CHAPTER 4
Layout Planning Procedures

1. Introduction
2. Systematic Layout Planning
3. From-to Program
4. Flow Planning & Patterns
5. Layout Planning Chart
6. Space Requirements
7. Facility Layout Program (FLAP)
Introduction

*Workstation*

It consists of fixed assets needed to perform specific operations. It can be considered as a facility itself. It includes space for equipment, materials, and personnel.

*Planning Department*

Planning departments are groups of workstations put together in a plant layout.
Types
(a) Production line departments
(b) Fixed materials location departments
(c) Product family departments
(d) Process departments
Guidelines for Combining Workstations in Planning Departments

<table>
<thead>
<tr>
<th>If the Product Is</th>
<th>The Type of Planning Department Should Be</th>
<th>And the Method of Combining Workstations into Planning Departments Should Be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized and has a large stable demand</td>
<td>Production line, product department</td>
<td>Combine all workstations required to produce the product.</td>
</tr>
<tr>
<td>Physically large, awkward to move, and has a low sporadic demand</td>
<td>Fixed materials location, product department</td>
<td>Combine all workstations required to produce the product with the area required for staging the product.</td>
</tr>
<tr>
<td>Capable of being grouped into families of similar parts that may be produced by a group of workstations</td>
<td>Product family, product department</td>
<td>Combine all workstations required to produce the family of products.</td>
</tr>
<tr>
<td>None of the above</td>
<td>Process department</td>
<td>Combine identical work stations into initial planning departments and attempt to combine similar initial planning departments without obscuring important interrelationships within departments.</td>
</tr>
</tbody>
</table>
Activity Relationships

- Organizational
- Flow
- Control
- Environmental
- Process

Success in grouping workstations to form planning departments greatly depends on the ability of the planners to recognize all important inter-departmental relationships.

Conceptual Illustration (Figure 4.1)
Systematic Layout Planning

Input Data: P, Q, R, S, T and Activities

1. Flow of Materials
2. Activity Relationships
3. Relationship Diagram
4. Space Requirements
5. Space Available
6. Space Relationship Diagram
7. Modifying Considerations
8. Practical Limitations
9. Evaluation

Plan X
Plan Y
Plan Z

Selected Layout Plan

Relationship Chart

Closeness Relationships
A = absolutely necessary
E = especially important
I = important
O = ordinary closeness acceptable
U = unimportant
X = not desirable to be close

Receiving (1)
Milling (2)
Press (3)
Screw Mch. (4)
Assembly (5)
Plating (6)
Shipping (7)
Flow Patterns

Within Workstations
  Motion studies & ergonomics

Within Departments
  Ring: Fig. 4.9 (a)
  Spine: Fig. 4.9 (b)
  Tree: Fig. 4.9 (c)
  Random: Fig. 4.9 (d)

Between Departments
  Straight line: Fig. 4.10 (a)
  L-shaped: Fig. 4.10 (b)
  U-shaped: Fig. 4.10 (c)
  S-shaped: Fig. 4.10 (d)
  Circular: Fig. 4.10 (e)

Flow Planning

Flow Planning = Flow Principles + Aisle Widths

1. Maximize direct flow paths (no intersections, no backtracking)
2. Minimize flow (work simplification)
3. Minimize flow costs.

See Table 4.2, p. 91 for guidelines on aisle widths
FACTORS AFFECTING AISLE WIDTHS

Use of the aisle: material, personnel, handling equipment, machinery, and other equipment

Frequency of use: volume of traffic (at peak loads)

Speed of travel permitted or desired

One-way traffic or both

Possible future conditions of these points

SUGGESTED AISLE WIDTHS

<table>
<thead>
<tr>
<th>Use of Aisle</th>
<th>Suggested Aisle Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel only (2 persons to pass)</td>
<td>30&quot; minimum</td>
</tr>
<tr>
<td>For two-wheel hand truck (no passing or turning with load)</td>
<td>30&quot; minimum</td>
</tr>
<tr>
<td>For stock truck (where trucker must pass around it)</td>
<td>20&quot; plus width of truck</td>
</tr>
<tr>
<td>For stock truck (where other trucks and workers must pass)</td>
<td>38&quot; plus 2 times truck width</td>
</tr>
<tr>
<td>For hand-operated fork truck, pallet transporter, semilive skid and jack</td>
<td>5 to 8' depending on load size</td>
</tr>
<tr>
<td>For 2,000-pound fork truck</td>
<td>8' to 10'</td>
</tr>
<tr>
<td>For 4,000-pound fork truck</td>
<td>10' to 12'</td>
</tr>
<tr>
<td>For 6,000-pound fork truck</td>
<td>12' to 14'</td>
</tr>
</tbody>
</table>
Measuring Flow

1. Quantitative Flow Measurement
   From-To-Chart (large volumes moved)

2. Qualitative Flow Measurement
   Relationship Chart (low volumes but intensive communication & organizational relationships)
### Assumption

Component B is twice as large as Component A & moving 2 units of A is equivalent to moving 1 unit of B

<table>
<thead>
<tr>
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<tr>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>10+40 = 50</td>
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<td>4</td>
<td>-</td>
<td>40</td>
<td>-</td>
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Using Component A as the reference product

### Assumption

Component B is twice as large as Component A & moving 3 units of A is equivalent to moving 1 unit of B

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<td>10</td>
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<td>10+20 = 30</td>
</tr>
<tr>
<td>4</td>
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<td>20</td>
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<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>5+20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>-</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5+20 = 25</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Using Component B as the reference product
**Layout Planning Chart**

1. Combines the detail of the **process** with restrictions of **work periods** & **production quantity** requirements

2. Provides data upon which to base **machine**, **manpower**, **material handling** & **storage** requirements

3. Developed by extending the **route sheet** to obtain a **flow-process** chart

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**Chart Heading**

1. Part number, part name, assembly number, assembly name, material, and material size from **route sheet**

2. Pieces/assembly & assemblies /product from **assembly chart**

3. Production hours/day depend upon number of shifts/day, hrs/shift, efficiency
**Chart Body (Column Headings)**

1. Step Number (counter)
2. Flow Process (activity at each step)
3. Description of Step
4. Operation Number (for fabrication operations)
5. Department
6. Standard Time
7. Machine Fraction
8. Operators per Machine (crew size)
9. Crew Fraction & Workers Required
10. Material Handling Requirements
11. Remarks

**Flow Process**

1. Fabrication operation (F)
2. Move (M)
3. Storage (S)
4. Inspection (I)
5. Operation number from route sheet
6. Department assignment should be delayed until after decisions made on departments in final layout
**Time Factors**

1. Standard time per piece or per lot
2. Lot size included in chart heading
3. Storage & inspection times
4. Material handling time cannot be determined yet

\[
\text{Standard time} = (\text{observed time} \times \% \text{ rating}) \times (1 + \% \text{ allowances})
\]

**Machine or Equipment Requirements**

\[
N = \frac{TP}{60HC}
\]

**Manpower Requirements (Crews)**

\[
N_c = \frac{TP}{60HC_c}
\]
### Space Requirements

- **Calculation Method**
- **Conversion Method**
- **Standards Method**
Conversion Method
• New space estimated from present space
• Done on department-by-department basis
• Determined % change for @ department

Space Standards Method
• Most appropriate for service & storage areas
• Standards are usually per employee
• Determine % change for @ department

 Calculation Method

\[ N = \frac{Pt}{(H - s)p} \]

Production Quantities

Route Sheets

Machine space including travel (MSPACE)

Operator and maintenance space (OMSPACE)

Storage space (STSPACE)

\[ WSPACE = MSPACE + OMSCAPE + STSPACE \]

TOTAL WORKSTATION SPACE

DEPARTMENTAL SPACE

TRANSPORTATION SPACE

Minimum Op. Space = 24” X 36”

• Input buffer storage
• Supplies & maintenance materials
• Tools, dies, fixtures
• Rework, scrap, waste
• Output buffer storage

Transportation space

• Aisles
• Floor level conveyors

Allowance For Between-Department Aisles
Textbook, Section 4.8
A Micro-Computerized Procedure
for Layout Design

Cycle of Facilities Design and Management
How can the computer be used to make this process more productive?
A Microcomputer Program To Assist in Plant Layout

Program Description

1. The program carries out the transplantation, selection, and evaluation phases
2. The program uses as input an activity relationship chart and departmental area requirements
3. From the relationship matrix, a closeness rank is calculated for each department on the basis of number of A, E, I, O and X relationships
4. A selection order is determined on the basis of relationships and ranks

Closeness Ranks

1. From the relationship chart, a closeness rank for each department is calculated on the basis of the number of A, E, I, O, X relationships.
2. The department having the largest number of A's will receive rank 1 (most important). If necessary, break ties with E's, I's, etc.
3. Subsequent departments having A's are assigned ranks equal to 2, 3, 4, etc., as the number of A's decreases. Ties will be broken as indicated before.
4. Subsequent departments having E's are considered in a similar manner. Once they are finished, those with I's will be considered, and so on.
A Microcomputer Program To Assist in Plant Layout

Selection Order

1. Select the department with rank 1 (most important)

2. Select one department having the highest possible relationship with the most important department. If there are ties, break them by choosing the department with best rank (numerically lower) in the group.

3. Subsequent departments are selected on the basis of the total number of A’s, E’s, I’s and O’s between departments not yet selected and those already selected. Ties will be broken using ranks.

4. Construct a layout satisfying the selection order and the closeness relationships.

Layout Scoring System

1. Use point values of, for example, 8, 4, 2, 1, 0 and -8 for the symbols A,E,I,O,U, and X, respectively.

2. From the layout diagram identify the departments adjacent to each department.

3. A score is computed by adding the point values of the closeness relationship between adjacent pairs.
### EXAMPLE 3
pp. 97-100

<table>
<thead>
<tr>
<th>Departments</th>
<th>Area (sq. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Receiving</td>
<td>12,000</td>
</tr>
<tr>
<td>2. Milling</td>
<td>8,000</td>
</tr>
<tr>
<td>3. Press</td>
<td>6,000</td>
</tr>
<tr>
<td>4. Screw Machine</td>
<td>12,000</td>
</tr>
<tr>
<td>5. Assembly</td>
<td>8,000</td>
</tr>
<tr>
<td>6. Plating</td>
<td>12,000</td>
</tr>
<tr>
<td>7. Shipping</td>
<td>12,000</td>
</tr>
</tbody>
</table>

### RELATIONSHIP CHART

```
1
  /\  \\
2  E O 3
  /  \  /
\  \  \ 
4  U E 5
  \  /
   \ I
    \ 
    6

7
```

```
1
  /\  \\
2  A U 3
  /  \  /
\  \  \ 
4  U O 5
  \  /
   \ U
    \ 
    6

7
```

```
1
  /\  \\
2  E U 3
  /  \  /
\  \  \ 
4  U I 5
  \  /
   \ E
    \ 
    6

7
```
## DEPARTMENTAL RANKS

<table>
<thead>
<tr>
<th>Departments</th>
<th>A's</th>
<th>E's</th>
<th>I's</th>
<th>O's</th>
<th>U's</th>
<th>X's</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Receiving</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2. Milling</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3. Press</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4. Screw Machine</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5. Assembly</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6. Plating</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>7. Shipping</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

### Departmental Ranks

- Department 6 ➔ 1A, 1E
- Department 5 ➔ 1A, 0E
- Department 1 ➔ 0A, 1E
- Department 2 ➔ 0A, 2E
- Department 3 ➔ 0A, 0E
- Department 4 ➔ 0A, 1E
- Department 7 ➔ 0A, 1E

- Department 1 ➔ 1E, 1I
- Department 4 ➔ 1E, 2I
- Department 7 ➔ 1E, 1I

- Department 1 ➔ 1I, 2O
- Department 7 ➔ 1I, 0O

<table>
<thead>
<tr>
<th>Rank</th>
<th>Dept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>
1. Department 6 is selected first.
2. Department 5 is selected second.
3. For departments 1, 2, 3, 4 and 7 we have to find the department that has the best set of relationships with Departments 5 and 6:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>A’s</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E’s</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>I’s</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>O’s</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Department 7 has 1E and 1I relationships with those chosen. Note that this is better than department 2’s two I relationships. Therefore, department 7 is selected third.

As an exercise, the students can verify that the following selection order of departments is obtained:

<table>
<thead>
<tr>
<th>Selection</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>Department</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
PROPOSED LAYOUT

3 Press

7 Shipping

2 Milling

4 Screw Machine

6 Plating

5 Assembly

1 Receiving

LAYOUT EVALUATION

Score = 3+6+1+8+4 = 22
Documentation for Using the From-To Program

• This program creates the “From-To” chart for a given input of flows between departments for each of the different parts manufactured in the factory.

• The Excel Spreadsheet for keying the input has numbered (Red color) steps to follow.

1. Facts to be produced
   Input Quantity: 
   Production Department: 
   Input Quantity:

2. Enter Key Numbers in the corresponding cells.

3. Click here after finishing inputting each part.

4. Click here after finishing inputting each part.

5. Total Part 1  Total Part 2  Total Part 3  Total Part 4  Total Part 5  Total Part 6  Total Part 7  Total Part 8  Total Part 9  Total Part 10

6. Total

7. View Table

8. Start with a new product (Only click once after finishing inputting)
Repetitive process for each part number to be input

Button No. 3. Yellow cells are input cells.
• Clear all old values in yellow cells before input.
• Part number to be input.
• Quantity to be produced of that part in the time period under consideration.
• Batch size used for moving that part between machines.
• When a value is entered for the “Batch”, the program computes the no. of trips on its own using the formula \( \text{No. of trips} = \frac{\text{Quantity}}{\text{Batch}} \)

Button No. 4. Clear all old values in the yellow cells before input. Enter the sequence in which this part moves through different departments in the yellow cells under “Button 4”. After finishing entering the sequence click on “Button 4”.

Button No. 5. Click on “Total Part 1” for part number 1 as we are working on part 1 now.

Button No. 6. Click on “Button 6” (“Total”). The From To chart gets updated with this part when you click on this button.
**Button No. 7.** If you want to see the input that you just gave for this part, click on “Button 7” (View Table”). This will take you to the next worksheet named “Operation”. If you want to return to the input or main menu, then click on the Menu work sheet.

**Button No. 8.** Once you are in the Menu Worksheet, you can follow the same steps from 3 to 7 to input details for the other parts.

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*Once all the parts have been input, We need to ask the program to create the From-To Chart. The procedure is as follows.*

- Scroll down the “MENU” worksheet till you see the From To Format on the screen.
- Choose the number of Departments that you have from the set of Radio buttons.
- Click on the “Reset Value After Choosing Departments Number” button.
- Now choose the number of Departments that you have from the set of Radio buttons again.
- Click on the “Show From-To Chart” button. This will update the From To chart for the given data.*
FACILITIES LAYOUT PROGRAM (FLAP)
Textbook, pp. 101-110