Project and Production Management
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Lecture - 31
Layout Planning

In the last lecture we were talking about some mathematical models for facility location. Today we are going to be talking about the problem of layout planning. If you recall, the hierarchy of location problems is the next important problem where the objective is to determine the related positioning of different departments. In this lecture we look at the basic issues that are involved in the layout planning exercise. We shall look at a generic procedure known as systematic layout planning to develop a layout of a plant. What are the objectives in plant layout? When you develop a layout for a manufacturing plant, what are the typical objectives?

There could be many objectives some of them are listed on this slide for instance one objective could be to minimize the investment and equipment. Somebody might say how layout will influence the investment in equipment?

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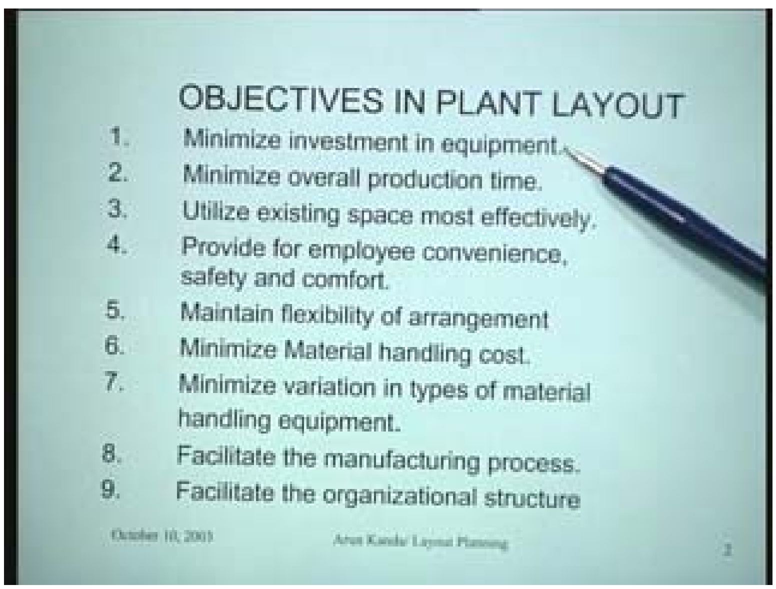

Obviously if you do not duplicate equipment and you have a streamline layout then you could minimize the investment and equipment. The layout has considerable effect on the investment in equipment. It also helps you to minimize the overall production time. You can utilize the existing space most effectively with proper layout. A proper layout should provide for employee convenience safety and comfort. You should try to maintain flexibility of arrangement. Layout generally tries to minimize the material handling cost. It also tries to minimize the variation in types of material handling equipment for instance a good layout could try to standardize the kind of material handling equipment that it uses, for instance you do not expect forklift trolleys of very different sizes to operate in the same shop floor, you could expect standardize equipment. Generally the plant layout could facilitate the manufacturing process and it could also facilitate the organizational structure, because what could happen is that you are trying to place different kinds of equipment and trying to segregate different types of operations. Therefore it will tend to facilitate the organization structure as well. Let us have a brief idea about different types of layouts.

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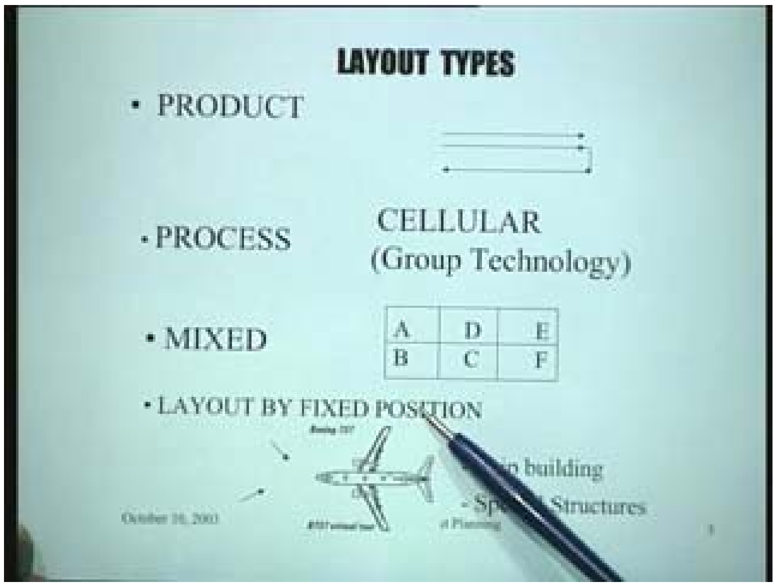

Brightly speaking we can talk about the product layout, a process layout or mix of these two, which is called a mixed layout or the layout by fixed position. Let us see for instance as to what are the features of each of these different types of layouts. The product layout is essentially one where a product enters the line and one side and you keep on performing different operations on the product. Finally finished products come out in the outside. So, all assembly lines for instance are typically examples of product layouts. The idea here is that the layout is dictated by the product. Whatever operations are required on the product, they are laid out in either straight line or in U mode or in serpentine time mode or in any other mode but the essential thing are that all the operations are to be performed on the product or performed in sequence. From the raw material you ultimately get the final product. This is the typical feature of a product layout. In fact when you are talking about product layouts you tend to generally resort to products layouts when the volume of production is large and for instance and you have a dedicated product, you are not changing the product design that frequently. Another kind of layout is a process layout.

Essentially a process layout is something where you have different departments that are A B C D E F. Each of these departments houses machine which are similar in character though these machines are not identical. For instance A could be all the lathes. So lathes with different features are in the lathe shop, this could be a milling shop, this could be a grinding shop and so on. Each shop has different types of machines clubbed together and what happens is that a particular product depending upon it is requirement will move from one department to another to another till finally the product is produced. The major advantage of this type of layout is the product variety that it can handle unlike the product layout which typically handles the single type of product. You can make a variety of products in this particular layout and of course what will be the major problem here? The major problem obviously is B is large number of products moving here and there. So there will be a lot of confusion in terms of movement.

There will be lot of delays as product weight and move to different departments therefore the production time generally tend to be large in such situations. So you could try to have the situation where you have both the product and the process layouts mixed, so it is a mixed layout. Mixed layout is a very common layout in industry, for instance what could happen is if you go to a factory like Maruthi ute for instance, you could find that the final product is being produced as an assembly line. So it is a product layout. But the various components which go into the product are actually being produced in a process layout in different shops. So you invariably have a mixture of both the product and the process layout in various organizations. Of course one can also talk about a cellular layout or a group layout which is something that is generally suited to a situation where you have a predictable variety of products to make and the idea is that you try to group products into product families, part into part families and these individual parts are part family is then subjected to processing in individual cells. The basic idea is that in a cell, the processing sequences are almost uniform, so the modification behind the cellular layout is that we try to get advantages of both product layout and process layouts, that means you get the variety of the process layout and you try to get the speeds by this grouping of parts which are all then processed in various kinds of cell.

Then we talk about layout by fixed position. In a layout by fixed position what happens is that the layout is determined by the size of the product, for instance this is true for special structures of a ship building or for assembly of an aircraft depending upon the type of the aircraft, you have different machines, different pupil keep coming and moving. In all these cases what was happening was that the job was moving and the machines was stationary here. The job is stationary and the machines are moving. There is really not much to choose as far as the layout is concerned, this is governed by the shape of the product itself. If you are building a ship, the shape of the ship it itself will dictate the layout and machines will come do the welding operations of the riveting operations and go back. Then somebody else will do the painting and this is what it is. We are looking at this layout design problem. It is important to note how this problem is actually affected by other decisions pertaining to the product, the schedule and the process.

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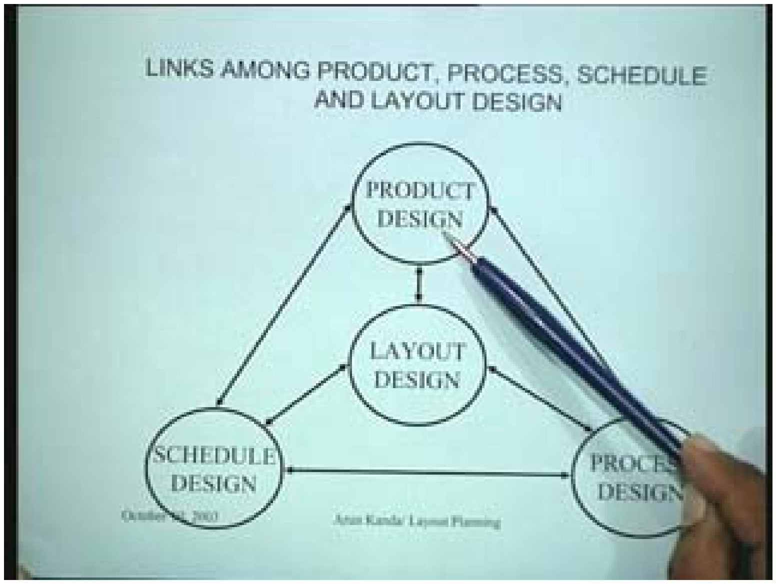

You see that the layout design problem which we are trying to a address is governed by the product design, the process design and the schedule design. The product design means what you have to make that determines the layout. How you have to make it means the process that you have selected for making the product. So this will term in the various machines and equipment that you need. Schedule design which talks about how much you need to make. So this is essentially a decision that comes from marketing forecasting of the man which tells you how much how many pieces you need per day. The product process and schedule constitutes the basic information that you need for layout design. Mind you it is not only layout design which is linked to this but these decisions in and sales are also related to each other. To call the choice of the product will also determine what process to take. Choice of the process will also determine the schedule that you have to follow and so on. So in the layout design process, we are here primarily talking about the layout of process layout. In the layout design process, you need inputs from the product, the process and the schedule that is the important thing. If you try to compare for instance what could be the features of a product layout in this category? You find what is the product layout? Product layout is a situation where the input is some raw material and it is being processed in different works station and sequence till finally the final product comes out here. So in a situation like this you have smooth and logical flow lines. You need to have very small in process inventories because the part which is processed here will immediately go to the next machine, so there has to be very little in process inventory here.

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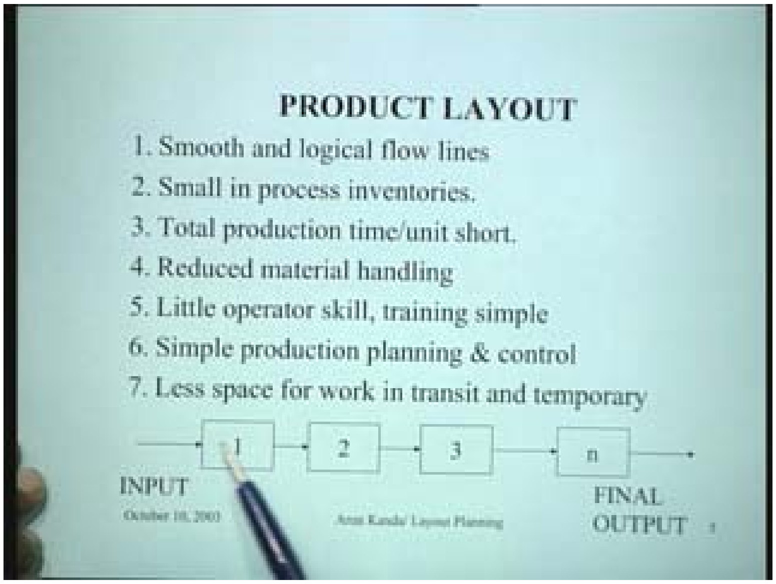

Total production time per unit is short. There is a reduced material handling because the parts directly move from one workstation to the other. So it does not have to be transported in trolleys and tracks to other departments. There is little operator skill and the training is therefore simple production, planning and control and there is less space for work in transit and temporary storage. These are some of the features of a product layout.

Let us look at the process layout. Now what is our basic concern in this particular session? A process layout is a collection of departments A B C D E F which are housed in maybe different rooms or different buildings. Therefore the advantages are there is better utilization of machines, hence fewer machines and needed. Why this is happening is because here you have a lathe that is a special purpose lathe. So all jobs which require processing on that special purpose lathe will come here and get the processing done and go away. Whereas if the same thing was to be done in a product layout, you will have to duplicate the machine at whatever operation it came.

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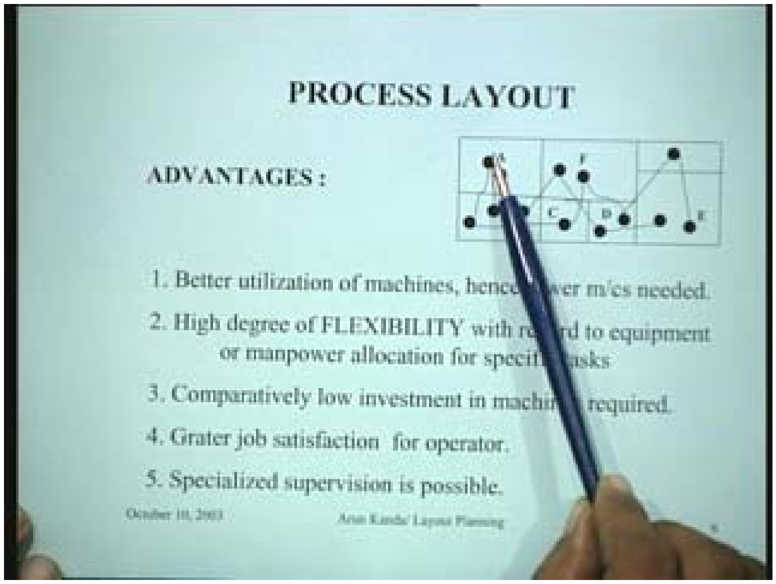

If you need a lathe here, after ten operations you require the same lathe, you duplicate. So generally, better utilization of machines and fewer machines are needed in a process layout. There is a high degree of flexibility with regard to equipment or manpower allocation for specific tasks. What this means is if a job comes to a department of the milling machine, there is often a choice. It can be put in either machine 1 or machine 2 or machine 3 because they are all capable of doing the operation. It can be given to definitive operators depending upon their skills. You have this flexibility with regard to both equipment and manpower allocation for specific tasks. Comparatively low investment in machine is required, this follows from one. There is greater job satisfaction for the operator. Why is there a greater job satisfaction for the operator because the operator who is working in a particular department during the day handles variety of jobs, different types of jobs unlike an operator who is working on a product layout, who could be sitting on a machine and operating a pedal. So you operate a pedal maybe 250 times a day and that is the end it is life.

Here there is greater job satisfaction for the operator and specialized supervision is also possible here. Why specialized supervision? because the supervisor for the lathe section nearly spent 10 years in the lathe section and become a supervisor and in our knows the ins and outs of all the machines which are there in this particular shop. If you talk about the product layout on a line there are different machines manufactured by different manufactures and having different features. It is impossible for one particular individual to be an expert of all those machines. The kind of supervision that he will be able to give is only general and not specialized. However the process layout has some limitations and we should be aware of those limitations. Since longer flow lines usually result, material handling is more expensive. Obviously a part has to go from here to here. It has the first weight then somebody has to load it on to a trolley and then the trolley has to go. The trolley may weigh in that department; somebody unloads it and so on.

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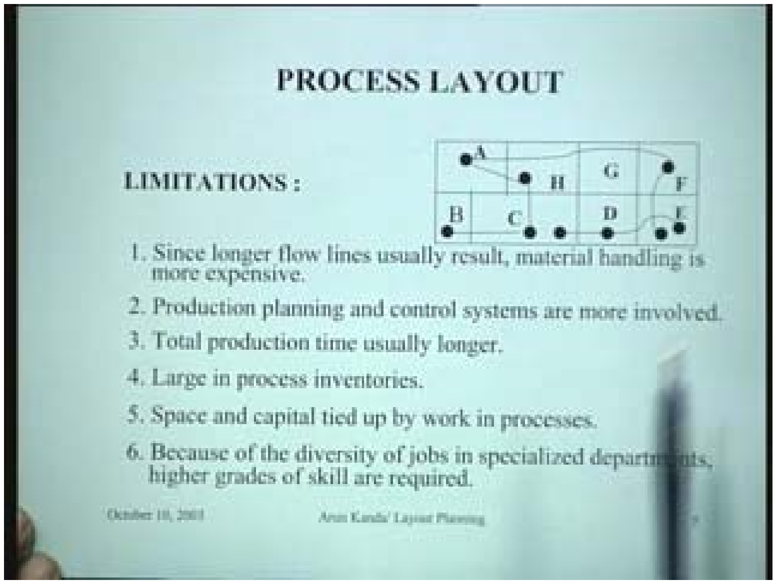

So longer flow line used result material handling is more expensive. In fact the general objective function in designing a layout of this type is one of the major objectives to minimize the material handling cost. Production planning and control systems are more involved in such systems. Total production time is usually longer. Large in process inventories take place because material might be stored up in different departments without being processed. Space and capital are tied up by work in processes and because of the diversity of jobs in specialized departments, higher grades of skill are required. This is also another feature because quite often if you need somebody to operate a grinding machine, you could at least expect that he has done an ITI diploma and has put in three years therefore he can undertake to operate such machines. All these operators operating this machine would generally be pupil who have higher grades of skill unlike an operator on a product line because on a product line, if you even select a man from the street, all you has to do is to press a pedal 250 times and that practice can be given to him in half a day and therefore training people and product for operating product layout is generally much easier whereas here it will be much more difficult. Let us look at this chart which is called a P-Q chart and essentially what we have said is consider a situation where we have to make a large number of products,

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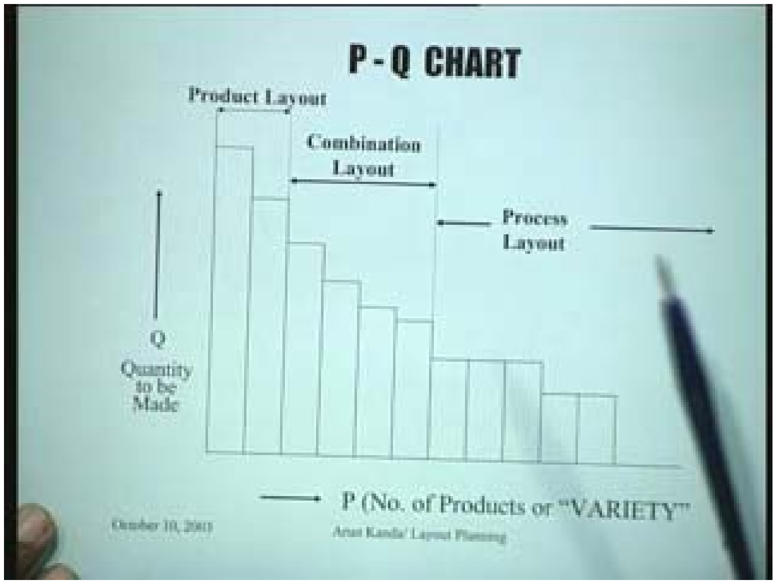

P is the product variety and we arrange these products in the descending order of the quantity that you need. What really happens is that this product is the first one to be made in large quantity. This product is to be made in lesser quantity and so on. So we have products which are arranged in the descending order of the air quantity. Now this chart which was suggested by Muether, gives an idea of the situation under which you should use different types layouts. For instance what you said is once you got these products lined like these, the products which are here, that means for products for which the varieties low but the quantities are high, those are the products for which product layout is more suitable. I mean you set up assembly line, and on this end here where you have a large number of products but the quantities are electively smaller. So it is a large amount of variety but low production quantities. This is the situation where a process layout is recommended and in between these two categories when you have intermediate variety and intermediate production quantity, generally you could use a combination layout which is the product of these. The idea here is only to give you an overall intuitive feel when a product layout and process layout should be selected. Product layout is most appropriate when you are having less number of products to produce in large quantities and the process layout is used when you have large variety but to be produced in small quantities. This summarizes the features of product and process layouts in that sense. Let us now look at the process of designing a process layout. Normally when you talk about layout planning we are generally talking only about process layouts because product layout is generally fixed by the sequence of operation. So, there is nothing much to design except to ensure that you have the space to layout those machines.

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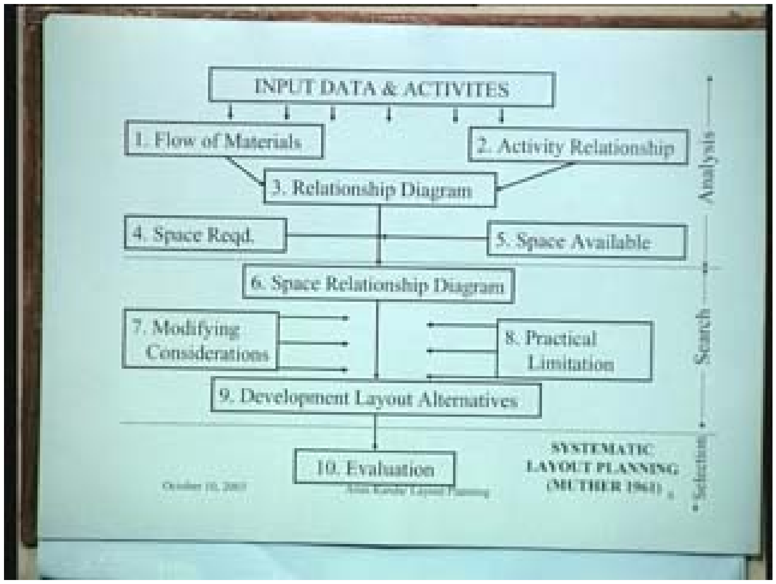

There is a procedure which is called systematic layout planning SLP. SLP procedure of Muether was proposed way back in 1961 where we gave a general framework for how these process layouts are to be designed. You might wonder as to why a procedure developed so long ago is still being talk about. You talk about something when it is still useful. The zero invented so many years ago is still useful. But the point here is that the systematic layout planning procedure of Muether has suddenly become important because this has now become the basis for many of the computerized layout planning algorithms which are available. In the next class we shall be talking about some computerized layout planning procedures. Those procedures are actually base their inputs and operations on the SLP procedure. We look at the SLP procedure in this class to understand what all is required. The first in that required is to input data and activities. What is the kind of data or activity that you have to input for this particular problem?

There are three kinds of data that you need to input, the product data, the process data and the scheduled data. The input to the process of planning a process layout is essentially inputting this kind of data about the product the process and schedule and from this input data the first step that is done is to identify the flow of material. The second step is to identify the activity relationship based on step one and step two. We develop what is called a relationship diagram and then this relationship diagram is converted into what is called as space relationship diagram. In order to develop the space relationship diagram, you have to compute in step 4, the space required, match it with the space available, that means if you find that the space required is 4000 square feet you must make sure that 4000 square feet of space is available. So it is just to check in that direction and then you develop the space relationship diagram in step six. This space relationship diagram is then subjected to modifying considerations and practical limitations which you may not have considered in the entire process so for. On the basis of space to develop the layout alternatives, you evaluate these alternatives and pickup the best layout alternative that you have. So this is the brad framework and it is a very systematic framework for a problem like designing a layout. You can see that you can divide this framework into three different phases. Up to here is the phase of analysis, up to step five is the phase of analysis, where your analyzing your data, finding out the flow of material activity relationships, depending upon the activity relationship diagram, the space required and the space available. Once the analysis part is over you search for the solutions. So from the space relationship diagram, you are developing layout alternatives, so you are searching for alternatives solution and then once you have searched you have developed these solutions, you have to identify which is the best so it is the selection of the solution. Search followed by selection, preceded by analysis is the general order of this particular algorithm. The one reason why it is popular is that it provides a framework for intensive exactly what is to be done. When you are developing computer program you must tell the computer exactly what is to be done and that is why this framework has been used in layout planning exercise. This is the SLP procedure of muether. We will try to illustrate this procedure to a sample problem so that you get an idea of what exact or how the layout operations can be done. Just to give you a feel if we are to organize production as a product layout essentially what it means is that you have to start from the raw materials stage.

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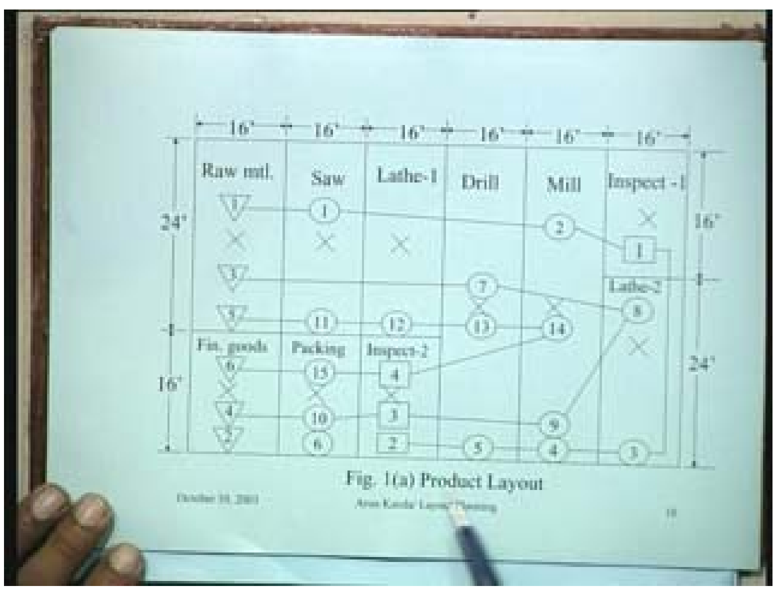

You have different types of products. You go to the saw department, you go to the milling department, you come to inspection one and then do this operation here and then final operation here and you come out and similarly what we are trying to say is every departments which are laid out core also be laid out so that you are trying to facilitate a product layout for three different product. Now we in this particular scheme of things have essentially used these three symbols.

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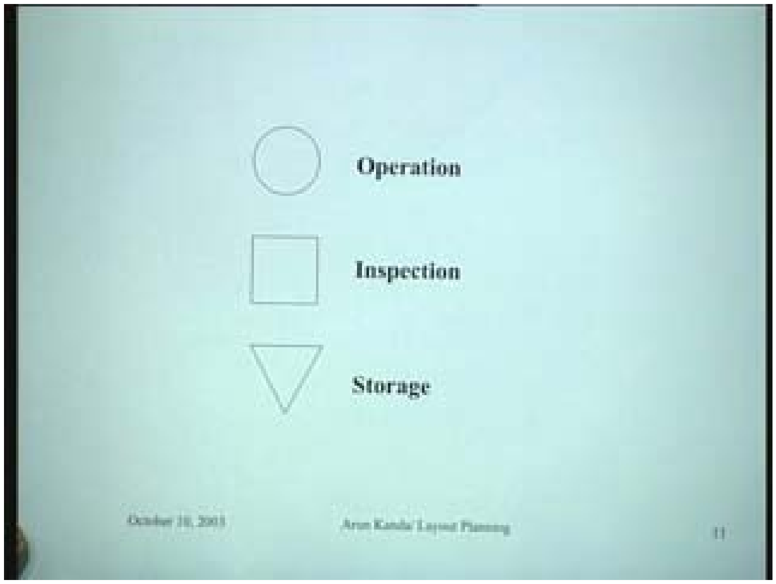

The circle represents an operation being done like machining operation or mettle removal or grinding whatever a square represents and inspection and a inverted triangle of this nature represents storage. This is a convenient way of representing the types of operations which are required here. Let us assume that we have a process layout for the same thing, so what we have is, we have these different departments, raw materials, storage, saw department, where saw is done of the material, the lathe department, the drilling department, the milling department, the inspection the packing and finish goods and here again we have different products which we try to move. So these products move according to their needs. There is a lot of criss crossing so typically this is the kind of thing it happens in a process layout.

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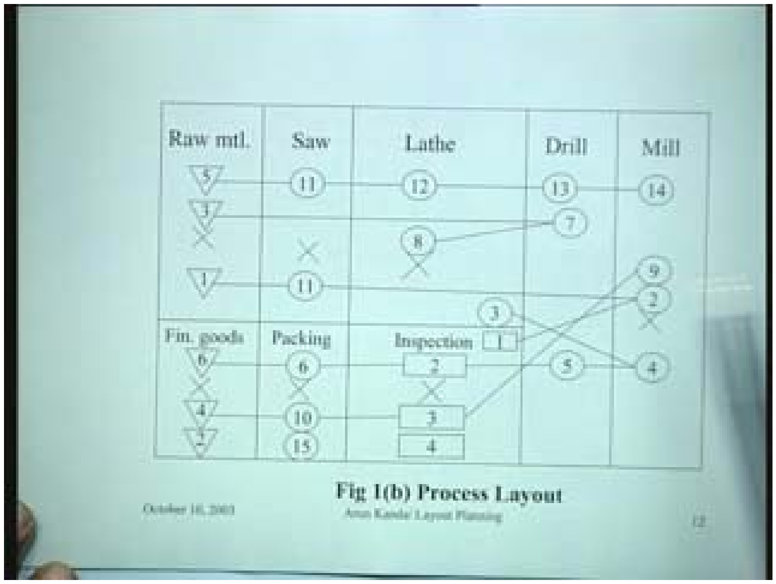

These crosses I think are supposed to be the centralized of these individual departments, if your raw material stored, this is the center. If this is the one, these are the centers. We need them later. Let us suppose that we are trying to work on this particular process layout and we are maybe trying to evaluate this process layout. We are trying to find a better layout by using SLP. We will see how we can do that. So the operation could be something like this. This is out input data for the problem. We are saying essentially that they are three products A, B and C which we want to manufacture and the processing sequence of these products is this first goes to saw, then mill then inspect then turn, then mill, then drill then inspect then package and similarly for this and similarly for this that means we know for each product the processing sequence.

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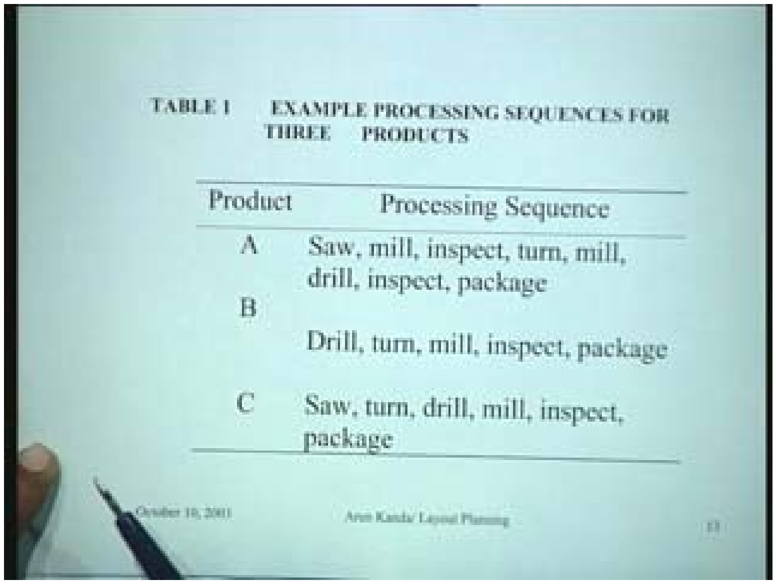

We know the information pertaining to the product, what is the product and how it is going to be processed? Product and the process information is available to us for these three products, then we would also like to know the schedule information to how much is the demand for each of these products. What my happen is that these products may be considerable in size, this maybe a small costing, this maybe a much bigger thing, this maybe a smaller thing and so on.

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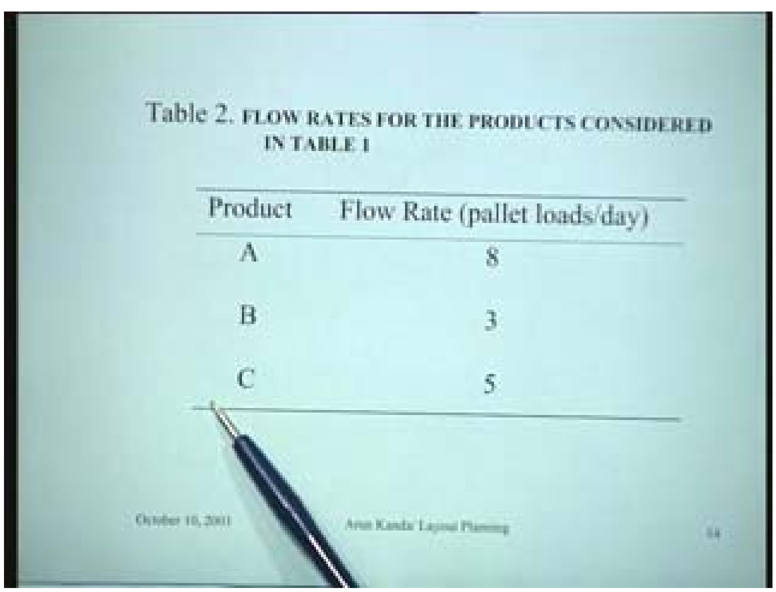

In order to take care of that aspect we are simply standardizing the material flow required in the plant to pallet loads per day, that means how many trolley loads per day will be needed? What we are saying is that as far as product is concerned we required eight pallet loads per day in terms of production. This might be something like 160 products or whatever it is. We are talking in terms of pallet loads. Similarly B requires 3 pallet loads which maybe 300 components so whatever could be different and C could be five pallet loads per day, so we are using a common unit for measuring the material handling of these products throughout the plant. This is essentially our schedule requirement. Firstly, how many trolley loads of A, B, C must be produce per day in the factory? We need information about the processing the products the processing and the quantities. This is the input to it. What we are going to do is we are going to actually construct what is called a from-to chart and from-to chart is actually a convenient means of reducing a large volume of data into a workable form.

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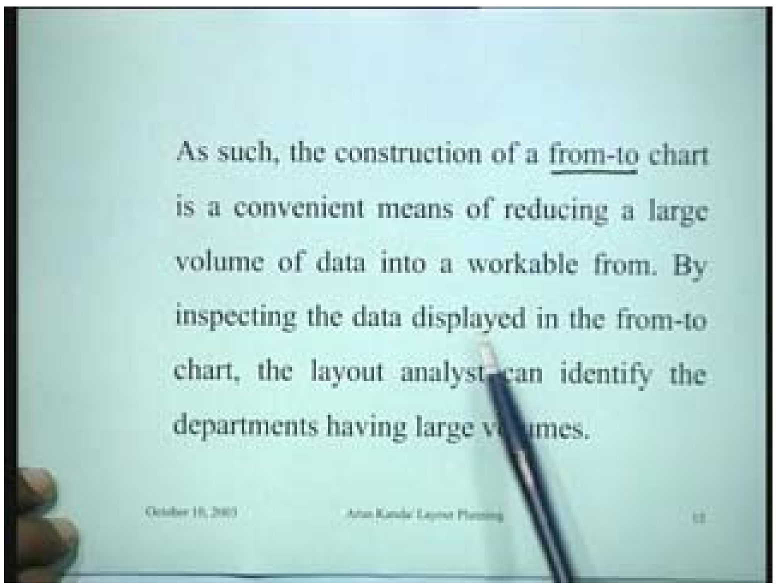

By inspecting the data displayed in the from-to chart the layout analyst can identify the departments having large volumes of movement. So let us try to do it for our example,
What we find here is let us say we construct this information, from-to chart is actually a square matrix. In the matrix we have listed all the departments, raw materials, saw lathe, drill mill inspection packaging and finish goods, and same departments here and so on. What we are trying to basically find out is what is the total movement from this to this so it is a from-to chart it is very much like a distance chart, which is say what are the distances from one pair of cities to another pair of cities? For instance what you find is everything begins from the raw materials stage, so you have the total movement which will take place form raw material to saw.

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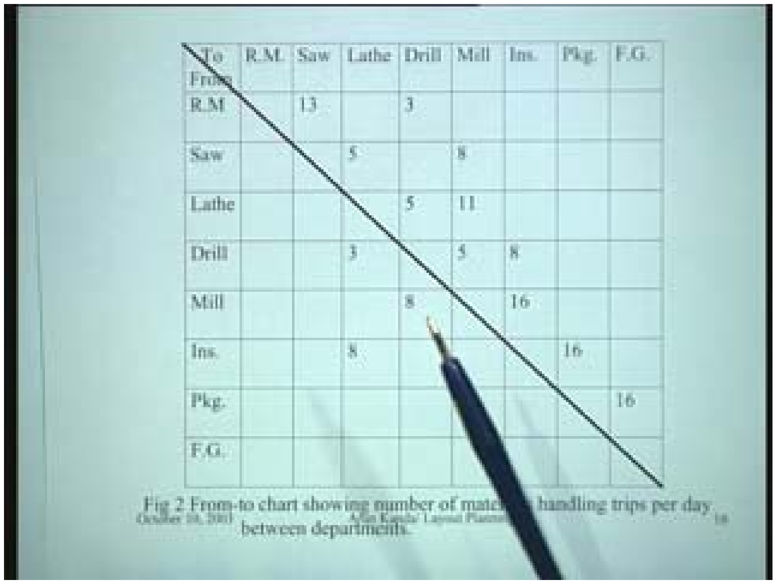

To / From	R.M.	Saw	Lathe	Drill	Mill	Ins.	Pkg.	F.G.
R.M		13		3				
Saw			5		8			
Lathe				5	11			
Drill			3		5	8		
Mill				8		16		
Ins.			8				16	
Pkg.								16
F.G.								

What you are saying is let us look at this requirement. This product A will go from raw material to saw C, will also go from raw material to saw, but B will go from raw material to drill, it does not go to saw, so as far as this is concerned product A and C will make a movement from raw material to saw and you can easily find out what is the total movement of raw materials of product A and C. So A trolleys are moving and C is five trolley loads are moving, so 8 + 5 is 13, that how you get this figure of 13 and similarly for the other entries in this particular chart. So it shows that the total movement which takes place from raw material to saw, 13 daily they will be 13 trolley loads moving from raw material to saw and from raw material to drill 3 will be moving and as far as this movement is concerned from milling to inspection 16 will be moving and so on. This from- to charts shows the number of materials handling trips per day between all the departments. Now what is the idea? The idea is that those departments which have a large amount of movement, especially these departments should be as close to each other, the layout is possible. They should be as much as possible, close to each other and for those departments which do not have any movement, need not be that close. So from this from-to chart we can we can make a common like this. Normally the from-to chart is used to analyze the flow in process layouts. The item movement that occurs over some specified period of time is totaled for all products and entered in the from-to chart as shown in the next figure. What do you like to simply show is this information?

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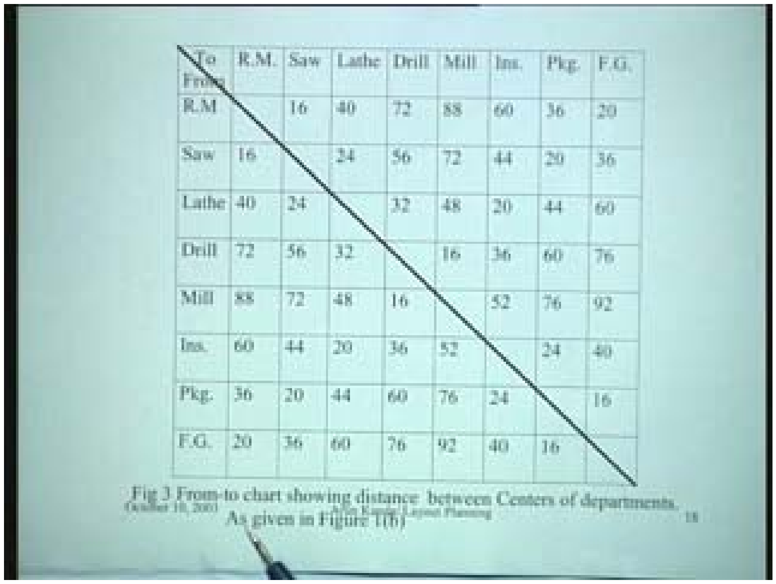

To / From	R.M.	Saw	Lathe	Drill	Mill	Ins.	Pkg.	F.G.
R.M		16	40	72	88	60	36	20
Saw	16		24	56	72	44	20	36
Lathe	40	24		32	48	20	44	60
Drill	72	56	32		16	36	60	76
Mill	88	72	48	16		52	76	92
Ins.	60	44	20	36	52		24	40
Pkg.	36	20	44	60	76	24		16
F.G.	20	36	60	76	92	40	16	

Fig 3 From-to chart showing distance between Centers of departments. As given in Figure 1(b)

In this figure which is also from-to chart, the previous chart was total flow or material handling material flow taking place between all pairs of departments. This particular chart is the information pertaining to the distances between the various departments. You are asking me about the centers in that layouts, so if you are now talking about this layout, we look at the centralized of each department and find out what is the distance from the centroid of one department to the centroid the other departments. On that basis we can construct a diagram of this nature, which should show that the raw material to drill department is 72. Note that the various distances between all pairs of departments are listed here. This particular matrix could be either symmetric but it is not necessary that it be a symmetric. The distance from one department to another need not be the same as the distance from the same department back to cell if there are unidirectional flows and so on. If you are permitting all kind of flows, then this maybe the same. Whatever be the distances they can be accommodated and this is the distance matrix, so we have a flow matrix and we have a distance matrix which we have constructed. An important thing to note here is that the distance matrix can be constructed only if you have a tentative layout.

So it is for that tentative layout that we have made the distances, so then what we do is we multiply the two matrices element by element. Now we have the total material handling effect. This is the total loads multiplied with distance which we had in the previous matrix. We have two matrices; we multiply that so this is the total material handling effect. You will have these entrances here. We can sum up the rows; you will get 424 which is the material handling effort. Total material handling movement from the raw material is 424 units and total material handling movement to the saw is 208. So this is the to and this is the from, in terms of total material handling effort and a zero in a particular column shows that this is a source and a zero in a particular row shows that this is the sink, obviously because what is happening is that everything flows from the raw materials store. It is a source, there is nothing coming to it and the finish goods is last operation. So that is where you have, and nothing goes out of it. If you sum up these values, this column or this row, the total value is 4032. So it shows that the process layout which we are at the movement investigating has a total material handling effort of 4032, this is significant a development because what have we done? We have been able to quantify the material handling movement for a layout and this is the likely objective function for that particular layout. We are able to say that the total material handling effort for this layout is so much. Clearly we could use this information to evaluate different layouts. Plant one, plant two, plant three, each one we can calculate the distance matrix will be different the load matrix will be the same. You will get different material handling figures which is like the objective function values and you can choose a particular layout which in fact has the minimum material handling effect and in fact this is one of the basic logic that is provided in the development of craft which is a computerized relative allocation of facilities technique which we can talk about in the next class.

We can plant a layout by following these steps is something like this. Suppose these are the departments which are to be placed in a layout, the foreman office, the conference room, the parcel post parts, shipment repair and service area, servile area receiving testing and general storage, first thing that you can do is apart from the material handling effect, we were initially talking about box number one in the SLP procedure, i.e., development of the flow of materialism in the various types. We are not talking about box number two, where you are trying to develop activity relationships for these things. What you can say is for each pair for instance you can say that as far as repair and service parts is concerned its proximity two, for instance the conference room is unimportant, so we give a U rating here so this is the significant of the U. You have various ratings. Normally what we give is we give typically the ratings A E I O U and X. A means it is absolutely essential to locate the departments close to each other for instance, this is A, it is shows that parts shipment and general storage is absolutely essential to have them close to each other so you have an A rating. E means that is essential but not absolutely essential, so for instance service area and testing is essential to have them close to each other. I is important so for instance here the conference room in the foreman room is important to have them close to each other because you can call them for conference, O ordinary close nesses.

You have an overrating between the repair and service department and the parcel post and U is unimportant that they be close to each other, for instance conference room it is unimportant that it is close to parcel post or parts shipment and so on. X means it is highly undesirable to have these two departments close to each other. You do not see that here. What may happen is for instance you might have a boundary; you might not want that to be close to your air condition metrology shop. You can give X rating; it is highly undesirable to have these things there. What is really important is given this ratings for these are giving the general preferences that you may have for locating certain department close to each other or not. You accommodate those priorities that you have in the form of these ratings, these are called activity relationships. The numbers are normally given because a factor say E might, you might have a number of reasons 1, 2, 3, 4, 5 which you document.

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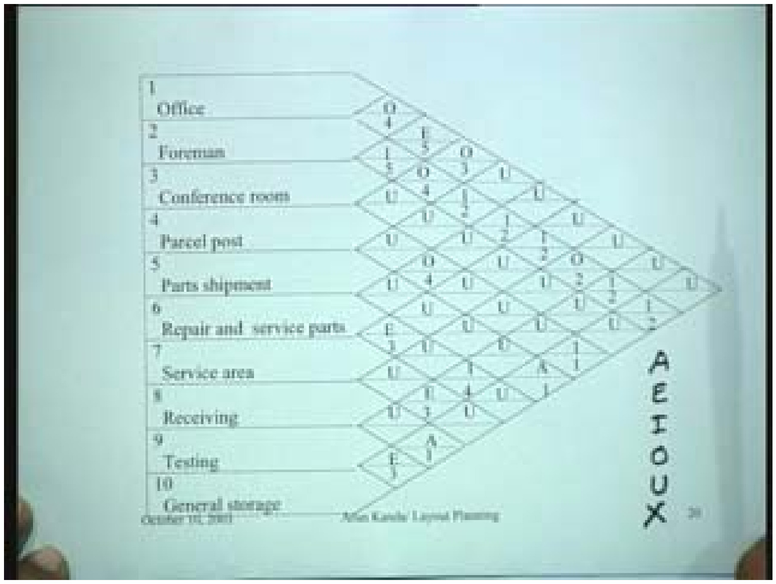

'Might' refers to for what reason we identify E. When you are documenting this, the numbers are also clear here.

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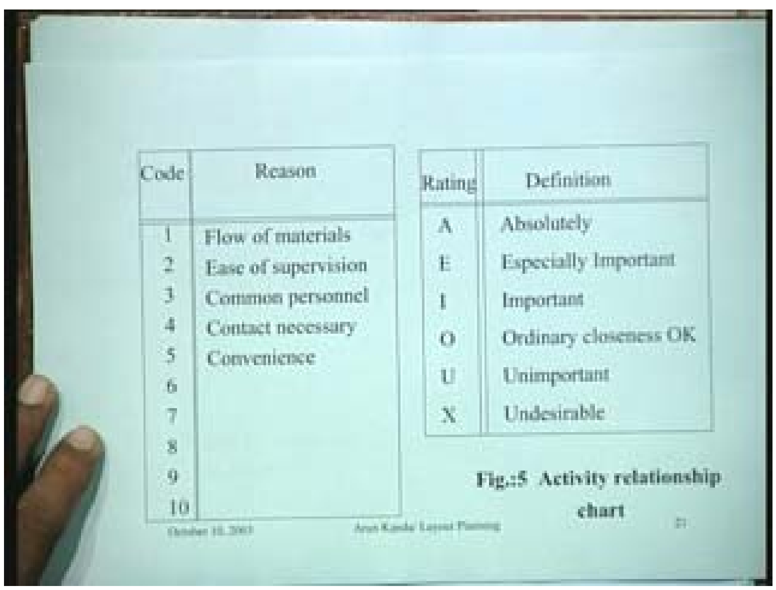

We talk about these ratings:
Absolutely essential
Especially important
Important
Ordinary closeness OK
U unimportant

and X is undesirable.

When you are giving any rating it could be for various reasons for which you get a code like flow of materials, ease of supervision, common personnel, and contact necessary and convenience or something else. When you give a rating you might see whether it is for this reason or that reason whatever that is the idea. On the basis of this information we can develop what is called an activity relationship chart. This is what an activity relationship chart looks like. We have these departments from 1 to 10 which you can talk about, so each square represents a department 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. After being represented by a square, you identify what kind of a rating you want to get between these departments. Mind you the rating can also consider the material handling effort which you computed in step one. You can have various types of situation. It should be one line here, two lines here, three lines here and four lines here that is it and X U is no relationship and X rating could be wave V diagram. What will happen is for instance between one and three there are three lines. It means that there is an E rating between 1 and 3.

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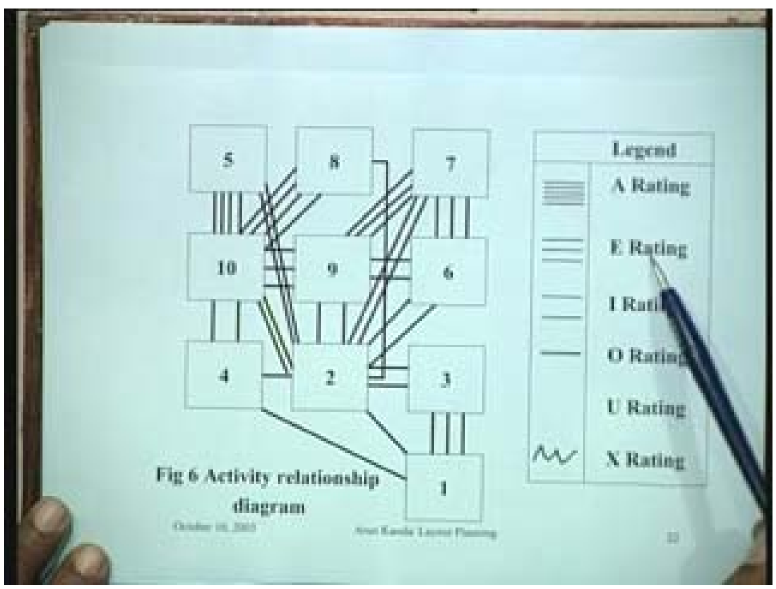

Similarly for the others what will happen is that the number of lines between a department actually shows the a affinity between these departments that is the related desirability of different departments to be close to each other is stronger if the bond is stronger and the number of lines show the bond. You are basically getting an idea of which department should get close to each other to this. This is called an activity relationship diagram. Here we assumed that the same size was there for department particular to calculate the requirements of each department. So what will happen is typically how we will be able to do that for different departments? say if this is the saw department you know that this houses the equipment, the Amstrong hack saw and there are 3 of these the machine center dimension for each of these in feet in 10/9. The total machine area requirement is 190 per machine and the total process area required is because there are 3 machines 570 square feet.

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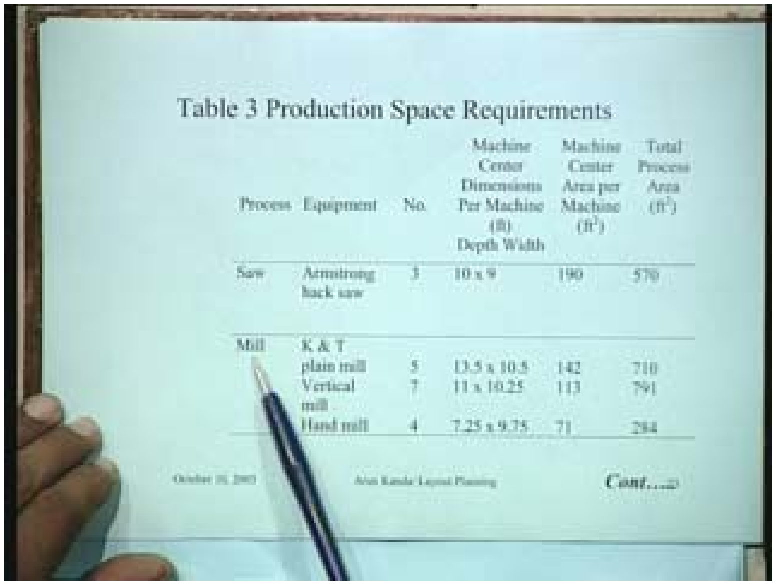

Table 3 Production Space Requirements

Process	Equipment	No.	Machine Center Dimensions Per Machine (ft) Depth Width	Machine Center Area per Machine (ft^2)	Total Process Area (ft^2)
Saw	Armstrong hack saw	3	10 x 9	190	570
Mill	K & T plain mill	5	13.5 x 10.5	142	710
	Vertical mill	7	11 x 10.25	113	791
	Hand mill	4	7.25 x 9.75	71	284

You can find out immediately the amount of machine area that you need for this department called saw, similarly in the mill you might have different types of machines. You have a plain mill - 5 of them, vertical mill - 7 of them, hand mill- 4 of them. You know the department sizes of the machines center requirements, area of which department and the total area corresponding to each of these machines. This exercise can be done for the calculation of the production space.

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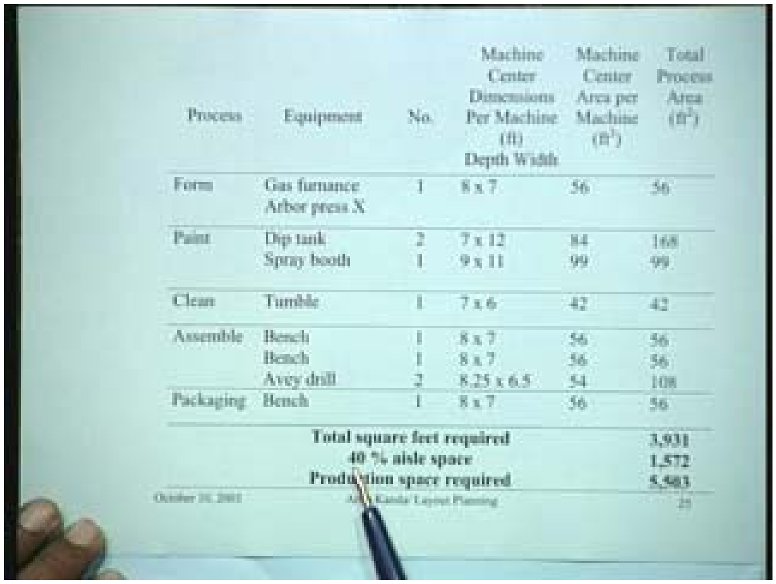

Process	Equipment	No.	Machine Center Dimensions Per Machine (ft) Depth Width	Machine Center Area per Machine (ft^2)	Total Process Area (ft^2)
Form	Gas furnance Arbor press X	1	8 x 7	56	56
Paint	Dip tank	2	7 x 12	84	168
	Spray booth	1	9 x 11	99	99
Clean	Tumble	1	7 x 6	42	42
Assemble	Bench	1	8 x 7	56	56
	Bench	1	8 x 7	56	56
	Avey drill	2	8.25 x 6.5	54	108
Packaging	Bench	1	8 x 7	56	56
	Total square feet required				**3,931**
	40 % aisle space				**1,572**
	Production space required				**5,503**

We do it for each department in the same manner and at the end of it we have been able to find out the total at that mean, the final area requirements the total square feet required is now 3931. This is the space required only for the machines, so normal practice in factory design is to add 40 percent space for aisle that is movement within the department. 40 percent aisle space of this is 1572. The total production space required is 5503 that is how we calculated this space and we also know the space requirement of individual departments as a consequence. We have so far not considered non productive activity space, this is only protection space.

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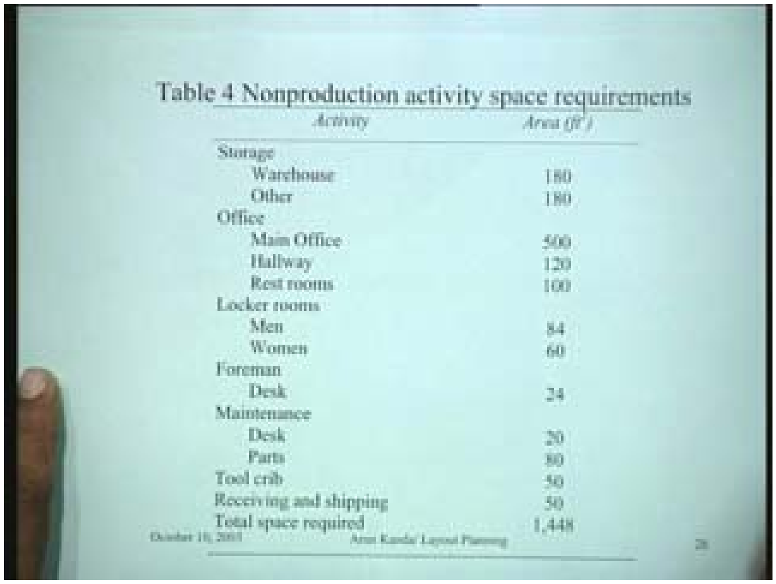

Table 4 Nonproduction activity space requirements

Activity	Area (ft²)
Storage	
Warehouse	180
Other	180
Office	
Main Office	500
Hallway	120
Rest rooms	100
Locker rooms	
Men	84
Women	60
Foreman	
Desk	24
Maintenance	
Desk	20
Parts	80
Tool crib	50
Receiving and shipping	50
Total space required	1,448

You will have to add the requirements of the non production activity space for storage, office, locker rooms, foreman maintenance, and tool crib and so on. This total area comes out to 1448 square feet in addition to that you already had. We have to add to the earlier area production area 5503, this additional space 1448 and get the total requirement of 6951 square feet of floor space required in total.

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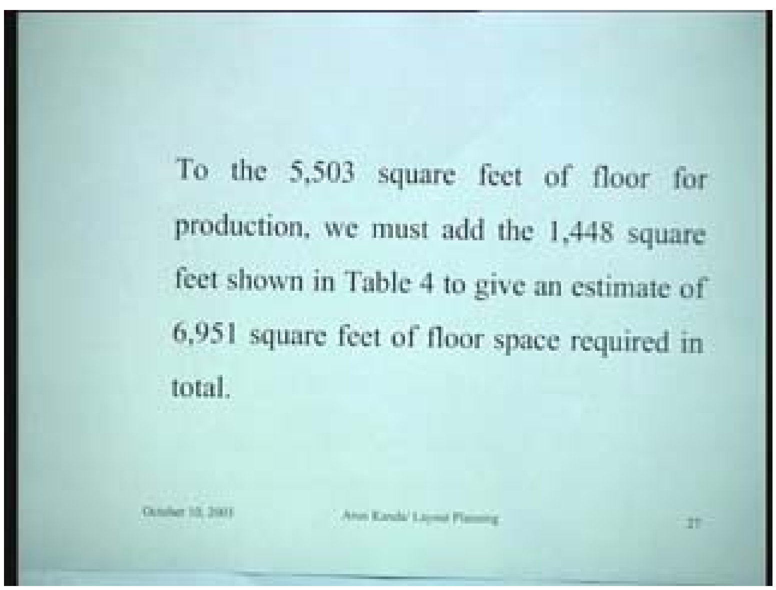

This is the activity involved in calculating the space from the production requirements and the non production requirements. What is then finally done is we have the activity relationship diagram. The activity relationship diagram of each department was shown as a square; this is called a space relationship diagram. We did the calculations for the space; each department is shown propositional to its size. This department has a size of so much.

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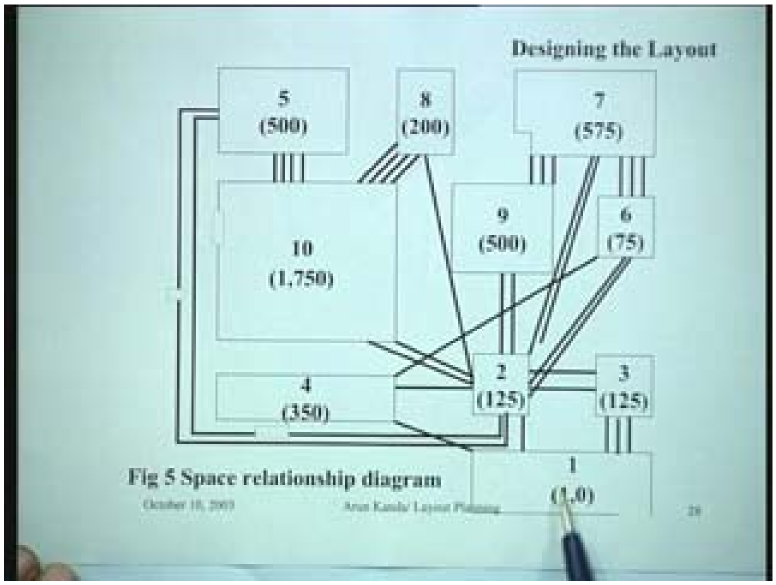

This department has a size of so much and so on. This was a bigger department and it has a size of 1750 and so on. You represent these departments in terms of sizes propositional to the areas. What is the problem now? If you can imagine that these individual blocks are cut out of card board with various things, you could shift them around and try to range them in the form of a layout and you could then ultimately get a layout. This is basically what may of the computer programs do. They begin with this diagram as an input and then by shuffling around these departments, generate a layout. Obviously there are infinite possible combinations. You have to look for a best combination and best means. What is your objective? The objective could be anything; generally the objective is a material handling effort. If you are using activity relationships, you are trying to maximize the material handling and other factors also. What you do is you can give some weightages to A E I O U X, some marks and ultimately develop a layout for those particular boxes.

Finally what we do is we can develop a plant layout by shuffling these departments. Ultimately this shuffling leads to what is called a block plan. So this is the block plan. We show department 1 should be here, 2, 3, 4, 5

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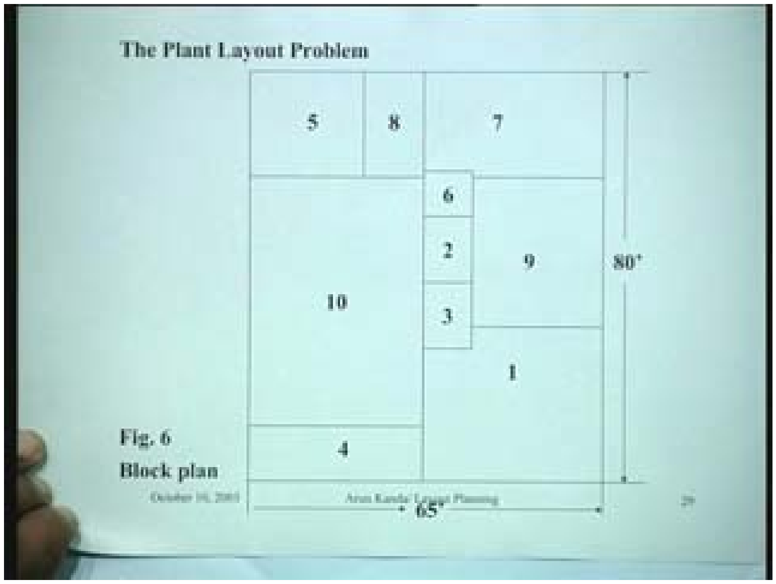

We actually solved the plant layout problem for this particular case by developing a block plant which looks like this. Finally when we look at what we have tried to do in this particular lecture, we have seen that the objectives in different types of layouts whether you talking about process layout, product layout or mixed layout or even cellular layouts, the objectives are different. Therefore the ways of handling these layouts are all different. Systematic layout planning is a systematic procedure for designing process layouts and basically we looked at this procedure in this particular class to identify how systematic layout planning can be done for process layouts.

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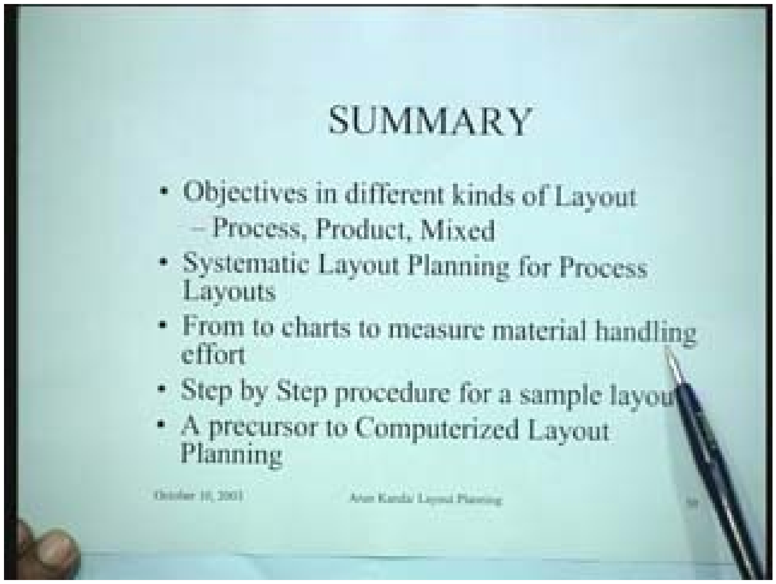

From-to charts measure material handling effort. A step by step procedure for a sample layout was done and the major advantage of this particular systematic layout planning procedure is that it is a precursor to computerized layout planning. Therefore in the next class we will try to look at some of the computerized layout planning procedures that are available for handling the layout planning problem course. This will constitute a basis for doing the exercise.

Thank you!