International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Layout designing using Systematic Layout Planning for Electronics Division of a Manufacturing Facility

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Received 15 Aug 2017, Accepted 05 Oct 2017, Available online 11 Oct 2017, **Vol.7, No.5 (Sept/Oct 2017)**

Abstract

At a manufacturing facility, the management decided to merge all the electronic product divisions spread over three branches into one location. The main objective of the paper was to systematically arrange all the sub divisions in accordance with the parent divisions. This was achieved by implementing the systematic layout planning (SLP) tool. The paper at hand focuses mainly on products, product families, tools, material handling equipment, utilities and different processes and the placement of the various departments based on their interdependency. Also, a detailed study of the plant layout using operation process chart, material flow chart and activity relationship chart was carried out.

Keywords: *Systematic Layout Planning (SLP), ALDEP, CORELAP, Activity Relationship Chart*

1. Introduction

Facility planning is an overall approach concerned with the design, layout and incorporation of people, machines and activities of a system. Huang emphasizes that facility layout design defines how to organize, locate, and distribute the equipment and support activities in a manufacturing facility to accomplish minimization of overall production time, maximization of operational efficiency, growth of revenue and maximization of factory output in conformance with production and strategic goals.

The systematic layout planning (SLP) is a tool used to arrange a workplace in a plant by locating areas with high frequency and logical relationships close to each other. The process permits the quickest material flow in processing the product at the lowest cost and least amount of handling. Muther has proposed this methodology to design plant layout based on analysis, search and selection procedure. In this paper two alternate layouts were prepared using Automated Layout Design Program (ALDEP) and Computerized Relationship Layout Planning (CORELAP). ALDEP is construction based algorithm and is used when activity relationship is a major consideration. It develops a layout design by randomly selecting a department and placing in the layout. The departments are placed in layout based on its closeness rating. CORELAP is also a construction algorithm with activity relationship a major consideration. It is designed to accommodate situations when constantly changing conditions prohibit the collection of precise numerical data. (Chee Ailing et al)

Company X is a leader in process efficiency and energy conservation for Process Industry, with over seven decades of experience building steam engineering and control instrumentation solutions. At the Company's new facility there was unreasonable material handling and excessive transportation which lead to problems in material flow and hence resulted in less production than available capacity. Due to continuous expansion in the electronic segment and to exercise close control on the production lines, the management decided to redesign the layout for the electronic division. This paper aims to design a new layout using Industrial Engineering tools to satisfy the management's requirements.

2. Objectives of the Research

To arrange the product lines in a systematic manner so as to exercise close control for efficient management. To facilitate extension or change in the layout to accommodate new product line and technology upgradation.

- To organize the product lines in order to establish a streamline material flow.
- To reduce movement of workers, raw material and equipment
- To utilize the available space in an optimal manner.

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- To ensure that the new layout satisfies the essential safety requirements and create safe and comfortable work environment.

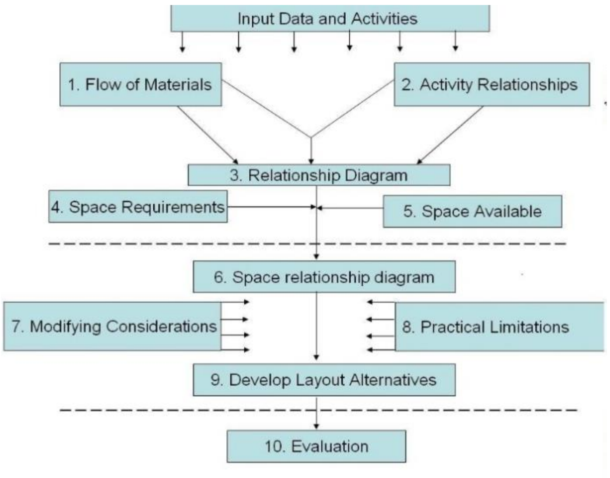


Figure 1 Systematic Layout Planning

3. Methodology

After the team was assigned the task of developing a new layout for the Electronics Division at the facility, it was decided that the most appropriate tool for achieving the desired objective would be Systematic Layout Planning (SLP) methodology. And as per the methodology the first step was to gather Input Data and Activities.

3.1. Input Data and Activities

The first step was to gather data about the current setup and information about the various sub divisions involved. This information was related to the products and the product families existing within the facility. The variables configured by the team were:

Product (P)- P is defined as the products which are being manufactured within the division. These products were systematically categorized under the following categories as established by the Management.

1) Analytical Division
2) Boiler House Division
3) Codel Division
4) Integrated Systems Division

Routing (R)- In order to determine the path through which the various products travel, it was required to design the blueprint of the original layout using AutoCad. This blue print enabled researchers to gain insights of the present working conditions of the existing facility and the need for devising a new layout that would optimize the material flow.

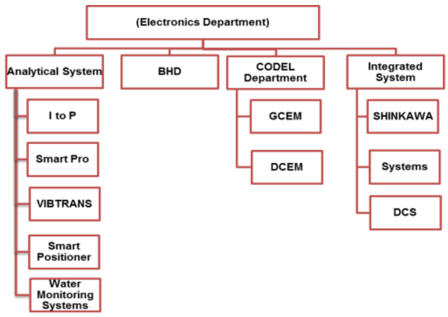


Figure 2 Product Classification

Supporting Service (S)- The team identified that for certain products, additional utilities were required. These utilities supported the production of the products and were identified as follows:

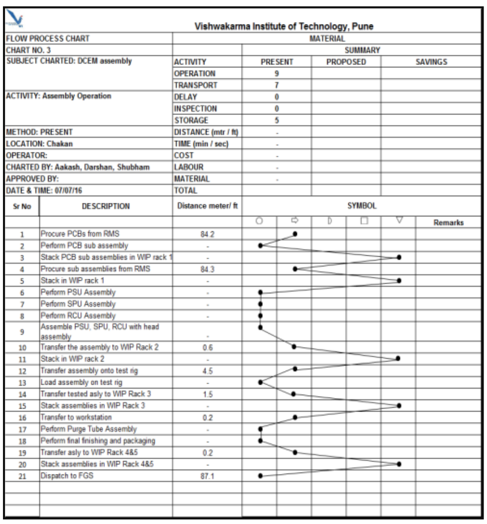
a. Water line
b. Air line
c. Usage of Crane
d. Air conditioning
e. Work-In-Process Inventory area

3.2. Flow of Materials

In order to identify the material flow it was necessary to chart the flow process of raw material from Raw Material Stores (RMS) to the production line and the subsequent dispatch of finished products to the Finished Goods Store (FGS). The Flow Process Chart-Material Type (FPC) enabled researchers to classify each activity performed into

1) Operation
2) Inspection
3) Transportation
4) Material Waiting
5) Storage

The FPC for DCEM assembly is shown in the Figure . Similarly, FPC for the rest of the products was charted which helped in determining the most effective sequence of work and material.



Vishwakarma Institute of Technology, Pune

FLOW PROCESS CHART	MATERIAL			
CHART NO. 3		SUMMARY		
SUBJECT CHARTED: DCEM assembly	ACTIVITY	PRESENT	PROPOSED	SAVINGS
	OPERATION	9		
	TRANSPORT	7		
ACTIVITY: Assembly Operation	DELAY	0		
	INSPECTION	0		
	STORAGE	5		
METHOD: PRESENT	DISTANCE (mtr / ft)	-		
LOCATION: Chakan	TIME (min / sec)	-		
OPERATOR:	COST	-		
CHARTED BY: Aakash, Darshan, Shubham	LABOUR	-		
APPROVED BY:	MATERIAL	-		
DATE & TIME: 07/07/16	TOTAL			

Sr No	DESCRIPTION	Distance meter/ ft	SYMBOL ○	⇨	D	□	▽	Remarks
1	Procure PCBs from RMS	84.2		●				
2	Perform PCB sub assembly	-	●					
3	Stack PCB sub assemblies in WIP rack 1	-					●	
4	Procure sub assemblies from RMS	84.3		●				
5	Stack in WIP rack 1	-					●	
6	Perform PSU Assembly	-	●					
7	Perform SPU Assembly	-	●					
8	Perform RCU Assembly	-	●					
9	Assemble PSU, SPU, RCU with head assembly	-	●					
10	Transfer the assembly to WIP Rack 2	0.6		●				
11	Stack in WIP rack 2	-					●	
12	Transfer assembly onto test rig	4.5		●				
13	Load assembly on test rig	-	●					
14	Transfer tested asly to WIP Rack 3	1.5		●				
15	Stack assemblies in WIP Rack 3	-					●	
16	Transfer to workstation	0.2		●				
17	Perform Purge Tube Assembly	-	●					
18	Perform final finishing and packaging	-	●					
19	Transfer asly to WIP Rack 4&5	0.2		●				
20	Stack assemblies in WIP Rack 4&5	-					●	
21	Dispatch to FGS	87.1	●					

Figure 3 Material Flow Process Chart- DCEM Assembly

3.3. Activity Relationship Chart

In this stage, the identification of the relationships between different product lines is discussed. The product lines are the various sub divisions of the electronic division. The relationships were tabulated in an activity relationship chart. The team identified the various factors which defined interdepartmental relationships. These factors included

A. Intra- departmental material and information flow
B. Inter- departmental material and information flow
C. Material Handling Equipment Requirement
D. Utilities

In order to decide the ranking of the relationship that each department shares with the others, the conventional ranking system was used which is as follows.

Value	CLOSENESS
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary OK
U	Unimportant
X	Not desirable

Figure 4: REL Chart Precedence Rating

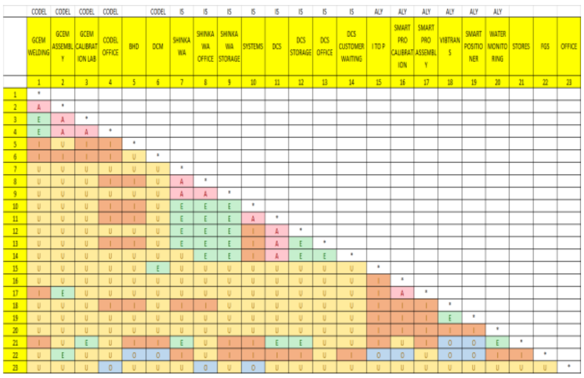


Figure 5 Activity Relationship Chart

3.4. Relationship Diagram

The activity relationship diagram is a visual display of the activity relationship chart. Different colored lines are used to distinguish the importance between each process as shown in the Figure.

Value	CLOSENESS
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness OK
U	Unnecessary
X	Not desirable

Figure 6 Relationship Diagram Precedence

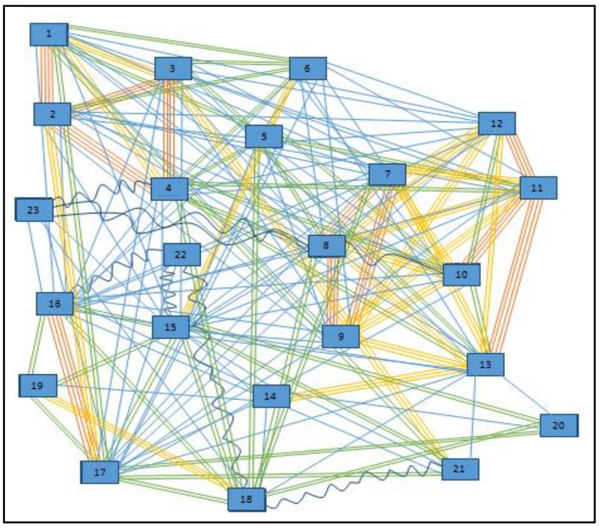


Figure 7: Relationship Diagram

3.5. Space Requirements and Analysis

After defining the relationships among processes, the next step is determining the space requirements needed for each process to translate it into the actual layout. The space requirements discussed and space available discussed. The existing different departments utilize space on the shop floor as follows:

Table 1 Area Requirement - AC region

Type	Dept	FUNCTION	Existing Area (m^2)
AC	Codel	GCEM ASSEMBLY	44
AC	Codel	CODEL OFFICE	16
AC	Codel	GCEM CALIBRATION LAB	63
AC	Codel	DCEM	66
AC	IS	SHINKAWA	255
AC	IS	SHINKAWA OFFICE	
AC	IS	SHINKAWA STORAGE	
AC	IS	SYSTEMS	
AC	IS	DCS	
AC	IS	DCS STORAGE	
AC	IS	DCS OFFICE	
AC	IS	DCS CUSTOMER	
AC	Analytical	E TO P	32
AC	Analytical	SMART PRO CALIBRATION	56
AC	Analytical	SMART PRO ASSEMBLY	
AC	Analytical	VIBTRANS	24
AC	Analytical	SMART POSITIONER	40
AC	BHD	BHD	25
		Total AC Area	621
		Gangway	108
			729

Table 2 Area Requirement - Non AC region

Type	Dept	FUNCTION	Existing Area (m^2)
Non AC	Codel	GCEM WELD	36
Non AC	IS	IS WIP	68
Non AC	Analytical	Analytical Panel Assembly	45
Non AC	ABC^2	ABC^2 WIP	308
		Total Non-AC Area	457
		Gangway	445
			902

In addition to these departments new departments were to be added which had to be accommodated in the modifying layout. Also, due consideration had to be given to modify the existing layout in order to simplify the flow of the materials.

3.6. Space Available

The total space which was has been decided by the management for supporting the new layout includes the current layout area as well as additional area as below.

Table 3 Area Requirement of Newly added sections

Type	Dept	FUNCTION	Area (m^2)
Non AC	Codel	CSD Lab	58
Non- AC	Common	RMS	218
Non-AC		FGS	436
Non-AC		Free Space	404
			1116

The total area available for modification purpose consisted of the existing area covered by the layout and the additional area considered by the management which summed up to **2748 m²**.

3.7. Modifying Constraints and Practical Limitations

The primary considerations while developing the new layouts were as follows:

- Workstations and departments should be placed by considering the internal as well as external material flow.
- All departments should be placed in accordance to their parent divisions.
- Central gangway provided which will enhance accessibility
- IS Division and GCEM Assembly section placed on either side of the gangway for optimized use of both the cranes

After learning about the space requirements and the space available, the team identified certain constraints and limitations. These points have been systematically documented as follows:

3.7.1. CSD Lab

- For rework of Codel related products a separate section was to be provided (After sales service)

3.7.2. Calibration Lab

- The position of the lab was not to be changed as it would had been a costly affair dismantling the rigs and piping system.

3.7.3. GCEM Weld

- It was required to be placed outside the AC region for proper ventilation of welding fumes.
- It was required to be placed by considering the installation difficulties of existing crane facilities.
- Additional area was required for free material flow.

3.7.4. GCEM Assembly

- Area was to be expanded to accumulate sufficient WIP inventory and their respective fixtures and for enhancing accessibility of monitoring systems with the product.

3.7.5. New Rig Area

- Separate area was to be allocated for customer testing of ready-to-dispatch products

3.7.6. Codel Office

- Centrally located office was to be established with respect to all Codel departments

3.7.7. Thermal Cycle Chamber

- It was to be placed in isolation due to its excessive noise.
- It was to be placed such that the exhaust system doesn't affect the aesthetics of the outer side of the building

3.7.8. Analytical WIP

- It was to be placed outside the AC region because it didn't require air conditioning.
- Sufficient area was to be allotted to accumulate all types of inventories.

3.7.9. PCB Test Cell

- It was to be accommodated inside the AC region because the PCB required dust free environment.
- It was to be placed in accordance to relation with PCB requiring departments.

3.7.10. Smart Positioner

- Area was to be expanded to satisfy all present and future requirements
- Hall Sensor Assembly and PCB Assembly workstations were to be included near the assembly line.
- Racks were to be added to accumulate different types of inventories
- Separate workstations were to be provided for assembly of housing, PCB and hall sensor (Previously done on top of wooden WIP rack)
- Extra space was to considered for oncoming new fixtures.

3.7.11. Vibtrans – (Product name)

- Area was to be expanded for oncoming new product (Vibtrans Rack)

3.7.12. Smart Pro

- It was to be placed in accordance to Hydro Test Rig which was not to be disturbed.
- Dedicated workstations were to be provided for each process
- Racks were to be added to accumulate different types of inventories
- Unnecessary tables were to be (currently used for storing WIP) removed

3.7.13. E/P

- Dedicate department was to be established for E/P product

3.7.14. Analytical Panel Assembly

- Separate WIP area was to be added in the layout to optimize assembly area.

3.7.15. Customer Meeting Room

- Meeting room for BHD and IS division related discussion was to be established.

3.7.16. IS WIP

- Dedicated space for storage of IS WIP was to e provided.

3.8. Develop Alternate Layouts

Initial designs were created using the requirements and constraints described before. This was done using two Layout construction algorithms

A. Automated Layout Design Program
B. Computerized Relationship Layout Planning

ALDEP is basically a construction algorithm but it can also be used to evaluate two layouts. The algorithm uses basic data on facilities and builds a layout by successively placing the layout using relationship information between the departments. The basic inputs to ALDEP are:

- Length and width of facility.
    - Length= 75m
    - Width= 15m
- Minimum closeness preference (MCP) value.
    - MCP value is 4
- Sweep width.
    - Value is 3
- Relationship chart showing the closeness rating.
    - Refer the relationship chart in Figure
- Location and size of any restricted area.

CORELAP constructs layouts by locating rectangular-shaped departments when the departmental area and layout scale permit a rectangular representation of the departmental area. It is based on REL chart and numerical weighted rating assigned to the closeness ratings. The evaluation phase employs a placing rating and a boundary length.

The input data of CORELAP are

- Number of departments
    - No. of departments are 23
- Relationship chart
    - Refer the relationship chart in Figure
- Weights for relationship chart
- Department pre-assignment (only along the periphery of the layout.)
- GCEM calibration lab is assumed to be pre-assigned

Table 4 Departmental Areas

DEPT	FUNCTION	AREA
1	GCEM WELD	38.2
2	GCEM ASSEMBLY	45.6
3	CODEL OFFICE	16.4
4	GCEM CALIBRATION LAB	59.8
5	BHD	25.2
6	DCM	69.1
7	SHINKAWA	18.9
8	SHINKAWA OFFICE	27.3
9	SHINKAWA STORAGE	81.9
10	SYSTEMS	45.9
11	DCS	36.8
12	DCS STORAGE	21.1
13	DCS OFFICE	16.8
14	DCS CUSTOMER	10.5
15	I TO P	33.3
16	SMART PRO CALIBRATION	22.9
18	VIBTRANS	27.3
19	SMART POSITIONER	40.9
20	WATER MONITORING	45.5
	Total	**683.4**

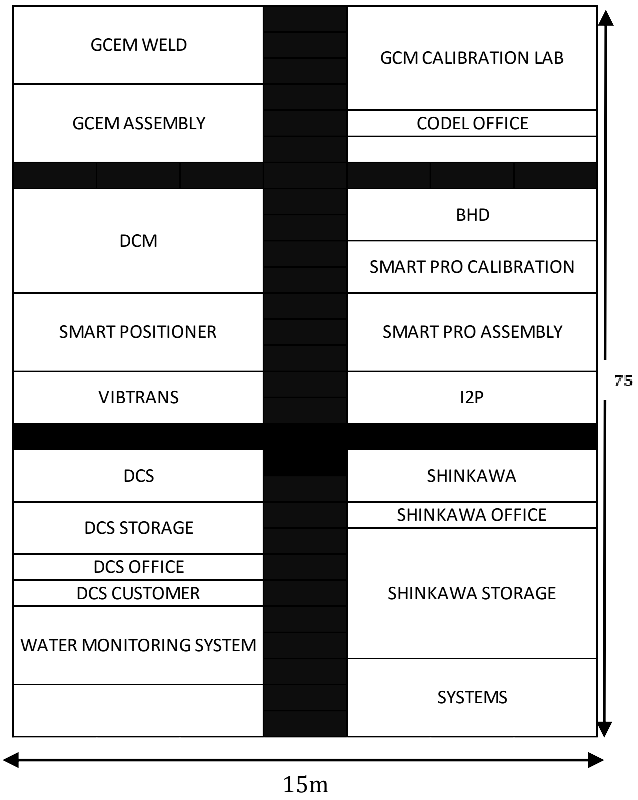


Figure 8 ALDEP

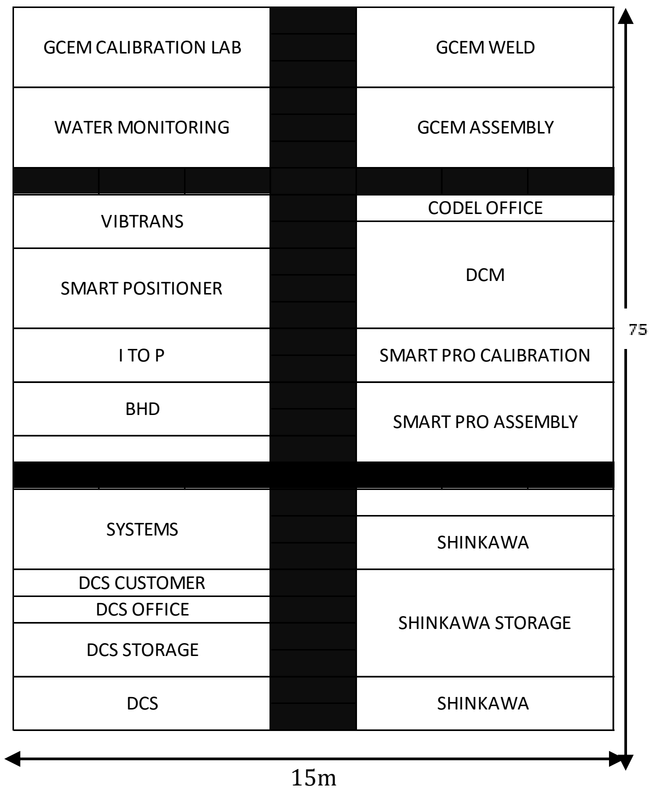


Figure 9 CORELAP

4. Results

The layouts which have been developed using the computer aided algorithms, ALDEP and CORELAP were evaluated on the basis of numerous criteria which were found relevant to this paper.

4.1. *Reduction in material handling*

Many departments are manufacturing products which are used as raw materials by other product divisions. As a result, there is high frequency of material movement between these departments. Therefore, these departments were placed close to each other in order to reduce material handling. The overall material handling between the raw material store and various departments and simultaneously from the departments to finished goods store has been minimized.

4.2. *Reduction in investments*

Certain departments require specific utilities, for example GCEM Weld department has an individual crane installed for loading and unloading of products. Similarly, many departments also required specific utilities like hydro test rig, pneumatic pressure lines, rigs and piping system etc. Therefore, the team found it wise to keep the initial configuration intact in the final layout so as to keep the expenses low.

4.3. *Efficient use of space*

Originally in 2760m^2 of space the various departments which exist today were placed as and when they were introduced in a tetris - A type of game where blocks are arranged in haphazard manner - like fashion. So, the team realized that the departments were using the space in a highly disorganized and inefficient manner. Therefore, the layouts developed were evaluated in such a way there was optimal utilization of space.

4.4. *Environmental Impact*

Since the layouts have been prepared for the 'electronic division' most of the products manufactured within, use PCBs. PCBs require a dust free environment with regulated temperature. So originally some part of the layout was subjected to temperature control and dust free environment. However, this isolated region was not sufficient for storing PCBs for all the departments. Concurrently most of the production required precise job work which further demanded the operators to be highly focused. However, only a few operators were subjected to this favorable condition. Therefore, to counter this problem, with management's approval the team decided to expand this isolated area. It was also beneficial for the new departments which were to be added.

4.5. *Original Structure (columns/waterworks)*

The placement of department had to be done keeping in mind the original structure of the facility that is various columns, exits, entrances, electric and plumbing connections etc. This consideration was kept in mind while evaluating the layouts.

Conclusion

It is obvious that layout optimization task is crucial to any facility planning and layout study (Grajo, 1996). If not tackled in the early phases, it can generate logistics implications for the company involved. Instead of selecting from either of the two layouts, the team extrapolated the advantages of each layout and developed a new layout which was considered to be the most optimal layout.

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