

## Simplified Systematic Plant Layout

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When manufacturing firms find themselves in the enviable position of scrambling to keep pace with rising demands, they are faced with the following questions:

1. How can we increase throughput using our existing facility and resources?
2. How can we increase throughput by adding resources to our existing facility?
3. How can we increase throughput by adding to our facility or relocating to a larger facility?

One of the many answers to each of the above questions is by improving plant layout. According to D. R. Sule in his book (1994) *Manufacturing Facilities*, plant layout is important for two reasons: 1) material handling costs comprise 30-75% of total manufacturing costs and 2) modifications or rearrangements are usually costly in terms of both time AND money.

While you may not be able to “optimize” your facility in the mathematical sense of the term, you should be able to make improvements in areas such as:

- time spent handling materials
- cost of material handling
- distance traveled by materials and personnel
- number of moves made by materials and personnel
- congestion
- process flow

How does one go about improving plant layout? If you have done it before you know it is not an easy task! You must take into account every phase of plant operations plus diverse considerations such as order taking, employee break room, utilities, special ventilation requirements as well as all processes and activities. In other words, many factors must be considered. Since it is difficult to take that many different factors into account in any one problem, a systematic approach is needed in order to arrive at the “best” layout for you. One approach is documented in Richard Muther’s *Simplified Systematic Layout Planning* (1994). This method is broken down into six basic steps. The steps and a brief description of each are shown below.

### 1. Chart the relationships.

This begins by identifying departments, activities, or work centers to be included in the project. It’s best to keep the number in the range of 10-15 different work centers with a maximum of 20. More than that and the number of possible arrangements inhibits arriving at an agreed upon

solution. A Relationship Chart is then created using a spreadsheet format or a mileage-type chart. A sample of a mileage-type chart is shown in Figure 1.

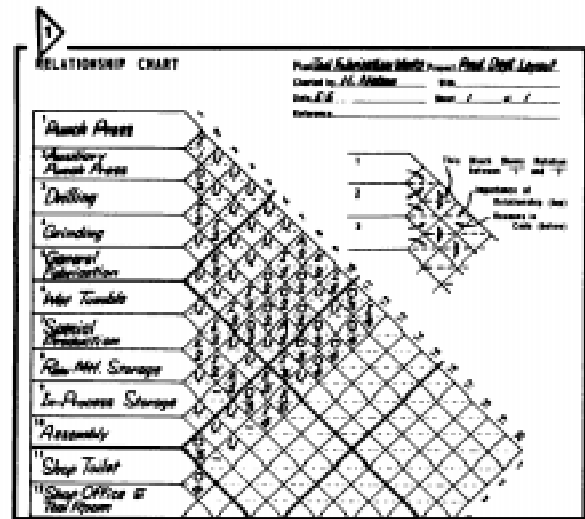


Fig 1

The Relationship Chart is used to document the desired “closeness” between a work center relative to all the other work centers. As a mnemonic device, the vowels and “X” are used to indicate the relationships between each pair of activities. The desired closeness of each relationship value is defined in Table 1. If you find that the relationships for a certain work center or activity are similar to that of another work center, take a look at consolidating or combining the work centers into a common area. Each relationship is also documented with a reason or reasons for the desired closeness. A number code represents each “reason” and is defined on the Relationship Chart for future reference. A “U” relationship needs no reason since it is by definition unimportant. Documenting the reason(s) for

VALUE	CLOSENESS
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary - Closeness OK
U	Unimportant
X	Not Desirable

Table 1

a relationship is very important when past or future changes are considered. It provides historical documentation on why a particular closeness was desirable or undesirable. Some examples of reasons for a specific relationship value are:

- Shared equipment*
- Shared personnel*
- Movement of material*
- Movement of personnel*
- Shared utilities*
- Noise*
- Dirt*
- Contamination*
- Fumes*
- Shared dock*
- Supervision*
- Cost of material handling*

This is by no means a complete list but it should give you an idea of what is meant by the reason for a closeness value or relationship.

## 2. Establish space requirements.

The next step in Muther's method is to prepare an "Activities Area & Feature Sheet." At this point you will need to determine the area required for each activity, work center, or department. The information needed is overall square footage as well as length and width dimensions. You should also document other physical features that may be required, such as:

- Overhead clearance*
- Maximum overhead supported load*
- Maximum floor loading*
- Minimum column spacing*
- Water and drains*
- Steam*
- Compressed air*
- Foundations or pits*
- Fire or explosion hazard*
- Ventilation*
- Electrical*

The above features are included on the form but should not be considered all-inclusive. Each manufacturing facility will have its own unique considerations and the form should be amended to include any necessary features. A sample of a completed Activities Area & Features Sheet is shown in Figure 2.

Fig. 2

## 3. Diagram activity relationships.

In this step, a node diagram is constructed, showing a graphical representation of the activities and their closeness relationships. Each node represents an activity.

Starting with the "A" relationships, draw in nodes for the activities that share an "A" relationship. Then, connect

the nodes with four parallel lines. These four lines

represent an "A" relationship. Once the "A" related activities have all been placed and the relationship lines drawn, rearrange and redraw as necessary to achieve the best arrangement.

Follow this procedure through the rest of the relationships and activities using three lines for an "E," two lines for an "I," and one line for an "O" relationship. No lines are used for a "U" and a zigzag or wiggly line represents an "X" relationship. Again, after adding each set of relationships and the necessary activities, rearrange or redraw as necessary to achieve the best arrangement. It is helpful to think of each line as a rubber band that you are stretching across the space between each pair of related work centers. The object is to minimize the tension present in a given arrangement. This analogy will facilitate creating an arrangement that will keep the A relationships closest, then E's, then I's and so on. Think of the wiggly line for an X relationship as a spring in compression that is trying to push the related work centers apart. Once a final diagram is created, add the square footage requirements next to each activity node for future reference. A sample of a completed diagram is shown in Figure 3.

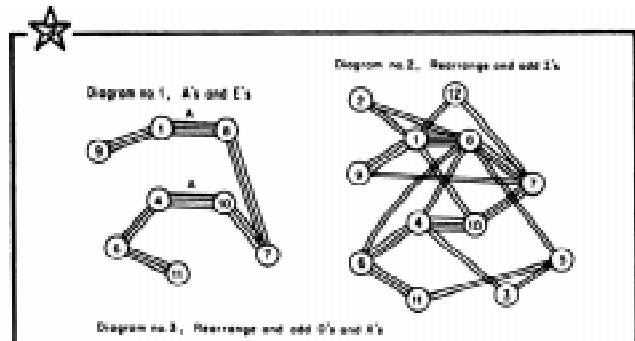


Fig. 3

## 4. Draw space relationship layouts.

The next step is to combine the relationships diagram with the space requirements for each activity. When doing this by hand, it's best to use paper with a grid and to set a scale such that the entire drawing will fit on one sheet. Draw in each activity on the grid according to its square footage requirements. Adjustments should be made in order to fit realistic exterior wall configurations. Make sure to show any dominant physical features such as columns, access doors, walls, etc.

If the building or addition already exists, overlay your layouts on the building outline. In the case of an existing building, depict permanent physical features like load-bearing walls, docks, windows and doors, etc. Replicate this activity for all the various layout options being considered. The more options you consider, the more confidence you can have in the final layout. A sample space relationship layout is shown in Figure 4.

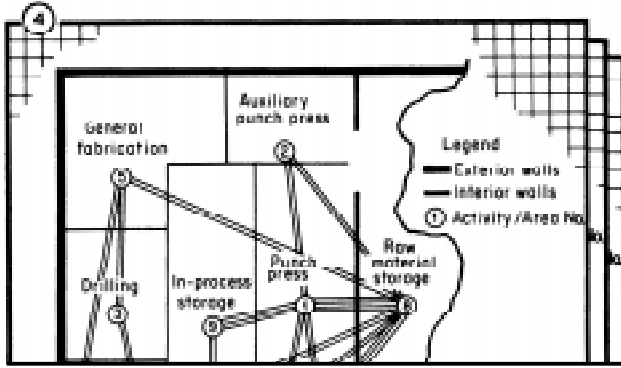


Fig. 4

**5. Evaluate alternative arrangements.**

The first step in evaluating different arrangements is to decide on the criteria by which each layout will be evaluated. These criteria may include such things as ease of supervision, flexibility in expansion, cost, material flow, etc. These criteria or factors must then be prioritized and assigned a weight value with the highest priority factor being a 10, the second a lower weight, the third lower, etc.

Then, evaluate and rate each alternative layout by these factors using the same A,E,I,O,U ratings as used previously. After rating each alternative, convert the letters to numbers (A=4, E=3, I=2, O=1, U=0) and multiply by the respective weight values. Total the weighted rate values for each layout. The layout with the highest total score should be the best alternative. A sample of a completed evaluation is shown in Figure 5.

EVALUATING ALTERNATIVES

Product: *Tool Fabrication Works* Project: *Production Dept. Layout* Date: *5-7*

Description of Alternative: *1. Punch Presses of Left, Gen'l Fab Right; Punch Presses of Right, Gen'l Fab Left*

Drawn by: *H. Nelson E. RWL* Modified by: *H. Nelson E. RWL* Title by: *H. Nelson*

FACTOR/CONSIDERATION	WT.	A	B	C	D	E	COMMENTS
<sup>1</sup> Convenience of Service	6	I 12	E 18	F 18			
<sup>2</sup> Ease of Supervision	5	O 5	A 20	I 10			
<sup>3</sup> Flow of Material & Handling Economy	10	I 20	E 30	A 40			
<sup>4</sup> Flexibility	8	O 8	O 8	I 16			
<sup>5</sup> Least Investment	8	F 24	I 16	A 32			
<sup>6</sup> Appearance & Ease of Housekeeping	3	A 12	E 9	I 6			

Fig. 5

**6. Detail the selected layout plan.**

Up to this point, the layout consists of blocks or various shapes for departments and areas. In this step you will be developing the final plan that will be used as a guide to show precisely where everything goes when you install the plan.

Reproduce the selected layout plan, preferably to a scale of 1/8- or 1/4-inch equals a foot. Identify and draw in the activities and major features, major equipment, and primary services not already included. Then begin to draw in the details of individual equipment, machinery, utilities, or auxiliary services, and label them.

As you begin to do this, you will find yourself re-evaluating the fit of these details and making minor adjustments for such things as free door swings, adequate aisle space, space for maintenance or service, etc. Make sure that the arrangement is functionally sound. One of the best ways of accomplishing this is to involve employees from the individual areas in this step.

Finally, indicate the type of scale used. Add the compass points (or at least "north" to orient users), mark any key dimensions, and add the title block. You are then prepared to install the plan. A sample of a detailed area is shown in Figure 6.

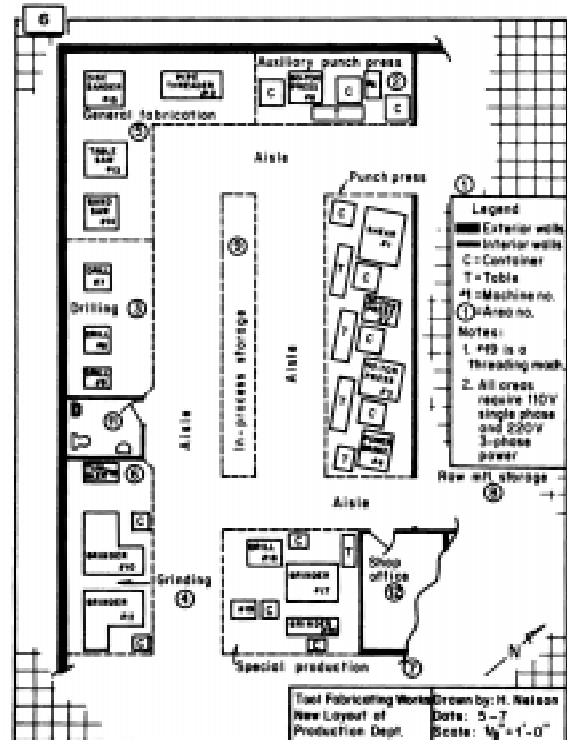


Fig. 6

**Summary**

Using this six-step, systematic approach will take much of the guesswork out of developing a new layout, resulting in increased confidence in your final plan. As suggested earlier, this system works best when employee teams are utilized for each step. Indeed, Muther designed his method to be used by self-directed work teams to arrange their own work areas. By using teams, not only will you find that you will come out with a better layout, but you will have less resistance in installing the plan because employees will take ownership of a plan they helped develop.

Simplified Systematic Layout Planning is especially useful in job shops or process layouts, where there are many different products that are produced in limited quantities. Where there is no consistent process flow, the development of a relationship chart may be the best data you have to determine relative placement of separate work areas. The value of a relationship chart should not be ignored in product-oriented layouts or production lines. The six-step process will aid you in locating all the necessary support functions.

Muther does caution that this simplified method should be limited to layout projects that include individual office areas up to 3000 square feet, individual shop areas no larger than 5000 square feet, and individual storage areas up to 10,000 square feet. When proceeding with the method manually, increasing the size and number of work centers drastically increases the difficulty in creating alternatives and evaluating them. (See Software & The Six-Step Method.)

### Software & The Six-Step method

While Muther's Six-Step Simplified Systematic Layout Planning is a manual method, there are software packages that guide you through the same process. The use of software for this type of project effectively increases the number and size of work areas that can be considered. Engineering Animation, Inc. (EAI), an Ames, IA company, has one such software in its Factory Group of products. FactoryPLAN®, one component of EAI's VisFactory™, was developed by David Sly, an Iowa State industrial engineering graduate. FactoryPLAN® runs in tandem with AutoCAD and helps manage the process of rearranging areas into alternative layouts and evaluating them.

With FactoryPLAN®, the user inputs: 1) the work centers, activities, or departments; 2) square footage and length and width of each department; and 3) the relationships and reasons. The software then guides the user through a process that approximates steps 3 and 4 and shows a visual representation of the relationships for each alternative layout created. The software then performs the calculation for the evaluation in step 5 and presents a score for each alternative block layout.

With software like FactoryPLAN®, it is possible to effectively use the six-step method on much larger layout projects. Larger projects are extremely difficult, if not impossible, to evaluate using the manual method. Like the manual six-step method, FactoryPLAN® helps promote a team approach that offers participants ownership of the new layout and makes the most of minimal data.

### Case Study

An eastern Iowa company, having experienced astounding growth, planned to build a new facility that would triple the size of their current building. A CIRAS specialist worked with a team of 10 persons representing departments throughout the plant. The group received training in Muther's six-step process, gathered data, and estimated square footage requirements and relationships between work centers. During this process, the team considered environmental and safety concerns, material flow, constraints, and monetary factors. The data was then input into EAI's FactoryPLAN® software. Several alternative layouts were developed by the team and scored using FactoryPLAN®. Finally, the team chose the best of the alternative arrangements and after a series of revisions and re-scorings, arrived at a final layout.

According to the company project leader, the process was invaluable in prompting the team to think through relationships between areas that wouldn't have been considered otherwise. There was also a great benefit in bringing the team together so that individuals could see the "big picture" instead of only looking at how each area related to their area of expertise. ■

### References

Richard Muther & John D. Wheeler, Simplified Systematic Layout Planning (Management and Industrial Research Publications, 1994)

D. R. Sule, Manufacturing Facilities: Location, Planning, and Design (PWS Publishing Company, 1994)

James A. Tompkins & John A. White, Facilities Planning (John Wiley & Sons, 1996)

For more information about how CIRAS can assist your company with plant layout, contact the CIRAS Simulation Team: phone 515-294-3420; FAX 515-294-4925; e-mail Mike Willett at [mwillett@ciras.iastate.edu](mailto:mwillett@ciras.iastate.edu) or