STUDY AND RE-DESIGN OF THE LAYOUT USING FACILITY PLANNING TOOLS

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Abstract— XYZ Service Industry aims to provide an everlasting experience and value for money. In order to achieve such a feat, the organization must present to its employees the best working conditions. Facility layout design is one such factor which plays a pivotal role in achieving it. The objective of this paper is to re-design the existing layout of the administrative floor to reduce the flow cost. According to Lean manufacturing, we must first measure a process before making a change to ensure that the change is an improvement. So how does an Industrial Engineer ensure that the new layout is better than the current layout? Initially, the efficiency indices of the present layout were calculated which indicated the need for improvement. To rectify the drawbacks, CRAFT algorithm is applied to improve the indices and obtain a better layout that would increase the operational efficiency. AutoCAD software is used to draw the layout. Also, we wanted to ascertain the importance of Facility Planning if it is done prior to construction of the Hotel. Hence, CORELAP algorithm was applied and we also calculated the flow cost and efficiency indices of the obtained layout.

***Key words*:** Facilities Planning, CRAFT, CORELAP, AutoCAD, Efficiency Indices.

I. LITERATURES ON LAYOUT DESIGN

Diana Riopel and Andre Langevin [2] provide the facility planner with a method of judging the quality of the various facility layout alternatives, taking into account the location of the material transfer through the aisle network, by using the actual distances traveled.

Particle Swarm Optimization (PSO) algorithm is a new optimization method that is inspired by social behavior of bird flocking or fish schooling. Nimtawat and Nanakorn [13] have explained the use of PSO to be used as an optimization technique using many search points, called particles, to find the optimal solution.

The research paper published by N. Bilalis et al [4] indicates that, poor ergonomic conditions can adversely affect the workers' efficiency by increasing the probability of mistakes.

II. LITERATURES FOR THE ALGORITHMS ADOPTED TO RE-DESIGN LAYOUT

The relative placements of departments on the basis of the total closeness ratio (TCR), based on the number of trips a person makes and the material flow intensities have to be considered to achieve the most optimal layout.

Reuven R. Levary and Sylvia Kalchik [3] have mentioned the main characteristics essential to address facility layout problems. These characteristics include input required, limitations, type of output obtained, and some other general characteristics such as cost per trip and initial layout of the organization.

The algorithm used in this paper, to improve the plant layout is:

A. CRAFT: Computerized Relative Allocation of Facility Technique:

Lissa Galbraith and William Miller [6] state in their journal that CRAFT, CORELAP outputs are discussed in terms of quantitative measures such as flow inefficiency, distance between functional areas and growth capacity. Flow linearity, access to functional areas, and maintenance of critical relationships between functional areas are examined for qualitative layout comparison. At the end, these two approaches are assessed in terms of costs incurred to the company and the best layout is selected.

B. CRAFT:

CRAFT is the abbreviation of Computerized Relative Allocation of Facilities Technique and it is presented by Armour and Buffa (1963). Fahrettin Eldemir and Hatice E. Sanli [7] mention that CRAFT is an improvement type layout. The initial layout is given and, the algorithm computes the distance between the centers of each facility and determines the cost of the initial layout. The limitation of CRAFT algorithm is that the facility pairs for the pairwise exchange are considered only if they have the same area or they are adjacent and the solution is highly dependent on the initial layout.

C. CORELAP:

CORELAP is the abbreviation for Computerized Relationship Layout Planning. It generates a layout on the basis of total closeness rating (TCR) for each department. The details of the algorithm can be obtained from Tompkins et al [8]. The user interface in our implementation of CORELAP is the spreadsheet. To obtain a layout, the user is required to input the following: number of departments, the area of each department and the relation between departments.

D. PROBLEMS:

- WelcomLab has lesser space than required which has led to all the equipments to be haphazardly placed.
- WelcomLab is situated far away from the Receiving section, Cafeteria and General Stores.
- Some Departments with no relation are located next to each other.

- Receiving Section and Waste Disposal are located next to each other and have a common path.

E. OBJECTIVES:

- Analysing the Problem
- Re-Designing according to requirement to improve operational efficiency
- Implementation of the design

F. LAYOUT STUDY:

The existing layout consists of nineteen departments. After careful analysis of various constraints we have come to a conclusion that seven departments are already well located whilst the remaining twelve departments had to be altered.

G. Departments that require relocation:

1) Cafeteria:

The cafeteria has a seating capacity of 88 and 3 chefs handle the food preparation who are assisted by five assistant chefs. Breakfast, lunch and dinner are served and tea is served at appropriate timings.

2) IT Room:

IT room manages the network and maintenance of all the systems being used in the hotel.

3) General Stores:

Receives stores and keeps track of all the items brought in and dispatches the required items to the various parts of the hotel.

4) Meat Cutting:

involved in cleaning, chopping and dispatching the meat to the kitchens.

5) Storage (greens):

As the name indicates, this department is used to store daily perishables (vegetables and fruits).

6) Disposal:

Consists of Garbage Sorting room, Dry Garbage room and Wet Garbage room. The waste from the entire hotel gets collected here.

7) Receiving:

The daily receivables are Perishables, Meat, General grocery and Engineering supplies.

8) Grooming:

This department ensures that the employees adhere to the hotel's WelcomStyle.

9) WelcomAssistance:

All queries by guests are responded to, by this department.

10) Doctor's room:

All medical needs of the employees are taken care of here.

11) WelcomLab:

The department is in charge of food safety and hygiene according to the three audits (Starwood, ISO 22000 and FSSAI).

12) Six Sigma:

Maintains quality standards, eliminates waste and improves service efficiency.

It also conducts data analysis with respect to sales.

H. COST ANALYSIS:

Salary per month (OF TRAINEES) (Rs)	8000
Working days per month (days)	26
Earnings per day (Rs)	308
Hours per shift	9
Salary per hour (Rs)	34
Number of trips per day	167
Cost per trip (Rs) (c)	1.84

Table. 1: Salary of only trainees are considered as they move the highest between each department

Efficiency Indices of Initial Layout

1) Index of direct material handling = b

b → Total actual distance the material (food) moves from Receiving to Cafeteria. [Receiving > WelcomLab > General Stores > Cafeteria]

b = 141.9m

2) Index of line flexibility = j/k

j →No. of departments performing operations on food that can be moved to a new location in the same line.

k → No. of workstations in that line

j = 6 (1,3,4,5,6,7) ; k = 8 (1,2,3,4,5,6,7,8)

j/k = .75 = 75%

3) Index of aisle place = r/q

r → total aisle area

q → total layout floor area

r = 519.70 m^2 ; q = 4213.44 m^2 [69.3*60.8]

r/q = 0.123 = 12.3%

I. PRESENT LAYOUT:

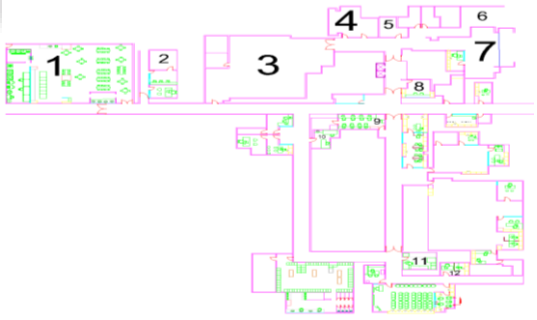

Fig. 1:Layout

J. CRAFT:

This algorithm is used to propose an optimal layout by minimising the total cost of shipment or movement. In this paper, we proposed a layout by minimising the cost of movement.

*K. FLOW MATRIX (f): *All distances are in meters*

Flow Matrix:

		1	2	3	4	5	6	7	8	9	10	11	12
1	Cafeteria	-	4	12	6	4	12	2	3	4	3	6	5
2	IT Room	4	-	4	0	0	0	5	1	6	1	2	3
3	General Stores	12	4	-	2	1	2	11	1	0	0	1	0
4	Meat Cutting	6	0	2	-	0	8	7	1	0	1	3	1
5	Storage (greens)	4	0	1	0	-	3	10	0	0	0	3	0
6	Disposal	12	0	2	8	3	-	0	2	0	1	2	0
7	Receiving	2	5	11	7	10	0	-	2	0	1	12	1
8	Grooming	3	1	1	1	0	2	2	-	1	0	1	1
9	Welcom Assistance	4	6	0	0	0	0	0	1	-	0	0	1
10	Doc Room	3	1	0	1	0	1	1	0	0	-	0	1
11	Welcom Lab	6	2	1	3	3	2	12	1	0	0	-	3
12	6 Sigma	5	3	0	1	0	0	1	1	1	1	3	-

Fig. 2:Flow Matrix

L. DISTANCE MATRIX (d):

Distance Matrix of Initial Layout

		1	2	3	4	5	6	7	8	9	10	11	12
1	Cafeteria	-	11	22	44	49.5	61.5	59.5	51	46.7	49.2	86	93
2	IT Room	11	-	11	33	38.5	50.5	48.5	40	35.7	38.2	75	82
3	General Stores	22	11	-	22	28.5	39.5	37.5	29	35.7	27.2	64	71
4	Meat Cutting	44	33	22	-	5.5	17.5	30.5	26	21.7	24.2	61	68
5	Storage (greens)	49.5	38.5	28.5	5.5	-	12	25	20.5	22.2	26.7	55.5	62.5
6	Disposal	61.5	50.5	39.5	17.5	12	-	19	18.5	34.2	38.7	57.9	57.5
7	Receiving	59.5	48.5	37.5	30.5	25	19	-	16.5	32.2	36.7	55.9	53.9
8	Grooming	51	40	29	26	20.5	18.5	16.5	-	15.7	20.2	39.4	42
9	Welcom Assistance	46.7	35.7	35.7	21.7	22.2	34.2	32.2	15.7	-	4.5	39.3	46.3
10	Doc Room	49.2	38.2	27.2	24.2	26.7	38.7	36.7	20.2	4.5	-	36.2	43.8
11	Welcom Lab	86	75	64	61	55.5	57.9	55.9	39.4	39.3	36.2	-	2
12	6 Sigma	93	82	71	68	62.5	57.5	53.9	42	46.3	43.8	2	-

Fig. 3: Distance Matrix

M. TOTAL COST (Z) = $\sum fcd$

f → flow

c →cost

d → distance

Total Cost Matrix for Initial Layout :

		1	2	3	4	5	6	7	8	9	10	11	12
1	Cafeteria	-	80.96	485.76	485.76	364.32	1357.92	218.96	281.52	343.71	271.58	949.44	855.60
2	IT Room	80.96	-	80.96	0.00	0.00	0.00	446.20	73.60	394.13	70.29	276.00	452.64
3	General Stores	485.76	80.96	-	80.96	52.44	145.36	759.00	53.36	0.00	0.00	117.76	0.00
4	Meat Cutting	485.76	0.00	80.96	-	0.00	257.60	392.84	47.84	0.00	44.53	336.72	125.12
5	Storage (greens)	364.32	0.00	52.44	0.00	-	66.24	460.00	0.00	0.00	0.00	306.36	0.00
6	Disposal	1357.92	0.00	145.36	257.60	66.24	-	0.00	68.08	0.00	71.21	213.07	0.00
7	Receiving	218.96	446.00	759.00	393.00	460.00	0.00	-	60.72	0.00	67.53	1234.27	99.18
8	Grooming	281.52	74.00	53.36	47.84	0.00	68.00	60.72	-	28.89	0.00	72.50	77.28
9	Welcom Assistance	343.71	394.13	0.00	0.00	0.00	0.00	0.00	28.89	-	0.00	0.00	85.19
10	Doc Room	271.58	70.00	0.00	44.53	0.00	71.00	67.53	37.00	0.00	-	0.00	80.59
11	Welcom Lab	949.44	276.00	117.76	337.00	306.36	213.00	671.00	72.50	0.00	0.00	-	11.04
12	6 Sigma	855.60	452.64	0.00	125.12	0.00	0.00	99.18	77.00	85.00	80.59	11.04	-

Fig. 3: Total Cost

Total Cost: 25810.05

N. EXCHANGE OF DEPARTMENT 1 & 2:

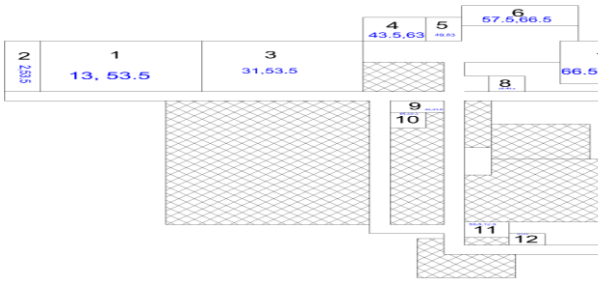

Fig. 4: Exchange of Department

3 iterations are done with all the possible exchanges and the results are tabulated below.

NO.	EXCHANGES (Departments)	COST (Rs)
1.	Initial Layout	25810.05
2.	1 & 2	26428.29
3.	2 & 3	24967.33
4.	4 & 5	25622.37
5.	9 & 10	25825.50
6.	11 & 12	25730.56
7.	9 & 11	24298.67

Table. 2: Cost Table for Iteration 1

SL NO	EXCHANGES (Departments)	COST (Rs)
1.	Initial Layout (9 & 11)	24298.67
2.	1 & 2	23314.27
3.	2 & 3	24916.91
4.	4 & 5	24409.07
5.	9 & 12	24105.84
6.	10 & 11	23124.38

Table. 3: Cost Table for Iteration 2

SL NO	EXCHANGES (Departments)	COST (Rs.)
1.	Initial Layout (10 & 11)	23124.38
2.	1 & 2	24943.41
3.	2 & 3	23511.52
4.	4 & 5	24426.37
5.	9 & 12	23980.35

Table. 4: Cost Table for Iteration 3

No more exchanges are possible after iteration 3 as the cost of the initial layout of iteration 3 is the least amongst all five iterations. Hence, the CRAFT algorithm ends here

O. EFFICIENCY INDICES OF CRAFT LAYOUT:

(1) Index of direct material handling = b = 85.5m
(2) Index of production line flexibility = j/k = 7/8 = 0.875 = 87.5%
(3) Index of aisle space = r/q = 519.7/4213.4 = 0.123 = 12.3%

P. CORELAP:

VALUES FOR CALCULATING TOTAL CLOSENESS RATING

In CORELAP, the Total Closeness Rating (TCR) is calculated for each of the departments using the following values and weightage.

RELATIONSHIP	DESCRIPTION	VALUE	WEIGHTAGE
A	Absolutely necessary	6	243
E	Essential	5	81
I	Important	4	27
O	Ordinary Importance	3	9
U	Unimportant	2	1
X	Undesirable	1	0

Table. 5: Description of the Relationships

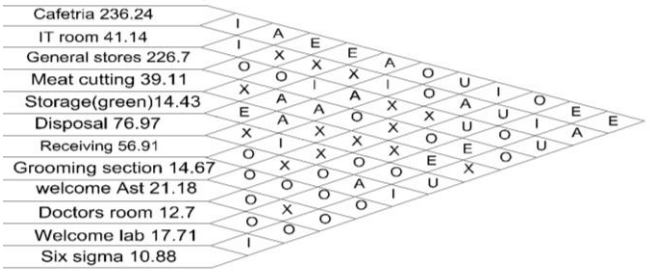

Fig. 5: ACTIVITY RELATIONSHIP CHART

Specimen Calculation of TCR for the 1st Department
Number of 'A' relationship department 1 is sharing with other departments = 2
Value assigned to the relationship 'A' = 6
Therefore, closeness rating (2*6) = 12
Number of 'E' relationship department 1 is sharing with other departments = 4
Value assigned to the relationship 'E' = 5
Therefore, closeness rating (4*5) = 20
And so on for I, O, U and X
Therefore, TCR = 12 + 20 + 8 + 6 + 2 + 0 = 48

III. DETERMINATION OF DEPARTMENT SEQUENCE:

the highest area is selected. Next, the relationship chart is scanned and if a department is found having 'A' relationship is brought into the sequence. If there is no A relationship, chart is scanned for 'E' relationship, then 'I', and so on.

With reference to appendix 1, the department having the highest TCR is department 1, with a TCR of 48. So it is first in the sequence.

Next, select the departments having 'A' relationship with department 1. If there is a tie, select the one having the higher TCR value.

With reference to the appendix 1, it is observed that department 6 has an 'A' relationship with department 1. It is the next department in the sequence.

And so on,
The final sequence is,

1 – 6 – 4 – 7 – 11 – 5 – 3 – 2 – 12 – 10 – 8 – 9

A. PROPOSED LAYOUT:

TOTAL AREA = 777m^2
<64m2=1grid

5	7	4	6	6	8
11	7	1	1	10	
	3	3	2	9	
				12	

>64m^2 = 2 grids
Intermediate Proposed Layout:

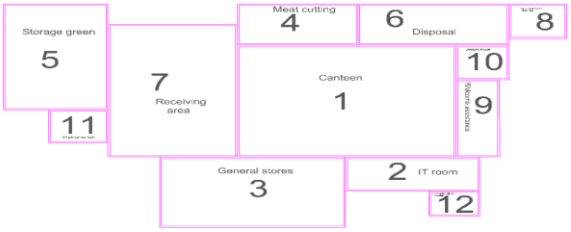

Fig. 6: Proposed Layout

Aisle space between departments is 2.83m.

B. DETERMINATION OF COST:

The concept of CRAFT algorithm is used to determine the cost of CORELAP layout.

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Flow Matrix (f) for CORELAP
TOTAL COST (Rs) = 12051.08

Flow Matrix:

		1	2	3	4	5	6	7	8	9	10	11	12
1	**Cafeteria**	-	4	12	6	4	12	2	3	4	3	6	5
2	**IT Room**	4	-	4	0	0	0	5	1	6	1	2	3
3	**General Stores**	12	4	-	2	1	2	11	1	0	0	1	0
4	**Meat Cutting**	6	0	2	-	0	8	7	1	0	1	3	1
5	**Storage (greens)**	4	0	1	0	-	3	10	0	0	0	3	0
6	**Disposal**	12	0	2	8	3	-	0	2	0	1	2	0
7	**Receiving**	2	5	11	7	10	0	-	2	0	1	12	1
8	**Grooming**	3	1	1	1	0	2	2	-	1	0	1	1
9	**Welcom Assistance**	4	6	0	0	0	0	0	1	-	0	0	1
10	**Doc Room**	3	1	0	1	0	1	1	0	0	-	0	1
11	**Welcom Lab**	6	2	1	3	3	2	12	1	0	0	-	3
12	**6 Sigma**	5	3	0	1	0	0	1	1	1	1	3	-

Table. 5: EFFICIENCY INDICES OF CORELAP

C. LAYOUT

(1) Index of material handling = b = 48.28m
(2) Index of production line flexibility = j/ k = 5/7 = 74%
(3) Index of aisle space = r/q = 356.2/1809.5 = 0.1968 = 19.68%

D. RESULT:

	Index of Material Handling (in meters)	Index of Line Flexibility	Index of Aisle Space	FLOW COST (in Rs) per year
INITIAL LAYOUT	141.9	0.74	0.123	80,52,736
CRAFT	85.5	0.875	0.123	72,14,807
CORELAP	48.28	0.74	0.1968	37,59,937

IV. CONCLUSION

The existing area has certain departments which have been inappropriately positioned with respect to its relationship to other departments which causes a lot of problems during operations. But, we have enhanced the layout without disturbing the real system. The XYZ Service Firm's Management have liked our proposal and are most likely to implement the new design which would improve their day-to-day operations.

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