MBA 538 – OPERATIONS MANAGEMENT

FACILITY LAYOUT

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Session Objective

At the end of this session you would be familiar with,

- Facility Layout and Basic Formats
- Process Layout and Product Layout
- Layout Planning
- Assembly Line balancing

Facility Layout - *Defined*

Facility layout can be defined as the process by which the placement of departments, workgroups within departments, workstations, machines, and stock-holding points within a facility are determined.

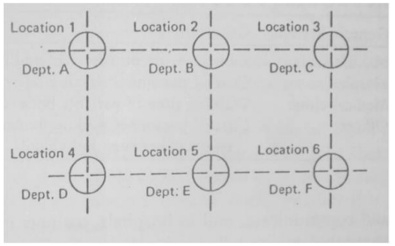
Basic Production Layout Formats

- Process Layout
- Product Layout
- Group Technology (Cellular) Layout
- Fixed-Position Layout

Process Layout: *Interdepartmental Flow*

- Given
  - The flow (number of moves) to and from all departments
  - The cost of moving from one department to another
  - The existing or planned physical layout of the plant
- Determine
  - The "best" locations for each department, where best means interdepartmental transportation, or flow, costs are lower

Complexity of the Relative Location Problem



- 6 processes located at 6 departments
- 6! = 720 different combination could be arranged.
- Enumerating all the department location combination, comparing aggregate cost and select the best that minimizes the total cost
- The complexity increases when number of processes increase

Schematic Layout Planning

- Analyze product (resource) flows and prepare flow diagram (from to chart)
- Identify non-flow factors where significant.
- Develop Activity Relationship chart

Closeness Rating

Value	Closeness	Number of Rating	
A	Absolutely necessary	4	Two operation regarded same facilities of gear
E	Especially important	3	Require same personnel
I	Important	2	Workflow both dept
O	Ordinary closeness ok	1	Convenient, but not essential
U	Unimportant	0	Does not matter
X	Not desirable	-1	

Example of Schematic Layout Planning: Relating Reasons and Importance

From	To 2	3	4	5	Area (sq. ft.)
1. Credit department	I	U	A	U	100
	2	0	4	0	
2. Toy department			I	A	400
			1	4	
3. Wine department			U		
			0		
4. Camera department					
5. Candy department					100

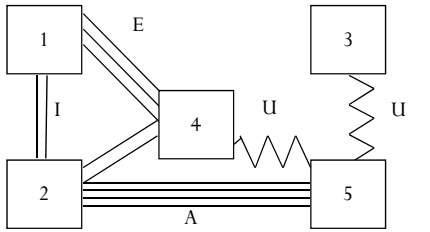
Note here that the (1) Credit Dept. and (2) Toy Dept. are given a high rating of 2

Note here that the (2) Toy Dept. and the (5) Candy Dept. are given a high rating of 4

Closeness rating: Letter

Reason for rating: Number

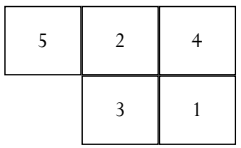
Example of Schematic Layout Planning: Initial Relationship Diagram



The number of lines here represent paths required to be taken in transactions between the departments. The more lines, the more the interaction between departments.

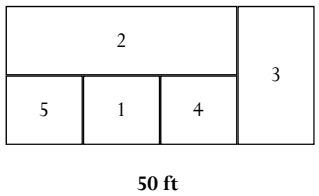
Note here again, Depts. (1) and (2) are linked together, and Depts. (2) and (5) are linked together by multiple lines or required transactions.

Example of Schematic Layout Planning: Initial and Final Layouts



Initial Layout

Ignoring space and building constraints



Final Layout

Adjusted by square footage and building size

Note in the Final Layout that Depts. (1) and (5) are not both placed directly next to Dept. (2).

CRAFT

Computerized Relative Allocation of Facilities Technique

- The graphical approach learned is more tedious method and impossible to find better solution when number of departments are more.
- CRAFT is a computer software which helps handling 40 such departments to find a solution.
- CRAFT is heuristic program; it uses a simple rule of thumb in making evaluations:
- "Compare two departments at a time and exchange them if it reduces the total cost of the layout."
- It does not guarantee an optimal solution.
- CRAFT assumes the existence of variable path material handling equipment such as forklift trucks.

Solutions Considered by CRAFT

- N! solutions to problem with N departments.
- Craft considers only

$\frac{N(N-1)}{2}$ pairs of exchanges, starting with each dept.

Input to CRAFT

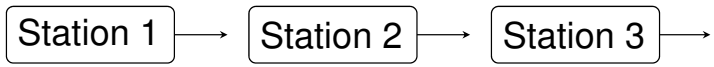
- Interdepartmental flow
- Interdepartmental unit transaction cost
- Initial block layout
  - Could be an existing layout (to improve)
  - Could be a random layout (for a new facility)

Output of CRAFT

- The program does several iterations based on input data and prints a final layout which minimizes cost.
- There could be a situation where few departments should not be moved in and existing layout due to a location of fixed machine or shipping terminal near the road.
- CRAFT automates this requirement.
- It also considers the re-location costs involved.

Product Layout: Line Balancing Concepts

Question: Suppose you load work into three work stations such that each will take the corresponding number of minutes as shown. What is the cycle time of this line?



	Station 1	Station 2	Station 3
Minutes per Unit	6	7	3

Answer: The cycle time of the line is always determined by the work station taking the longest time. In this problem, the cycle time of the line is 7 minutes. There is also going to be idle time at the other two work stations.

Example of Line Balancing

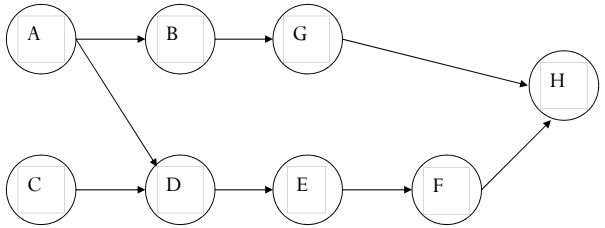
- You've just been assigned a job of setting up an electric fan assembly line with the following tasks:

Task	Time (Mins)	Description	Predecessors
A	2	Assemble frame	None
B	1	Mount switch	A
C	3.25	Assemble motor housing	None
D	1.2	Mount motor housing in frame	A, C
E	0.5	Attach blade	D
F	1	Assemble and attach safety grill	E
G	1	Attach cord	B
H	1.4	Test	F, G

Structuring the Precedence Diagram

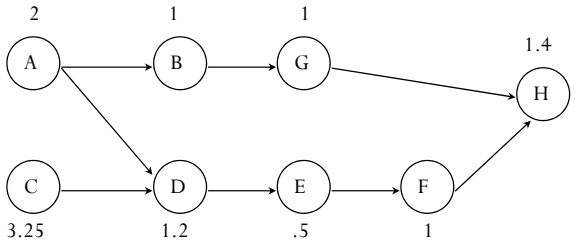
Task	Predecessors
A	None
B	A
C	None
D	A, C

Task	Predecessors
E	D
F	E
G	B
H	F, G



Precedence Diagram

<u>Question:</u> Which process step defines the maximum rate of production?



<u>Answer:</u> Task C gives the cycle time of the line and therefore, the maximum rate of production.

The Bottleneck

$$\text{Max Production} = \frac{\text{Production time per day}}{\text{Bottleneck time}} = \frac{420 \text{ mins}}{3.25 \text{ mins/unit}} = 129 \text{ units}$$

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A	2	Assemble frame	None
B	1	Mount switch	A
C	3.25	Assemble motor housing	None
D	1.2	Mount motor housing in frame	A, C
E	0.5	Attach blade	D
F	1	Assemble and attach safety grill	E
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H	1.4	Test	F, G

Determine Cycle Time

Question: Suppose we want to assemble 100 fans per day. What would our cycle time have to be?

Answer:

$$\textit{Required Cycle Time, } C = \frac{\text{Production time per period}}{\text{Required output per period}}$$

$$C = \frac{420 \text{ mins / day}}{100 \text{ units / day}} = 4.2 \text{ mins / unit}$$

Determine Theoretical Minimum Number of Workstations

Question: What is the theoretical minimum number of workstations for this problem?

Answer:

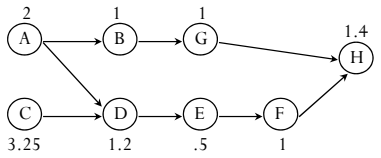
$$\textit{Theoretical Min. Number of Workstations, } N_t$$

$$N_t = \frac{\text{Sum of task times (T)}}{\text{Cycle time (C)}}$$

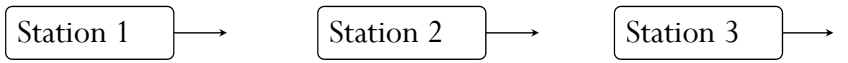
$$N_t = \frac{11.35 \text{ mins / unit}}{4.2 \text{ mins / unit}} = 2.702, \text{ or } 3$$

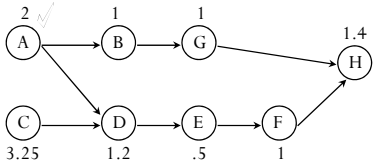
Rules To Follow for Loading Workstations

- Assign tasks in order from the largest number of following tasks.
- Assign tasks in order of the longest operating time



Task	Followers	Time (Mins)
A	6	2
C	4	3.25
D	3	1.2
B	2	1
E	2	0.5
F	1	1
G	1	1
H	0	1.4





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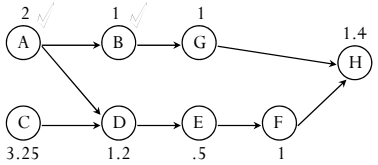
F	1	1
G	1	1
H	0	1.4

Station 1 → Station 2 → Station 3 →

A (4.2-2=2.2)



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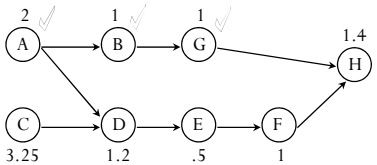
A (4.2-2=2.2)
B (2.2-1=1.2)



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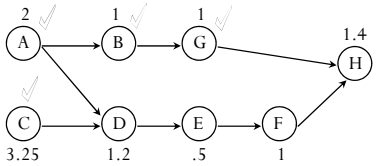
A (4.2-2=2.2)
B (2.2-1=1.2)
G (1.2-1= .2)

Idle= .2



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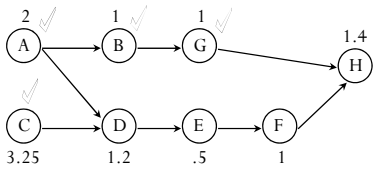
Station 1 → Station 2 → Station 3 →

A (4.2-2=2.2)
B (2.2-1=1.2)
G (1.2-1= .2)

C (4.2-3.25)=.95

Idle= .2



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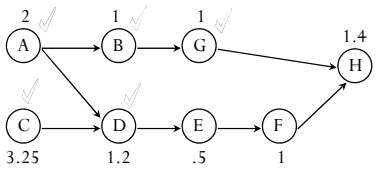

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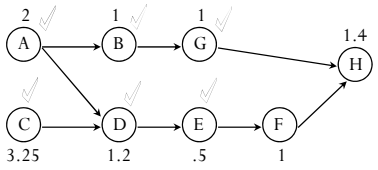
G (1.2-1= .2)

C (4.2-3.25)=.95

D (4.2-1.2)=3

Idle= .2

Idle = .95



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G (1.2-1= .2)

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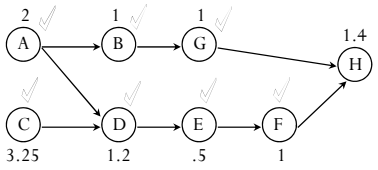
D (4.2-1.2)=3
E (3-.5)=2.5

Idle= .2

Idle = .95



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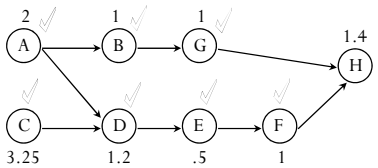

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Station 1 →	Station 2 →	Station 3 →
A (4.2-2=2.2)	C (4.2-3.25)=.95	D (4.2-1.2)=3
B (2.2-1=1.2)		E (3-.5)=2.5
G (1.2-1= .2)		F (2.5-1)=1.5
		H (1.5-1.4)=.1
Idle= .2	Idle = .95	Idle = .1

Determine the Efficiency of the Assembly Line

$$\text{Efficiency} = \frac{\text{Sum of task times (T)}}{\text{Actual number of workstations (Na) x Cycle time (C)}}$$

$$\text{Efficiency} = \frac{11.35 \text{ mins / unit}}{(3)(4.2 \text{mins / unit})} = \mathbf{.901}$$

Group Technology: Transition from Process Layout

1. Grouping parts into families that follow a common sequence of steps.
2. Physically grouping machines and processes into cells.

Group Technology: Advantages

1. Product Design – Can refer similar part family designs
2. Improved operator expertise
3. Less in-process inventory and material handling
4. Faster production setup / Tooling
5. Employee satisfaction

Disadvantages of GT

1. More equipment requirement as machines are grouped together
2. Machines will be idling without products from same part families while it can be used to produce some other products.

Group Analysis

- Objective is to create part families and machine groups
- There are steps to perform group analysis
- The following example will explain the steps to be done.

Group Analysis - Example

Step 1: Create part/machine matrix

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Group Analysis – Example..

Step 2: Pick any row in the matrix and draw a horizontal line.

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Group Analysis – Example..

Step 3: For each 1 in the row that has been crossed, once draw a vertical line through the corresponding column

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Group Analysis – Example..

Step 4: Pick each new column identified in the previous step. For each 1 in the column that has been crossed once, draw a horizontal line through the row.

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Group Analysis – Example..

Step 5: Repeat the step 4 until there are no single-crossed 1s in the matrix.

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Group Analysis – Example..

Step 6: Remove the rows and column that have been crossed to form a part family/machine group

	B	E	G
2	1	1	1
5	0	1	1

Group Analysis – Example..

Step 6: Continue the same steps for the rest of the matrix

	B	E	G
2	1	1	1
5	0	1	1

Group Analysis – Example..

The solution would be

- 1, 3, 4 and 6 with A, C, D, F and H
- 2 and 5 with B, E and G

	A	B	C	D	E	F	G	H
1	1	0	1	0	0	1	0	0
2	0	1	0	0	1	0	1	0
3	0	0	1	1	0	0	0	1
4	1	0	0	0	0	1	0	0
5	0	0	0	0	1	0	1	0
6	1	0	0	0	0	0	0	0

Fixed Position Layout

- Relatively low number of production units compare to other layouts.
- High degree of task ordering is common
- Layout might be developed by arranging the materials according to their technological priority.

  Eg. Building custom yachts

Fixed Position Layout

Question: What are our primary considerations for a fixed position layout?

Answer: Arranging materials and equipment concentrically around the production point in their order of use.

Lets Summarize

- Definition of facility layout and types
- Process layout
- Layout Planning
- Learned how to balance an assembly line