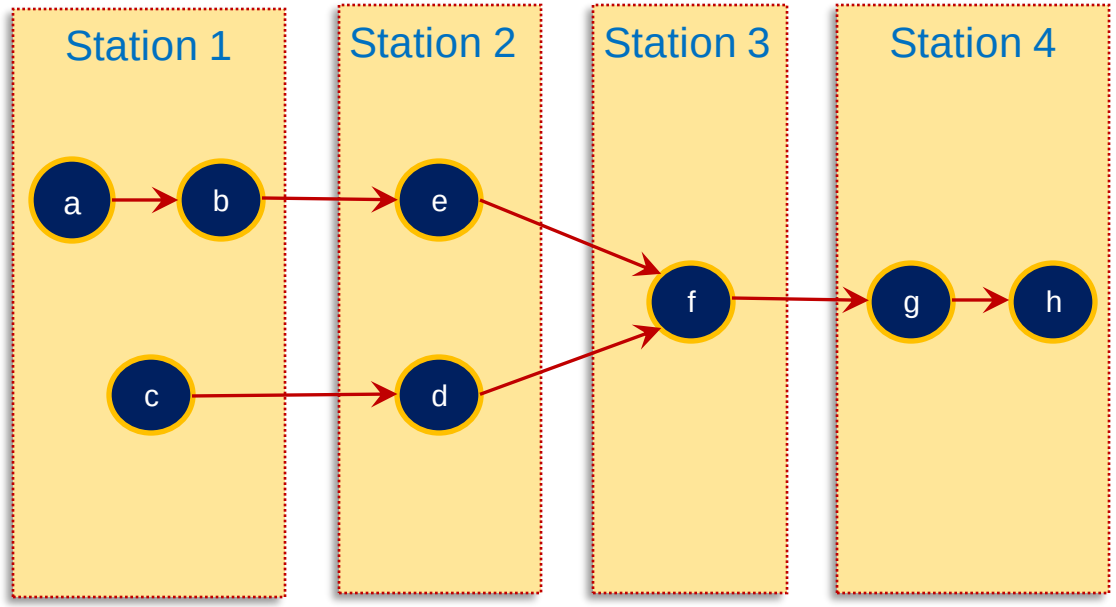
- Assign tasks to workstations (Balance the line)

Station	Time remaining	Eligible	Will fit	Assign (task time)	Revised Time Remaining	Idle
1	**1.2**	a, c	a, c	a (0.2)	1.0	
	1.0	c, b	c, b	c (0.8)	0.2	
	0.2	b, d	b	b (0.2)	0.0	
	0	e, d	None	-		0.0
2	**1.2**	e, d	e, d	d (0.6)	0.6	
	0.6	e	e	e (0.3)	0.3	
	0.3	f	None	-		0.3
3	**1.2**	f	f	f (1.0)	0.2	
	0.2	g	None	-		0.2
4	**1.2**	g	g	g (0.4)	0.8	
	0.8	h	h	h (0.3)	0.5	
	0.5	-	-	-		0.5
						1.0 min

Line Balancing – Step 5 (Continued)

- Assign tasks to workstations (Balance the line)

Station	Time remaining	Eligible	Will fit	Assign (task time)	Revised Time Remaining	Idle
1	1.2	a, c	a, c	a (0.2)	1.0	
	1.0	c, b	c, b	c (0.8)	0.2	
	0.2	b, d	b	b (0.2)	0.0	
	0	e, d	None	–		0.0
2	1.2	e, d	e, d	d (0.6)	0.6	
	0.6	e	e	e (0.3)	0.3	
	0.3	f	None	–		0.3
3	1.2	f	f	f (1.0)	0.2	
	0.2	g	None	–		0.2
4	1.2	g	g	g (0.4)	0.8	
	0.8	h	h	h (0.3)	0.5	
	0.5	–	–	–		0.5
						1.0 min.



Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks)
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Line Balancing – Step 6

- Compute Efficiency, Idle Time.

$$\text{Efficiency} = 100\% - \text{Percent idle time}$$

$$\text{Percent idle time} = \frac{\text{Idle time per cycle}}{N_{\text{actual}} \times \text{Cycle time}} \times 100$$

$$\text{Percent idle time} = \frac{1.0 \text{ min.}}{4 \times 1.2 \text{ min.}} \times 100 = 20.83\%$$

$$\text{Efficiency} = 100\% - 20.83\% = \mathbf{79.17\%}$$

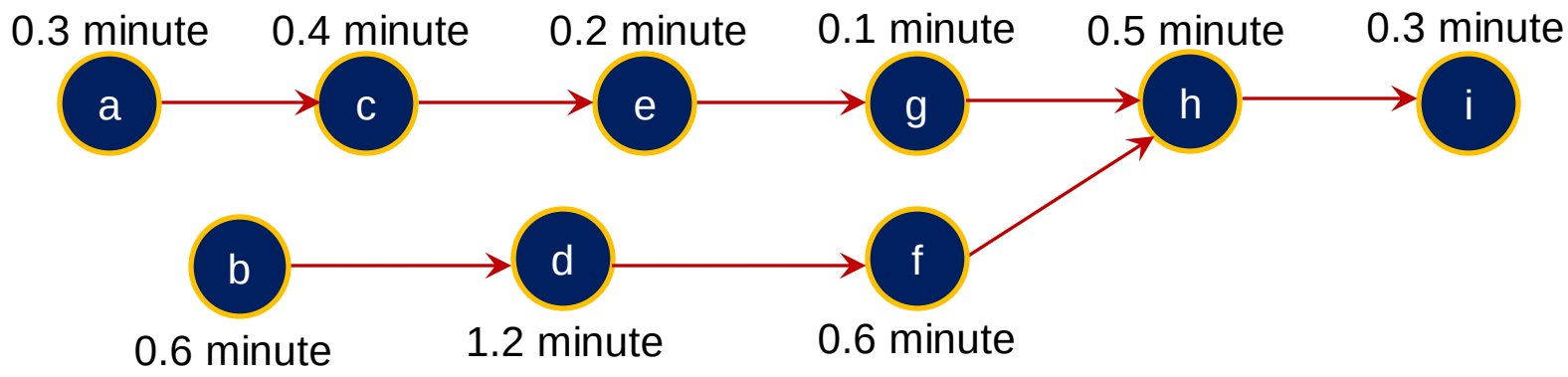
Product Layout Improvement – Line Balancing Steps

- **Step 1:** Identify tasks and their immediate predecessors (Draw a precedence diagram)
- **Step 2:** Determine the criteria (Tiebreaker: greatest positional weight OR Most following tasks) .
- **Step 3:** Determine Cycle Time.
- **Step 4:** Compute the Theoretical Minimum Number of Stations.
- **Step 5:** Assign tasks to workstations (Balance the line).
- **Step 6:** Compute Efficiency and Idle Time.

Exercise 3 – Line Balancing

5 min

The tasks shown in the following precedence diagram are to be assigned to workstations with the intent of minimizing idle time. Management has designed an output rate of 275 units per day. Assume 440 minutes are available per day.



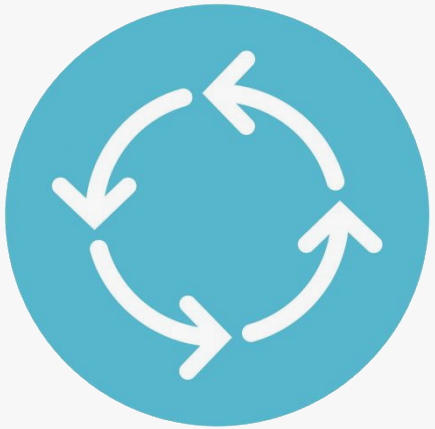
a) Determine the appropriate cycle time.

b) What is the minimum number of work stations possible?

c) Assign tasks using the “positional weight” rule: Assign tasks with highest following times (including a task’s own time) first. Break ties using greatest number of following tasks.

d) Compute efficiency

Facility Layout – Improvement



Product Layout
Repetitive processing

Line Balancing

Process Layout
Nonrepetitive processing

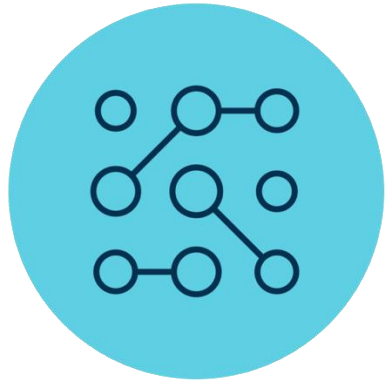
Minimizing Transportation Costs/Distances

Product Layout Improvement

Process Layout Improvement: The process of assigning departments to locations in a process layout in order to minimize transportation costs, distances, or time.

Process Layout Improvement – Methods

From-to-chart



Relational diagram

Muther grid

From-to-Chart – Steps

Step 1: Gather information.

Step 2: Develop a block plan or schematic of the layout.

Step 3: Develop a detailed layout.

From-to-Chart – Step 1

Step 1: Gather information.

- A list of departments or work centers to be arranged, their approximate dimensions, and the dimensions of the building or buildings that will house the departments.
- A projection of future work flows between the various work centers.
- The distance between locations and the cost per unit of distance to move loads between locations.
- The amount of money to be invested in the layout.
- A list of any special considerations (e.g., operations that must be close to each other or operations that must be separated).
- The location of key utilities, access and exit points, loading docks, and so on, in existing buildings.

From-to-Chart – Step 1 (Continued)

Step 1: Gather information.

- The most common goals in designing process layouts are minimization of transportation costs or distances traveled.

From \ To	LOCATION A	B	C
A		20	40
B			30
C			

Distance between locations

From \ To	DEPARTMENT 1	2	3
	1	30	170
Dept.	2		100
	3		

Loads per day

From-to-Chart – Step 2

- Develop a block plan or schematic of the layout.

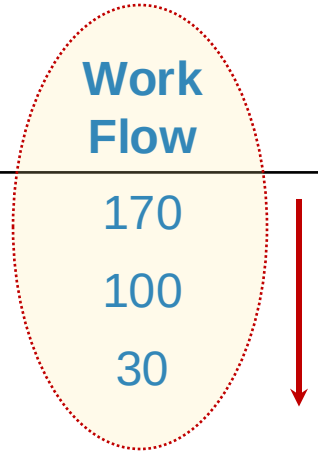
Distance between locations

From	To	LOCATION A	B	C
A			20	40
B				30
C				

Loads per day

From	To	DEPARTMENT 1	2	3
Dept.		1	30	170
		2		100
		3		

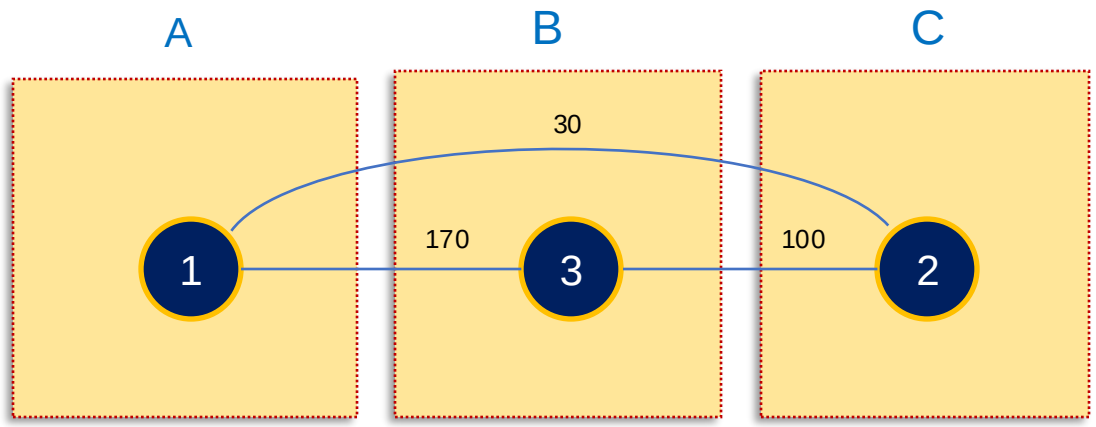
Trip	Distance (meters)	Department Pair	Work Flow
A-B	20	1-3	170
B-C	30	2-3	100
A-C	40	1-2	30



From-to-Chart – Step 3

- Develop a detailed layout.

Trip	Distance (meters)	Department Pair	Work Flow
A-B	20	1-3	170
B-C	30	2-3	100
A-C	40	1-2	30



Exercise 4 – From-to-Chart

5 min

Five departments are to be assigned to locations B–F in the grid. (For technical reasons, department 6 must be assigned to location A.) Transportation cost is CHF 2 per meter. The objective is to minimize total transportation cost. Information on interdepartmental work flows and distances between locations is shown in the following tables. Assign departments with the greatest interdepartmental work flow first.

DISTANCE BETWEEN LOCATIONS (FEET)

From \ To	A	B	C	D	E	F
A	–	50	100	50	80	130
B		–	50	90	40	70
C			–	140	60	50
D				–	50	120
E					–	50
F						–

NUMBER OF TRIPS PER DAY BETWEEN CENTERS

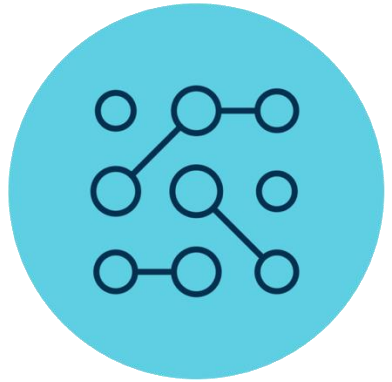
From \ To	1	2	3	4	5	6
1	–	125	62	64	25	50
2		–	10	17	26	54
3			–	2	0	20
4				–	13	2
5					–	5
6						–

Relational Diagram (Muther Grid) – Steps

Step 1: Gather information.

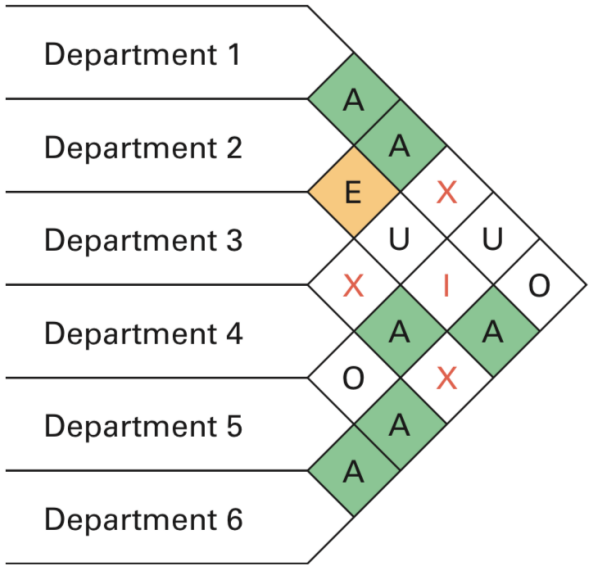
Step 2: Develop a block plan or schematic of the layout.

Step 3: Develop a detailed layout.



Relational Diagram – Step 1

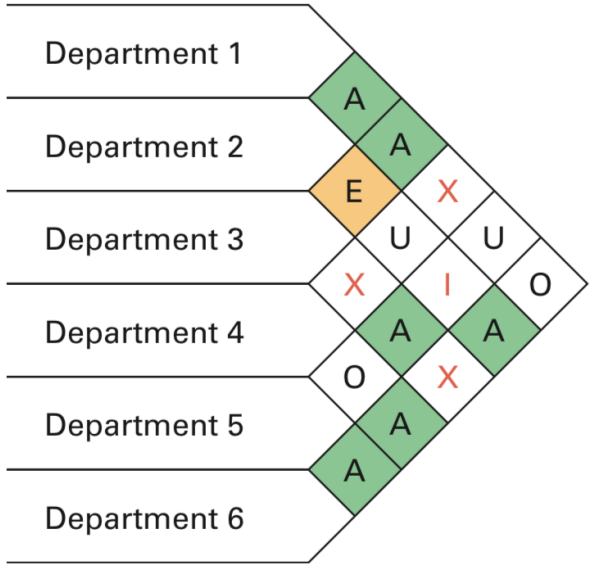
- Gather information.



Code	Degree of closeness
A	Absolutely necessary
E	Very important
I	Important
O	Ordinary importance
U	Unimportant
X	Undesirable

Relational Diagram – Step 2

- Develop a block plan or schematic of the layout.

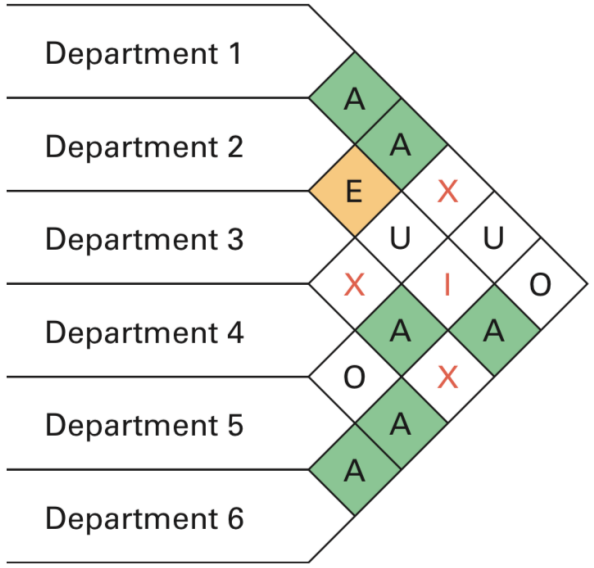


Code	Degree of closeness
A	Absolutely necessary
E	Very important
I	Important
O	Ordinary importance
U	Unimportant
X	Undesirable

A Links	X Links
1-2	1-4
1-3	3-6
2-6	3-4
3-5	
4-6	
5-6	

Relational Diagram – Step 3

- Develop a detailed layout.



Code	Degree of closeness
A	Absolutely necessary
E	Very important
I	Important
O	Ordinary importance
U	Unimportant
X	Undesirable

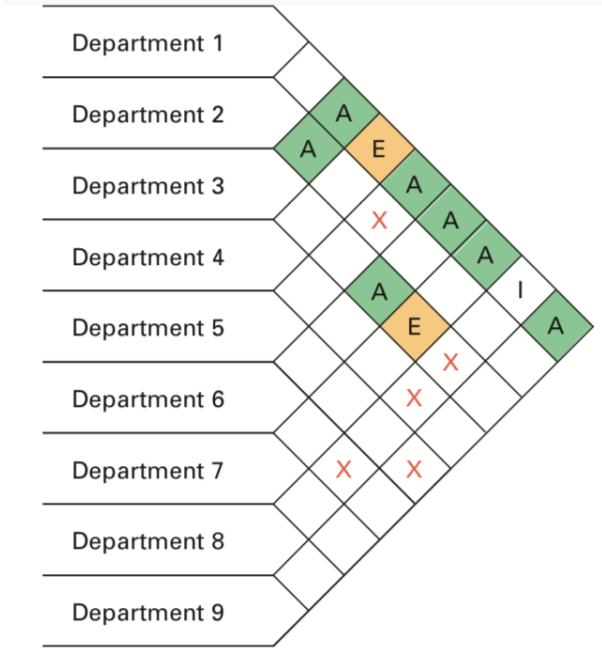
A Links	X Links
1-2	1-4
1-3	3-6
2-6	3-4
3-5	
4-6	
5-6	

1	2	6
3	5	4

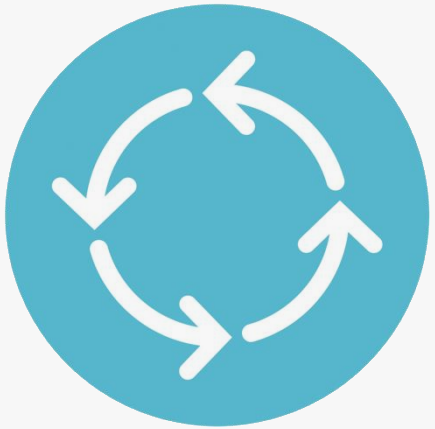
Exercise 5 – Relational Diagram

5 min

Assign nine automobile service departments to bays in a 3 * 3 grid so that the closeness ratings in the following matrix are satisfied. (The unimportant and ordinary-importance ratings have been omitted to simplify the example.) The location of department 4 must be in the upper right-hand corner of the grid to satisfy a town ordinance.



Facility Layout – Improvement



Product Layout
Repetitive processing

Line Balancing

Process Layout
Nonrepetitive processing

Minimizing Transportation Costs/Distances

Assignment 9 – Tasks are

5 min

Reflect, share and collect ideas of your group members and answer the following question in your work;

- Briefly describe the production strategy of your case study.
- What are the related production processes in your case study?
- Why is facility layout important in your case study?
- What type(s) of facility layout are used in your case study?
- What improvements do you propose for the facility layout? What specific changes should be implemented?
- What are the expected impacts of your proposed changes?
- How does the current layout affect operational efficiency?
- What challenges might arise from your proposed changes to the facility layout?