

## Technical Note 6 Facility Layout

October 15, 2008

## OBJECTIVES

- ▶ Facility Layout and Basic Formats
- ▶ Process Layout
- ▶ Layout Planning
- ▶ Assembly Line balancing
- ▶ Service Layout

## 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

This process requires the following inputs:

- ▶ Specification of objectives of the system in terms of output and flexibility
- ▶ Estimation of product or service demand on the system
- ▶ Processing requirements in terms of number of operations and amount of flow between departments and work centers
- ▶ Space requirements for the elements in the layout
- ▶ Space availability within the facility itself

## Basic Production Layout Formats

- ▶ Process Layout (also called *job-shop* or *functional layout*)
- ▶ Product Layout (also called *flow-shop 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 maximizing flow, which minimizing costs

### Process Layout: *CRAFT Approach*

- ▶ **It is a 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**

### Process Layout: *Systematic Layout Planning*

- ▶ Numerical flow of items between departments
  - ▶ Can be impractical to obtain
  - ▶ Does not account for the qualitative factors that may be crucial to the placement decision
- ▶ **Systematic Layout Planning**
  - ▶ Accounts for the importance of having each department located next to every other department
  - ▶ Is also guided by trial and error
    - ▶ Switching departments then checking the results of the “closeness” score

### Example of Systematic Layout Planning: Reasons for Closeness

Code	Reason
1	Type of customer
2	Ease of supervision
3	Common personnel
4	Contact necessary
5	Share same price
6	Psychology

### Example of Systematic Layout Planning: Importance of Closeness

Value	Closeness	Line code	Numerical weights
A	Absolutely necessary	=====	16
E	Especially important	=====	8
I	Important	=====	4
O	Ordinary closeness OK	-----	2
U	Unimportant	-----	0
X	Undesirable	~~~~~	80

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### Example of Systematic Layout Planning: Relating Reasons and Importance

From	To				Area (sq. ft.)
	2	3	4	5	
1. Credit department	I 6	U --	A 4	U --	100
2. Toy department			I 1	A 1,6	400
3. Wine department			U --		
4. Camera department					
5. Candy department					

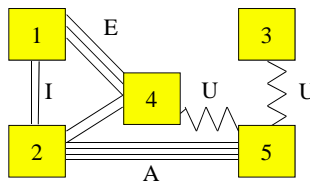
Note here that the (1) Credit Dept. and (2) Toy Dept. are given a high rating of 6.

Note here that the (2) Toy Dept. and the (5) Candy Dept. are given a high rating of 6.

Closeness rating Letter  
 Reason for rating Number

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### Example of Systematic Layout Planning: Initial Relationship Diagram

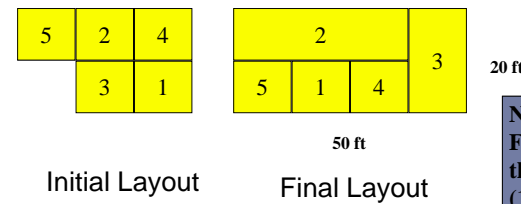


Note here again, Depts. (1) and (2) are linked together, and Depts. (2) and (5) are linked together by multiple lines or required transactions.

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

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### Example of Systematic Layout Planning: Initial and Final Layouts



Initial Layout

Final Layout

Ignoring space and building constraints

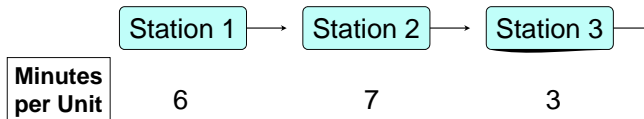
Adjusted by square footage and building size

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

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## Assembly Lines Balancing Concepts

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



**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.

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## Example of Line Balancing

▶ You've just been assigned the job a 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

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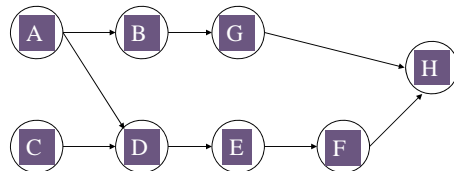
## Example of Line Balancing: Structuring the Precedence Diagram

### Task Predecessors

A	None
B	A
C	None
D	A, C

### Task Predecessors

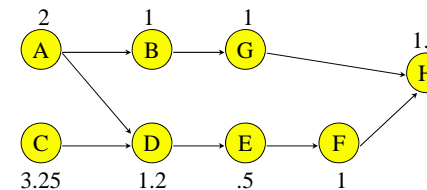
E	D
F	E
G	B
H	E, G



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## Example of Line Balancing: Precedence Diagram

**Question:** Which process step defines the maximum rate of production?



**Answer:** Task C is the cycle time of the line and therefore, the maximum rate of production.

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## Example of Line Balancing: The Bottleneck

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

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	E, G

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## Example of Line Balancing: Determine Cycle Time

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

**Answer:**

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

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

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## Example of Line Balancing: Determine Theoretical Minimum Number of Workstations

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

**Answer:**

Theoretical Min. Number of Workstations,  $N_t$

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

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

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## Example of Line Balancing: Rules To Follow for Loading Workstations

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- ▶ **Assign tasks to station 1, then 2, etc. in sequence. Keep assigning to a workstation ensuring that precedence is maintained and total work is less than or equal to the cycle time. Use the following rules to select tasks for assignment.**
- ▶ **Primary:** Assign tasks in order of the largest number of following tasks
- ▶ **Secondary (tie-breaking):** Assign tasks in order of the longest operating time

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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

Station 1 → Station 2 → Station 3 →

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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

Station 1 → Station 2 → Station 3 →

A (4.2-2=2.2)

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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

Station 1 → Station 2 → Station 3 →

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

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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

Station 1 → Station 2 → Station 3 →

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

Idle= .2

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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

Station 1 → Station 2 → Station 3 →

A (4.2-2=2.2)      C (4.2-3.25)=.95  
 B (2.2-1=1.2)  
 G (1.2-1= .2)

Idle= .2

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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

Station 1 → Station 2 → Station 3 →

A (4.2-2=2.2)      C (4.2-3.25)=.95  
 B (2.2-1=1.2)  
 G (1.2-1= .2)

Idle= .2      Idle = .95

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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

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)  
 G (1.2-1= .2)

Idle= .2      Idle = .95

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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

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)

Idle= .2      Idle = .95

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## Group Technology: Transition from Process Layout

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1. Grouping parts into families that follow a common sequence of steps
2. Identifying dominant flow patterns of parts families as a basis for location or relocation of processes
3. Physically grouping machines and processes into cells

Ref. Group Technology at Cummins: LP5.avi

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## Fixed Position Layout

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**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.**

Ref. Layout/Lean improvements featuring Gortrac manufacturing: GTE3.avi

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## Retail Service Layout

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- ▶ Goal--maximize net profit per square foot of floor space
- ▶ Servicescapes
  - ▶ Ambient Conditions
  - ▶ Spatial Layout and Functionality
  - ▶ Signs, Symbols, and Artifacts

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## Question Bowl

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**Which of the following are distinguishing features of CRAFT?**

- a. It is an optimization methodology
- b. Does not require any assumptions about the layout or inter-relationships of departments
- c. Can handle over 50 departments
- d. All of the above
- e. None of the above

Answer: e. None of the above (It is a heuristic program, does not guarantee an optimal solution, requires layout assumptions and can handle up to 40 departments. Cf. p. 233)

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## Question Bowl

Which of the following is a process that involves developing a relationship chart showing the degree of importance of having each department located adjacent to every other department?

- a. Systematic layout planning
- b. Assembly-line balancing
- c. Splitting tasks
- d. U-shaped line layouts
- e. None of the above

**Answer: a. Systematic layout planning**

## Question Bowl

If the production time per day is 1200 minutes and the required output per day is 500 units, which of the following will be the required workstation cycle time for this assembly line?

- a. 2.4 minutes
- b. 0.42 minutes
- c. 1200 units
- d. 500 units
- e. None of the above

**Answer:**

**a. 2.4 minutes**  
( $1200/500=2.4$  min)

## Question Bowl

You have just finished determining the cycle time for an assembly line to be 5 minutes. The sum of all the tasks required on this assembly is 60 minutes. Which of the following is the theoretical minimum number of workstations required to satisfy the workstation cycle time?

- a. 1 workstation
- b. 5 workstations
- c. 12 workstations
- d. 60 workstations
- e. None of the above

**Answer:**

**c. 12 workstations**  
( $60/5=12$ )

## Question Bowl

If the sum of the task times for an assembly line is 30 minutes, the actual number of workstations is 5, and the workstation cycle time is 10 minutes, what is the resulting efficiency of this assembly line?

- a. 0.00
- b. 0.60
- c. 1.00
- d. 1.20
- e. Can not be computed from the data above

**Answer: b. 0.60** ( $30/(5 \times 10)=0.60$ )

## Question Bowl

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Which of the following are ways that we can accommodate a 20 second task in a 18 second cycle time?

- a. Share the task
- b. Use parallel workstations
- c. Use a more skilled worker
- d. All of the above
- e. None of the above

**Answer: d. All of the above**

## Question Bowl

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Which of the following are “ambient conditions” that should be considered in layout design?

- a. Noise level
- b. Lighting
- c. Temperature
- d. Scent
- e. All of the above

**Answer: e. All of the above**