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A method of industrial plant layout and material flow analysis in AutoCAD

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A method of industrial plant layout
and
material flow analysis
in AutoCAD
by
David Paul Sly

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
Department: Industrial and Manufacturing Systems Engineering
Major: Industrial Engineering

Signatures have been redacted for privacy

Iowa State University

Ames, Iowa

1990

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INTRODUCTION

The Problem

In the methods for the analysis of manufacturing plant layout and material handling systems commonly used today, the production data (products, parts, and routings), the facility layout drawings, and other data and calculations are in separate software or paper embodiments. The time and effort to calculate useful results by conventional means is usually prohibitive. Hence the need for an unconventional software tool to make this process not only possible but also feasible for the average facilities planner. This thesis develops a micro-computer based program that is iterative, interactive, and integrates the graphics of a Computer Aided Drafting (CAD) system with the analysis of plant layout and material handling systems. This thesis also investigates the acceptance of the software program by industry.

Justification for Development of the Model

A recent review by Oriscoll and Sangi (14) of 56 Computer Aided Facilities Layout (CAFL) software packages from all over the world, stated that many first generation lineprinter-oriented layout programs are still used, but their ability to tackle real world problems is very limited.

Computer aided facilities layout programs like CRAFT, COFAD, PLANET, CORELAP, and ALDEP are only marginally successful at generating usable layouts, and are not used much by industry. Oriscoll and Sangi quoted the following paragraphs.

"Second generation software will have to deal with highly accurate layout geometries and to be capable of providing a range of design and evaluation models. Interactive working is essential under these circumstances. Design models will embrace both construction and improvement and evaluation models both technical and financial evaluation."

"Finally use will be increasingly made of proprietary software in support of CAFL programs. CAD packages are already well established and experimental work is under way in advanced modeling and decision support. Integrated CAD-CAFL facilities design systems appear particularly attractive as a way forward."

James Moore, (9) a leader in CAFL for many years, did a similar study in 1974, and many of these results were included in his report. The difference between the Moore report, and the Oriscoll and Sangi study is that Moore does not discuss the influence of CAD and Expert Systems. These two areas have progressed significantly over the past 12 years. A discussion with James Moore revealed that he is currently trying to adapt some of the deterministic algorithms he developed 15 years ago to the Autocad program.

The majority of facilities layout and design software evaluated by Oriscoll and Sangi attempted to simplify the many factors needed to consider a feasible layout. These factors included material handling costs/distances and qualitative layout elements (11) such as noise, safety, vibration and cleanliness. Once simplified, several mathematical and algorithmic models were applied to the data, and alternative layouts were generated by the computer for human evaluation. One factor that Oriscoll and Sangi did not study was whether or not if such a program were to be developed, would it be accepted and used by industry.

Procedures for Development of the Model

This thesis proposes that it is more effective to present the user with graphic and tabular information right on the actual plant layout drawings in the CAD system, and allow the user to evaluate several different alternatives interactively, while giving the facilities planner an instant feedback on the quality and magnitude of each change as it is made. Only through this method can all of the constraints of the previous software programs be lifted while at the same time, improving the quality of the layouts designed, including the documentation and justifications of those layouts, and reducing the time necessary to achieve these objectives. This thesis also proposes that if such a software program were written, that it would be accepted by industry as an ideal tool for analyzing plant layouts.

This thesis describes the development, and industrial acceptance testing, of the program FactoryFLOW, a microcomputer program written in a popular CAD system that meets the above criteria, and that is useful to both the typical and more advanced industrial facilities planner.

The need for an interactive CAD-based system that could calculate the material handling costs and distances within a factory appears obvious. To be effective, the system needs to allow the user to easily move workcenters or storage areas in a CAD drawing of their facility, or change production volumes, part routings, material handling systems or material handling paths, then easily recalculate the costs and material handling distances of that revised layout during the design process. Ideally, the actual CAD layout should be used to support rapid prototyping and the material handling cost should be represented graphically. The purpose of this system would be to allow the facilities planner to quickly and quantitatively evaluate a set of layouts based on material flow, and to create a set of

graphical diagrams and reports that would allow for easy and informative presentations to management.

Once the user enters the appropriate data, the program should calculate the total material handling cost and the total travel distance, generate the Product Flow Diagram, the Composite Flow Diagram, the Distance-Intensity Chart, and the Product-Quantity Chart, the Material Handling Report, and the Material Handling Equipment Utilization Report.

In addition to analyzing material handling and workcenter, storage locations, the program should compute operator/machine/workcenter utilizations. The analysis should show the user the effect of routing and layout changes on the work load of all of the machines, workcenters, and operators included.

LITERATURE REVIEW

Concepts of Facilities Planning

To properly design and use the proposed software program requires an in-depth knowledge of Facilities Planning, especially with respect to material handling analysis techniques.

The main objectives in facilities planning, according to Tompkins and White (19), are to effectively utilize people, equipment, space, and energy at a minimal capital investment while remaining flexible, safe and clean.

Facilities planning can be categorized into five distinct components; Layout, Handling, Communications, Utilities and Buildings (12):

Layout Layout involves the location of areas and departments within the boundaries of the facility. These boundaries may include the building, the plot of land, the town, state country or even the planet earth. The goal of this component is to lay out the facility to ensure that those areas that should be close to one another are, and those that should not be near each other are not. This method is often referred to as "relationship planning", "Affinity analysis," "Stacking and Blocking," or "AEIOUX" diagramming (11).

The input data for this type of analysis is purely qualitative. There need be no hard numbers representing the importance of the area relationships, only that those relationships are strong together, strong apart, or anything in-between. Typical qualitative relationship criteria are safety, communications, utility availability, floor strength, access to windows, doors and docks, air quality, and noise (11). Often, quantitative criteria such as material handling distances and costs are also represented in this type of analysis.

Handling Handling is the component of plant layout concerned with moving the products through their various production stages in, through, and out of the facility in the most efficient manner possible. In an industrial facility, material flow is one of the main constraints used to guide the layout (10).

The two main variables in handling analysis are the distances and intensities of material flow. Distances refer to the actual or approximate distance between the two areas over which a material move occurs. Intensities refer to the number of trips that are taken over that distance per unit time. Minimizing material flow requires computing the distances and intensities of all moves within the area to be studied and finding ways to eliminate the moves or decrease the cost associated with the move by reducing the move distance or intensity or both. The best way to visualize move distance and intensity is by means of product flow diagrams that show the actual path of material handling movement with a variable thickness line whose width corresponds to the cost of the move, and distance intensity charts that show an XY plot of the move distances versus the move costs (10).

Communications Communications is typically the main component in office layouts but is a secondary one in industrial layouts; nonetheless, it is still important. In industrial facilities, improved communications are arrived at by placing workcenters close enough together to allow the manufacturing process to balance the production line and schedule jobs automatically. If sequential production processes are located next to one another, then the shop floor personnel can quickly determine if there is a problem or backlog before or after their workstation. With this information they will then be able to respond quickly to get the line back on schedule.

Utilities and Building Utilities and Building components are the utility supply lines and physical shell of a facility. Facilities planners have been using CAD for some time to improve utilities and building design.

A good facility layout and design will include an analysis of all five main components (12). It is not sufficient to just look at area relationships, or material handling costs and distances. The area under design must not be designed separate from the environment in which it must function. It may be true that material handling is the main component to drive the new layout, but improvements to other components may add to a much greater overall savings and productivity improvement than material handling costs alone, and these must be considered in the design and planning stage.

Typical criteria for evaluating a new layout are communication between successive workcenters, amount of backtracking, amount of aisle and intersection congestion, utilization of group technology cells to eliminate external material handling, and reduced work in process (WIP).

Concepts of Material Handling Analysis

This thesis is concerned with plant layout using the main criteria (constraint) of industrial plant layout, the material handling distances and costs. Material handling costs are typically the main component that drives the justification of the layout, and the layout is a large component in the design of material handling systems.

In order to design a software program to improve the analysis of a particular system, it is necessary to break the process of analysis into a set of procedures. The

following is a systematic method for conducting a material handling analysis and plant layout study (10):

Collect the Products, Quantities, Routings, Services, and Timing information

This step involves the collection of information on the types and quantities of materials moved per unit time, as well as where these materials are routed.

Classify the materials This step is concerned with classifying, the type of containers required to transport the materials, and special handling requirements for those materials which are abnormally fragile or dangerous. This step will require the user of the program to input the necessary information.

Develop a layout plan in which to analyze the moves In this stage, the user is required to draw the initial existing or proposed facility. In order to improve a plant layout, a layout must first exist to improve upon.

Analyze the moves This stage is where the distances, intensities, and routings of the materials are computed. Compute the time necessary to travel between workcenters and add the time for all of the necessary loads and unloads, this will result in the total move time. Add all the move times for a device and the time spent by the material handling device travelling empty to get to workcenters, to find the total busy time. The material handling device's available time divided by its busy time equals its utilization.

Visualize the moves This stage involves the conversion of the numerical results computed in stage 3 into a graphic format that the user can easily and quickly interpret. It is at this step that Product Flow Diagrams, Composite Flow Diagrams, Distance Intensity Charts, and Product Quantity Charts are produced at the users request.

Product Flow Diagrams are pictures of the layout over which variable width lines representing intensity/cost and direction of flow for a particular material move are laid. Each line represents a path over which a particular type of material will travel. Typically these lines are drawn straight between the workcenters, or rectilinearly taking horizontal and vertical moves only between the workcenters. A third, and more detailed method of specifying these lines, is to draw them over the actual path that the material handling device would take to get between the two workcenters. The purpose of the product flow diagrams is to show "what" materials are being transported "where", over "which" path and at "what" intensity or cost. Figure 3.2 on page 30 shows an example of a product flow diagram.

Composite Flow Diagrams are pictures of the layout over which variable width lines representing total intensity/cost for all materials moving between a particular set of workcenters are laid. The fundamental difference between composite flow lines and product flow lines, is that the composite flow lines are the summation of all material's moves between a particular set of workcenters. This diagram allows the viewer to look at the interrelationships of workcenters based on material flow. This diagram usually consists of far fewer flow paths and is thus much easier to use when making layout decisions. Figure 3.3 on page 30 shows an example of a composite flow diagram.

Distance Intensity Charts are X-Y plots of all material moves being studied, with the distance of travel plotted on the independent X axis, and the intensity of material travel plotted on the dependent Y axis. This graph allows the user to categorize moves into classes from which proper material handling devices can be selected. This graph also allows the user to pinpoint moves resulting from poor layout. An example of a distance intensity chart is shown in the Figure 3.4 on page

32. Preceding the diagram is a small report to show what the program tells the user when one of the X-points is queried.

Product Quantity Charts are bar charts of all products being produced, and their respective quantities in the area under study. The product quantity charts are printed with high quantity products on the left in a decreasing, according to quantity, fashion to the right. It is the purpose of the product quantity chart to help the viewer categorize products being produced into product flow, group technology, and process layouts. An example of a product quantity plot can be seen in Figure 3.6 on page 33.

Develop potential solutions At this stage the user combines their knowledge of material handling and plant layout with the visual and numerical information presented to them by the program. A myriad of possible layout alternatives are present, and the user systematically tries what appears to be the most viable solutions by trying many different layout combinations and selecting only the best for review as preliminary plans

Preliminary plans At this stage the user organizes the various alternative layout and material handling plans into a series of reports that can be easily reviewed and compared. With proper design, the software program will be able to prepare these reports as a natural result of the analysis. This is simplified by being completely conducted in one CAD system based program. Since most of these reports will be presented to management, they will need to be very graphic in nature, illustrating how the proposals affect the layout, material flow, and material handling costs.

Evaluation and comparison of alternative plans Alternative plans will have to be modified and worked into implementable solutions. At this stage all things are

considered with respect to the layout and qualitative criterion. Often modified plans will have to be reanalyzed and represented for final approval. This should be quick and easy to do with the program.

Relevant Software

Now that the concepts of facilities planning and material handling analysis have been presented it is important to review previous facilities planning and material handling analysis software programs. As was reported by Oriscoll and Sangi (14), there have been at least 56 software programs that fit into this classification. It is not the purpose of this thesis to do another review of all available facilities layout programs but to present only those that relate to the development of the model.

There are two categories of facilities layout software; improvement and construction. Improvement software requires an existing layout, and then suggests potential rearrangements within that layout. In this category, some workcenters can be fixed, as is typically the case in an existing facility, and mobile workcenters are arranged around the fixed equipment within the boundaries of the facility. Construction software assumes that there is no existing layout, and will arrange all workcenters in what appears to be the best layout. Typically software that fit into these two categories will accept either qualitative or quantitative input from the user, representing the relationship of the workcenters.

An example of a quantitative system is one which attempts to minimize material handling costs between workcenters. In this situation workcenters with high material handling costs are placed close together and those with low costs tend to be further apart. The problem with these algorithms is that they are unable to

take into account qualitative factors such as noise, safety, pollutants or vibration. A software program with qualitative inputs requires the user to subjectively determine the intensity of the relationship of two workcenters. This relationship may involve many factors including the cost of material handling. Typical qualitative programs require the user to enter a number within a range that approximates the relationship between two respective workcenters, relative to all other workcenter interrelationships. A more popular method of specifying qualitative workcenter relationships is via a relationship matrix using the A, E, I, O, U, X, XX scale developed by Richard Muther (11). The examination of software packages that follow in this literature review will classify each CAFL package according to construction/improvement and qualitative/quantitative inputs. The following discussions will be organized as follows:

1) Foundation software in facilities planning

These consist of the five foundation programs developed in the late sixties and early seventies.

2) Precedence software to this thesis

These consist of the two programs developed in succession at Iowa State University that truly are the foundation and inspiration for the development of the model.

3) Current generation CAFL programs

These consist of the most popular programs available, and in use today, for industrial facilities layout and planning.

Foundation software in facilities planning

CORELAP CORELAP (18) (COmputerized RELationship LAYout Planning) is a qualitative-construction type program that constructs a layout for a facility by calculating the total closeness rating (TCR) for each department where the TCR is the sum of the numerical values assigned to the closeness relationships. CORELAP selects the first department to enter into the layout and breaks ties with the total closeness rating. The TCR uses an (A, E, I, O, U, X) chart by assigning numerical values to each of the letters. The values are user defined, with A being the largest number, U being close to zero, and X typically being negative. CORELAP continues to bring in new departments to place by selecting a department with the highest relationship, compared to all unplaced departments, to an already placed department. When a department is selected for placement, it is temporarily placed and scored in all possible positions next to the placed department that it has the highest relationship to. When the best location is found the department is placed. When all departments have been placed, CORELAP computes a layout score which is the sum of all the numerical values of the closeness ratings multiplied by the distance of the shortest path between the nearest boundaries of the respective workcenters. CORELAP gives no regard to the actual building shape, or the actual shape of the workcenters, so alternative CORELAP layouts must be rearranged to fit the available space.

ALDEP/OPDEP ALDEP/OPDEP (18)(13) (Automated Layout and DEsign Program/Optimal Plant layout and DEsign Program) are two very similar programs. For the sake of simplicity they will be referred to as ALDEP only for the remainder of this review. ALDEP is a qualitative-improvement layout program that

was originally written in the late sixties by IBM. Al Nelson in his masters program at ISU in the late seventies greatly improved Its efficiency and layout quality. This new program was then called OPDEP.

Where CORELAP attempts to find the best layout, ALDEP generates many layouts, scoring each and printing the highest scored layouts for the users review. ALDEP selects departments to be placed as CORELAP does, however, instead of placing departments from the center of the facility and working outwards, ALDEP starts in the upper left corner of the facility and serpentine through the facility with a user specified swath width called the sweep width.

PLANET PLANET (18) (Plant Layout Analysis and Evaluation Technique) is a combination qualitative/quantitative-improvement layout program. PLANET allows for three alternative methods of specifying material flow data.

The first method is to specify the production sequence by department for each part to be handled within the facility. PLANET also requires the user to enter a cost per move per 100ft that the program uses to construct a from-to-chart that it uses to display a flow-between-chart which it uses in its construction algorithm.

The second method is by inputting material flow from a from-to chart directly, and as was done in the first method, PLANET will create a flow between chart for its construction algorithm.

The last method allows the user to enter data in the form of a penalty matrix. The matrix is used to indicate relative move frequencies and or costs. PLANET will then convert this penalty matrix into the flow between chart.

PLANET requires the user to assign a priority number between 1 and 9 to all departments to be placed. A 9 priority is the highest. PLANET then uses three methods for selecting the order of placement of the departments. PLANET uses

the typical relationship (A, E, I, O, U, X) matrix. Like CORELAP, PLANET gives no regard to the actual building shape, or the actual shape of the workcenters, so alternative PLANET layouts must be rearranged to fit the available space.

CRAFT CRAFT (18) (Computerized Relative Allocation of Facilities Technique) is the first computer aided layout package, and is a quantitative-improvement layout program. CRAFT attempts to develop a layout that minimizes transportation cost, where transportation cost is defined as the product of flows, distances, and unit distance travel costs. Distances used are rectilinear, and these distances are taken from the workcenter centroids. The method used by CRAFT is very similar to what is planned by FactoryFLOW with the exception that CRAFT assumes that move costs are independent of the utilization of the equipment, and that move costs are linearly related to the length of the move. Both of these assumptions will be overcome by the model.

CRAFT develops a final layout by following a path of improvement from the initial layout through several iterations to the final layout, the final layout obtained is dependent on the initial layout. Similar sized workcenters are swapped in a pairwise or three-way interchange. CRAFT will arrange workcenters to fit a building shape, but the building shape must be rectangular, and the input departments must fill all of the available space. If there are not enough departments to fill the space, dummy departments must be inserted. Recently an updated version of this program has been released and is called MOCRAFT (17). This program is a port of the CRAFT program to the PC with some improvements to the department interchange routines and user interface. This program as well as another PC version of CRAFT called MicroCRAFT is reviewed later in this chapter.

COFAD COFAD (18) (COmputerized FAcilities Design) is another quantitative-improvement layout program, and is a modification of CRAFT. COFAD adds the capability to vary the move costs for a variety of material handling equipment alternatives. This model is able to jointly consider both the layout and the material handling system. COFAD attempts to adjust the loading on the material handling equipment which adjusts its utilization. With this set of iterations, the program can apportion the fixed costs of the smallest number of equipment arriving at what appears to be the best device loading configuration. FactoryFLOW will be designed around the move cost equation of COFAD since both the fixed cost and variable costs of each class of material handling equipment is used to determine the overall move cost of the layout. COFAD does not allow the evaluation of varying production volumes or product mixes, however an update to the original COFAD program called COFAD-F does allow for these variables.

Precedence software to this thesis

FLAG FLAG (2) (Facilities Layout and Analysis using Graphics) is a heuristic/quantitative technique that was developed in 1980 by Ronald Ketcham. FLAG is the first known attempt to compute travel distances and score layouts from within a CAD system. Since no programmable CAD systems were available during the development of FLAG, one was written using the IGL (Interactive Graphics Library) for the VAX 11/780. FLAG requires the user to enter the routings for various products or parts in the facility, along with fixed move costs per foot. FLAG will then compute the move cost for the facility, and allow the user to move workcenters around to attempt to decrease the overall move cost of the facility. The shortcomings of FLAG are that the graphics environment is very poor by today's

standards of CAD systems, the user interface for product and part routings is not adequate for industrial use, and a fixed move cost for an entire routing is not realistic, and very misleading to the user.

LEVA LEVA (3) (Layout and Evaluation using Autocad) is a heuristic/quantitative technique that allows the user to move workcenters from within the CAD system, Autocad in this case, and get an instant recalculation on material handling costs. LEVA is identical to FLAG except that the user interface has been improved, and that an actual CAD system is used for the graphics interface. An advantage of LEVA over FLAG, is that the user can specify the actual material handling path for any given distance between departments. LEVA allows for the simultaneous analysis of multiple products and subassemblies, heterogeneous production.

Like FLAG, LEVA requires the facilities planner to design the initial layout, and all movements are fully heuristic. No linear algorithms are used in determining best layout based on material handling costs between workcenters. This constraint makes it necessary to use one of the linear algorithms to solve an initial best fit layout. LEVA still uses fixed move costs to compute the travel cost, and this is perhaps its greatest limitation. In addition LEVA did not develop any material flow diagrams, all distances between workcenters were computed with the straight line euclidean method, and the user interface was still too poor for industrial use.

Current generation CAFL programs

Spaceplan Spaceplan (16) is a space planning and affinity relationship (AEIOUX) diagramming program developed for the Computervision CADD5 4X CAD system. Spaceplan was developed jointly between Computervision, the

Leawood Group and Invotek Inc. Spaceplan takes routing, relationship and intensity information from the user, and combines this with the actual CAD layout of the facility. Once integrated, Spaceplan develops space requirements, and allows the user to do space requirement forecasting. The layout analysis portion of the program combines material flow, and subjective relationships to interactively allow the user to manipulate block simplifications of the layout and arrive at an improved layout score. The exact technique used by Spaceplan is confidential, however, because of its authors close relationship to the developers of the CORELAP program, it is thought to be very similar to CORELAP. This package can do both blocking (layout of areas on a floor) and stacking (layout of areas between floors). SPACEPLAN is currently marketed by Computervision and the Leawood Group for around \$50,000 a copy including a Computervision workstation.

SPACE SPACE (15) is a combination construction/improvement - qualitative program developed and marketed by Graphic Systems, Inc. SPACE is a PC based software program for single and multi-floor layout. The program allows the user to define the outline of each floor as well as blocking out spaces where no areas can be placed. Both the floor outlines and blocked out spaces can be specified in the VersaCADS, Arris and AutoCAD CAD systems. This interface is very weak however, because it only allows for the importation of straight lines on one layer. No arcs, furniture, machines or any other objects can be imported. SPACE allows the user to project space increases and decreases over 5 successive time periods. SPACE will develop layouts based on the activity relationships, and allow the user to interact with these layouts and score different alternatives. SPACE scores layouts graphically by changing the color of activity areas based on how well the

relationships to that area have been satisfied. SPACE is currently being offered for sale at \$895.00 per copy.

CADG-FM CADG-FM (7)(8) Space planning system. This package is a combination construction/improvement - qualitative program developed and marketed by the Computer Aided Design Group. This package is unique in that it first lays out the facility using a construction routine similar in concept to CORELAP and then goes through and attempts to improve the layout just generated with an improvement routine. CADGFM locates areas where space permits, and allows the user to interact with the process by allowing areas to be shrunk, or available space expanded when a department needs to be placed in an area (zone) where there is not enough room. The input from the user is the relationships of all areas between floors and on the same floor. The user also defines zones which are spaces where areas may be placed, and allows the user to define which areas cannot or should not be placed in these spaces. The space program is sold as a module for under \$10,000, and works both on mainframes and PC computers.

Blockplan Blockplan (2) is a nongraphic qualitative/quantitative-construction program that combines material handling information with relationship information. Blockplan was written by C. E. Donaghey, a professor in the Industrial Engineering Department at the University of Houston in Houston TX. Blockplan is being sold for \$25 through the Alpha Pi Mu chapter there. This program requires the user to enter AEIOUX relationship scores along with department areas and XY centroid locations. The user also enters part routing sequences and material flow intensities. This program then computes the total travel distances and relationship scores of various layouts that it creates, or that the user creates/edits. These two

scores are also combined into what Blockplan calls a REL-DIST score in an effort to provide a common comparison value of the combined qualitative / quantitative relationships.

MicroCRAFT MicroCRAFT (5) is a scaled down version of the mainframe CRAFT and is available on the microcomputer in the BASIC programming language. This program is currently being marketed by the Institute of Industrial Engineers. This software program has marginal capabilities for the typical facilities planner as it simply creates from-to charts from from-to information, and allows the user to generate ASCII text representations of a simplified facility designed via a simplified version of the CRAFT algorithm.

MOCRAFT MOCRAFT (17) is a PC based update to the CRAFT program developed at Cleveland State University. MOCRAFT is an improvement upon CRAFT in that it utilizes a graphical and window based user interface with integrated help facility. MOCRAFT also incorporates a pairwise departmental interchange algorithm similar to the Biased Sampling algorithm developed in HC63-66 (4), as well as a relationship based scoring algorithm. The relationship algorithm uses the product of the activity area distances and a user specified numerical weight for the relationship score. MOCRAFT allows the user to score material flow distances and costs as does CRAFT, and weight these with the relationship values as does Blockplan. The author of MOCRAFT currently is using FactoryCAD and FactoryFLOW, and is working to incorporate his routines into those programs.

CAD Software

According to a recent Daratech survey, there are over 120 different commercially available CAD systems on the market today. After reviewing several

CAD systems that were considered applicable to a facilities drawing environment, and then selecting those that offered the degree of programmability needed for this project, and worked on a micro computer, the obvious choice became AutoCAD by AutoDESK, Inc.

AutoCAD

AutoCAD (1) is a fully programmable CAD system for the microcomputer, and is the CAD system with the largest sales in the world. Over 350,000 copies have been sold as of the date of this thesis. AutoCAD is installed on over 60% of all CAD systems in use in the world today. AutoCAD offers 5 different programming alternatives, each with their own special capabilities.

The two most powerful programming methods are LISP and the SHELL. The LISP language called "AutoLISP" is a very full implementation of the LISP language developed at MIT by McCarthy in the 1950's. The SHELL is a way for AutoCAD programs to access other programs written in languages at the operating system level. Common languages used at the operating system level are Fortran, Pascal, Basic and C. AutoCAD is a 2-D/3-D program that currently has 4 CAFL programs available for the office environment.

AutoCAD is the best environment available for manufacturing facilities layout and design because of its superior 2-D user interface, data interchange capability, and virtually infinite drawing size capacity. AutoCAD was chosen as the graphics environment for this thesis because of the previous reasons.

Market Research on Facilities Planning

Market research in facilities planning is needed to determine how many people must use the model before it can be considered as accepted by industry.

U.S. Labor statistics estimate that there are 200,000 Industrial Engineers and 300,000 Mechanical Engineers in practice. Unfortunately these statistics do not reflect how many of these engineers work in the area of facilities planning, or how many nonengineers are working in this field as well. The Institute of Industrial Engineers had 38,863 members as of February 1990. Of these 38,863 members, 2,775 of them say that facilities planning is their primary job function. If the percentage of industrial engineers working in facilities planning that belong to Industrial Engineering magazine could be compared to the total number of Industrial Engineers in the work force, then it could be estimated that 14,000 Industrial Engineers perform facilities planning functions as their primary or secondary job function in the United States. These figures do not include the number of mechanical engineers or the number of nonengineers working in facilities planning. Since no statistics on nonindustrial engineers working in facilities planning, it can only be said that there are at least 14,000 people working in the field of industrial facilities planning in the United States. It should be noted that there may be many facilities planners working in the fields of architecture and interior design, however none of these would need to analyze material flow, so they are not included in these figures.

Professionals who work in the field of material handling engineering are also potential users of the model. There are two main publications for those interested in material handling. These publications are "Material Handling Engineering" and "Modern Materials Handling". Both magazines have a monthly circulation of around 100,000 copies. It is not known how many subscribers subscribe to both magazines. It is known that the majority of readers are interested in

containerization and identification of materials, so they would not be potential users of the model.

It is the impression of the author, that if more than 1,000 copies of this model are in use by the end of 1 year, with aggressive sales and marketing activities, that this model will be considered as accepted by industry.

DEVELOPMENT OF THE MODEL

Requirements for Development of the Model

The objectives of the model are to design, implement and test a software package that can evaluate actual industrial plant layouts using material handling costs and distances as a main factor. This program must be capable of providing the user with the numerical and visual information necessary to make layout and material handling decisions to improve the layout. The program must allow the user to iteratively try several alternatives, and provide the user with new visual and numerical information, as well as compare this information to the previous layout to determine the magnitude and direction of that user's changes. This system must be able to work within a popular commercially successful CAD system, and use an existing plant layout without much if any modification required for analysis.

Since many facilities design projects can involve alterations in the processing and routing of products, the program must also be capable of computing the utilizations of the workcenters in the analysis. This capability is needed to determine loading requirements in order to give the user an aid to improve load balancing where routing changes may affect the balance of loads.

The methodology of this model is to develop a quantitative layout scoring technique, that could be implemented on a computer, and provide the user with instant numerical and visual feedback on the overall value of the layout, and the last change to the layout.

The goal of this thesis is not just to write another software program for facilities layout, but to develop a systematic environment whereby a user may experiment with facility layouts. The user is defined as anyone that is assigned the task of creating, modifying and or improving an actual industrial facilities layout.

The user most typically will be an industrial engineer, or technician with at least some training in facilities layout and design, however, this should not be a requirement for use of the model. The term actual industrial facilities layout refers to real facilities in actual industrial plants. This is not strictly an academic exercise designed to explore the technical merits of quantitative layout scoring, but also an exercise in the definition of a human-computer interface whereby such an activity can take place in actual organizations. A popular example of an ingenious human-computer interface is the PC-spreadsheet such as the software products Lotus and Visi-Calc. These programs pioneered how business and technical people can use a personal computer to help them solve mathematical and financial problems. These programs were the foundation for the words iterative and interactive, and user friendly. It is thus an important component in this thesis to test the acceptance of the proposed model in actual facilities around the world.

For this thesis to be successful, it must not only exist in the halls of academia, but must be in daily use at many successful corporations of all sizes all over the world. Only in that environment can the true test of a successful human-computer interface designed for quantitative evaluation of industrial layouts be performed.

Input and Output of the Model

Based on the requirements for undergoing a plant layout and material handling analysis study described in the literature review, there are several inputs and outputs that the program must be capable of receiving and reporting.

Inputs

The program must be capable of prompting the user for Products, Quantities, Routings, Services, and Timing information pertaining to the area of study. Based

on the requirements for an efficient user interface this information must be prompted for in colorful pop-up windows that allow for full screen editing and data input formatting. The pop-up menus need to be organized so that the user is able to move into and out of the product structure in a logical manner. The information required will be held in the following three files:

- 1) The PRODUCT file will contain:
 - a) product names
 - b) production quantities of products
 - c) color for representation of each product

- 2) The PART file will contain:
 - a) part names required in each product located in windows under each product.
 - b) quantities of each part required per product
 - c) routings of the parts through the facility
 - d) material handling devices used for every path in the routings
 - e) bulk factors describing how many parts fit on each load of the material handling device for every path (route)
 - f) setup times, machining times, lot sizes and scrap rates for the machining and assembly of all parts (should be optional)

- 3) The Material handling equipment file will contain:
 - a) a user assigned material handling device (system) name
 - b) a class of material handling equipment that this particular material handling device fits in (i.e., Fork Truck, Conveyor, Hand Truck, etc.). Required to tell the program what formulas should be used to compute the move cost.
 - c) number of like devices available in the area (parallel servers).
 - d) the sum of the power and maintenance variable costs in dollars per hour.
 - e) the variable labor cost in dollars per hour
 - f) the yearly lease/depreciation fixed cost of each piece of equipment
 - g) the number of minutes per shift that the device is available for service. Used to compute the utilization of the device.
 - h) the effectiveness (percent of time device is travelling with a load versus total travel time) of each device in the system

This information should be stored in separate ASCII (American Standard Code for Information Interchange) data files in a space delimited fixed format. This type of format will allow for importation and exportation of these files to/from a spreadsheet or text processor.

As previously described, the user must provide the program with a layout, already created in the CAD system. Since AutoCAD will be used for this model, the user must have their layout drawn or input into AutoCAD. By using the AutoCAD CAD system, the user will also be able to input/output their drawings via IGES and/or DXF.

There must not be any major editing of the layout required, as that would defeat the purpose of working with the actual plant layouts, and would require a considerable amount of work on the users part to preformat data solely for the purpose of analysis.

Another element of data required for the analysis is the distance between workcenters. There are three different distances available; Actual Path, Rectilinear, and Euclidean. The user should select which distance they want to use, and the program will prompt the user for the Actual Path or compute the Rectilinear and Euclidean distances automatically from workcenter points that the user must specify. In the case where workcenter points and/or flow paths are specified from the user, they must be able to be saved to data files and recovered for later use. The user should never have to respecify anything during the operation of the program unless that situation has changed.

Once the data have been provided as specified in the previous two paragraphs, the remainder of the input must be in the form of menus that are logically arranged and displayed as alternatives are available. The user will interact with the program via these menus. A logical tree diagram of these menus is shown in Figure 3.1, on the following page.

FactoryFLOW Screen Menu Hierarchy

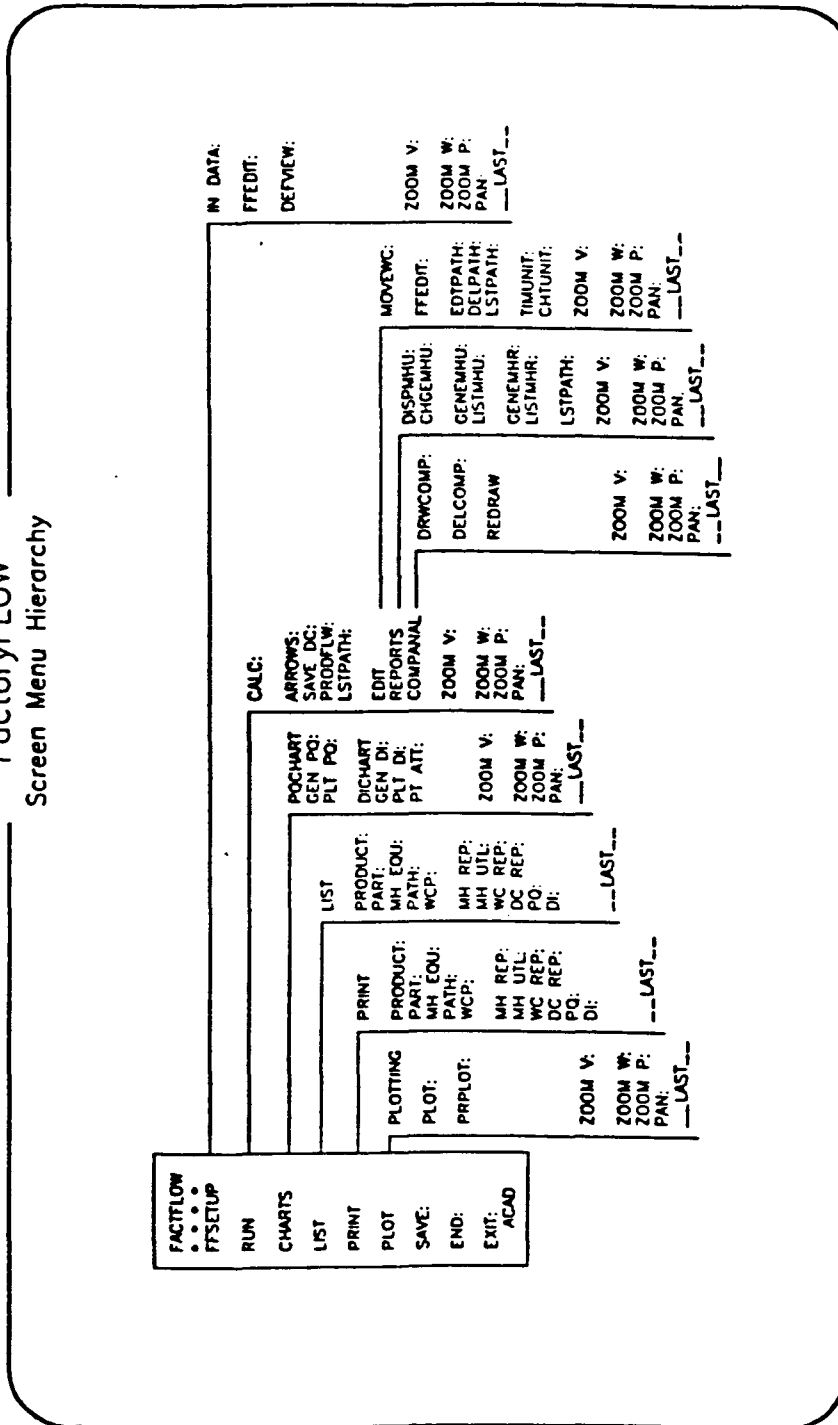


Figure 3.1. FactoryFLOW menu diagram

Output

The output of the model will be in the form of the standard charts, diagrams and reports that would be normally used for a manual material handling analysis or plant layout project. The graphical output will consist of a product flow diagram, composite flow diagram, distance intensity chart, and product quantity chart. All graphics will be created within, and displayed on, the AutoCAD CAD system. This will allow for manual editing of the diagrams when necessary, and the availability to plot and print to several different output devices.

The Product Flow Diagram should show the path, direction and relative cost/intensity of each individual move path directly on the plant drawing. Every product's paths should be organized on individual layers with names equal to the product names. Each unique product layer should also be given its own color that can be assigned by the user. The thickness of the path should correspond to the cost per foot of the device that is travelling along the path. This will also enable the user to assign a strictly variable cost to the device, and have the intensity of the path dictate its thickness. Thus with one algorithm the program will be able to generate either cost or intensity flow paths. A sample of what this diagram should look like is shown in Figure 3.2 on the following page.

The Composite Flow Diagram represents the combined cost of all moves between their respective workcenters. The composite flow path should always be drawn in a euclidean fashion, so it will resemble a relationship diagram and be easy to read. The purpose of this diagram will be to allow the user to easily determine the cost/intensity relationships of the workcenters irrespective of the products or their actual paths. The thickness of the composite flow lines should also be the additive cost per foot of all moves between those workcenters.

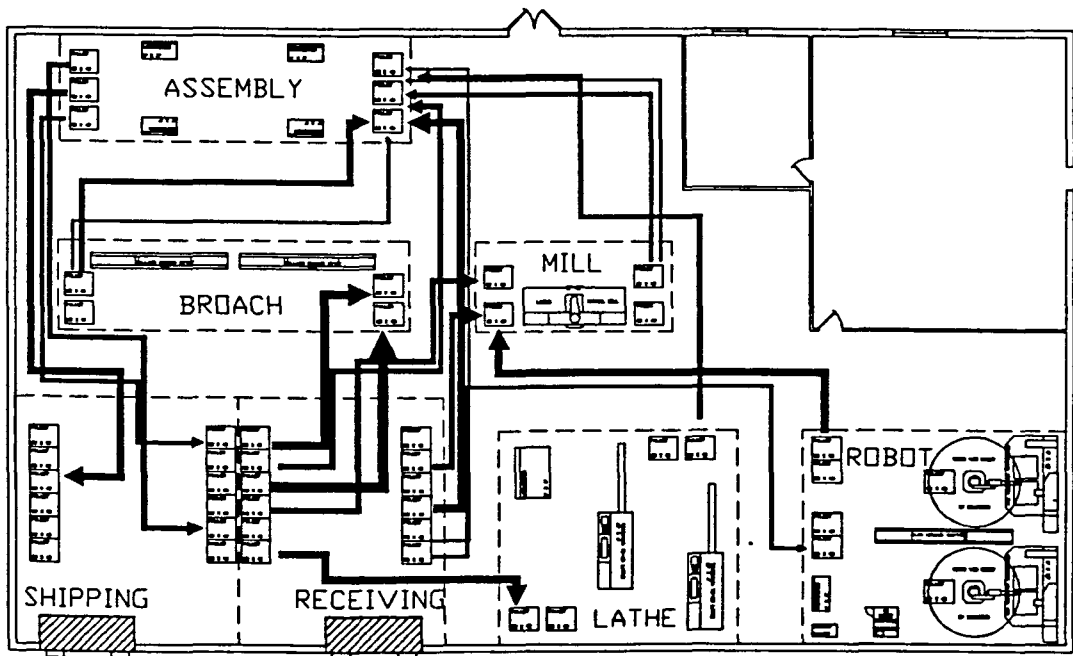


Figure 3.2. Product flow diagram

A sample of a composite flow diagram is shown below.

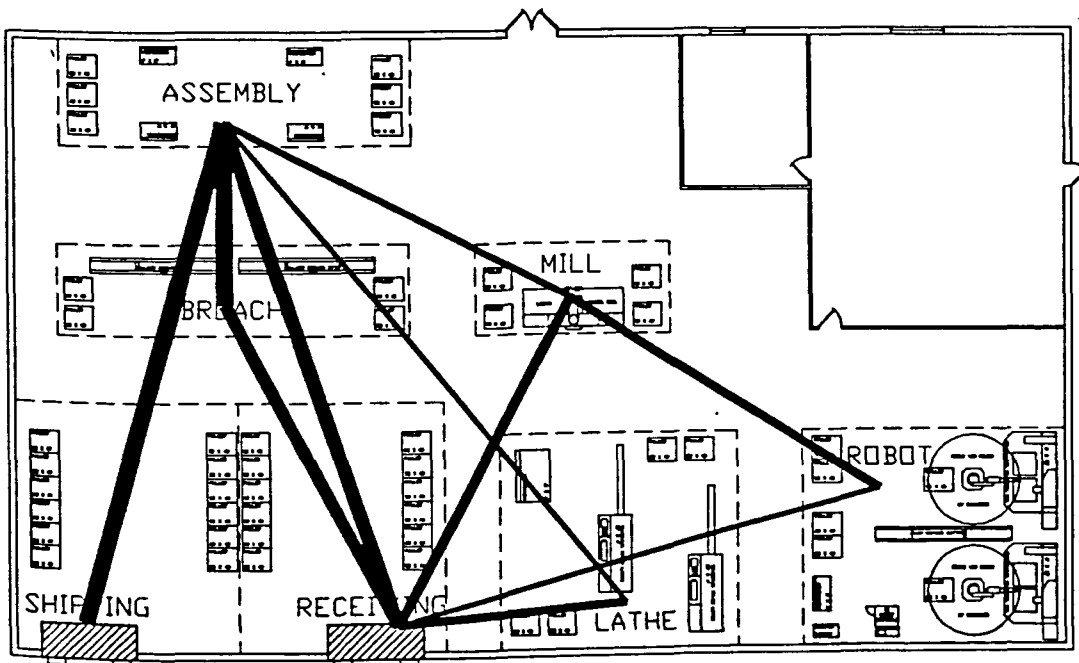


Figure 3.3. Composite flow diagram

The Distance Intensity Chart is an XY plot of all of the individual moves in the layout. The X-axis will be the distance of those moves and the y axis will correspond to the intensity of the moves. An X-point will mark a move's location on the chart, and the color of this X-point will correspond to the color of the move path in the product flow diagram. Each X-point will be intelligent, in that it will have associated to it the product name, part name, from cell, and to cell that it corresponds to. In addition, that path's material handling device, its move intensity, and its move distance will be associated to the X-point. A command called ATTPT will allow the user to point to any X-point on the chart and obtain its attribute information. An example of an X-point information query is shown in Figure 3.4 below, and a Distance Intensity Chart is shown in Figure 3.5 on the following page.

```
Product: PROD3
Part: PART33
From Work Center: RECEIVING
To Work Center: ASSEMBLY
Material Handling Device: MH1

Distance (ft): 64.35
Intensity: 3000.00
```

Figure 3.4. Distance intensity chart query

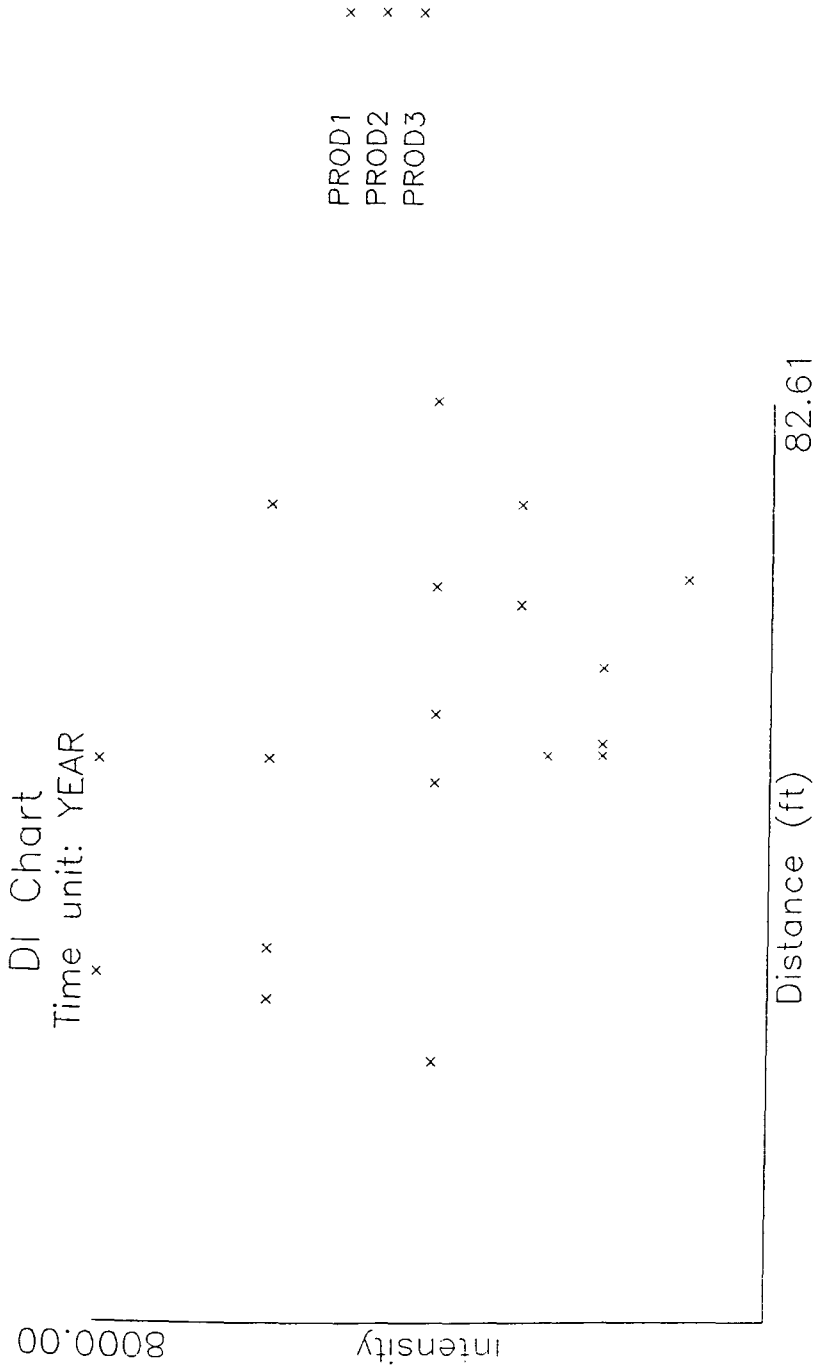


Figure 3.5. Distance intensity chart

The Product Quantity Chart is a bar chart that shows all of the products being analyzed with the highest quantity produced on the left successively down to the lowest quantity produced on the right. Obviously the X axis contains all of the products produced from fast movers to slow movers, and the Y axis contains the quantities of the products from zero on up. This chart is used to determine what manufacturing layout philosophy (i.e., product, group technology, or process) should be used for which products. A sample product quantity chart follows in Figure 3.6.

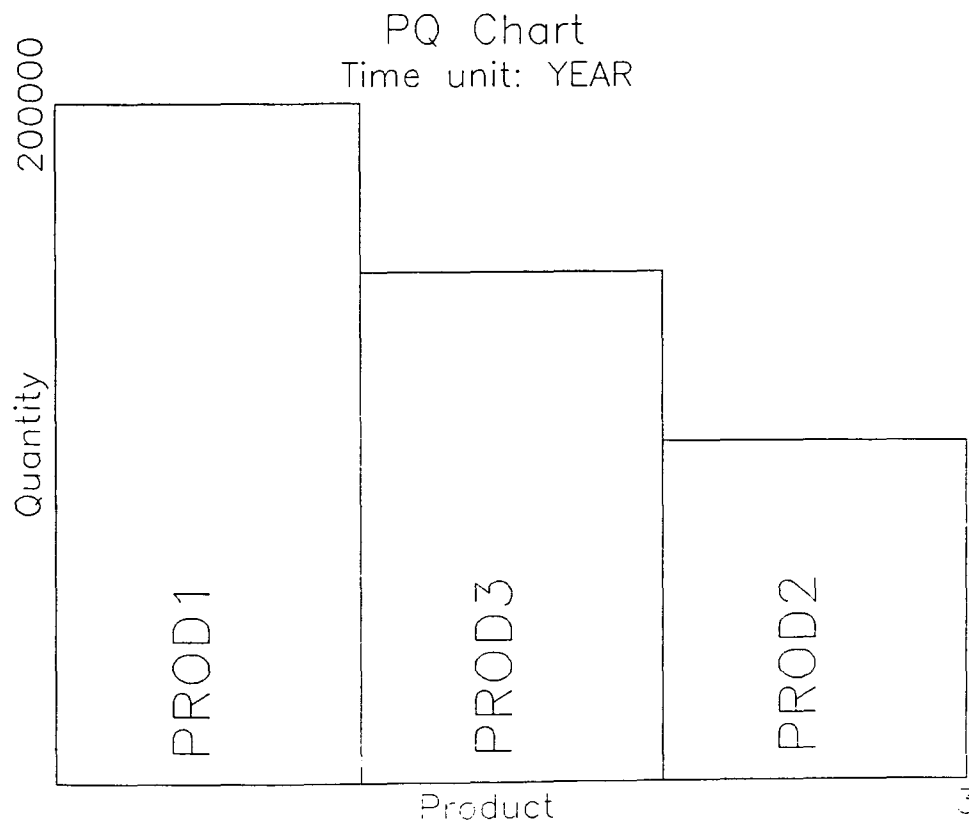


Figure 3.6. Product quantity chart

The reports and displayed results that will be available to the user will be the material handling report, material handling equipment utilization report, and a workcenter utilization report. Examples of what these reports should look like, and what they should contain is shown in Figures 3.7, 3.8, and 3.9 on the following pages.

COMPANY NAME: CIMTECHNOLOGIES
 PROJECT NAME: TUTORIAL
 DATE: 03/14/1990
 TIME: 13:41

MATERIAL HANDLING REPORT

By Workcenters

Time unit: YEAR

	Distance	Cost
Between RECEIVING and ROBOT	63 Mi.	\$ 1,183
Between RECEIVING and BROACH	134 Mi.	\$ 3,487
Between RECEIVING and MILL	64 Mi.	\$ 2,829
Between ROBOT and MILL	126 Mi.	\$ 2,376
Between RECEIVING and ASSEMBLY	121 Mi.	\$ 5,832
Between BROACH and ASSEMBLY	129 Mi.	\$ 2,394
Between MILL and ASSEMBLY	93 Mi.	\$ 1,770
Between ASSEMBLY and SHIPPING	153 Mi.	\$ 6,734
Between RECEIVING and LATHE	63 Mi.	\$ 1,541
Between LATHE and ASSEMBLY	139 Mi.	\$ 2,120
Grand Total	1,084 Mi.	\$ 30,266

Figure 3.7. Material handling report

COMPANY NAME: CIMTECHNOLOGIES
PROJECT NAME: TUTORIAL
DATE: 11/21/1989
TIME: 10:07

MATERIAL HANDLING UTILIZATIONS

Material handling system name: MH1
Available minutes / equipment / YEAR: 105000.00
Busy minutes / system / YEAR: 32875.02
Quantity: 0.50
Utilization (%): 62.62

Material handling system name: MH2
Available minutes / equipment / YEAR: 95000.00
Busy minutes / system / YEAR: 68569.99
Quantity: 1.00
Utilization (%): 72.18

Figure 3.8. Material handling equipment utilizations report

COMPANY NAME: CIMTECHNOLOGIES
PROJECT NAME: TUTORIAL
DATE: 02/14/90
TIME: 13:43

WORKCENTERS UTILIZATIONS

Workcenter name: ASSEMBLY
Available minutes / server / YEAR : 230000
Busy minutes / workcenter / YEAR : 346631
Number of servers: 2.00
Utilization (%): 75.35

Workcenter name: MILL
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 97258
Number of servers: 1.00
Utilization (%): 84.43

Workcenter name: BROACH
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 169104
Number of servers: 2.00
Utilization (%): 73.40

Workcenter name: ROBOT
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 169697
Number of servers: 2.00
Utilization (%): 73.65

Workcenter name: LATHE
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 197917
Number of servers: 2.00
Utilization (%): 85.90

Figures 3.9. Workcenter utilizations report

Formulas for Development of the Model

The model will calculate material handling costs using formulas similar to those in COFAD. Material handling equipment will be classified as either fixed path or mobile. The fixed path equipment includes all types of conveyors. Mobile equipment is not restricted to a path, and includes forklift trucks, pallet trucks, AGVS and tractor-trailers.

Similar material handling equipment is grouped together to form a material handling system. Each system will be defined with a fixed and variable system cost. The fixed cost is the investment cost, and includes the depreciation or rental cost per piece of equipment.

The variable cost is composed of fuel, maintenance, and labor costs, or the overhead costs of the equipment. The available time per piece of equipment is also defined. In the case where an operator is dedicated to a particular material handling device, that employee's labor cost will be represented as a fixed cost instead of a variable one.

For mobile material handling equipment, the load and unload times, average speed, equipment effectiveness, and quantity of equipment per system are also needed.

The material handling effectiveness is the ratio of the distance travelled while carrying a load to the total distance travelled to accomplish a move, including distance travelling empty, as shown below:

Let:

L_1 = total distance travelled to accomplish move

L_2 = distance travelled carrying a load

Then the material handling effectiveness is:

$$E = L_2 / L_1$$

The material handling cost of transporting material from workcenter i to workcenter j using material handling system k is:

$$C_{ijk} = M_{ijk} \cdot F_{ijk}$$

Where:

M_{ijk} = move cost from workcenter i to workcenter j using system k

F_{ijk} = frequency of material flow from workcenter i to workcenter j using system k

For Mobile Equipment:

$$M_{ijk} = [(T_{ijk}/\text{SUM}T_k) \cdot N_k \cdot C_k] + [T_{ijk} \cdot O_k]$$

$$T_{ijk} = A_k + B_k \cdot (D_{ijk}/E_k)$$

Where:

T_{ijk} = move time from workcenter i to workcenter j using system k

$\text{SUM}T_k$ = sum of transportation times using system k

N_k = number of equipment type in system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per equipment type per unit time in system k

A_k = load and unload time per move in system k

B_k = inverse of average transportation speed of equipment in system k

D_{ijk} = distance from workcenter i to workcenter j using system k

E_k = material handling effectiveness of system k

For Fixed Path Equipment:

$$M_{ijk} = (D_{ijk}/\text{SUM}D_k) \cdot (C_k + O_k)$$

D_{ijk} = distance from workcenter i to workcenter j using system k

$\text{SUM}D_k$ = sum of transportation distances using system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per piece of equipment per unit time in system k

The move frequency F_{ijk} is expressed in terms of the production volume, quantity of parts per product, unit load size, and scrap rate. The move frequency for part y of product x is:

$$F_{ijk} = [P_x \cdot Q_{xy}] / [U_{xy} \cdot (1 - (SR_{xy}/100))]$$

Where:

P_x = production volume of product x
 Q_{xy} = number of parts of y per product x
 U_{xy} = unit load size of part y
 SR_{xy} = scap rate in producing part y

The utilization of material handling equipment is calculated for mobile equipment.

The utilization of material handling system k is:

$$U_k = \text{SUMT}_k / (A_k \cdot N_k)$$

Where:

SUMT_k = sum of transportation distances using system k
 A_k = available time per piece of equipment of system k
 N_k = quantity of equipment type per system

The workcenter utilization is also calculated: The utilization of workcenter k is:

$$U_k = B_k / (A_k \cdot N_k)$$

Where:

$B_k = \text{SUM}[(P_k \cdot Q_y \cdot (SU_y / \text{LOT}_y + CT_y)) / (1 - (SR_y / 100))]$
 B_k = busy time in workcenter k
 P_k = production volume of product x
 Q_y = quantity of parts y in product x
 SU_y = set-time for part y in product x
 LOT_y = manufacturing lot size of part y in product x
 CT_y = cycle time per part y of product x
 SR_y = scrap rate in producing part y of product x
 A_k = available time per machine/server in workcenter k
 N_k = number of machines/servers in workcenter k

APPLICATION OF THE MODEL

Setting Up a Problem for Study

From this point on, the model will be referred to by its name FactoryFLOW.

There are six stages in an accurate and successful FactoryFLOW analysis:

- 1) Determine the level of detail for the analysis.
- 2) Get the layout into AutoCAD
- 3) Organize Products and Parts data
- 4) Decide on naming conventions for the products, parts and workcenters/cells/storage areas
- 5) Enter Products and Parts data
- 6) Run FactoryFLOW

The stages are briefly described below:

Determine the level of detail for the analysis

FactoryFLOW allows the user to do many different levels of analysis. The user must determine what they wish to analyze before they can begin; it's usually a mistake to attempt to analyze all of the levels at the same time. Typical levels of detail are the

- layout of the site
- layout of a building in the site
- layout of an area in the building
- layout of a workcenter in the area
- layout of a workstation in the workcenter

For example, if the user wishes to revise the layout of one of the buildings in their factory, the user may just want to concentrate on the locations of the workcenters and then attempt to do a separate layout analysis within each workcenter, instead of attempting to layout both details at the same time. In this situation the user would probably just draw the walls and workcenter borders, and then conduct their FactoryFLOW analysis. When the user has laid out all of the

workcenters, they can use drawings that contain only each workcenter's objects to do a FactoryFLOW analysis on each workcenter separately.

Get the layout into AutoCAD

Methods of getting the facility layout into AutoCAD include:
 drawing the facility in AutoCAD
 drawing the facility with FactoryCAD
 translating from another CAD system drawing
 scanning a hard copy drawing

Drawing the facility in AutoCAD The user can use AutoCAD to draw their facility. FactoryFLOW does not require a lot of detail, and a simple layout can be created fairly easily by an experienced AutoCAD user. Many operations can be done much more easily, though, if the user uses an application such as FactoryCAD.

Drawing the facility with FactoryCAD If the user doesn't already have their layout in a CAD system, FactoryCAD, a software program designed by Dave Sly, provides powerful software tools for drawing facility layouts in AutoCAD. Drawing the facility with FactoryCAD is easy and quick; FactoryCAD takes care of all of the layering and most of the symbols. FactoryCAD also allows the user to easily draw double line walls and insert any size of doors, windows and docks. Also with FactoryCAD are the standard area planning symbols and hatching patterns as well as AEIOUX diagramming aids as defined by Richard Muther and Associates as well as the American Society of Mechanical Engineers A.S.M.E. (10)(11)(12).

Translating from a CAD system drawing If the user's plant drawings currently exist in another CAD system the user may be able to translate their drawings into AutoCAD. Translation can be accomplished in one of three ways. The first is to use IGES, which is a generic drawing translation standard that works fairly well for simple 2D drawings that don't have too many layers, linetypes, and textstyles. The second method is to use DXF which is AutoCAD's neutral file

format support by many CAD systems. DXF is usually better than IGES, however it is not available for all CAD systems. The third and best method, but also the most expensive and least available, is a direct translator. Many direct translators into and out of AutoCAD are available for various CAD systems.

Scanning Scanning is another method for getting the users plant into AutoCAD quickly. This method is not suggested because of the large file sizes and strange dimensions that scanners typically create. The user will find that the time and expense in scanning a drawing to a questionable accuracy and quality is not much different than creating that drawing using efficient drawing tools such as AutoCAD and FactoryCAD.

The drawings must be accurate, but the drawings only need to be detailed enough for the user to recognize the key areas in their facility for their level of analysis. FactoryFLOW does not try to interpret the user's drawn layout, but will ask the user for the locations of certain areas. The user needs to be able to accurately point to where these areas are located. Most importantly, their layout must be drawn to actual size in AutoCAD. If the user's drawing is not drawn to actual size the user can use the AutoCAD SCALE command to scale it appropriately.

Organize products and parts data

The first thing to do before the user begins to analyze their layout is to enter all of their products and their production quantities in the products window in FactoryFLOW. Usually this information already exists in a computerized format somewhere in accounting and the user can translate this information into the products window. Information on how to do this follows under the heading "Organize Parts and Products Data". When the user has their products information

in the products window, they can run FactoryFLOW and create a Product Quantity chart. This chart is also known as a Pareto curve or ABC analysis chart. The PQ chart will show the user those few products which are their big movers, or 'A' parts, on down to those many products which are produced in small quantities, 'B' and 'C' parts. If the user has many different products, all with their own detailed routings, the user will probably want to only analyze the fast movers, ('A' parts) and a few representative slow movers, ('B' and 'C' parts) for their first run analysis. The user can always add more detail and products to any analysis, so it is a good idea to start their analysis around a few main products, and work into a more detailed analysis as time permits.

A rule of thumb to keep in mind when collecting data, and laying out the facility, is to lay the facility in a production line layout for the fast movers, and a process or group tech layout for the medium to slow movers. This may not always be possible, but it is a good guideline to work around.

If the user is a job shop, or their products are all produced in medium or small quantities, then they should select groups of products that represent their most common process routings. Most job shop facilities have groups of products that are composed of similar processes.

The user will want to enter all of their products for analysis if they have only a few main products in the area being analyzed. Obviously this is the most accurate method, and preferred method of analysis, but not the most feasible for all companies. The paragraphs below explain the organization of the data for the above mentioned methods.

The Product method In the Product method the user enters the products and their quantities per production period in the product file (called PRODUCT.PRD in the following example). The user enters each product's parts and their respective routings in the parts file (called PRODUCT.PRT in the example). An example of this method is shown in the following table.

Example: PRODUCT.PRD
Products and parts files produced using the product method.

```
YEAR
PROD1 100000.00 CYAN
PROD2 50000.00 WHITE
PROD3 80000.00 MAGENTA
```

Example: PRODUCT.PRT

```
PROD1 PART1 1.000 ASSEMBLY SHIPPING MH1 50.00 100.00 50.00 2.00 3.00 C20
PROD1 PART11 2.000 MILL ASSEMBLY MH2 100.00 50.00 100.00 1.00 4.00 C20
PROD1 PART12 1.000 BROACH ASSEMBLY MH2 100.00 60.00 100.00 1.00 3.00 C20
PROD1 PART13 4.000 RECEIVING ASSEMBLY MH1 100.00 0.00 1.00 0.00 0.00 C20
PROD1 PART111 4.000 ROBOT MILL MH2 100.00 70.00 500.00 1.00 1.00 C21
PROD1 PART112 2.000 RECEIVING MILL MH2 100.00 0.00 1.00 0.00 0.00 C21
PROD1 PART121 4.000 RECEIVING BROACH MH2 100.00 0.00 1.00 0.00 0.00 C20
PROD1 PART1111 4.000 RECEIVING ROBOT MH2 200.00 0.00 1.00 0.00 0.00 C21

PROD2 PART2 1.000 ASSEMBLY SHIPPING MH1 25.00 100.00 50.00 2.00 5.00 C20
PROD2 PART21 2.000 MILL ASSEMBLY MH2 100.00 75.00 100.00 1.00 2.00 C21
PROD2 PART22 1.000 RECEIVING ASSEMBLY MH1 100.00 0.00 1.00 0.00 0.00 C20
PROD2 PART211 2.000 RECEIVING MILL MH1 75.00 0.00 1.00 0.00 0.00 C21

PROD3 PART3 1.000 ASSEMBLY SHIPPING MH1 50.00 100.00 80.00 2.00 3.00 C20
PROD3 PART31 4.000 LATHE ASSEMBLY MH2 100.00 40.00 100.00 1.00 4.00 C21
PROD3 PART32 2.000 BROACH ASSEMBLY MH2 50.00 70.00 200.00 1.00 2.00 C21
PROD3 PART33 1.000 RECEIVING ASSEMBLY MH1 50.00 0.00 1.00 0.00 0.00 C20
PROD3 PART311 4.000 RECEIVING LATHE MH2 100.00 0.00 1.00 0.00 0.00 C21
PROD3 PART321 2.000 RECEIVING BROACH MH2 50.00 0.00 1.00 0.00 0.00 C20
```

The Path method Another method for organizing the information is to enter it by paths. If the facility contains literally hundreds of different products that are constantly varying in quantity, and the user has historical information on loads transferred between any two workcenters (possibly from pick sheets) then they may be a candidate for the path method of analysis. In this method the user has no

products per se and they enter the flow of materials between workcenters directly. Although this method can typically be the least accurate method of analysis, it can work very well for a quick and dirty method of comparative analysis. The paragraphs below describe the organization of this method in more detail. It should be noted that if the user chooses this method they will not be able to compute any workcenter utilizations with these data.

In the Path method, the user creates the same two types of files as in the Product method, but in the products file the user enters one fictitious product with a quantity per time unit of 1 (PATH.PRD in the example), and in the parts file they enter each interworkcenter move as a separate part (PATH.PRT in the example). Let's say that the user knows that there are 1000 moves between workcenter A and workcenter B every year. Then the partname would be wcAtowcB (actually the path from workcenter A to workcenter B), and the quantity per product would be 1000. The "from workcenter" would be A and the "to workcenter" would be B. Lastly, the quantity per unit load would be 1. The user might want to use this method of analysis when it is difficult, or impossible, to break down all of the products into a part structure, when they wish to limit the size of the parts file, or when they know the number of moves between workcenters and that data are easier to specify than the product structure information.

Example: PATH.PRD

Products and parts files produced using the path method.

```
YEAR
PATH 1.00 CYAN
```

Example: PATH.PRT

```
PATH   WCA_WCB 1000.00   WCA WCB 1.00 0.00 1.00 0.00 0.00
PATH   WCD_WCA 100.00   WCD WCA 1.00 0.00 1.00 0.00 0.00
PATH   WCF_WCJ 100.00   WCF 2CJ 1.00 0.00 1.00 0.00 0.00
PATH   WCA_WCD 400.00   WCA WCD 1.00 0.00 1.00 0.00 0.00
```

PATH	WCC_WCB	3500.00	WCC	WCB	1.00	0.00	1.00	0.00	0.00
PATH	WCD_WCK	20000.00	WCD	WCK	1.00	0.00	1.00	0.00	0.00
PATH	WCL_WCM	4732.00	WCL	WCM	1.00	0.00	1.00	0.00	0.00
PATH	WCP_WCU	1680.00	WCP	WCU	1.00	0.00	1.00	0.00	0.00

Decide on naming conventions

When the user has determined which method they will use to organize their parts and products information, then they must decide on the names for their parts, products and workcenters. The user probably already has a standard at their company for their products and parts names. If they do, and if the product and parts names are no greater than 14 characters long, the user should use those standard naming conventions. The same rule applies to workcenter names. Most companies have a standard naming convention for their workcenters; however, many companies do not have any convention for naming bins and pallets within a workcenter, and the user will have to determine these themselves.

Deciding on a good naming convention is important because during the analysis process, FactoryFLOW will ask the user for the path between workcenters for each part in each product. If the user doesn't know exactly where any of these areas are, or what parts travel to and from these areas, they will tend to make mistakes in the path specifications, thereby compromising the accuracy of the analysis.

Enter parts and products data

The user should now be ready to begin assembling and entering the information to conduct their analysis. There are several different methods available to assemble and enter information to conduct an analysis.

There are four ways that the user can create the products and parts information files: IN DATA, FFEDIT, a spreadsheet, or a word processor. These data entry methods are described below. The user may also want to refer to the

blank data entry forms in the appendix of the FactoryFLOW instruction manual in the appendix of this thesis and make copies of these to take to the plant floor with them while they gather their information. In addition to the products and parts files, the user will need to create a material handling equipment file. It is usually best to use FFEDIT to create the material handling equipment file since it is normally very small.

IN DATA IN DATA is a command-line oriented program within FactoryFLOW that reads an existing fixed-format file or prompts the user to enter data one field at a time.

FFEDIT FFEDIT is a windowing program within FactoryFLOW that allows the user to enter the products, parts, and material handling equipment information.

Spreadsheet The user can create or change their files with a spreadsheet program such as Lotus 1-2-3. Create their spreadsheet, print their spreadsheet to a file, then read the file into FactoryFLOW using FFEDIT. The user may need to load the printed file into a word processor and delete any blank lines before reading the file into FactoryFLOW. The user can also load files from other computer systems into the spreadsheet and manipulate the information before inputting it into FactoryFLOW. This is perhaps the easiest method to create the tables.

To use a spreadsheet, format each column according to the data file formats in Appendix D and include a one or more space column between two consecutive fields. There can be no blank lines at the top or bottom of the spreadsheet file and no spaces at the beginning of the lines.

Word Processor For global changes or editing of the tables, the user can use a word processor. The user needs to make certain to save their file

unformatted. If the user is creating a file from scratch they will need enter at least one blank space between each field. It is also important to not put too many characters in any field. There is a specific list of the field maximums in the appendix of the FactoryFLOW manual in the appendix of this article. Once the data file has been created, simply load them into the FFEDIT program and then save them. This process will properly format the files for the INDATA program.

Once the user has decided on one of the three methods of analysis,

- 1) Selected products, or process routings, entered in a product structure
- 2) All products entered in a product structure
- 3) All products entered in a path structure

determined the naming conventions of their products, parts, and workcenters, and they have entered this information into FactoryFLOW; they are ready to run FactoryFLOW to analyze their layout.

Run FactoryFLOW

There are three main interrelated components in any plant layout and material handling analysis study, the processes and their quantities, the layout, and the selection of the material handling equipment. Since the processes and their quantities are usually, or at least should be, decided upon by the time the user sets out to design the layout and material handling system, the main focus will be upon trying to optimize the layout and selection of material handling equipment. The most effective procedure to arrive at the best possible system is to first design the layout, and then select the material handling equipment. In many existing facilities, the material handling system may already exist, however, the user should always be open to changes in this system if it is cost effective to do so. As the user changes their existing layout, the material handling requirements will also change, and what was an effective material handling system may now be ineffective.

To run FactoryFLOW, first install FactoryFLOW according to the directions in Installing FactoryFLOW in the manual in the appendix of this thesis. Then, after the user directory system prompt, type

C:\USER> FACTFLOW <return>

This command will set environment variables and the DOS search path, will load EXTLISP, and will start AutoCAD. Select begin a new drawing or edit an existing drawing.

1 <return> or 2 <return>

Every time the user begins a FactoryFLOW analysis of a new drawing they must load the FactoryFLOW menu by typing AutoCAD's MENU command at the command prompt.

Command: menu

AutoCAD will then ask you for the menu file name.

Menu file name or . for none <ACAD>: FACTFLOW (type FACTFLOW and press <return>)

Once the menu has been loaded, follow along with the rest of the manual to actually run the program.

Once the data and paths are entered, FactoryFLOW can run a complete analysis of up to 400 paths in about 3 minutes on an 80386-based microcomputer running at 16Mhz. There is no limit on the number of products, parts, or workcenters that the user may have. The number of paths that can be analyzed is limited to the amount of main RAM available, and to how long the user is willing to wait for the program to load the data and calculate the results. Over 1000 paths have been analyzed at the same time with only 512k of extended memory.

Analyzing the Output Data

To most effectively run FactoryFLOW to arrive at the best solution, the user should input their products and parts information based upon the strategies mentioned above, and then define a single default material handling device, and give this device an investment cost of \$0, a fuel, power and maintenance cost of \$0, and a labor cost of \$1. Then they should CALC the layout and look at the Product Flow diagram and the Composite Flow diagram. Since all of the material handling systems are equal, the user will be looking at flow lines that vary in width based upon the intensity (quantity) of moves between various workcenters. The user should lay out their facility so as to reduce the distance between workcenters reducing the distance for thickest lines first, leaving the thinner lines for last. The goal is to reduce the area of all of the flow lines. Obviously, since the thickness is fixed, reducing the distance of the thicker lines first and then the thinner lines, will result in the most efficient layout.

Once the user has the layout as good as possible, then they should go to the CHART menu and generate a Distance Intensity plot. The user will want to use this plot along with the flow diagrams to select their material handling equipment.

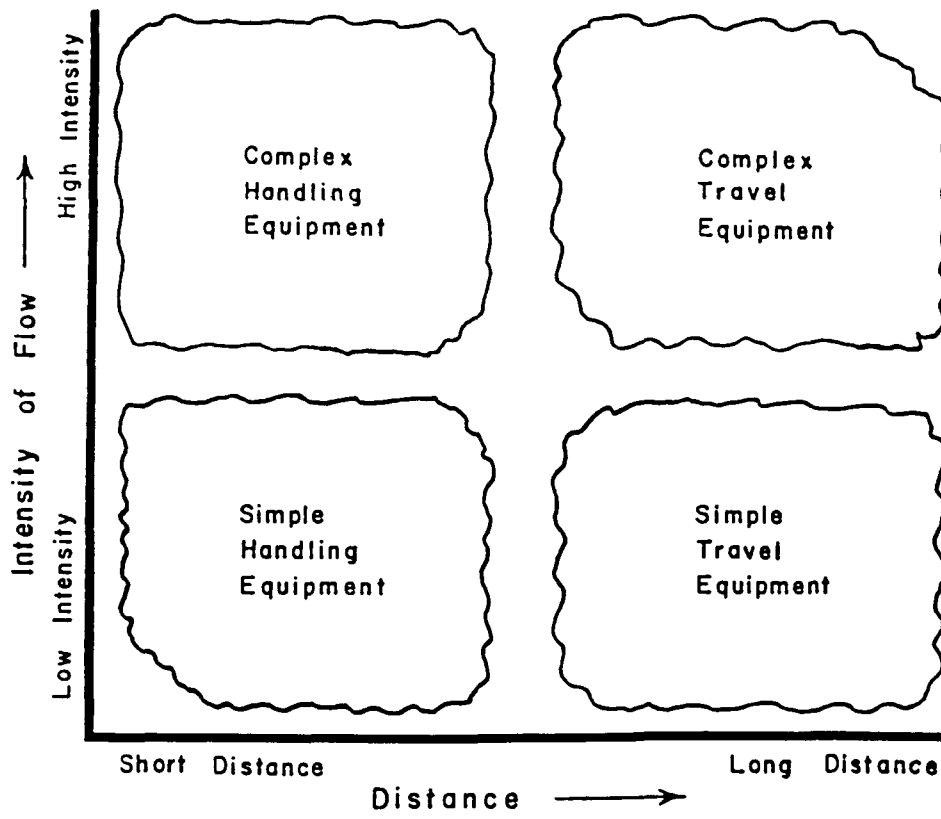


Figure 4.1. Distance intensity chart broken into four quadrants

The distance intensity chart can be interpreted by breaking the chart into four quadrants (10) as shown in Figure 4.1 on the previous page.

The lower left quadrant will classify all moves that are likely candidates for simple handling equipment. Simple handling equipment is equipment such as hand trucks, pallet jacks, stand up lift trucks, carts, dollies, and bins. Moves in this area are moved short distances, so the bulk of the move cost is in the load and unload of the material.

The lower right quadrant will classify all moves that are likely candidates for simple travel equipment. Simple travel equipment is equipment such as skate wheel/roller conveyors, sit down powered lift trucks, low cost tractor trailer trucks, or maybe even some automatic guided vehicles. Moves in this area are moved long distances, so the bulk of the move cost is in the transport of the material versus the load and unload. The user needs to keep in mind that the quantities of materials is still small in this quadrant, so the capacity of the equipment may not need to be large.

The upper left quadrant will classify all moves that are likely candidates for complex handling equipment. Complex handling equipment is equipment such as high capacity conveyor systems, automatic storage and retrieval systems, tractor trailer transport systems, and stand up fork lift trucks. Moves in this area are moved short distances, so the bulk of the move cost is in the load and unload of the material and not necessarily its transport. Since there is a high volume of moves in this category, the user needs to keep in mind that the frequency and or capacity of the material handling devices will need to be high.

The last, and hopefully least encountered, quadrant is the upper right quadrant. All moves in this quadrant are likely candidates for complex travel

equipment such as tractor trailer automatic guided vehicles, high capacity/high speed powered conveyors, high capacity and speed powered lift trucks, and often specially designed creative and expensive material handling solutions. Moves in this area should be avoided whenever possible, since they typically represent a bad layout. As was mentioned earlier, if the user has a high intensity of moves between any two workcenters, then the distance between them should be as small as possible. Moves in this area are moved long distances at high intensities. This means that both the travel and load unload costs are very high, so eliminating moves from this quadrant should be the first objective.

Once the material handling equipment has been selected for the moves, the user should enter the costs, and related information in the handling equipment window and CALC the layout. The user will typically see a drastic change in the thickness of the flow lines, and as before they need to concentrate on those long thick lines, as these lines represent the largest handling costs. Since the layout, hence the distances, are fixed; the user now needs to concentrate on selecting the most efficient equipment for each move in an effort to reduce the total handling costs.

If the user is pressed for time, as many of them will undoubtedly be, they can combine the layout and material handling selection steps. When they do this, their flow diagrams will need to be interpreted differently. The objective in this method of analysis is still to reduce the area of all of the flow lines, but both the thickness and distance of the lines can be affected simultaneously. The interrelationships of the two factors can be a bit tricky, however, the user need only concentrate on reducing the distance AND thickness of thick lines, and move onward accordingly. The user needs to keep in mind that as they modify the layout, material handling

equipment, especially conveyors, may not be feasible anymore, and these will have to be changed when the workcenters are moved so that flow diagrams will constantly be accurate.

No matter which method the user chooses for their analysis, after they have decided on the layout and material handling equipment they can print a material handling equipment utilization report to determine how many material handling devices will be required to handle their quantity of flow. FactoryFLOW computes these quantities based upon averages, so the user will need to be certain to increase this quantity if they expect to have many of their moves during short periods of time.

Two other features of FactoryFLOW are the DC (distance cost) report and the workcenter utilizations report. The DC report should be printed when the user plots out their flow diagrams so they will have a written report on the actual costs and distances represented in the flow diagrams. The workcenter utilizations report is to be used to forecast the loading of the workcenters based upon the production quantities. The user should be aware that they can only use this function if they are using the product method for organizing their products and parts information, and if they are using summarized information, their utilizations will be lower than they should be since the user is leaving out some of the flows.

The workcenter utilizations report is an optional report, so the user will need to complete the extra fields in the parts window in order to receive this report. The user need also be aware that like the material handling equipment utilizations report, the workcenter utilizations report is based on averages, and does not represent maximum or minimum flow in cases where there is a lot of variability.

CASE STUDY OF THE MODEL

As was mentioned in the objectives of this thesis, there were two main concepts being studied; the development of a software program that can allow the user to easily model the material flow in a factory, and the acceptance of such a model. The case study will be organized in two sections, entitled case studies of application of the model in actual industrial facilities, and case studies of acceptance of the model in actual industrial facilities respectively.

Case Studies of the Application of the Model in Actual Industrial Facilities

During the course of the three years it took to develop and test FactoryFLOW, there have been dozens of industrial facilities analyzed with the software. Three applications of the software that best summarizes all of its uses to date will be described. The three cases were as follows: The analysis of placement of WIP in a manufacturing cell at Pella Rolscreen Windows, Pella, IA, the analysis and visualization of material flows in a metal stamping and forming facility at John Deere's Horicon facility, Horicon, WI, and the analysis of combining injection molding and assembly of plastic washing machine tubs into one workcenter at Mid Central Plastics, Des Moines, IA.

What follows is a detailed presentation of the study at each of the three facilities. In most cases details of what was produced, the quantities of production, or the names and quantities of parts required for production have been omitted in order to protect the confidentiality of the companies studied.

Case study of the Pella Windows project

The goal of the study at Pella Windows was to study the flow of materials inside, and feeding into a manufacturing cell of a type of window. The initial layout of the facility can be found in Figures 5.1 and 5.2 on the following two pages. What is shown is an actual path product flow diagram and a composite flow diagram created by the software program. The study began by taking a drawing of the area which was already created in AutoCAD by Pella, and combining this with material flow data about the cell formatted in the PRODUCT data format. What resulted was a product file of one product, consisting of approximately 80 paths for flow. The software program computed that there was approximately 35,677 miles of material flow in this area at a cost of approximately \$260,000.

Before the analysis of this cell by FactoryFLOW, it was assumed by the industrial engineers at Pella that by rearranging some of the workcenters inside the cell that a significant savings in material flow distance and cost would result. The product flow and composite flow diagrams of these moves are shown in Figures 5.3 and 5.4 on the following two pages. What can be seen is that although moving the machines did reduce material flow inside the workcenter, it increased some of the flows of WIP external to the workcenter. This resulted in much lower savings of material flow than was expected. The actual figures computed were a new flow distance of 33,709 miles, a 5.8% improvement, and a new flow cost of \$250,000, a 3.9% improvement.

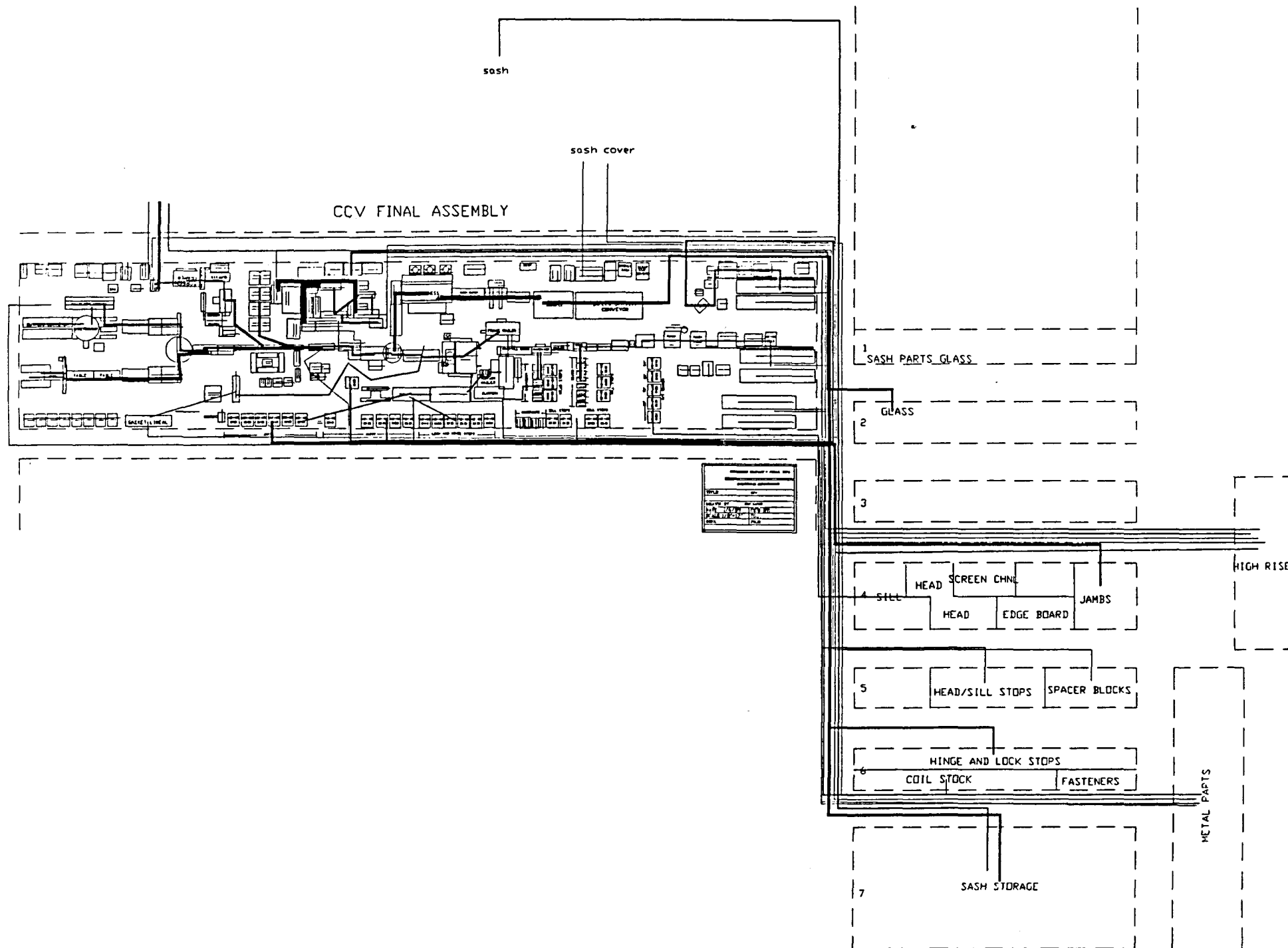


Figure 5.1. Initial product flow diagram of Pella facility

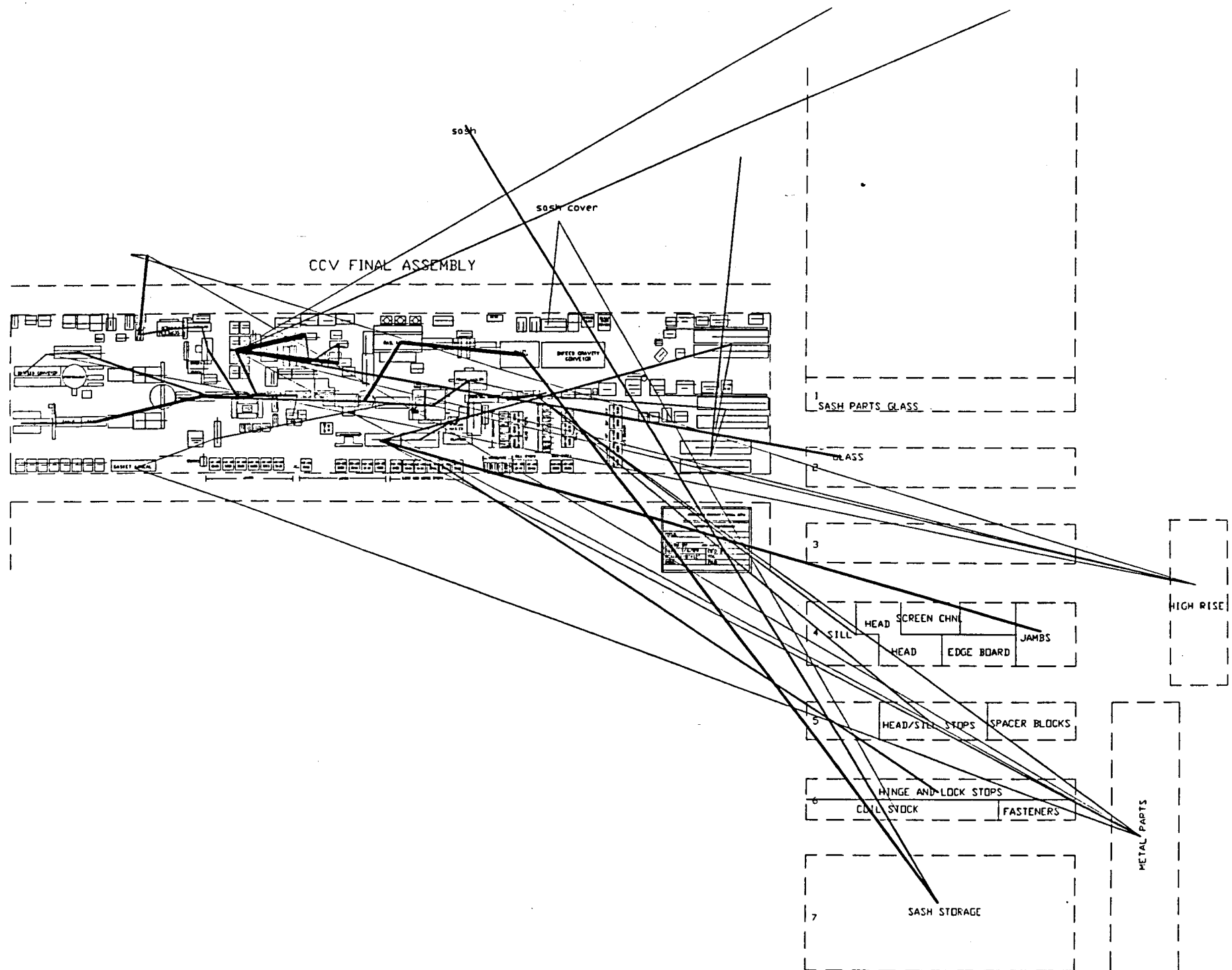


Figure 5.2. Initial composite flow diagram of Pella facility

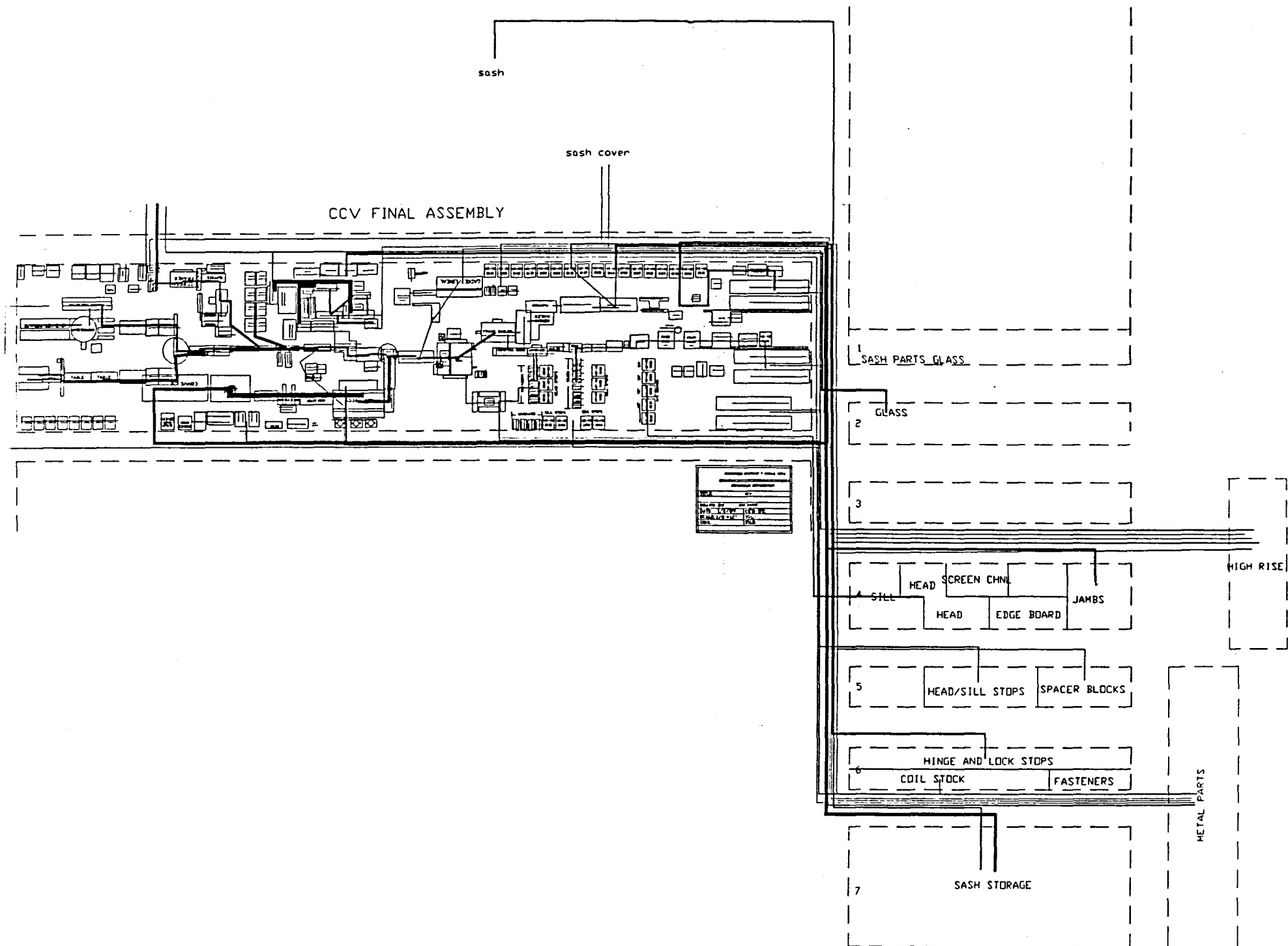


Figure 5.3. First alternative product flow diagram of Pella facility

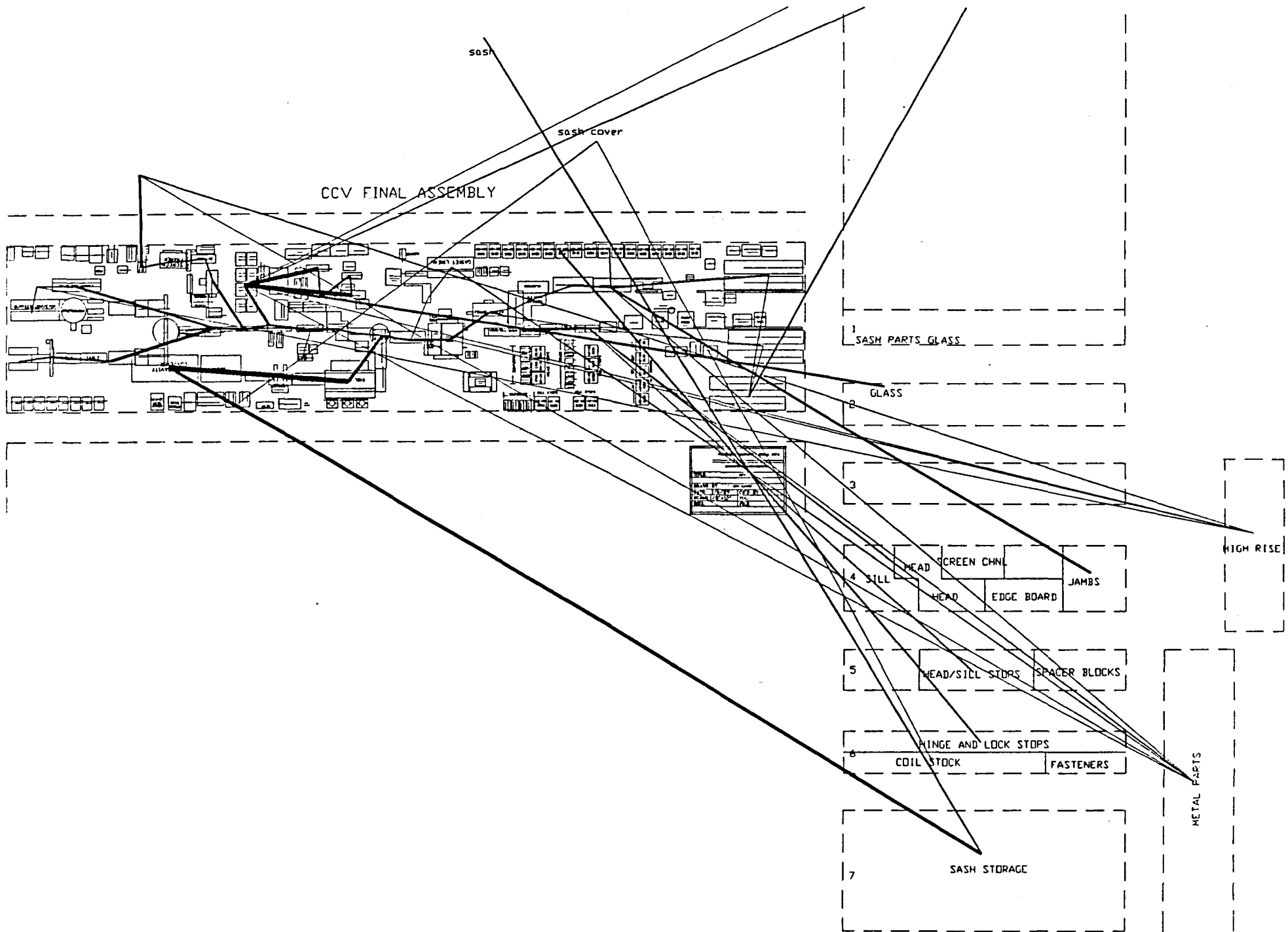


Figure 5.4. First alternative composite flow diagram of Pella facility

After a careful review of the flow diagrams it was decided that an analysis of moving all of the WIP for the line into the workcenter, would be worthy of analysis. Doing this would require a larger workcenter to make room for 1 to 2 days of WIP. The only direction that could be extended was the side of the workcenter near raw materials storage. The workcenter was extended into raw materials storage, and the model was reanalyzed by FactoryFLOW. The new flow diagrams are shown in Figures 5.5 and 5.6 on pages following. This new layout resulted in a new flow distance of 34,000 miles, a 4.5% improvement, and a new flow cost of \$215,000, a 17.5% improvement. The reason for the low improvement in flow distance is that the length of the manufacturing cell was extended requiring the windows to travel farther on long conveyors than they did previously. Since FactoryFLOW computes flow distance of materials on a conveyor as the number of units flowing on the conveyor times the distance of the conveyor, the overall conveyor travel distance increased significantly. This increase in flow is virtually negligible from a cost of flow perspective, and thus the total cost reduction of the new layout was substantial.

This layout did pose one significant problem in that a main aisle was blocked by the workcenter extension. When this layout was approved, an aisle was put through the workcenter, and windows were delivered by carts from the front workcenter to the end workcenter. The effects of this activity were not studied, as the decision was made during implementation.

This study revealed several weaknesses about the program.

1. When there are several product flow diagrams in a drawing, it becomes very confusing and hard to read. To remedy this situation a ProdfLOW command and Listpath command were added to allow the user to only display certain paths going into and/or emanating from a particular workcenter.

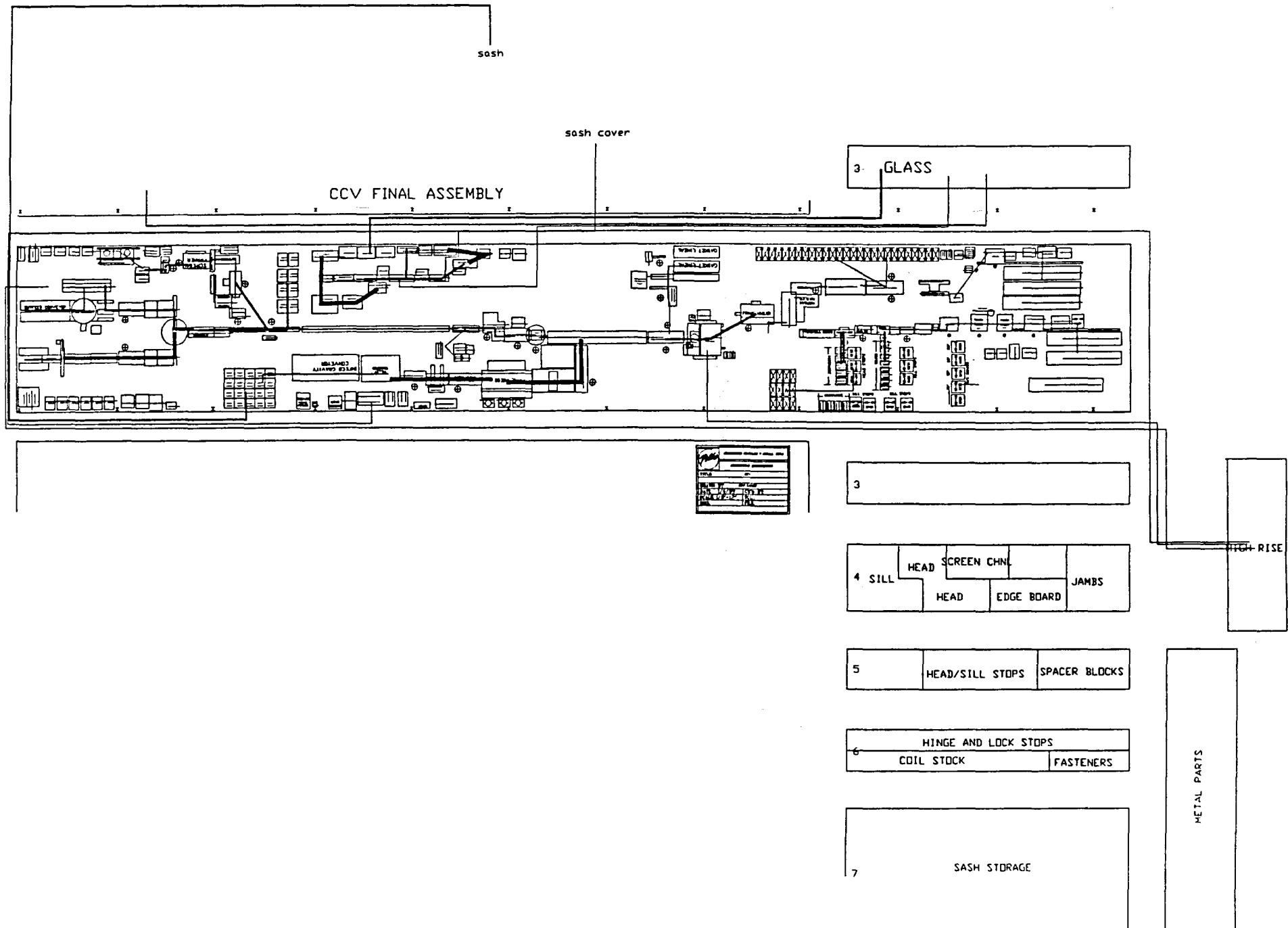


Figure 5.5. Second alternative product flow diagram of Pella facility

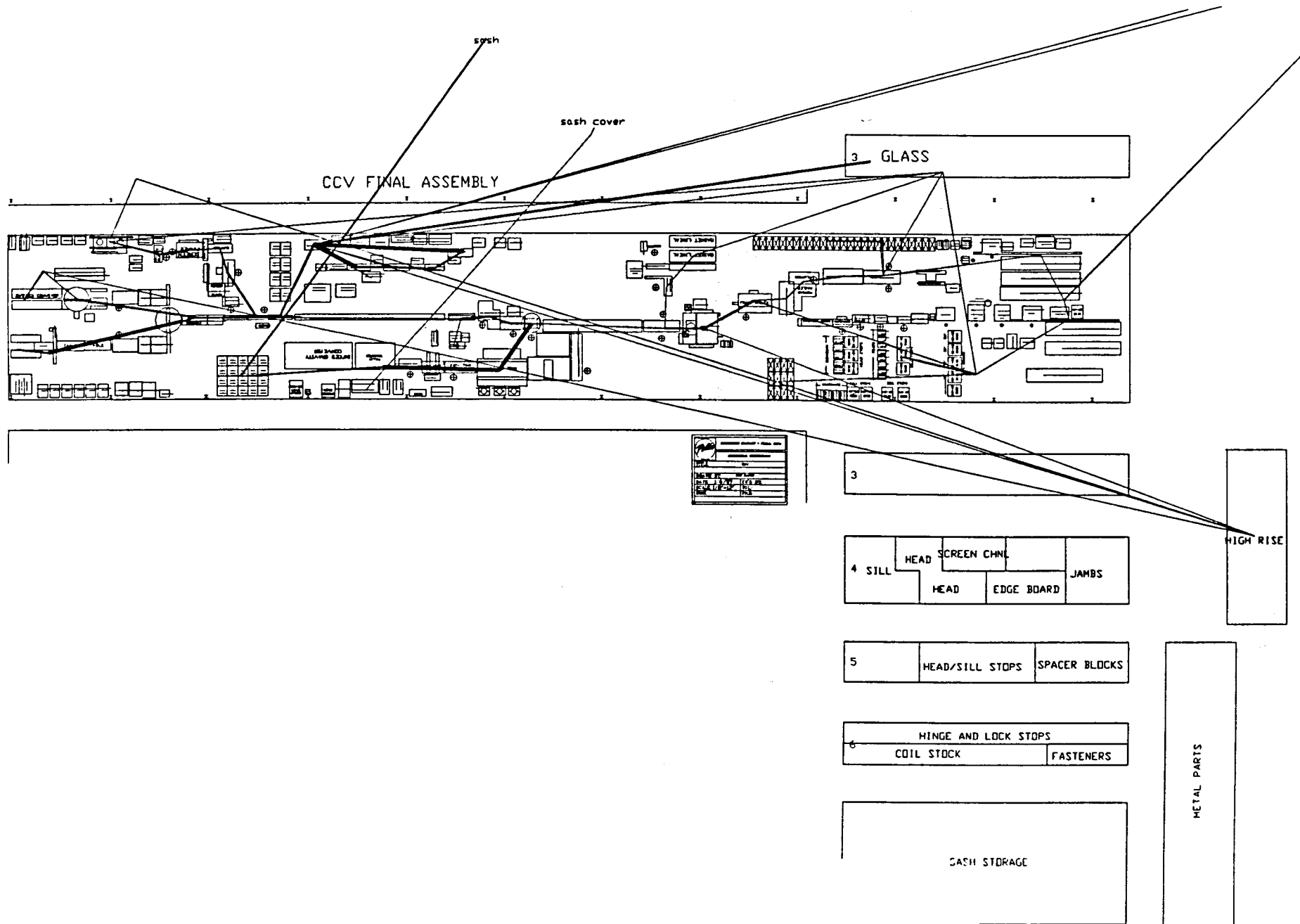


Figure 5.6. Second alternative composite flow diagram of Pella facility

2. The material flow reports need to have a project name, company name, date, and page number on them so it is not so easy to confuse pages of one project with those of another. So these functions were added to the program.

3. It was very helpful to allow the user to sort the results by material handling equipment type in order to determine which equipment was being affected and by how much.

4. The distances were all output in feet, which can make for some very large numbers in overall travel distance, so an option was made to allow these distances to be output in miles also.

5. It was difficult to determine the direction of material flow, so arrow heads were added to the ends of the flow paths.

6. It was noted that if the user was not consistent in selecting the incoming and outgoing points for workcenters and machines, this can greatly affect the results, especially for large production quantities. This problem was documented in the manual, and is stressed heavily in the training courses of the product.

This case study can be considered a success from the perspective of the operation of the model to visualize and compute material flow information. It was a direct result of output from the program that the workcenter was extended and WIP was brought on line. It was also very beneficial in producing the necessary reports and graphs that sold the project to management.

However, from the perspective of program acceptance the project was not so successful. A total of 60 to 80 man hours were invested in this project including the collection of the flow data from the shop floor, to the organization and presentation of the results to management. This was deemed too much time by the engineers studying the system. It took too much time to collect the data on where the products

were going and in what quantities. Previously, this information was approximated by an engineer familiar with the manufacturing process and reviewed qualitatively. No flow distances, costs or diagrams were ever generated. Although the results were very beneficial, the time required to collect the base information outweighed those benefits.

Case study of the John Deere Horicon project

The goal of the study at the Horicon facility was to justify and provide visual flow diagrams on a new layout being proposed. In this case the previous layout was not studied, and the real objective was to sell this new layout to management. During the design of the new layout, all material flow information had been computed, summarized, formatted and entered into a computer. Even the layout had been drawn in a CAD system.

This case study was an excellent example of using the program in a totally ideal environment. The data were preformatted into ASCII files compatible with the FactoryFLOW format. Approximately 1000 paths were analyzed simultaneously using the data format of the PATH method; which is more than have ever been analyzed since. The drawing was converted via the DXF process from the Pointline CAD system to AutoCAD. The actual computation of the flow diagrams and travel distances and costs took approximately 8 to 16 hours. Most of this time was spent drawing the actual flow paths on the layout, a process that has been improved as a result of this study. The final flow diagrams are shown in Figures 5.7 and 5.8 on the following pages.

As can be seen, the goal of Deere's design was to separate the facility into two areas, virtually eliminating flow between those areas. The layout was near

perfect, if not for one flow path that was missed during their analysis. This missed path was caught immediately when the flow lines were computed by FactoryFLOW, and has been corrected in the system design. The total travel distance of flows was computed to be 8,598, only 558 dollars off from Deere's computations of the flow distance.

In this study the following was learned:

1. It was this study that the PATH method of organizing the database was conceived. Since there were literally thousands of parts being manufactured and sent to several plants, it was impossible to use the product method of data organization. All flows of certain material classes were summarized into intensity per workcenter pair. This was the input data to the program.
2. The greatest benefit of the program in this study was the development of the material flow diagrams for the purpose of making a management presentation. This was perceived as the software program's greatest benefit, opening new possibilities for its justification on projects.
3. This was the largest case ever studied in terms of the number of flow paths. Nearly 1000 flow paths were studied, taking a 386 computer over 9 minutes to compute and display the new travel distances, costs and diagrams. Much to the developers excitement and amazement, the program worked flawlessly with such a large data base. At a later date this database was appended to itself creating a total database of nearly 2000 flow paths. The program worked flawlessly with this database also.

Like the Pella case study, this project was very successful in performing its objective. The new layout that they were trying to sell to the Horicon facility was

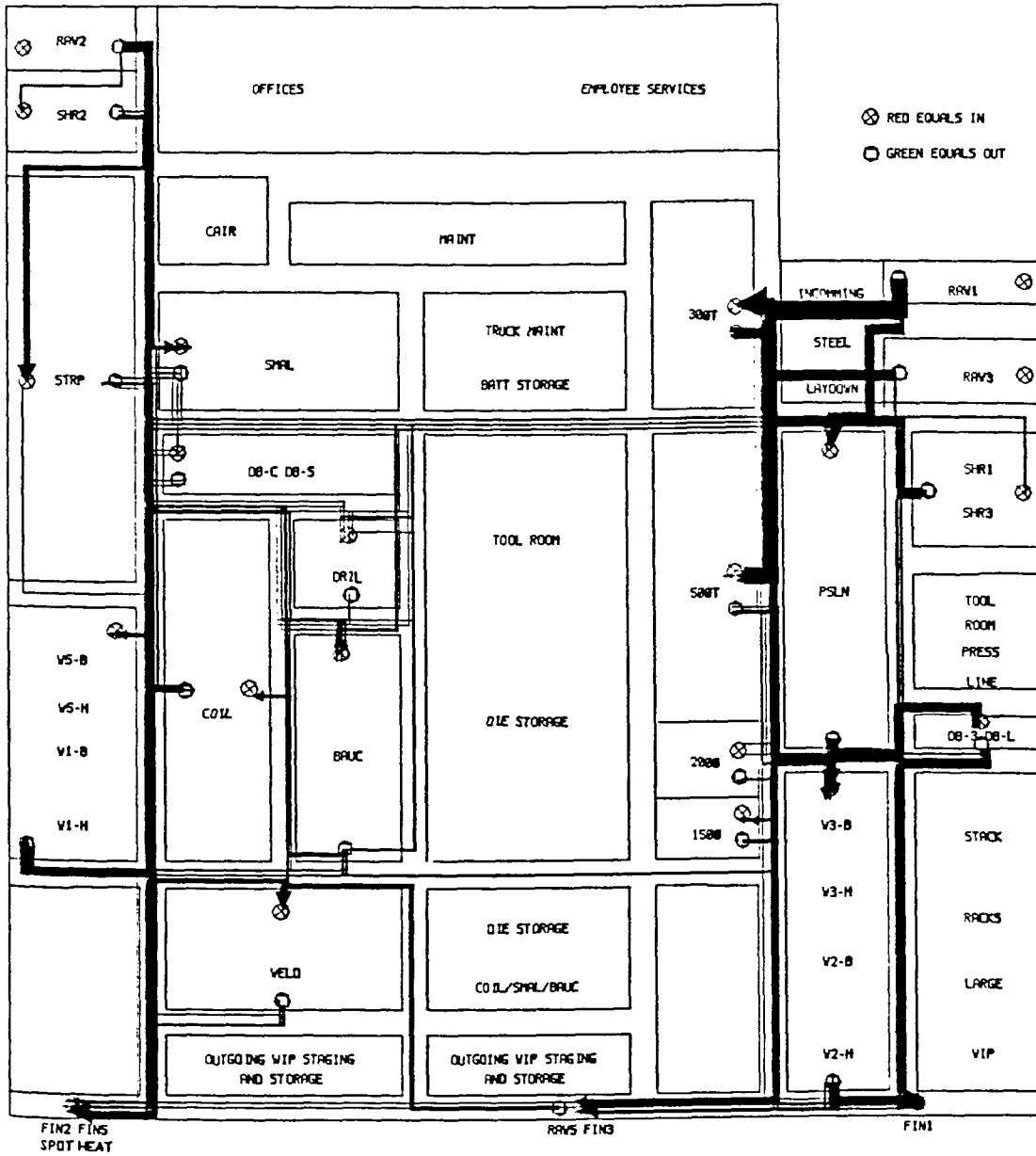


Figure 5.7. Product flow diagram of the Deere facility

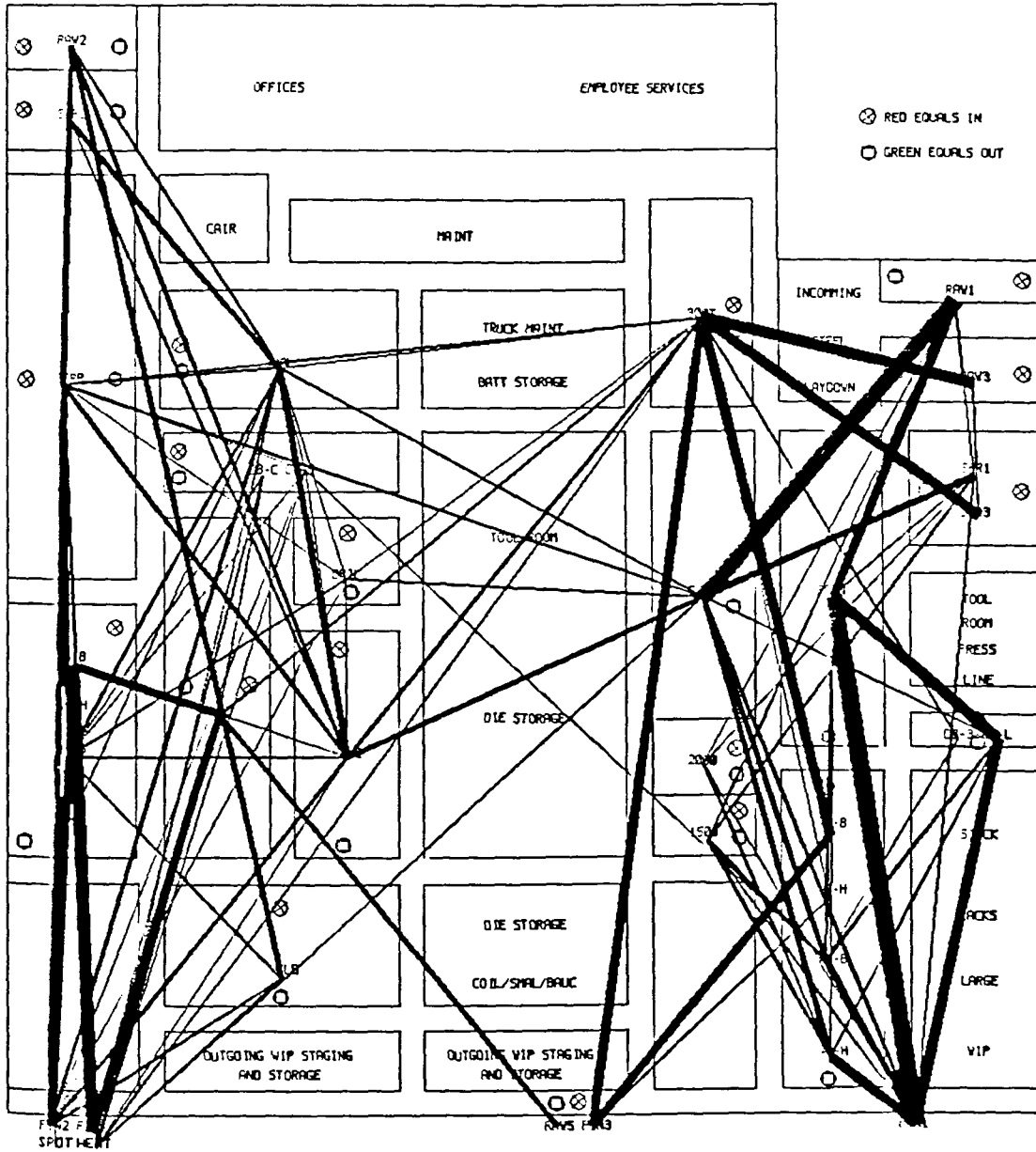


Figure 5.8. Composite flow diagram of the Deere facility

unanimously approved, and at the meeting where the layout was presented on FactoryFLOW, attenders commented on the high quality presentation of the flows, and how important the flow diagrams were to their approval of the project.

Unfortunately, like the Pella case study, this was not enough to justify further use of FactoryFLOW at their facility. First, this was a one of a kind complete relay layout of the facility, whose main design was to improve material flow. It is not anticipated that any layout projects in Horicon will be undertaken in quite a while. Second, there was a considerable amount of effort by corporate and local computer services in order to properly format and assemble the flow information. Deere stated that it is very rare that they would expend this amount of resources for any layout project in the near future. Deere did state that when any layout projects in which visualization and computation of material flows is important is undertaken in the future, they will use FactoryFLOW.

Case study of the Mid Central Plastics project

The two previous case studies involved very large and medium sized manufacturing firms. It can be much easier to justify or undergo material flow analysis projects at larger companies than smaller ones. This case study involves a company of only 100 workers that does plastic injection molding. Mid Central Plastics had AutoCAD and had also entered their plant into the CAD system using the software package FactoryCAD written by the Author. In this case study, the industrial engineer at Mid Central Plastics wanted to observe the potential benefits by combining a washing machine tub assembly process into the workcenter where the tubs were being injection molded.

In the existing facility, an inner and outer tub were molded on separate machines that were located next to each other, and were then transported to the

back of the facility to be assembled. Because the tubs were large, and fit inside each other, one days stock filled a 500 square foot stockroom 14' high. It was thought that this space could be freed up, and employees could be reduced by taking idle time from the injection molding press operator to assemble the tubs.

It is impossible to show any of the diagrams or numerical results of this study, so only the overall results and conclusions will be discussed. The interesting component of this study that makes it ideal for this thesis, is that it used an extra feature of the program that allows it to compute the utilizations of the workcenters, which in this case are actually machines and assembly operations. These workcenter utilizations along with the material flow and layout results were used to justify and sell the new layout change.

From this study it was learned:

1. There was a programming bug in the workcenter utilizations routines that appeared when inconsistent time units for the input data were being used. This bug was corrected.

2. Triggering the workcenter utilizations off of material flow information is not always a good idea. In this case a workcenter was defined as an operation. This definition was required to properly assign machining times for the utilization report. If a workcenter happened to contain more than one machine, workcenter utilizations would have been impossible to compute. This problem was not corrected, because of its complexity, however, this problem was brought up in the instruction manual and training courses to alert the users.

3. A very small company was able to conduct an entire flow and utilization analysis on a very small project and receive satisfactory results in what was perceived to be an acceptable amount of time.

As with the previous two case studies, the program worked flawlessly and provided accurate and conclusive results that resulted in justification and implementation of the project. This new layout has been in use for several months now, and has been recently reviewed as a complete success. This entire analysis was also done successfully on a very small project at a very small company.

As far as the user acceptance of this project it was one of very few projects in which the user plans to continue use of FactoryFLOW in the future. Unfortunately, since the company is so small, there are not many new layout/processing projects in the near future.

Case Studies of Acceptance of the Model in Actual Industrial Facilities

FactoryFLOW took approximately one year to develop. The first version was ready for testing under the name VALDEP on December 20, 1988. This version went under extensive testing and development for six months after that date.

Sales and marketing Sales and marketing activities consisted of magazine articles in several popular monthly periodicals including IIE magazine, Cadence, and Cadalyst. Pictures of these advertisements are included in the appendix. When potential users responded to the advertisements, they were sent out brochures on the product of which most were followed up by phone calls. Most all of the phone calls were made by the author of this thesis. Approximately 3,300 professionals from all over the world have responded to these advertisements as of December 31, 1989.

Demonstrations Over 50 companies have been given demonstrations of FactoryFLOW at their plant site. Most demonstrations involved Departments heads of Industrial Engineering and Manufacturing departments. Many

demonstrations were the result of unique interest from companies in the Midwest, where personal visits were feasible.

Presentations of FactoryFLOW were also made at 4 facilities planning courses put on by the Sims Consulting Company and sponsored by the Society of Manufacturing Engineers. Six other presentations were also put on for facilities planning courses taught by Richard Muther of Richard Muther and Associates.

Lastly, individual presentations of FactoryFLOW were made by the author to Dr. James Tompkins, Dr. John White, Dr. James Apple, Ralph Sims, Richard Muther, and Dr Sidney Gilbreath, as well as many other recognized experts in facilities planning.

Trade shows The author set up booths at over 10 trade shows during the year of 1989. These trade shows included AEC, Autofact 88 and 89, as well as several local SME, and IIE trade shows.

Technical Articles Several technical articles on FactoryFLOW were sent to many periodicals. Currently small excerpts in the new product sections of several magazines have appeared. Feature articles of FactoryFLOW are expected in the April 1990 issue of Cadence magazine and a future issue of IE magazine whose date has not been set.

Testing Testing was conducted entirely on factory sites by facilities interested in conducting a material flow analysis at their facility. All testers received the software free, as well as a version of FactoryFLOW as soon as it was complete. Approximately 25 companies participated in the testing and development of FactoryFLOW. Some of the most active and helpful companies were RR Donnelly, Case/Steiger Tractor, Deere and Company, Pella Rolscreen Company, Precision Pulley, Thermador Inc., Combustion Engineering, Mid Central Plastics, Inc.,

Universal Gym, Heft and Associates, Sims Consulting Group, Preciptech Inc., and Dave Witham and Assoc.

All companies who participated in testing and development were required to submit their project's input and output on paper and magnetic media as well as complete two evaluation forms. One form was to be completed before the analysis and another afterwards. These forms are located in the appendix of this thesis. All project information is in confidential files located at CIMTECHNOLOGIES CORPORATION.

The results of the surveys from the testers was very conclusive. Virtually all testers found the visualization of the material flows, and the reports of travel distances and costs to be the greatest features of the program. Most testers found these features to be of greatest benefit when selling their proposals to management. Most testers said that they would continue using FactoryFLOW on their facilities analyses, however follow up phone calls made 4 months after the testing period showed that virtually none had used the program since the test period. Most companies cited lack of projects to work on, or lack of available time on the AutoCAD system as their excuse.

CONCLUSIONS AND DISCUSSION

Overall Conclusion

To summarize the results of this project in one sentence it would be said that this CAD based material flow analysis program does offer significant advantages to its users in terms of visual interpretation of flows for the engineer and management, and an excellent method of scoring alternative layouts, however, these benefits typically cannot be justified because of the intensive amount of data required to conduct the analysis. No matter how beneficial and/or easy to use a facilities layout program based on material flows may be, it will never be greatly accepted in industry because of industries unwillingness to spend the time necessary to collect the information required to conduct the analysis. In the entire year that FactoryFLOW was available and in testing only 46 copies have been shipped, and of that number 19 copies were free for evaluation and testing, 9 were shipped to universities.

Suggestions for Further Research

Because of the above results conclusion, little further research on the analysis of material flows for plant layout is planned. It is evident that if a factory layout program is to succeed it must be based on qualitative data that can be supplied by the user with little to no data collection. This program would be based on Muther's Systematic Layout Planning concepts of Relationship charting/diagramming and scoring. This project is currently in development and the verdict is still out on its possibilities for success. However, the preliminary analysis of potential users of this project is revealing one distressing problem. Most

industrial facilities planners have no concept of relationship planning, systematic planning, or any other method of planning at all. This would require a person or company wishing to develop products for use by manufacturers to educate the prospective users before they can understand what the software program could do for them.

Unfortunately educating thousands of industrial planners on these topics would be a very substantial obstacle, especially when many of them are not interested in learning about relationship planning to begin with.

The author plans to continue developing the qualitative analysis program and to integrate this with FactoryFLOW. It is the intent to then integrate a manufacturing simulator with the two programs and allow for factory layout, (both qualitative and quantitative), factory simulation and factory animation all in the same program sharing the same database. It is the belief of the author that many of these concepts are not industry acceptable as individual software products, but may be accepted when integrated together as one software product feeding off of a common database.

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ACKNOWLEDGMENTS

The FactoryFLOW project was a monumental effort involving three solid years of research and testing. During this time literally dozens of people were closely involved in development, testing and marketing, and over \$800,000 was invested. Eventually the program was completely rewritten a total of 6 times involving 4 developers. I would like to thank everyone who helped make this project possible.

Special thanks go to Jihad Labban who was responsible for the coding of the last version of the program, and Chuck Brandt who wrote the 'C' code for the colorful pop up menus. I would also like to thank Prof. Vic Tamashunas and my committee for having the patience and guidance to see me through the 4.5 years it took me to complete this thesis and my degree. Lastly I would like to thank the board of directors and investors, who without their financial contributions and guidance this project truly would never have been possible.

APPENDIX

Technical Articles on the Model

The following two articles were sent to several magazines to be published. The first article is to appear in Cadence magazine in April of 1990. A variation of the second article is to appear in Industrial Engineering Magazine sometime in 1990.

**PLANT LAYOUT
AND
MATERIAL HANDLING ANALYSIS
USING INTERACTIVE GRAPHICS**

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Abstract

In the methods for the analysis of manufacturing plant layout and material handling systems commonly used today, the production data (products, parts, and routings), the facility layout drawings, and other data and calculations are in separate software or paper embodiments. The time and effort to calculate useful results by conventional means is usually prohibitive. Hence the need for an unconventional tool--FactoryFLOW. FactoryFLOW is a micro-computer-based iterative, interactive program which integrates the graphics of a CAD system with the analysis of plant layout and material handling systems. The program enables the user to alter production volumes, part routings, material handling methods, or storage and machine locations and then receive automatic cost and distance calculations. The material handling costs are listed in management reports and highlighted graphically by the thickness of the actual material handling paths overlayed on the plant drawing. The authors believe this is the first microcomputer program with these capabilities. This paper describes the FactoryFLOW program in detail.

Keywords

CAD, Plant Layout, Material Handling Analysis, Material Flow Diagrams, Layout Evaluation, FactoryFLOW, AutoCAD, Computer Aided Facilities Layout (CAFL)

Previous Computer Aided Facilities Layout Programs

A recent review by Oriscoll and Sangi of 56 CAFL software packages from all over the world stated that many first generation lineprinter-oriented layout programs are still used, but their ability to tackle real world problems is very limited. Computer aided facilities layout programs like CRAFT, COFAD, PLANET, CORELAP, and ALDEP are only marginally successful at generating usable layouts, and are not used much by industry. These programs are difficult to use, run in batch mode often on mainframe computers, and have no graphics capabilities.

Oriscoll and Sangi also stated that for a CAFL software package to be successful it would have to be interactive, iterative, and tie into a popular proprietary CAD system to allow high quality graphics input and output.

The authors have developed FactoryFLOW, a microcomputer program written in a popular CAD system that meets the above criteria, and that is useful to both the typical and more advanced industrial facilities planner.

Why FactoryFLOW?

The authors saw the need for an interactive CAD-based system that could calculate the material handling costs and distances within a factory. To be effective, the system needed to allow the user to easily move workcenters or storage areas in a CAD drawing of their facility, or change production volumes, part routings, material handling systems or material handling paths, then easily recalculate the costs and material handling distances of that revised layout during the design process. Ideally, the actual CAD layout should be used to support rapid prototyping and the material handling cost should be represented graphically. The purpose of this system would be to allow the facilities planner to quickly and quantitatively evaluate a set of layouts based on material flow, and to create a set of graphical diagrams and reports that would allow for easy and informative presentations to management.

This program is FactoryFLOW. FactoryFLOW allows the user to interactively change production levels, part routings, material flow paths, storage and workcenter locations, unit loads,

material handling devices, and other key information. Once the user enters the appropriate data, FactoryFLOW calculates the total material handling cost and the total travel distance, generates the Product Flow Diagram (fig. 1), the Composite Flow Diagram (fig. 2), the Distance-Intensity Chart (fig. 3), and the Product-Quantity Chart (fig. 4), the Material Handling Cost Report (fig. 5), and the Material Handling Equipment Utilization Report (fig. 6).

In addition to analyzing material handling and workcenter/storage locations, FactoryFLOW computes operator/machine/workcenter utilizations. This analysis shows the user the effect of routing and layout changes on the work load of all of the machines, workcenters, and operators included in the analysis (fig. 7).

FactoryFLOW runs in the AutoCAD environment. The authors chose AutoCAD because it is both the most programmable PC CAD system available, and the most sold and used CAD system in the world. Its reasonable price and availability make it a good CAD system for use in facilities planning departments, as well as in schools and universities.

How to use FactoryFLOW

Graphical Input

To begin the analysis, the user must first draw the plant, or the relevant production or storage areas, using the AutoCAD CAD system. If the plant drawing already exists in another CAD system, it can be transferred to AutoCAD using the IGES or DXF format. The plant drawing must be drawn to size. FactoryFLOW does not actually try to interpret the drawing; however, it will prompt the user either to enter the actual material handling path between any two workcenters, or to accept automatically generated rectilinear or euclidean distances between all workcenters. In either case, the path distances are calculated from the CAD drawing. Hence, the drawing only needs to be detailed enough for the user to recognize the location of workcenters, storage areas, and aisles.

Alphanumeric Input

In order to determine which workcenters have material flows either in or out, and what the costs and intensities of these flows are, the user needs to input either the actual paths of the flows and their respective intensities (referred to as the PATH method), or to specify the part routings for all the parts in the products being analyzed (referred to as the PRODUCT method). Either data set can be added directly with the pop-up windows of FactoryFLOW, or can be imported from an external ASCII file.

The data input is provided by the user in three files: the products file, the parts file, and the material handling equipment file.

Products File

The products file includes the product names, their production volumes, and a unique color selected to represent a product's material flow paths in the subsequent flow diagrams. The products file format is as follows:

TIME UNIT - Period of time in which production quantities are produced (year, month, week, day, or shift).

PRODUCT - Name of product.

PRODUCTION - Production volume of product per time unit.

COLOR - Path color of product.

Example:

YEAR		
PROD1	200000.00	CYAN
PROD2	100000.00	WHITE
PROD3	150000.00	MAGENTA

Parts File

The parts file contains routing and production information for all parts in all products. There is one entry for each move a part makes. The parts file format is as follows:

PRODUCT - Name of product this part is associated with.

PART - Name of part.

QUANTITY/PROD - Quantity of parts per product.

FROM WORKCENTER - Workcenter or storage area that part moves from.

TO WORKCENTER - Workcenter or storage area that part moves to.

MATERIAL HANDLING SYSTEM - Name of the material handling system for moving/handling part.

UNIT FACTOR - Average number of parts moved in one trip.

SETUP TIME - Time it takes to set up the FROM workcenter to produce a part.

CYCLE TIME - Average cycle time to produce one part.

LOT SIZE PER RUN - Average number of parts produced per setup.

SCRAP RATE % - Scrap rate in the FROM workcenter.

GROUP CODE - Organizational code assigned to move (used to account for costs).

Example:

PROD NAME	PART NAME	QTY/ PROD	FROM WC	TO WC	MH SYST	UNIT FACT	SETUP TIME	CYCLE TIME	LOT SIZE	SCRAP RATE	GRP CODE
PROD1	PART1	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	50.00	2.00	3.00	C20
PROD1	PART11	2.000	MILL	ASSEMBLY	MH2	100.00	50.00	100.00	1.00	4.00	C20
PROD1	PART12	1.000	BROACH	ASSEMBLY	MH2	100.00	60.00	100.00	1.00	3.00	C20
PROD1	PART13	4.000	RECEIVING	ASSEMBLY	MH1	100.00	0.00	1.00	0.00	0.00	C20
PROD1	PART111	4.000	ROBOT	MILL	MH2	100.00	70.00	500.00	1.00	1.00	C21
PROD1	PART112	2.000	RECEIVING	MILL	MH2	100.00	0.00	1.00	0.00	0.00	C21
PROD1	PART121	4.000	RECEIVING	BROACH	MH2	100.00	0.00	1.00	0.00	0.00	C20
PROD1	PART1111	4.000	RECEIVING	ROBOT	MH2	200.00	0.00	1.00	0.00	0.00	C21
PROD2	PART2	1.000	ASSEMBLY	SHIPPING	MH1	25.00	100.00	50.00	2.00	5.00	C20
PROD2	PART21	2.000	MILL	ASSEMBLY	MH2	100.00	75.00	100.00	1.00	2.00	C21
PROD2	PART22	1.000	RECEIVING	ASSEMBLY	MH1	100.00	0.00	1.00	0.00	0.00	C20
PROD2	PART211	2.000	RECEIVING	MILL	MH1	75.00	0.00	1.00	0.00	0.00	C21
PROD3	PART3	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	80.00	2.00	3.00	C20
PROD3	PART31	4.000	LATHE	ASSEMBLY	MH2	100.00	40.00	100.00	1.00	4.00	C21
PROD3	PART32	2.000	BROACH	ASSEMBLY	MH2	50.00	70.00	200.00	1.00	2.00	C21
PROD3	PART33	1.000	RECEIVING	ASSEMBLY	MH1	50.00	0.00	1.00	0.00	0.00	C20
PROD3	PART311	4.000	RECEIVING	LATHE	MH2	100.00	0.00	1.00	0.00	0.00	C21
PROD3	PART321	2.000	RECEIVING	BROACH	MH2	50.00	0.00	1.00	0.00	0.00	C20

Material handling equipment file

The material handling equipment file contains the material handling system names and each named system's type, quantity, fixed cost, variable cost, load and unload time, average speed, and effectiveness. The material handling equipment file format is as follows:

TIME UNIT - Period of time for investment cost and available minutes (year, month, week, day, shift).

MATERIAL HANDLING SYSTEM - Name of material handling system.

MATERIAL HANDLING TYPE - Type of material handling system.

INVESTMENT COST - Investment cost per piece of equipment per time unit.

FUEL, POWER, AND MAINTENANCE COST - Hourly fuel, power, and maintenance cost per piece of equipment.

LABOR COST - Hourly labor rate per piece of equipment.

AVAILABLE MINUTES - Available minutes per piece of equipment per time unit.

LOAD PLUS UNLOAD TIME - Load plus unload time per move in minutes.

SPEED - Average speed of material handling system in feet per minutes.

QUANTITY - Quantity of equipment in material handling system.

EFFECTIVENESS - Material handling system effectiveness in percent.

Example:

YEAR										
MH1	LIFT_TRUCK	4503	2.54	19.75	105000	1.40	310.00	0.50	75.00	
MH2	P.PALLET_TRUCK	1300	0.45	12.50	95000	0.75	163.00	1.00	60.00	

Program Execution

The user first loads AutoCAD and the plant layout drawing, then calls the FactoryFLOW program and menu under the AutoCAD umbrella. FactoryFLOW reads the products, parts, and material handling files, then prompts for the inter-workcenter paths. All the user must do is draw a series of straight line segments in the CAD plant drawing to specify the actual paths through the aisles from the originating workcenters/storage areas to the destination workcenters/storage areas.

Alternately, FactoryFLOW will generate euclidian or rectilinear paths automatically. FactoryFLOW

calculates the distance of the paths, adds up all of the paths for a particular material handling system, and amortizes the fixed costs over the time used. The variable costs are then added to the fixed costs to get the move costs for each path. The move distances, times, and costs are multiplied by the move frequency to get the total move distances, times, and costs. The total material handling cost and travel distance are obtained by adding the total move costs and distances.

FactoryFLOW computes the travel costs and distances for the interworkcenter/storage distances, then scales the width of the paths in the drawing to give the user a visual presentation of the associated handling costs. This product flow diagram is a tool which enables the engineer to visualize the material handling costs within the plant, recognize problem areas, and present alternatives to management. Fig. 1. shows the product flow diagram of a plant with seven workcenters. The relative thickness of the paths shows that the material flow between receiving and assembly is expensive and perhaps a change in location or material handling method is needed.

After the user makes one or more changes to the layout drawing or to the handling information, the program can calculate new material handling costs and travel distances and also present cost and distance changes from the previous layout. The user can then generate new material handling cost reports and flow diagrams.

In addition to the flow diagrams, FactoryFLOW also creates Distance-Intensity Charts and Product-Quantity Charts. The Distance-Intensity (DI) Chart is helpful when trying to determine which class of material handling equipment to use for specific interworkcenter moves, and also in determining the quality of the current layout. When the DI chart is used with material handling equipment and unit factors already selected, all the moves (represented as one point on the chart) should be close to the axes. A move falling in the middle of the chart indicates that this move has a high distance and high frequency and should be adjusted either by decreasing the distance or frequency. If many moves fall in the middle of the chart, the layout should probably be altered. Fig 3. shows a DI chart of the previous example.

The product flow diagram for each product is automatically generated on a separate CAD layer and composite flow diagrams can be generated on a special composite flow diagram layer. The composite flow diagram can consist of any combination of products. Product flow diagrams for different products are given different colors so one can easily look at the level of material handling activity in an area for any products. Layers can be turned on and off to highlight individual products. Fig. 2 shows the Composite Flow Diagram of the same plant presented in Fig. 1.

By including machine and workcenter utilizations in the same CAD database as the plant drawing, it becomes possible to review the relationships of part routings to workcenter utilizations. These workcenter utilizations are calculated using a simple analytical model and do not simulate the work loading on the machine.

The Formulas Behind FactoryFLOW

FactoryFLOW calculates the material handling costs using formulas similar to those in COFAD. Material handling equipment is classified as either fixed path or mobile. The fixed path equipment includes all types of conveyors. Mobile equipment is not restricted to a path, and includes forklift trucks, pallet trucks, AGVS and tractor-trailers.

Similar material handling equipment is grouped together to form a material handling system. Each system is defined with a fixed and variable system cost. The fixed cost is the investment cost, and includes the depreciation or rental cost per piece of equipment.

The variable cost is composed of power, fuel, maintenance, and labor costs, or the overhead costs of the equipment. The available time per piece of equipment is also defined.

For mobile material handling equipment, the load and unload times, average speed, equipment effectiveness, and quantity of equipment per system are also needed. **The material handling effectiveness** is the ratio of the distance travelled while carrying a load to the total distance travelled to accomplish a move, including distance travelling empty, as shown below:

Let:

- L_1 = distance travelled empty to workcenter 1
 L_2 = distance travelled carrying load from workcenter 1 to 2
 L_3 = distance travelled empty from workcenter 2

Then the material handling effectiveness is:

$$E = [L_2 / (L_1 + L_2 + L_3)]$$

The material handling cost of transporting material from workcenter i to workcenter j using material handling system k is:

$$C_{ijk} = M_{ijk} \cdot F_{ijk}$$

Where:

M_{ijk} = move cost from workcenter i to workcenter j using system k

F_{ijk} = frequency of material flow from workcenter i to workcenter j using system k

For Mobile Equipment:

$$M_{ijk} = [(T_{ijk} / \text{SUM}T_k) \cdot N_k \cdot C_k] + [T_{ijk} \cdot O_k]$$

$$T_{ijk} = A_k + B_k \cdot (D_{ijk} / E_k)$$

Where:

T_{ijk} = move time from workcenter i to workcenter j using system k

$\text{SUM}T_k$ = sum of transportation times using system k

N_k = number of equipment type in system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per equipment type per unit time in system k

A_k = load and unload time per move in system k

B_k = inverse of average transportation speed of equipment in system k

D_{ijk} = distance from workcenter i to workcenter j using system k

E_k = material handling effectiveness of system k

For Fixed Path Equipment:

$$M_{ijk} = (D_{ijk} / \text{SUM}D_k) \cdot (C_k + O_k)$$

D_{ijk} = distance from workcenter i to workcenter j using system k

$SUMD_k$ = sum of transportation distances using system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per piece of equipment per unit time in system k

The move frequency F_{ijk} is expressed in terms of the production volume, quantity of parts per product, unit load size, and scrap rate. The move frequency for part y of product x is:

$$F_{ijk} = [P_x \cdot Q_{xy}] / [U_{xy} \cdot (1 - (SR_{xy}/100))]$$

Where:

P_x = production volume of product x

Q_{xy} = number of parts of y per product x

U_{xy} = unit load size of part y

SR_{xy} = scrap rate in producing part y

The utilization of material handling equipment is calculated for mobile equipment. The utilization of material handling system k is:

$$U_k = SUMT_k / (A_k \cdot N_k)$$

Where:

$SUMT_k$ = sum of transportation times using system k

A_k = available time per piece of equipment of system k

N_k = quantity of equipment type per system

The workcenter utilization is also calculated. The utilization of workcenter k is:

$$U_k = B_k / (A_k \cdot N_k)$$

Where:

$$B_k = SUM [(P_k \cdot Q_y \cdot (SU_y/LOT_y + CT_y)) / (1 - (SR_y/100))]$$

B_k = busy time in workcenter k

P_k = production volume of product x

Q_y = quantity of parts y in product x

SU_y = set-time for part y in product x

LOT_y = manufacturing lot size of part y in product x

CT_y = cycle time per part y of product x

SR_y = scrap rate in producing part y of product x

A_k = available time per machine/server in workcenter k

N_k = number of machines/serves in workcenter k

Conclusion

FactoryFLOW provides a unique method of analyzing plant layout, material handling activity, and machine utilization, and their interrelation in the context of facility planning. By combining a standard CAD system with FactoryFLOW's ability to analyze what has been drawn, the user can now efficiently compare layout alternatives for production and storage areas based on the flow of materials, the material handling utilizations, and the workcenter utilizations during the design process.

FactoryFLOW's development owes much to the research conducted in the Industrial Engineering Department at Iowa State University, as well as to the assistance that many facility planners have provided in refining the user interface and overall effectiveness of the program.

Factory FLOW is under continuing development. Currently FactoryFLOW can run a complete analysis of up to 30 workcenters and 400 parts in about 3 minutes on an 80386-based microcomputer running at 16MHz. In the future the authors plan to speed up execution time to allow larger data sets to be analyzed. The authors also intend to add time-based algorithms to the program to allow for simulation. Currently the program runs with AutoCAD under DOS, but conversions to engineering workstations are planned.

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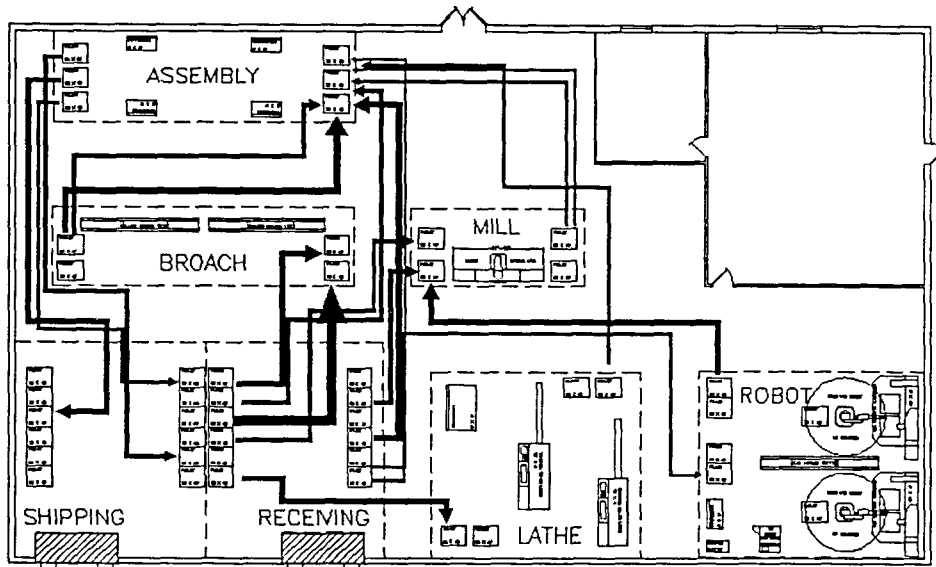


Figure 1. Product Flow Diagram

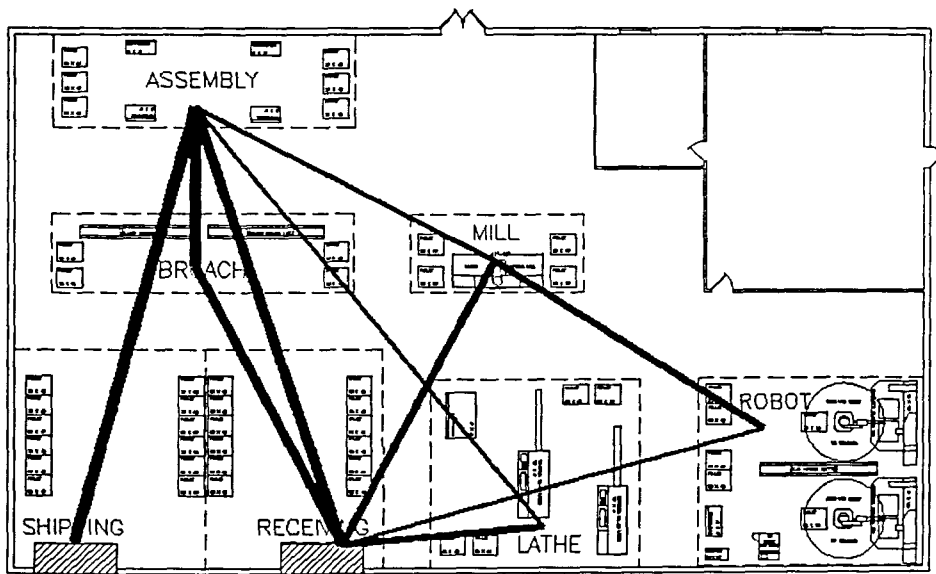


Figure 2. Composite Flow Diagram

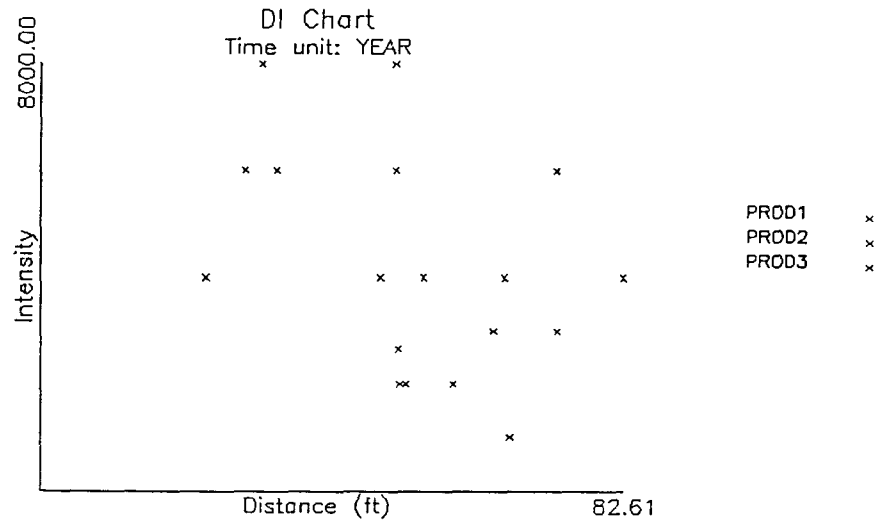


Figure 3. Distance-Intensity Chart

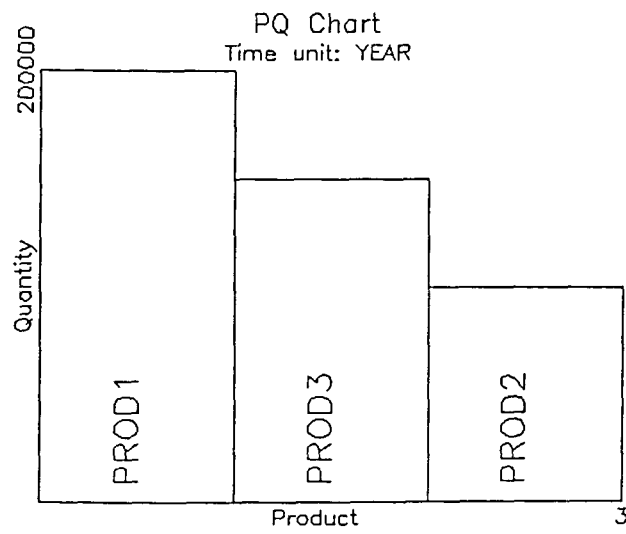


Figure 4. Product-Quantity Chart

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORYFLOW ANALYSIS
 DATE: 11/21/1989
 TIME: 10:04

MATERIAL HANDLING REPORT

PRODUCT	PART	FROM	TO	MATERIAL HANDLING	TOTAL COST (\$/YEAR)

PROD1	PART1	ASSEMBLY	SHIPPING	MH1	1,465.09
PROD1	PART13	RECEIVING	ASSEMBLY	MH1	2,876.26
PROD2	PART2	ASSEMBLY	SHIPPING	MH1	2,993.09
PROD2	PART22	RECEIVING	ASSEMBLY	MH1	742.22
PROD2	PART211	RECEIVING	MILL	MH1	1,898.69
PROD3	PART3	ASSEMBLY	SHIPPING	MH1	2,275.93
PROD3	PART33	RECEIVING	ASSEMBLY	MH1	2,213.29
Subtotal of MH1					-----
					14,464.57
PROD1	PART11	MILL	ASSEMBLY	MH2	1,170.07
PROD1	PART12	BROACH	ASSEMBLY	MH2	602.59
PROD1	PART111	ROBOT	MILL	MH2	2,379.84
PROD1	PART112	RECEIVING	MILL	MH2	928.71
PROD1	PART121	RECEIVING	BROACH	MH2	2,008.33
PROD1	PART1111	RECEIVING	ROBOT	MH2	1,497.66
PROD2	PART21	MILL	ASSEMBLY	MH2	597.16
PROD3	PART31	LATHE	ASSEMBLY	MH2	2,116.98
PROD3	PART32	BROACH	ASSEMBLY	MH2	1,787.12
PROD3	PART311	RECEIVING	LATHE	MH2	1,538.33
PROD3	PART321	RECEIVING	BROACH	MH2	1,472.90
Subtotal of MH2					-----
					16,099.69
Grand total					=====
					30,564.26

Figure 5. Material Handling Cost Report

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORYFLOW ANALYSIS
 DATE: 11/21/1989
 TIME: 10:07

MATERIAL HANDLING UTILIZATIONS

Material handling system name: MH1
 Available minutes / equipment / YEAR: 105000.00
 Busy minutes / system / YEAR: 32875.02
 Quantity: 0.50
 Utilization (%): 62.62

Material handling system name: MH2
 Available minutes / equipment / YEAR: 95000.00
 Busy minutes / system / YEAR: 68569.99
 Quantity: 1.00
 Utilization (%): 72.18

Figure 6. Material Handling Utilizations Report

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORYFLOW ANALYSIS
 DATE: 10/21/89
 TIME: 10:08

WORKCENTERS UTILIZATIONS

Workcenter name: ASSEMBLY
 Available minutes / server / YEAR : 115200
 Busy minutes / workcenter / YEAR : 346631
 Number of servers: 4.00
 Utilization (%): 75.22

Workcenter name: MILL
 Available minutes / server / YEAR : 115200
 Busy minutes / workcenter / YEAR : 97258
 Number of servers: 1.00
 Utilization (%): 84.43

Workcenter name: BROACH
 Available minutes / server / YEAR : 115200
 Busy minutes / workcenter / YEAR : 169104
 Number of servers: 2.00
 Utilization (%): 73.40

Workcenter name: ROBOT
 Available minutes / server / YEAR : 115200
 Busy minutes / workcenter / YEAR : 169697
 Number of servers: 2.00
 Utilization (%): 73.65

Workcenter name: LATHE
 Available minutes / server / YEAR : 115200
 Busy minutes / workcenter / YEAR : 197917
 Number of servers: 2.00
 Utilization (%): 85.90

Figure 7. Workcenters Utilizations

**A "Graphical Spreadsheet" for Factory Layout
at CIMTECHNOLOGIES CORPORATION**

Material Handling Cost Analysis within AutoCAD

Decisions, decisions. Manufacturing managers face many critical decisions about how to make their companies competitive. To help make these decisions, CIMTECHNOLOGIES has created FactoryFLOW. The program turns AutoCAD into a graphical decision-making tool for analyzing plant layout and material handling costs.

IMPROVING PLANT LAYOUT

The arrangement of machines and storage areas on the plant floor has a huge impact on production efficiency. This shows up most directly in the cost and effort involved with material handling.

While layout improvements can yield huge savings, it often takes a "momentous event" to motivate changes. Events like new construction or expansion have an obvious impact on layout. But many other situations require less obvious, but equally important, layout and handling decisions. For example, group technology typically leads to rearranging the shop floor into "focussed plants" or "cells". Installation of automated production equipment is another example of a situation that requires decisions about machine location and material movement.

COMPUTER-AIDED FACILITIES LAYOUT

Good layouts minimize handling costs. Material handling is an overhead cost which adds no value to the product. Analysts have often tried to minimize travel distances and assumed that costs varied directly. But each handling device has unique fixed and variable costs, capacities and performance characteristics. So device selection and utilization can often have a bigger impact on cost than distance alone.

Existing software had been of limited help in making facilities decisions. AutoCAD is a useful tool for creating drawings of alternative layouts. But drawings alone give no feedback on the quality or efficiency of various layout alternatives.

Since distance and cost are quantitative, a computerized "layout optimizer" seems possible. But the real world is rarely so simple. Qualitative factors play a big role in practical, real world layouts. A decision model must allow for qualitative considerations such as noise, dirt, vibrations, safety, etc. Further, since many layout projects involve improvements to existing facilities, the model must allow for immovable machines, walls, columns, etc.

Previous plant layout programs considered only distance or cost without considering the other constraints. None

were CAD-based and few let the knowledgeable engineer make adjustments within the model. Office-oriented layout programs (stacking and blocking, affinity analysis) consider only qualitative factors and ignore costs and distances which are important in the plant.

The power and programmability of AutoCAD offered a better solution. The possibilities occurred to an industrial engineer named Dave Sly while he was pursuing his master's degree. Sly, who founded CIMTECHNOLOGIES, combined his knowledge of layout with his AutoCAD/AutoLISP expertise to conceive of a "graphical spreadsheet" model of the facility which gives feedback on costs and distances while letting the layout expert control all decisions. The result is FactoryFLOW.

THE FactoryFLOW PROGRAM

FactoryFLOW integrates AutoCAD plant drawings with a database of production, routing and material handling information. The result is a CAD/CAE tool for the production facility which gives "what if" feedback on travel distances, handling costs, handling device utilizations, etc.

You execute FactoryFLOW from a customized AutoCAD menu. The program includes ten primary screen menus listing over 45 FactoryFLOW commands. The coding is extensive: there are

26 AutoLISP routines and five C programs which together embody nearly 900K of executable code.

The most valuable tool for analyzing layout is a material flow diagram. Flow diagrams give a graphical summary of material movement through a plant. In FactoryFLOW, product flow diagrams overlay the AutoCAD plant drawing with flow lines that illustrate direction of travel, exact travel path, and handling cost for each move you choose to analyze. Composite flow diagrams summarize movement of materials between workcenters. In both flow diagrams, wide lines represent high cost moves.

FactoryFLOW lets you draw the actual path taken by a material handling device right in the plant drawing. The "actual path" is an AutoCAD polyline that graphically represents the material flow. The path is linked to the production, routing and material handling database using entity handles. FactoryFLOW scales the width of a path to represent the cost/foot of that particular move.

Individual move costs are calculated by extracting the length of a path from the drawing and then running it through the program's algorithms. The program considers production volumes, unit loads, fixed and variable costs of the handling device, the device's average speed, load/unload times and its time used on other moves before arriving at the total distance and total cost for that move. Results

are summarized by product or product group, by workcenters, by device or in other ways depending on the user's needs.

FactoryFLOW reads the production, routing and handling information from a fixed-format ASCII file. Data can be entered using FactoryFLOW's FFEDIT program or can be imported from another source. FFEDIT is a C program run in the shell consisting of data entry and editing windows. The data specifies routing information (a from and to workcenter) for each move and the associated handling device and unit load.

The drawing, database, paths and workcenter points are the details which fully describe a layout alternative. From those inputs, FactoryFLOW's CALC command calculates distances, costs and device utilizations and produces the flow diagrams and other reports.

Any of this output can pinpoint layout problems. For example, a long, wide flow line between two workcenters highlights an expensive move. There are a variety of "what if" changes you can explore in FactoryFLOW to reduce costs. For example, using the MOVEWC command you can move the two workcenters closer together. MOVEWC enhances the AutoCAD MOVE command so that it also deletes paths going from or to the old workcenter locations.

You can change the travel route by editing a path with the EDTPATH command. You can also change the material

handling device, quantity of devices in a handling system, unit load, production volume, or any other element in the database. FactoryFLOW recalculates all results and shows percent improvement from the previous alternative. Any layout alternative and its associated drawing, paths, workcenter points and database can be labelled and saved.

Since FactoryFLOW lets the user control all changes, each analysis can consider real world problems like immovable machines, space constraints and other qualitative factors.

FactoryFLOW IN PRACTICE

One of FactoryFLOW's strengths is in justifying changes that facility planners have identified intuitively. The graphical output, along with the cost and distance reports, are perfect for management-level presentations.

A project we participated in at the Deere & Co. Horicon Works is an example of the value of FactoryFLOW. At the Horicon primary manufacturing facility in Wisconsin, Deere performs a variety of stamping operations to produce parts for their line of John Deere lawn and garden tractors.

Deere is well known for its commitment to advanced manufacturing techniques like group technology and just-in-time production. The planners at Horicon had studied their layout in some detail before FactoryFLOW was used. They had plant drawings in CAD and they were using several other

computerized tools. After analyzing production and routing information for their existing layout, they calculated that material was moved nearly 13,000 miles per year in the plant using a system of six fork trucks.

They knew that a group technology-based layout, organized around four manufacturing cells, would significantly reduce travel distances. However, they were working only with block diagrams of the proposed layout and had no diagrams showing the improved flow of materials. Further, they knew that the new layout might eliminate one or more fork trucks and the associated costs.

CIMTECHNOLOGIES' engineering staff brought in FactoryFLOW to help complete the project. Since Deere already had production and routing information in computerized files, we were able to reformat the data for use in FactoryFLOW using a spreadsheet program. We drew the new flow paths over the drawing of the proposed cellular layout and generated flow diagrams and other FactoryFLOW reports.

The results confirmed that the new group technology layout would significantly reduce travel distances. However, the new diagrams identified problem moves that, although fully described in the routing data, weren't fully illustrated by the block diagram program. FactoryFLOW also calculated utilization statistics for the system of fork

trucks. A few "what if" alternatives confirmed that two fork trucks, not six, were sufficient to move materials in the new layout, and the trucks would still be only 75 percent utilized.

FactoryFLOW helped show that the new layout would reduce handling travel distance by about 30 percent. More importantly, it showed that handling costs would decline by an even larger percentage. What the Horicon engineers liked best about FactoryFLOW, however, is the potential it has for selling the new layout to everyone from plant supervisors to top management. The flow diagrams in particular helped illustrate that the new layout was a practical, more efficient alternative.

CHALLENGES FOR IMPLEMENTATION

Unfortunately, not every company invests the time and effort studying layout as Deere. Even in companies dedicated to improving operations, layout and handling decisions are often made "by the seat of the pants". This is especially surprising since many of these same companies are committed to tackling the complexity of simulation to help model other aspects of plant operation.

The concern heard most frequently about using FactoryFLOW is whether you need to enter data on all parts for all products in the entire plant in order to get meaningful results. The answer is a strong no. The first

step to getting meaningful results from FactoryFLOW in a reasonable amount of time is properly defining the scope of your project. Often 80 percent of handling costs are accounted for by only 20 percent of the materials. As with any form of analysis, however, you can't get results without some data.

FURTHER DEVELOPMENTS

As we work in the area of industrial facility planning, we are always on the lookout for new product ideas. When we first introduced the concept of a layout analysis program that used an AutoCAD plant drawing, we were told that it wasn't easy to draw plants using AutoCAD alone. To address that need, we created FactoryCAD which includes dozens of AutoLISP drawing routines, an industrial symbol library and a system of layer organization designed especially to save time when drawing industrial facilities.

We are also exploring how a CAD-based program could be used to address the qualitative aspects of plant layout. These qualitative aspects are often summarized as relationships or closeness ratings between areas. We are researching a product which would integrate a plant drawing with numeric feedback on the satisfaction of these relationships.

The program would automatically create a "relationship diagram" overlaying the plant drawing in much the same way

FactoryFLOW creates a flow diagram. Lines of different thickness or color would represent different relationships between areas. The diagrams would give visual feedback to facilities planners on possible layout improvements which could be verified with scores measuring the satisfaction of relationships. We think it would be especially helpful if the program worked together with FactoryFLOW so that both the qualitative and quantitative impacts of a layout change could be measured in one CAD-based model

We recognize that a layout project might start with plant drawings, proceed through material handling and relationship analysis producing a best layout, and then end in simulating actual production through the proposed layout.

To help complete the process, we are researching a program which would take a layout alternative in FactoryFLOW, with all of its associated data, and automatically generate a simulation model. The program might use a simulator we design ourselves or it might use a popular simulation language so the user could further customize the model.

Our research is driven by our interest in increasing manufacturing productivity. Manufacturers have a huge investment in plant facilities. In order to stay competitive they need to make the right facilities

decisions. We're committed to providing practical software tools which make their work easier.

BIOGRAPHICAL INFORMATION

Ron Gilbert is President and CEO of CIMTECHNOLOGIES CORPORATION in Ames, Iowa. He has an MBA from the University of Iowa. He has been involved in marketing computer hardware and software solutions since 1982.

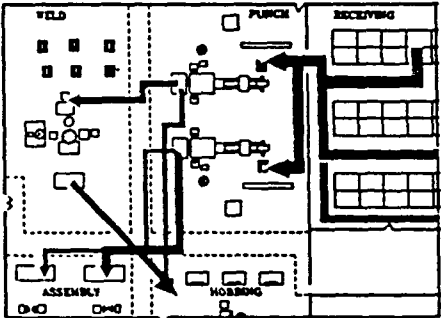
Advertisements for the Model

The following advertisements appeared repeatedly during the course of 1989 in the IIE, Cadence, and Cadalyst magazines.

Simplify drawing and layout of your factory and streamline your product flow with

VALDEP™

Visually Aided Layout and Design Program



Product Flow Diagram

VALDEP can make your production people experts in material handling and production layout. If they are experts already, **VALDEP** will cut their design time substantially.

VALDEP LAYOUT: speeds and simplifies plant floor drawing with AutoCAD® by providing automatic creation of walls, doors, windows, etc. and then allowing easy insertion of utility, machine, and storage symbols.


VALDEP ANALYSIS: provides the ability to interactively analyze the production line. With ANALYSIS, you can explore the benefits of:

- Altering product flow paths
- Changing material handling methods
- Moving storage and machines locations

or **VALDEP** will automatically create an efficient, economical layout for you!

Only **VALDEP** integrates automatic calculations of material handling costs and machine utilizations with AutoCAD graphics, using one common data base. "What if" changes and calculations become simple, fast and precise.

Minimize material handling costs with **VALDEP** — management's most cost effective tool to streamline the production line.



For more information or to order a demonstration disk call
Customer Service Rep 18 at 515-296-9914

CIMTECHNOLOGIES CORPORATION
MANUFACTURING SOFTWARE & SERVICES

ISIS Center, Ames, Iowa 50011

AutoCAD is a registered trademark of Autodesk, Inc.
VALDEP is a trademark of CIMTECHNOLOGIES CORPORATION.

Get More Information, Circle 121

If you're analyzing plant layout and material handling...

Until now you've had the challenge of struggling with:

- drawing the layout manually or in a stand-alone CAD system
- building an independent database of routing and material handling information
- using a calculator or a spreadsheet program
- creating your own reports and diagrams

Now there's FactoryFLOW! Designed for manufacturing facilities planners, FactoryFLOW integrates:

- The graphics of AutoCAD®
- Product routing and material handling data
- Interactive "what if" analysis with comparative costs and distances
- Flow diagrams and CAD graphic output
- Complete management reports

you need FactoryFLOW.™

CIMTECHNOLOGIES CORPORATION
MANUFACTURING SOFTWARE & SERVICES

For more information or to order a demonstration disk call
Customer Service Rep 27 at 515-232-9914

AutoCAD is registered in the U.S. Patent and Trademark Office by Autodesk, Inc.
FactoryFLOW is a trademark of CIMTECHNOLOGIES CORPORATION.

We're looking for a few good Dealers!

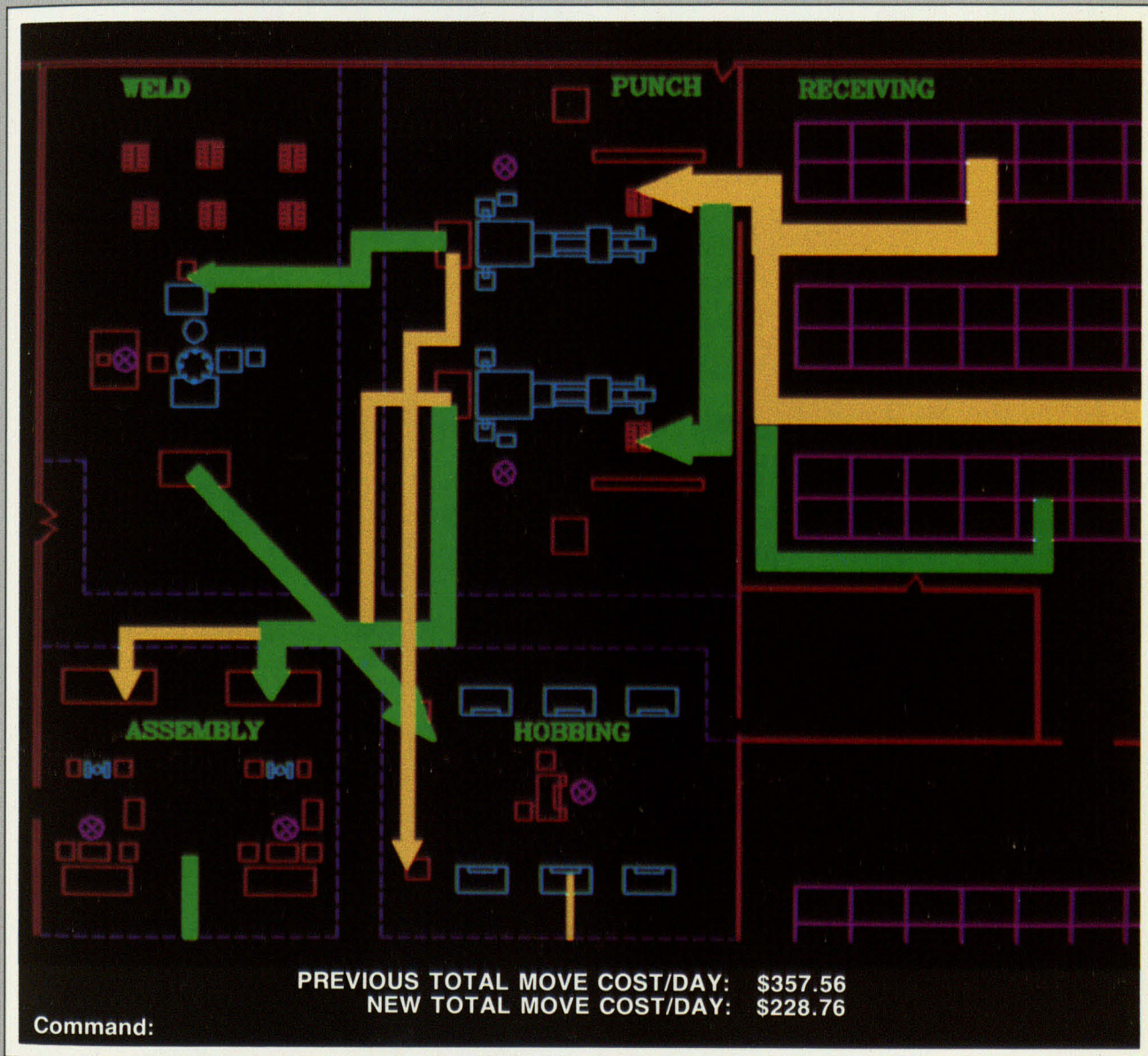
If you're an AutoCAD dealer who knows manufacturing and wants to penetrate the factory facilities management market, we would like to talk to you. Contact Ron Gilbert at
CIMTECHNOLOGIES CORPORATION 525 East Second, Suite 500 Ames, IA 50010 515-232-9914



CIMTECHNOLOGIES CORPORATION
MANUFACTURING SOFTWARE & SERVICES

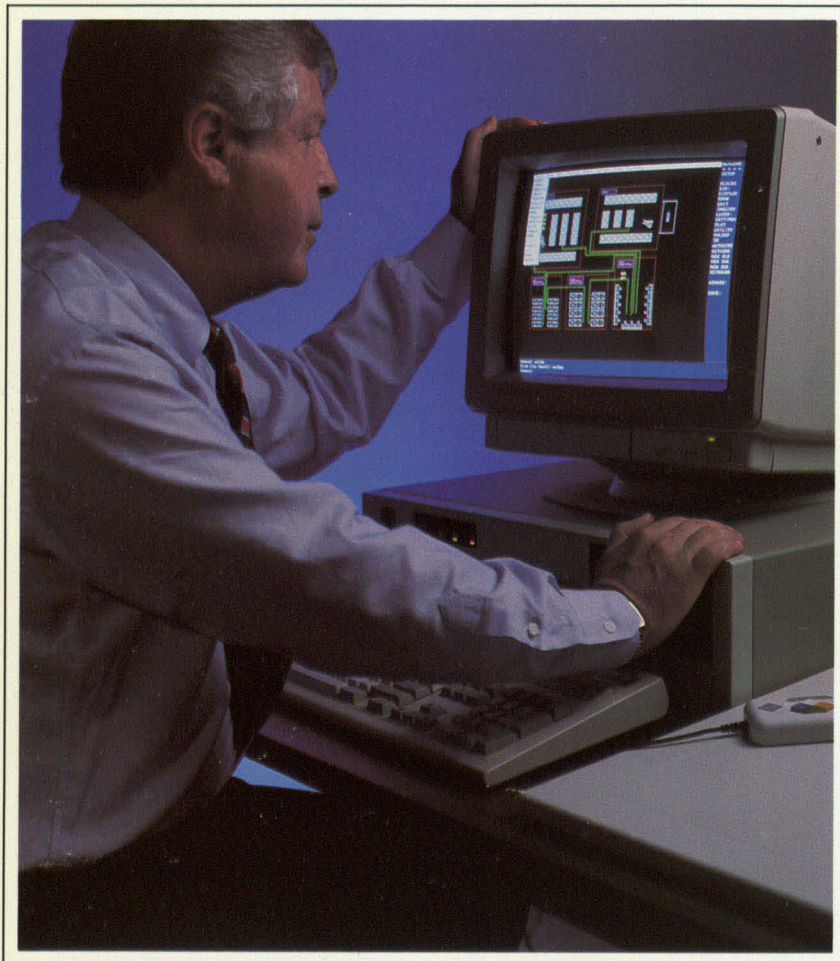
VALDEP™

Visually Aided Layout and Design Program



VALDEP Product Flow Diagram showing material handling cost savings generated by changing a storage location.

VALDEP *Designed by Industrial Engineers,
Tested in the Workplace.*



VALDEP helps manufacturers control production costs and stay competitive by providing:

- time saving tools to create accurate, up-to-date plant floor drawings more easily than architectural packages.
- graphic illustrations of costly material movement paths
- "what if" analysis of the benefits of changing material movement paths, material handling equipment, or storage and machine locations

VALDEP continuously helps manufacturers respond to fluctuating production levels, product mix changes, and new manufacturing or material handling methods. Each of **VALDEP's** three modules — **LAYOUT**, **ANALYSIS** and **AUTO OPT** — completely justifies the price of the program.

To stay competitive, every plant must find the lowest cost method of moving materials, and the most productive way to utilize machines and expensive manufacturing or storage space.

Few plants have the tools and information to do this as efficiently as they would like. Production planners typically must use several independent algorithms, make many tedious calculations, and then use a stand-alone graphics program to draw the results of their work.

This process takes lots of time and effort...and perhaps a main frame computer. In fact, these methods are so tedious and complex that many plants resort to intuitive, seat-of-the-pants decisions and hope for the best.

VALDEP, an integrated PC based program, revolutionizes all of this. Designed for the Production Manager or Industrial Engineer, **VALDEP** makes it easier to create plant floor drawings using AutoCAD® or architectural packages, then provides powerful tools to:

- analyze plant layout
- improve product flow
- lower material handling costs
- increase machine utilization

VALDEP integrates precise computer graphics with automatic calculations. Graphic layouts can be varied on a "what if" basis and **VALDEP** will immediately recalculate the cost impact. Easy to learn and use, **VALDEP** comes with extensive tutorials and complete, clearly written documentation.

VALDEP integrates the graphics of AutoCAD and a collection of powerful analytical tools into one easy-to-use program with a common database. Users can create plant floor drawings quickly and easily.

Management receives prompt, accurate cost and efficiency information that before was available only with great difficulty.

VALDEP continuously helps manufacturers respond to fluctuating production levels, product mix changes, and new manufacturing or material handling methods.

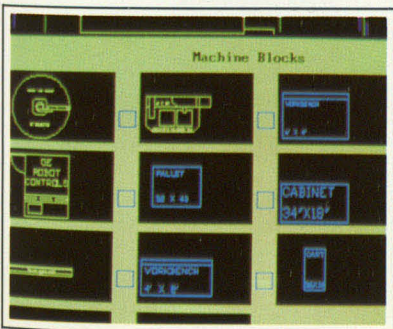
VALDEP FUNCTIONS

VALDEP comes in three modules which can be used independently or together. Each one — **LAYOUT**, **ANALYSIS** and **AUTO OPT** — justifies the cost of **VALDEP**.

LAYOUT speeds and simplifies plant floor drawing with AutoCAD by providing automatic creation/insertion of:

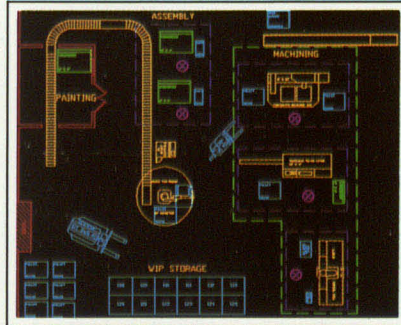
- walls, doors, windows, docks
- machines, workbenches, racks
- pallets, conveyors, material handling devices
- utilities, storage areas, safety envelopes, columns
- furniture, plumbing and lighting fixtures

Further, **LAYOUT** is designed especially for the manufacturing facility and eliminates many of the cumbersome features found in architectural facilities packages.



Machine Library

LAYOUT automatically creates drawings in separate "layers" for walls, machines, material handling, electrical, compressed air, HVAC and many more. These layers can be viewed or plotted independently or in any combination.

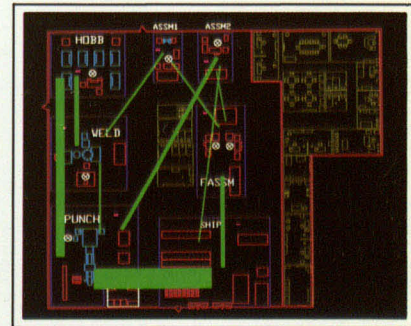


Plant drawing done with **LAYOUT**

ANALYSIS provides the ability to analyze the production line on a "what if" basis. With **ANALYSIS**, you can explore the benefits of:

- altering product flow paths
- changing material handling methods
- moving storage and machine locations

VALDEP uses a part information table with routing, material handling, and production data for whatever products/parts you choose. By following **VALDEP's** prompts, you merely draw the actual material flow paths and **ANALYSIS** will automatically calculate the material handling costs for the period you specify. Expensive paths are highlighted graphically with thicker flow lines in Product Flow Diagrams. These diagrams are integrated with the actual plant drawings.



Composite Product Flow Diagram

You may then interactively alter product flow paths, handling methods, or storage and machine locations.

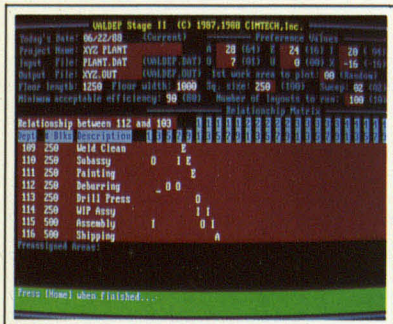
VALDEP will recalculate the new material handling costs, compare them with the old, and calculate the percent change. **ANALYSIS** generates Product Flow Diagrams for one or many products simultaneously. Distances travelled and material handling costs are calculated for each product, or between work centers for multiple products.

ANALYSIS also calculates machine utilization using your set-up and production times and scrap rates. **VALDEP** will highlight bottlenecks in the production line and do interactive "what if" calculations on the impact of adding or changing machines or operators.

VALDEP Part Table

PART	PRODUCT	QTY/PROD	BULK F	COST/FT	FROM WC	TO WC	TIME(MIN)	S RATE(%)
CRS	WENCH	0.2	8.0	0.006	SHIP	PUNCH		
SGEAR	WENCH	1.0	100.0	0.006	PUNCH	HOBBS	0.07	0.01
SGEAR	WENCH	1.0	100.0	0.006	HOBBS	WELD	1	0.01
SPLATE	WENCH	1.0	600.0	0.006	PUNCH	WELD	.15	0.01
ASSY1	WENCH	1.0	400.0	0.006	WELD	ASSM1	0.25	0.01
ASSY1	WENCH	1.0	400.0	0.006	ASSM1	FASSM	0.018	0.01
FASSM	WENCH	1.0	200.0	0.006	FASSM	SHIP	0.12	0.01
CRS	HANDLE	0.5	8.0	0.006	SHIP	PUNCH	0.14	0.01
LCKLINK	HANDLE	1.0	600.0	0.006	PUNCH	ASSM2	0.016	0.01
ARM	HANDLE	1.0	600.0	0.006	PUNCH	ASSM2	0.1	0.01
ASSY2	HANDLE	1.0	400.0	0.006	ASSM2	FASSM	0.32	0.01
FASSM	HANDLE	1.0	200.0	0.006	FASSM	SHIP	0.05	0.01
LABEL	HANDLE	1.0	2000.0	0.006	SHIP	ASSM2	0.052	0.01

AUTO OPT allows you to start from scratch! Using **AUTOMATIC OPTIMIZATION**, you provide the weighted factors and **VALDEP** will arrange work centers for you to minimize material handling costs and maximize efficient product flow. **VALDEP** turns these calculations into a set of efficient, economical plant layouts. You choose the ones you prefer and then use **LAYOUT** to turn them into detailed plant drawings.



Weighted Factor Analysis

SYSTEM REQUIREMENTS

VALDEP operates in an AutoCAD release 9.0 (or higher) environment on an IBM PC/AT® or compatible computer. The minimum system requirement is:

- 80286 CPU
- 80287 Math Coprocessor
- 640K of RAM
- Hard Disk Drive
- EGA or better graphics
- Mouse or Tablet

SYSTEM SUPPORT

VALDEP comes with extensive tutorials and complete, clearly written documentation. **CIMTECHNOLOGIES CORPORATION** and our staff of degreed Industrial Engineers offer full product support including regular courses in **VALDEP** and AutoCAD, product updates, and telephone support. **CIMTECHNOLOGIES** is a registered third party developer with Autodesk, Inc. and an AutoCAD Authorized Training Center.

GETTING STARTED—PLANT DRAWING AND ANALYSIS SERVICES

CIMTECHNOLOGIES' Industrial Engineers can create your **VALDEP** database from initial plant drawing through entry of part and machine data to initial analysis on a consulting basis. Call for more information.

VALDEP Reports

Material Handling Cost Report	
Part I: By Product	
Product name: WENCH	Production volume: 600000 / YEAR
Between SHIP and PUNCH	\$4,320
Between PUNCH and HOBBS	\$4,716
Between HOBBS and WELD	\$1,980
Between PUNCH and WELD	\$276
Between WELD and ASSM1	\$621
Between ASSM1 and FASSM	\$486
Between FASSM and SHIP	\$954
Total	\$13,353 / YEAR
Product name: HANDLE	Production volume: 600000 / YEAR
Between SHIP and PUNCH	\$9,000
Between PUNCH and ASSM2	\$1,740
Between ASSM2 and FASSM	\$207
Between FASSM and SHIP	\$954
Between SHIP and ASSM2	\$281
Total	\$12,182 / YEAR
TOTAL	\$25,535 / YEAR
Part II: By Work Centers	
Between SHIP and PUNCH	\$13,320
Between PUNCH and HOBBS	\$4,716
Between HOBBS and WELD	\$1,980
Between PUNCH and WELD	\$276
Between WELD and ASSM1	\$621
Between ASSM1 and FASSM	\$486
Between FASSM and SHIP	\$1,908
Between PUNCH and ASSM2	\$1,740
Between ASSM2 and FASSM	\$207
Between SHIP and ASSM2	\$281
TOTAL	\$25,535 / YEAR

Utilization Report	
Work center name: FASSM	Number of servers/machines: 1 Work center utilization (%): 88.55
Work center name: SHIP	Work center name: PUNCH Number of servers/machines: 1.7 Work center utilization (%): 102.95
Work center name: WELD	Number of servers/machines: 1.5 Work center utilization (%): 86.81
Work center name: HOBBS	Number of servers/machines: 6 Work center utilization (%): 86.81
Work center name: ASSM1	Number of servers/machines: 5 Work center utilization (%): 18.75
Work center name: ASSM2	Number of servers/machines: 2 Work center utilization (%): 83.34

CONVEYOR REPORT	
BE2490, 24 inch., 90 deg. Curve, Belt conveyor, 2	
BE2405, 24 inch., 5 ft. Straight, Belt conveyor, 1	
BE2410, 24 inch., 10 ft. Straight, Belt conveyor, 2	
BE2420, 24 inch., 20 ft. Straight, Belt conveyor, 1	
BE2440, 24 inch., 40 ft. Straight, Belt conveyor, 3	
RO1890, 18 inch., 90 deg. Curve, Roller conveyor, 4	
RO1805, 18 inch., 5 ft. Straight, Roller conveyor, 3	
RO1810, 18 inch., 10 ft. Straight, Roller conveyor, 2	
WH1290, 12 inch., 90 deg. Curve, Wheel conveyor, 3	
WH1205, 12 inch., 5 ft. Straight, Wheel conveyor, 3	
WH1210, 12 inch., 10 ft. Straight, Wheel conveyor, 15	
RO1800, 18 inch., 2.71 ft. custom-made, Roller conveyor	
RO1800, 18 inch., 1.65 ft. custom-made, Roller conveyor	
RO1800, 18 inch., 3.42 ft. custom-made, Roller conveyor	
RO1800, 18 inch., 0.09 ft. custom-made, Roller conveyor	
BE2400, 24 inch., 0.47 ft. custom-made, Belt conveyor	
BE2400, 24 inch., 3.67 ft. custom-made, Belt conveyor	
WH1200, 12 inch., 4.65 ft. custom-made, Wheel conveyor	
WH1200, 12 inch., 0.64 ft. custom-made, Wheel conveyor	
WH1200, 12 inch., 1.15 ft. custom-made, Wheel conveyor	

To order a demonstration disk, or to learn more about **VALDEP**, please contact:

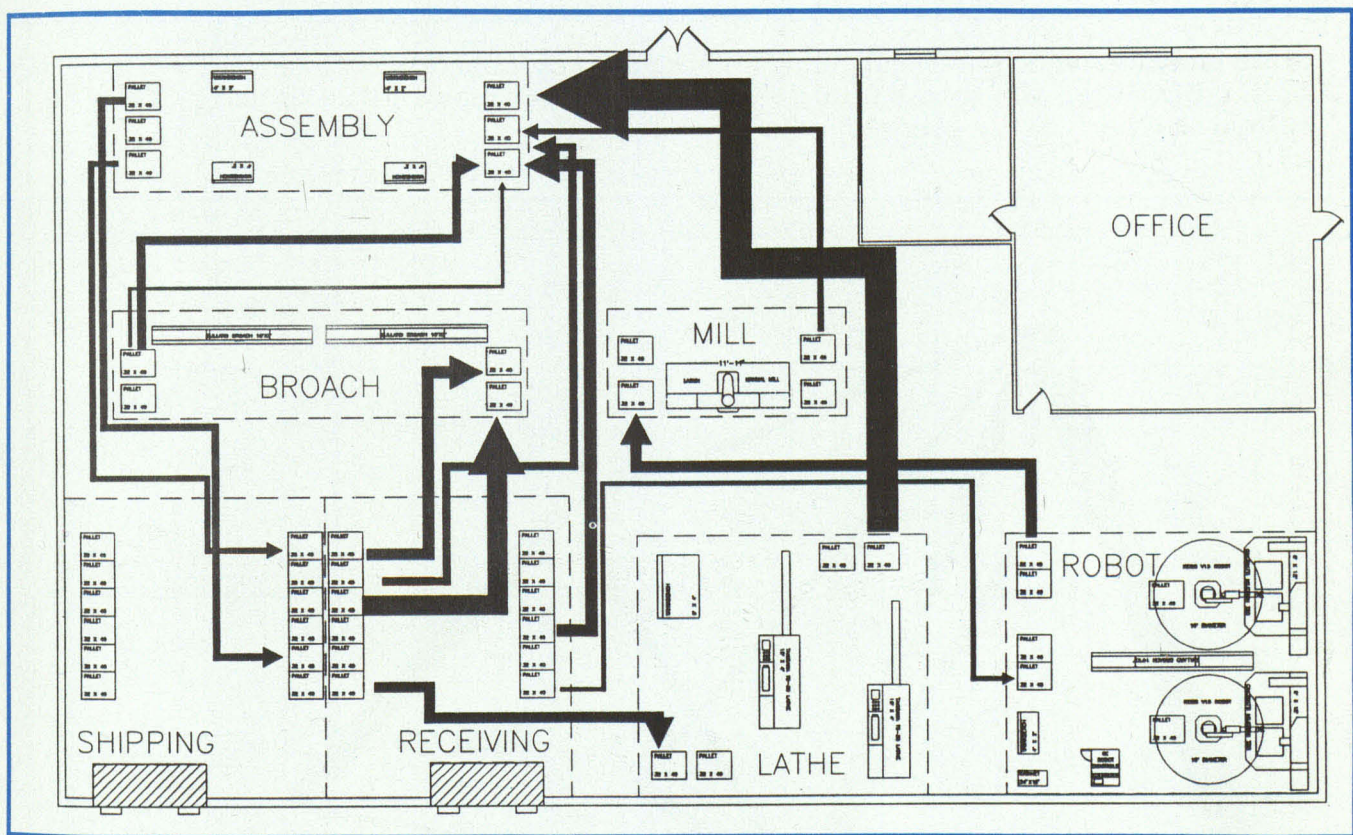
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FactoryFLOW™

Plant Layout and Material Handling Analysis within AutoCAD®

Sample Diagrams, Reports and Displays



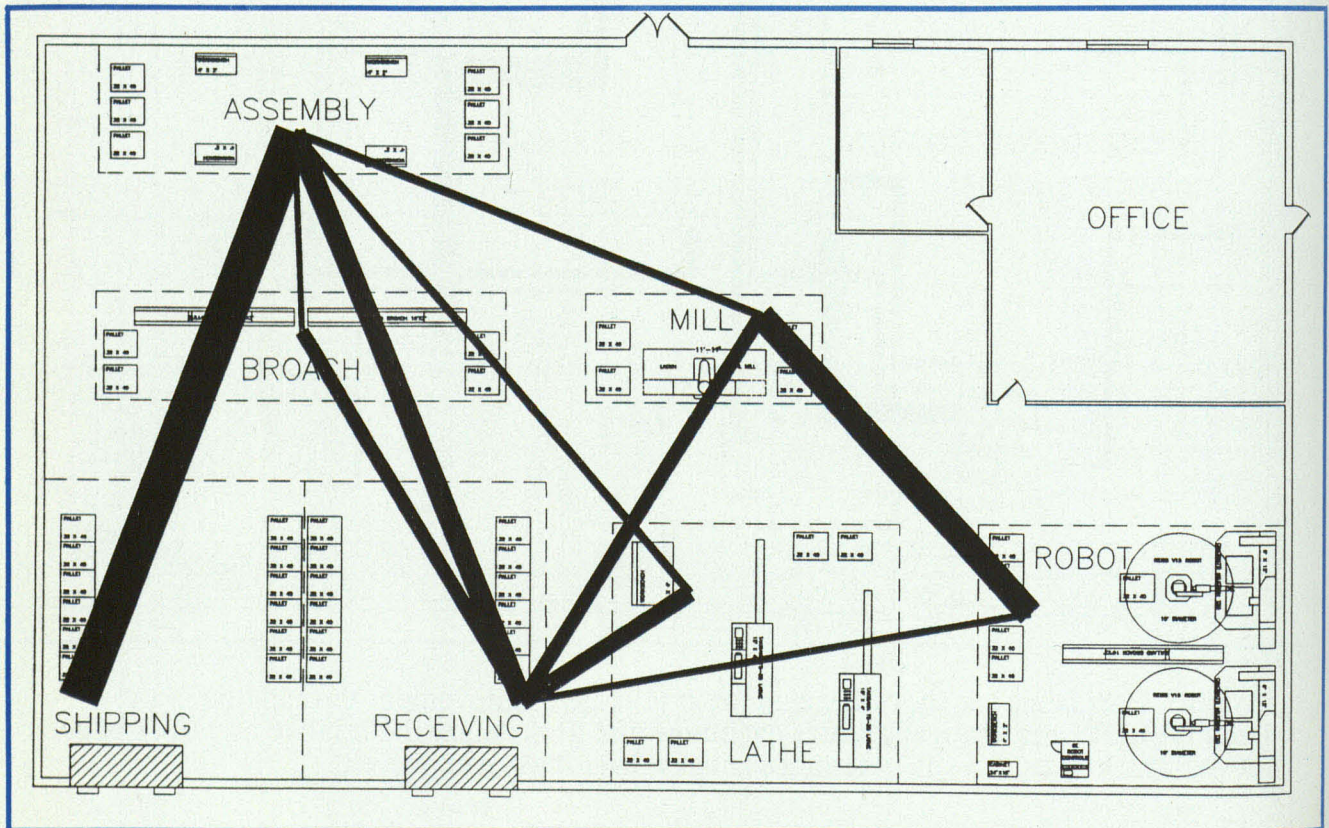
Product Flow Diagram showing actual path of material movement through the plant. **FactoryFLOW** automatically scales each flow line to highlight the relative cost/foot of each move. Thick lines identify potential savings if layout were improved.

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORY FLOW ANALYSIS
 DATE: 05/24/1989
 TIME: 14:29

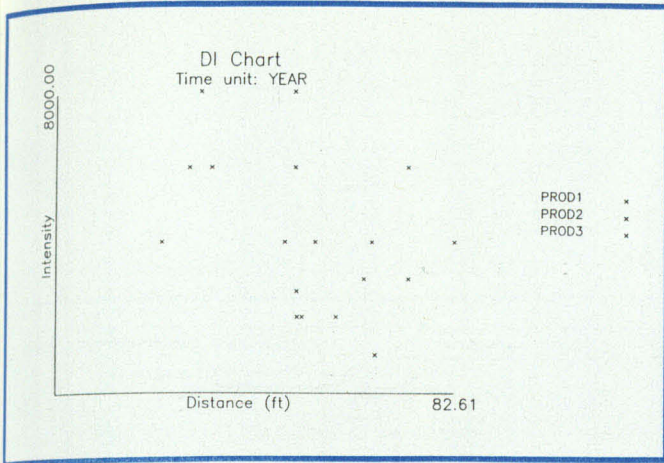
MATERIAL HANDLING REPORT

PRODUCT NAME	PART NAME	GROUP CODE	FROM WORK CENTER	TO WORK CENTER	MATERIAL HANDLING NAME	MATERIAL	TOTAL	TOTAL	FIXED	VARIABLE	TOTAL	TOTAL MOVE FREQUENCY	TOTAL	TOTAL	TOTAL
						DISTANCE (FT.)	MOVE (FT.)	MOVE TIME (MIN.)	MOVE COST (\$)	MOVE COST (\$)	MOVE COST (\$)		DISTANCE (FT.)	TIME (MIN.)	COST (\$)
PROD1	PART1	C20	ASSEMBLY	SHIPPING	MH1	64.53	86.04	1.40	0.31	0.52	0.83	2040.82	175582.77	2857.14	1690.50
PROD1	PART11	C20	MILL	ASSEMBLY	MH2	57.60	96.00	0.75	0.02	0.16	0.18	2020.20	193939.39	1515.15	372.39
PROD1	PART12	C20	BROACH	ASSEMBLY	MH2	57.71	96.18	0.75	0.02	0.16	0.18	1010.10	97149.27	757.58	186.19
PROD1	PART13	C20	RECEIVING	ASSEMBLY	MH1	62.50	83.34	1.40	0.31	0.52	0.83	4000.00	333342.22	5600.00	3313.38
PROD1	PART111	C21	ROBOT	MILL	MH2	50.40	84.01	0.75	0.02	0.16	0.18	4040.40	339416.39	3030.30	744.77
PROD1	PART112	C21	RECEIVING	MILL	MH2	23.00	38.33	0.75	0.02	0.16	0.18	2000.00	76655.56	1500.00	368.66
PROD1	PART121	C20	RECEIVING	BROACH	MH2	31.62	52.71	0.75	0.02	0.16	0.18	4000.00	210827.78	3000.00	737.32
PROD1	PART1111	C21	RECEIVING	ROBOT	MH2	75.34	125.57	0.75	0.02	0.16	0.18	2000.00	251138.89	1500.00	368.66
PROD2	PART2	C20	ASSEMBLY	SHIPPING	MH1	68.48	91.30	1.40	0.31	0.52	0.83	2040.82	186326.53	2857.14	1690.50
PROD2	PART21	C21	MILL	ASSEMBLY	MH2	43.93	73.22	0.75	0.02	0.16	0.18	1010.10	73957.63	757.58	186.19
PROD2	PART22	C20	RECEIVING	ASSEMBLY	MH1	80.50	107.34	1.40	0.31	0.52	0.83	500.00	53667.78	700.00	414.17
PROD2	PART211	C21	RECEIVING	MILL	MH1	33.18	44.24	1.40	0.31	0.52	0.83	1333.33	58982.22	1866.67	1104.46
PROD3	PART3	C20	ASSEMBLY	SHIPPING	MH1	81.34	108.46	1.40	0.31	0.52	0.83	1632.65	177072.11	2285.71	1352.40
PROD3	PART31	C21	LATHE	ASSEMBLY	MH2	65.72	109.53	0.75	0.02	0.16	0.18	3232.32	354024.69	2424.24	595.82
PROD3	PART32	C21	BROACH	ASSEMBLY	MH2	66.89	111.49	0.75	0.02	0.16	0.18	3232.32	360372.62	2424.24	595.82
PROD3	PART33	C20	RECEIVING	ASSEMBLY	MH1	51.32	68.42	1.40	0.31	0.52	0.83	1600.00	109475.56	2240.00	1325.35
PROD3	PART311	C21	RECEIVING	LATHE	MH2	36.39	60.64	0.75	0.02	0.16	0.18	3200.00	194062.22	2400.00	589.86
PROD3	PART321	C20	RECEIVING	BROACH	MH2	27.17	45.28	0.75	0.02	0.16	0.18	3200.00	144880.00	2400.00	589.86

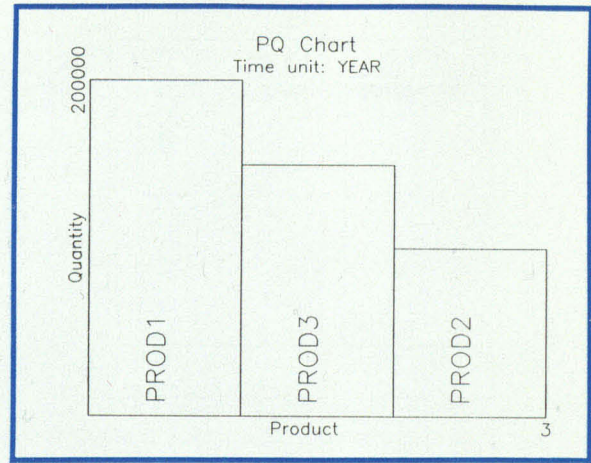
Material Handling Report highlighting distance and cost impact of each move. **FactoryFLOW** lets you choose from a variety of standard report formats or makes it easy to customize reports to suit your requirements.



Composite Flow Diagram illustrating relative cost/foot of all moves between pairs of workcenters. **FactoryFLOW** lets you quickly compare alternative layouts and examine "what if" scenarios.



Distance-Intensity Chart showing path distance and number of trips for each move. Points away from both axes highlight potential cost savings.



Product-Quantity Chart highlighting relative production volumes for a cross-section of products.

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORY FLOW ANALYSIS
 DATE: 05/26/1989
 TIME: 10:07

MATERIAL HANDLING UTILIZATION

Material handling system name: MH1
 Available minutes / equipment / YEAR: 105000.00
 Busy minutes / system / YEAR: 36247.62
 Quantity: 0.50
 Utilization (100%): 69.04

Material handling system name: MH2
 Available minutes / equipment / YEAR: 95000.00
 Busy minutes / system / YEAR: 42212.12
 Quantity: 0.60
 Utilization (100%): 74.06

Material Handling Equipment Utilization Report showing handling system statistics. **FactoryFLOW** helps you get the maximum return on your investment in expensive handling equipment.

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORY FLOW ANALYSIS
 DATE: 05/30/89
 TIME: 16:20

WORK CENTER UTILIZATION

Work center name: ASSEMBLY
 Available Minutes / Server / YEAR : 90000
 Busy Minutes / Server / YEAR : 890939
 Number of servers: 14.00
 Utilization (%): 70.71

Work center name: MILL
 Available Minutes / Server / YEAR : 100000
 Busy Minutes / Server / YEAR : 491071
 Number of servers: 7.00
 Utilization (%): 70.15

Work center name: BROACH
 Available Minutes / Server / YEAR : 100000
 Busy Minutes / Server / YEAR : 385357
 Number of servers: 5.00
 Utilization (%): 77.07

Work center name: ROBOT
 Available Minutes / Server / YEAR : 100000
 Busy Minutes / Server / YEAR : 460606
 Number of servers: 6.00
 Utilization (%): 76.77

Work center name: LATHE
 Available Minutes / Server / YEAR : 100000
 Busy Minutes / Server / YEAR : 466667
 Number of servers: 6.00
 Utilization (%): 77.78

Workcenter Utilization Report showing impact of product flow on workcenter loading. **FactoryFLOW** helps you measure the impact of layout or handling changes on machine loading.



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PRODUCTS FILE : FACTORY1		
PRODUCT	# / YEAR	PATH COLOR
WADDER	100000.00	YELLOW

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PARTS FILE : FACTORY1					
PRODUCT : LADDER					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD
RAIL	2.000	WC1	WC2	PPTRK	400.00
SRAIL	0.030	DOCK	WC1	LFTRK	30.00
RTOPCAP	1.000	IMIP	WC9	LFTRK	400.00
LTOPCAP	1.000	IMIP	WC9	LFTRK	400.00
TOPCAP	2.000	DOCK	IMIP	LFTRK	400.00
TOPCAP	2.000	OWIP	DOCK	LFTRK	500.00
TOPCAP	2.000	WCB	OWIP	LFTRK	500.00
TOPCAP	2.000	WC4	WCB	LFTRK	500.00

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MATERIAL HANDLING EQUIPMENT FILE : FACTORY1									
MATERIAL HANDLING	TYP	QTY	INVEST. COST /YEAR	HOURLY TP & M COST	HOURLY LABOR COST	AVAIL. MINUTES /YEAR	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)
LFTRK	5	1.00	3000	1.00	20.00	100000	1.00	250.00	70.00
CONVY	7	***	1000	1.00	0.00	10000	***	***	***
PPTRK	3	1.00	1000	1.00	15.00	100000	1.00	150.00	70.00

Data Input Screens from FactoryFLOW's FFEDIT module. Product, Part and Material Handling Equipment Files are quickly created and easily edited.

Order FactoryFLOW today!

Your FactoryFLOW Dealer:

Report Generator Material handling source file: EXAM

Select the type of report to generate

Standard Reports: Move Frequency, Total Distance, Total Time, Total Cost

Custom Reports: WC : Work Centers, MDIST : Move Distance, PRODPART : Products Parts, MHE : Material Handling Equipment, GCODE : Group Code

Press <F1> to print highlighted report, <F2> to edit highlighted report format, <F3> to create a new report format, <space> to switch boxes, <ESC> to exit.

Print Fields: Product Name, Part Name, Group Code, From Work Center, To Work Center, Material Handling, Move Distance, Total Move Dist., Total Move Time, Fixed Move Cost, Variable Move Cost, Total Move Cost, Move Frequency, Total Distance, Total Time, Total Cost

Sort Parameters (A or D): Primary, Secondary

Length of print lines: Total Dist. () miles, (/) feet, Total Time () hours, (/) minutes

Primary Subtotals (/) ON, OFF

Secondary Subtotals (/)

Press <F1> to set printer options, <- -> to move between columns and boxes, <ESC> to return to previous menu

<Enter> or <space> to select/unselect. A - Ascending, D - Descending

Report Selection and Customization is easy with FactoryFLOW. Information can be tailored to your individual preferences and project requirements.



FactoryFLOW™

Plant Layout and Material Handling Analysis within AutoCAD®

The challenge in manufacturing is clear--to stay competitive. The response takes many forms: reduce costs, increase quality, accelerate new-product introduction.

The solution goes by many names and comes in many forms, such as "World Class Manufacturing", Automation, Just-in-Time, Group Technology, and CIM.

Agreeing on a strategy is easy. Deciding how to implement that strategy is another story. You need to make the right decisions based on the right information. CIMTECHNOLOGIES has created FactoryFLOW to be the decision-making tool you need to design manufacturing facilities which best help you stay competitive.

No matter what the approach, a part of the solution is better design of expensive production facilities.

FactoryFLOW gives you the management information you need, integrated with powerful CAD graphics and actual plant drawings. FactoryFLOW's "Graphical Spreadsheet" lets you model alternatives, changes and improvements to production and material handling systems before undertaking expensive, irreversible changes.

FactoryFLOW gives you:

- Improved Layout Planning
 - Comprehensive Management Data
 - Efficient Material Flow
 - Instantaneous "What if" Feedback
 - Detailed Material Handling Cost Analysis
-

Financial Justification

How does FactoryFLOW justify itself? Here are just a few of the key features and benefits you won't find in any other facilities planning program, including simulation packages:

Feature:

Flow Diagrams with "Intelligent Flow Lines"

Benefit:

Turns an actual plant drawing into a comprehensive illustration of layout and flow problems. Highlights high-cost moves, inefficient travel, poor machine and storage locations, and more.

Feature:	Benefit:
Instant "What if" Analysis of Alternatives	Lets you explore changes and improvements before undertaking costly shop-floor implementation. Gives you complete control over all decisions and their impact.
Graphical and Quantitative Reporting	Produces the perfect output for management presentations. Justifies changes with comprehensive, quantitative management data focussing on the bottom line.
Flexibility of Application	Conforms to the needs of your project, whether you're planning an entire site, an individual work cell, or anything in between. Handles multi-buildings, multi-floors, etc.
Detailed Reporting on Handling Distances and Costs, Handling Device Utilization and Machine Utilization	Gives you quantitative feedback on all aspects of layout and handling changes. Removes the guesswork from the planning process and considers the tradeoffs involved with all changes.

All management reports are fully customizable to the particular requirements of your project. And all this in a flexible, easy-to-use package which includes a complete Tutorial and Reference Manual.

FactoryFLOW can help you...

- Implement new manufacturing technologies (J.I.T., Group Technology, etc.)
- Automate or install new production equipment
- Expand or relocate production facilities
- Introduce new products and new tooling
- Make changes to improve existing facilities
- Correct production bottlenecks and flow problems
- Adjust to changes in volumes, product mix, etc.
- Plan a site, a cell, or anything in between

Order FactoryFLOW today for only \$2495 plus shipping and handling. To order, or for more information, contact

CIMTECHNOLOGIES CORPORATION
525 East Second, Suite 500
Ames, IA 50010
(515)232-9914

Model Evaluation Comment Forms

The following alpha and beta testor forms were sent to all users of the model before and after they received the program.

APPENDIX D
VALDEP TEST SITE QUESTIONNAIRE
VALDEP 1.6 ALPHA 3/17/89

The following questions are to be answered after you complete your project analysis with VALDEP. If you have any questions about what response we are looking for, please don't hesitate to give us a call.

- 1) What is your overall opinion on how well VALDEP helped you to analyze your layout and material handling.

See Attached Letter

- 2) Rank the following reports in order of importance. 1 is most important and 7 is least important. Explain the usefulness of each of the above reports?

Composite Flow Diagrams

2. *Great for showing management how ridiculous present locations are.*

Product Flow Diagrams

1. *Excellent tool for finding and showing any path through the factory automatically.*

Distance Intensity Charts

3. *Great tool to illustrate proportion of poor material handling moves. We will constantly try to find ways to eliminate the ones above the diagonal.*

4. *It is nice to do a Pareto analysis with the aid of this chart and concentrate on the important ones.*

Material Handling Utilizations

6. This gives us data that we never had before. Our ~~times~~^{info} need to be more accurate before we can really use this.

Material Handling Report

5. The cost/distance by move + part is obviously important. It would be beneficial to see the summation of all cost between each possible work center pair.

Workcenter Utilizations

7. Another important report we'll use to keep an eye on capacity + space requirements. I don't feel our times are very accurate at this point though.
- 3) How long did it take you to prepare your Product Table and Part Table in the format that VALDEP requires?
-
- 4) Do you feel the time necessary to compile this information in the required format is worth the results you receive from the program?
 YES - I think Valdep will be very valuable in an upcoming sheetmetal fabrication department organization.
- 5) Can you think of any other format for this data, or ways of summarizing this data, that would make completing this analysis less data intensive?
 We will import ours off of culprit reports from the main frame.
- 6) a) Do we adequately explain the data requirements? b) Would examples of ways of gathering/summarizing data be helpful? c) Do you have any suggested examples?

YES

YES - Its different with every situation but summarizing data effectively could save a lot of work.

**BETA TEST SITE SELECTION QUESTIONNAIRE
FACTORYFLOW 1.0 BETA 7/10/89**

We will use your responses to the following questions to select the sites for our BETA test of FactoryFLOW 1.0. All of the questions below apply to the project that you have in mind, and not necessarily to your entire manufacturing facility.

- 1) Are you making, or planning to make improvements to your current layout and/or material handling system plan? *YES,*

- 2) What is motivating the changes to your layout or material handling system? Would this involve JIT, Group Technology or Equipment Realignment concepts?
Consolidation of Facilities, and the use of JIT concepts

- 3) Do you have your factory drawn in AutoCAD? If not what system is it in (if any)? *YES*

- 4) Do you own a copy of AutoCAD Release 10?
YES

- 5) Do you have access to an IBM or compatible 286 or 386 computer with at least 1.5MB of RAM, a mouse/tablet, a math coprocessor, and EGA graphics (or better) with a color monitor?
YES

- 6) Is the following information available? If yes, in what form?
 - * Products and Product volumes
Yes, ASCII format from Mainframe TSO; This info was generated specifically for use with your software.
 - * Parts, Quantity per product, routing, machining times
YES, "

- * Current material handling devices and bulk factor quantities

Yes

- * Current or proposed material handling paths

Yes

Note: The format that FactoryFLOW requires for this information is included in Appendix A of this questionnaire.

- 7) Do you have the time available for this project? (The deadline for your completed analysis, if you are selected as a test site, would be 8/22/89.) Note: for a definition of what we consider to be a completed analysis, please see the following form.

Yes

- 8) Would you consider your present layout to be process, product, or other?

Product

- 9) How many SKU's are you analyzing in the area under analysis?

208

- 10) Is your factory or area an assembly, machining, or chemical facility? (discrete or continuous?)

Fabrication/Assembly

- 11) In order to keep track of your project, we need the following information:

Name of project leader: WES PLUMMER
Telephone number of same: 213-562-1133 ext. 489

Name of project contact: WES PLUMMER
Telephone number of same: 213-562-1133 ext. 489

Company address at project site: 5119 DISTRICT BLVD.
L.A. Ca. 90070

- 12) Briefly describe the project that you propose to analyze using FactoryFLOW.

Alignment & placement of assembly lines and
Fabrication equipment.

User Manual for the Model

The following is a user manual for FactoryFLOW. The user manual consists of two main parts. The first part is a set of three tutorials to teach a user how to use the program. The second part is the reference section for the commands in FactoryFLOW.



CIMTECHNOLOGIES CORPORATION
MANUFACTURING SOFTWARE & SERVICES

FactoryFLOW™

Release 1.02

Plant Layout and Material Handling Analysis within AutoCAD®

Tutorial and Reference Manual

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Preface

Thank you for purchasing FactoryFLOW! We have taken great care in making sure that the FactoryFLOW program and this manual are well designed and thoroughly executed.

FactoryFLOW is the first layout analysis tool that integrates actual facilities drawings and material flow paths with production and material handling data. FactoryFLOW is a powerful graphical "what if" decision-making tool that lets you quickly analyze and compare alternative layouts and handling systems. Drawings and data can be entered easily into FactoryFLOW in a variety of ways, and FactoryFLOW output includes Product Flow and Composite Flow Diagrams, Material Handling Cost Reports, and much more.

The *FactoryFLOW Tutorial and Reference Manual* has been designed for people who hate to read most software manuals. It includes a complete, easy-to-follow tutorial exercise divided into three sections. By completing the tutorial you will be ready to use FactoryFLOW to improve the layout and material handling system in your plant.

Contents of the package

In this package you should have this *FactoryFLOW Tutorial and Reference Manual* and a sealed disk envelope containing one FactoryFLOW disk. Please read and understand the *License Agreement* before breaking the envelope seal.

Where to go first

Once you've read the *License Agreement*, read the *Registration and Support* information and follow the registration instructions so you will be eligible for technical support.

You must read the brief *Getting Started* section of the manual before using FactoryFLOW. *Getting Started* describes the installation process, tells how to use this manual, and gives lots of other important information which will make using FactoryFLOW even easier.

You will become productive fastest if you then spend a few minutes reviewing *Using FactoryFLOW* before getting hands-on experience with the program in the *Tutorial*. The *Tutorial* includes three exercises, including sample data, which step you through all aspects of using FactoryFLOW to successfully complete projects on your own.

The manual also includes a complete *Reference Section*, several helpful *Appendixes* with detailed information on selected topics, a *Glossary* of relevant terms and an *Index*.

Again, thank you for buying FactoryFLOW. If you have any questions, problems or suggestions, let us know. If you like FactoryFLOW, recommend it to someone else.

Sincerely,

The CIMTECHNOLOGIES FactoryFLOW team.

Signatures have been redacted for privacy

Signatures have been redacted for privacy

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CIMTECHNOLOGIES CORPORATION/Customer Service Representative/525 East Second, Suite 500/Ames, IA 50010.

Registration and Support

Thank you for purchasing FactoryFLOW! When you purchased FactoryFLOW, you didn't just purchase software, you purchased a powerful tool for analyzing and improving your plant layout and material handling system. The staff at CIMTECHNOLOGIES has worked hard to ensure that FactoryFLOW is easy to use as well as powerful. We hope that you do not experience any problems with FactoryFLOW but in the event that you do, call us. CIMTECHNOLOGIES' staff of industrial engineers is here to help.

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You must fill out and return the accompanying Registration form to be eligible for CIMTECHNOLOGIES customer support. **Returning the completed Registration form entitles you to the following:**

1. **Customer Support.** CIMTECHNOLOGIES provides customer support only to registered licensees of the Product.
2. **Product Upgrades.** Only registered licensees of CIMTECHNOLOGIES' products are eligible to obtain licenses for new versions of our products, when they are introduced, at special upgrade or exchange prices.

We have provided two copies of the Registration form on the following pages. Please fill out both copies. Keep the first copy in this manual and mail the second copy to CIMTECHNOLOGIES CORPORATION.

Product Support

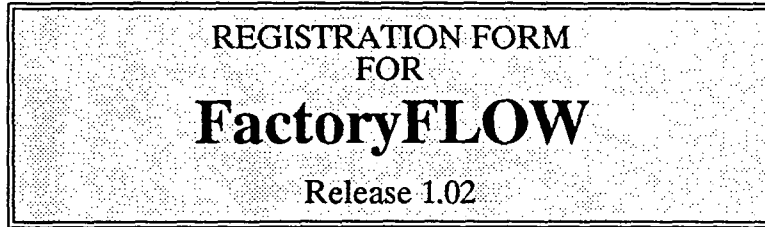
CIMTECHNOLOGIES offers registered users continuing support in the form of telephone advice and other assistance. If you have difficulty in using the program(s) or if it does not operate as described, we suggest that you do the following in numerical order:

1. Consult the documentation and other materials that accompany the product. They contain answers to most user's questions. Also check to see whether the program supports your particular operating system, interfaces, and peripherals.
2. If your question is not answered by reading the documentation, call the CIMTECHNOLOGIES support department:

(515) 232-9914
between 9 a.m. and 5 p.m. (Central time)
Monday through Friday.

CIMTECHNOLOGIES CORPORATION

Manufacturing Software and Services



Please print clearly in ink or type.
Fill out completely.

Send to: FactoryFLOW Registration
CIMTECHNOLOGIES CORPORATION
525 East Second, Suite 500
Ames, Iowa 50010

Questions call: FactoryFLOW Support
(515) 232-9914

Your FactoryFLOW Serial Number is:

Company	Department
Address	Phone
Address	
City, State, Zip Code	

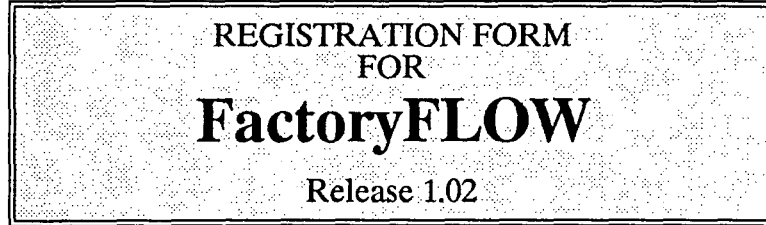
Registered User Information:

Last Name	First Name	M.I.
Title	Phone or extension	

Send this copy to CIMTECHNOLOGIES at the address listed above.

CIMTECHNOLOGIES CORPORATION

Manufacturing Software and Services



Please print clearly in ink or type.
Fill out completely.

FactoryFLOW Registration
CIMTECHNOLOGIES CORPORATION
525 East Second, Suite 500
Ames, Iowa 50010

Questions call: FactoryFLOW Support
(515) 232-9914

Your FactoryFLOW Serial Number is:

Company _____ Department _____

Address _____ Phone _____

Address _____

City, State, Zip Code _____

Registered User Information:

Last Name _____ First Name _____ M.I. _____

Title _____ Phone or extension _____

Keep this copy in the manual.

FactoryFLOW Bug Report

Name _____ Date _____

Company _____

Address _____

City _____ State _____ Zip _____ Country _____

Phone (please include area code) _____ Ext. _____

I am a Dealer Customer If you are a dealer, was the bug reported by a customer? Yes No

Customer's name _____

Customer's phone (please include area code) Ext. _____

FactoryFLOW Release _____ Serial No. _____

AutoCAD Release _____ Version _____

Memory _____ on motherboard _____ extended memory _____ expanded memory
_____ on expansion board (board: _____)

Problem Description

Use this space to describe the problem you are having. Be specific in the sequence of steps which caused the problem, and the exact results. Be sure to enclose copies of relevant materials: drawing files (on disk), script files, plots, etc.

Materials Enclosed: Diskette Listing Script Letter Plot Sketch

(attach additional sheets if necessary)

This section for use by CIMTECHNOLOGIES only.

Completed by: _____ Date: ____/____/____

First FactoryFLOW version containing fix: _____

FactoryFLOW Bug Report

Name _____ Date _____

Company _____

Address _____

City _____ State _____ Zip _____ Country _____

Phone (please include area code) _____ Ext. _____

I am a Dealer Customer If you are a dealer, was the bug reported by a customer? Yes No

Customer's name _____

Customer's phone (please include area code) Ext. _____

FactoryFLOW Release _____ Serial No. _____

AutoCAD Release _____ Version _____

Memory _____ on motherboard _____ extended memory _____ expanded memory
_____ on expansion board (board: _____)

Problem Description

Use this space to describe the problem you are having. Be specific in the sequence of steps which caused the problem, and the exact results. Be sure to enclose copies of relevant materials: drawing files (on disk), script files, plots, etc.

Materials Enclosed: Diskette Listing Script Letter Plot Sketch

(attach additional sheets if necessary)

This section for use by CIMTECHNOLOGIES only.

Completed by: _____ Date: ____/____/____

First FactoryFLOW version containing fix: _____

Getting Started

The Getting Started section contains some very important information, broken down into the following sections:

- System requirements for both AutoCAD 386 and standard DOS AutoCAD
- Configuring standard DOS AutoCAD for Extended AutoLISP
- Installing FactoryFLOW
- General instructions on using FactoryFLOW
- AutoCAD commands you should know
- Conventions used in this manual

The person installing FactoryFLOW should read all of the *Getting Started* section.

Once the system is installed, a new user should read the second half of *Getting Started*, beginning with the *General instructions* on page 6, before continuing with FactoryFLOW. When you have completed reading *Getting Started*, you will become productive fastest by reading *Using FactoryFLOW* and then proceeding with the *FactoryFLOW Tutorial*.

System Requirements

The FactoryFLOW disk contains the files needed to run FactoryFLOW on two different types of AutoCAD systems: AutoCAD 386 and standard DOS AutoCAD. The system requirements are different for the two versions.

AutoCAD 386

Before installing FactoryFLOW on your computer to run with AutoCAD 386, make certain that your computer has the following:

- an Intel 80386 microprocessor
- an 80287 or 80387 math coprocessor
- at least one high density floppy disk drive and one hard disk drive
- 640K base memory
- at least 1MB of AT-style extended memory (*not* Lotus/Intel/Microsoft expanded memory) not devoted to other purposes
- at least EGA color graphics
- a mouse or a tablet
- MS-DOS or PC-DOS operating system 3.3 or later
- AutoCAD 386 (DOS Extender) Release 10 with ADE-3
- AutoCAD support files in the AutoCAD program directory

Standard DOS AutoCAD

Before installing FactoryFLOW on your computer to run with the standard DOS version of AutoCAD, make certain that your computer has the following:

- an Intel 80286 or 80386 microprocessor
- an 80287 or 80387 math coprocessor
- at least one high density floppy disk drive and one hard disk drive
- 640K base memory
- at least 1MB of AT-style extended memory (*not* Lotus/Intel/Microsoft expanded memory) not devoted to other purposes
- at least EGA color graphics
- a mouse or a tablet
- MS-DOS or PC-DOS operating system 3.0 or later
- AutoCAD Release 10 for DOS with ADE-3
- Extended AutoLISP enabled
- AutoCAD support files in the AutoCAD program directory

Configuring Standard DOS AutoCAD for Extended AutoLISP

FactoryFLOW for standard DOS AutoCAD uses AutoCAD's Extended AutoLISP feature. Before installing FactoryFLOW for the standard DOS version of AutoCAD, you must configure AutoCAD to use Extended AutoLISP. If AutoCAD is not already configured for Extended AutoLISP, follow the instructions below.

If you are using AutoCAD 386, do not configure for Extended AutoLISP.

Change to whichever directory contains AutoCAD.

```
C:\> CD ACAD <Return>
```

Load AutoCAD and display the Main Menu.

```
C:\ACAD> ACAD <Return>
```

Choose "Configure AutoCAD".

```
Enter Selection: 5 <Return>
```

Display the Configuration Menu.

```
Press RETURN to continue: <Return>
```

Choose "Configure operating parameters."

```
Enter Selection <0>: 8 <Return>
```

Choose "AutoLISP feature."

```
Enter Selection <0>: 7 <Return>
```

Enable AutoLISP.

```
Do you want AutoLISP enabled? <CURRENT> Y <Return>
```

Enable Extended AutoLISP.

```
Do you want to use Extended AutoLISP? <CURRENT> Y <Return>
```

Choose "Return to Configuration Menu."

```
Enter Selection <0>: 0 <Return>
```

Choose "Exit to Main Menu."

```
Enter Selection <0>: 0 <Return>
```

Save changes.

```
Keep configuration changes? <Y> Y <Return>
```


At this point you should exit AutoCAD and return to the operating system. This may happen automatically; if not, you must choose 0 to "Exit AutoCAD."

Enter selection: 0 <Return> (needed only if you did not exit automatically)
C:\ACAD> (you are back at the DOS prompt)

Unless instructed to do otherwise, the standard DOS version of AutoCAD will use all available extended memory for Extended AutoLISP. One megabyte (1MB) of extended memory available for Extended AutoLISP should be enough to run even the largest analysis. If your system has more than 1MB of extended memory available, you should instruct AutoCAD to use only 1MB. Consult AutoCAD's *Installation & Performance Guide* for information on how to do this.

Installing FactoryFLOW

The FactoryFLOW disk contains the FactoryFLOW program and user files and INSTALL, a program to install and configure FactoryFLOW for your system. We recommend that you make a backup copy of your FactoryFLOW disk before installing FactoryFLOW. You may also want to write-protect your original disk.

Before you run the INSTALL program, you should know the drive and directory where you keep your AutoCAD program files, the version of AutoCAD you are using, a directory on your DOS search path, and you should know the contents of your CONFIG.SYS file.

The INSTALL program will do the following:

- copy the FactoryFLOW program files to the directory you specify
- copy the tutorial files to a user directory you specify
- modify your ACAD.PGP file in your AutoCAD directory to include some external commands that will be used by FactoryFLOW
- add the path to your FactoryFLOW program files to your DOS search path
- add two lines to your CONFIG.SYS file if you choose to do so
- create a custom batch file in your USER directory and place a copy of it in a directory of your DOS search path. The batch file is called FACTFLOW.BAT and will be used to run FactoryFLOW.

To install FactoryFLOW, insert the FactoryFLOW disk into floppy drive A: and close the drive door.

Run the installation/configuration program by typing:

C\> A:INSTALL <Return> (Be sure your hard drive is the current drive)

The INSTALL program displays a message telling you it will install FactoryFLOW and configure some of the environment variables necessary for FactoryFLOW operation. The installation can be aborted at any time by pressing <Esc>. INSTALL asks you whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y <Return>

To configure FactoryCAD for your system, INSTALL needs to determine which version of AutoCAD you are using. INSTALL asks if you are using AutoCAD 386 (DOS Extender). If you are using AutoCAD 386, press <Return> to accept the default. If you are using standard DOS AutoCAD, type N and press <Return>.

Are you using AutoCAD 386 (DOS Extender)? (Y/N) Y <Return> (or type N <return>)

INSTALL then displays the version of AutoCAD you specified and asks whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y

Next INSTALL asks you to specify the drive and directory where you want the FactoryFLOW program files copied. INSTALL will create the program directory on your drive if necessary.

The default program directory is C:\FACTFLOW. If you want the default press <Return>. If you want the FactoryFLOW program files to be installed on a drive other than C: or in another directory, enter the correct drive and directory at the prompt.

C:\FACTFLOW <Return> (or type the drive and directory path and press <Return>)

INSTALL again asks whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y <Return>

INSTALL next asks you to specify the drive and directory where you want the FactoryFLOW user files copied. The user files consist of the tutorial files and the FactoryFLOW batch file used to start FactoryFLOW. INSTALL will create the user directory on your drive if necessary.

The default user directory is C:\USER. If you want the default press <Return>. If you want the FactoryFLOW user files to be installed on a drive other than C: or in another directory, enter the correct drive and directory at the prompt.

C:\USER <Return> (or type the drive and directory path and press <Return>)

INSTALL again asks whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y <Return>

INSTALL needs to know the path to your AutoCAD program files. This information is needed to add some commands to the ACAD.PGP file and to allow the FACTFLOW batch file to run AutoCAD.

INSTALL asks you to specify the drive and directory in which AutoCAD is installed. The default drive and directory are C:\ACAD for AutoCAD 386 and C:\ACAD10 for DOS AutoCAD. If the default is correct press <Return>. If you have AutoCAD installed on another directory or drive, enter the correct drive and directory at the prompt and press <Return>.

C:\ACAD <Return> (or type the drive and directory path and press <Return>)
or
C:\ACAD10 <Return> (or type the drive and directory path and press <Return>)

INSTALL again asks whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y <Return>

INSTALL needs to know a directory included in your DOS search path. INSTALL will place a copy of FACTFLOW.BAT in the directory specified to allow FactoryFLOW to be run from any directory on your system.

INSTALL asks you to specify a drive and directory on your DOS search path. The default drive and directory is C:\DOS. If the default is acceptable, press <Return>. If you want to specify another directory on your path, type the correct drive and directory at the prompt and press <Return>.

C:\DOS <Return> (or type the drive and directory and press <Return>)

INSTALL again asks whether you want to continue. Press <Return> to accept the default.

Ok to continue? (Y/N) Y <Return>

FactoryFLOW needs to make some room in your DOS environment space for variables it needs set. FactoryFLOW will do this by adding the following commands to the end of your CONFIG.SYS file.

```
SHELL=C:\COMMAND.COM /p /e:512  
FILES=40
```

These commands require a little explanation.

SHELL is used to tell DOS to expand its environment space beyond its default size. The environment space is used to store the DOS **path** and other **set** statements you make. AutoCAD and FactoryFLOW require the use of several **set** statements. This **SHELL** line in

your CONFIG.SYS file establishes an environment of 512 bytes to be sure that you have enough room for all of the set statements. NOTE: if you are using DOS version 3.0 or 3.1, the number 512 should be changed to 32.

FILES is used to tell DOS the maximum number of files that can be opened concurrently. FILES will be set to FILES=40 for AutoCAD 386 and FILES=20 for DOS AutoCAD.

These settings for SHELL and FILES should be considered minimum. If your system already sets SHELL and FILES to larger values, you do not need to update your CONFIG.SYS file.

INSTALL asks you whether you want to update your CONFIG.SYS file. If you answer NO, you must edit your CONFIG.SYS file to include these minimum settings. Press <Return> to accept the default YES to update the CONFIG.SYS file, or type N and press <Return> to continue without updating the CONFIG.SYS file.

Do you want your CONFIG.SYS updated? (Y/N) Y (<Return> or N <Return>)

Before the FactoryFLOW files are copied, INSTALL lists your responses to all of the questions to let you check them. You are asked whether it is Ok to continue. If you answer YES, the files are copied to your hard drive. If you answer NO, the INSTALL program is terminated.

Ok to continue? (Y/N) Y <Return>

The FactoryFLOW file names will appear on the screen as they are copied to your hard disk. When all the files have been copied, you can press any key to end INSTALL and return to the DOS prompt.

If you updated your CONFIG.SYS file, you'll need to reboot the system to read the new CONFIG.SYS file before running FactoryFLOW. If you didn't update CONFIG.SYS, you must be sure SHELL and FILES are set correctly before you run FactoryFLOW.

For more information about installing FactoryFLOW, refer to *Appendix B Technical Information*.

General instructions on starting and using FactoryFLOW

FactoryFLOW is designed to be started from a batch file. The INSTALL program customizes the batch file, FACTFLOW.BAT, for your particular system configuration and places one copy in your USER directory and another in a directory on your path. Refer to *Appendix B Technical Information* for more information on FACTFLOW.BAT.

To run FactoryFLOW, type FACTFLOW and press <Return> or type FACTFLOW followed by the drawing name and press <return>.

C:\USER> FACTFLOW [default drawing name] <Return>

Your current directory should be the directory containing your drawing and data files. FactoryFLOW searches only the current directory for drawings and data files, but will look in your \FACTFLOW directory for its program files.

Before you run FactoryFLOW, you should know that FactoryFLOW is a menu-driven program. It differs from AutoCAD in that all FactoryFLOW commands and options must be picked from FactoryFLOW's screen menus. (In AutoCAD you have the option of typing commands in at the keyboard.)

The FactoryFLOW menu is a variation of the standard AutoCAD menu with a FactoryFLOW section containing FactoryFLOW functions and commands. Most AutoCAD commands are found in their normal location on the menus, and may be typed at the keyboard.

The first time you use FactoryFLOW on a particular AutoCAD layout drawing, you will need to use AutoCAD's MENU command to load FactoryFLOW's menu, FACTFLOW. When you save the drawing, the menu will be saved with the drawing. The next time you load the drawing, the FactoryFLOW menu will load automatically.

Command: **MENU** <Return>
Menu file name or . for none <ACAD>: **FACTFLOW** <Return>

AUTOCAD
* * * *
SETUP
BLOCKS
DIM:
DISPLAY
DRAW
EDIT
INQUIRY
LAYER:
SETTINGS
PLOT
UCS:
UTILITY
FACTFLOW
3D
SAVE:

The FactoryFLOW screen menu is similar to the AutoCAD screen menu except that FACTFLOW appears at the bottom of the menu. Picking FACTFLOW loads the FactoryFLOW program.

-->FACTFLOW

After you pick FACTFLOW from the menu, you're asked for the time unit for the analysis. The time unit you choose will determine how distances and costs are calculated.

* FactoryFLOW (C) 1989 CIMTECHNOLOGIES, CORP. *
Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>:

FactoryFLOW uses AutoCAD's HANDLES feature to keep track of certain entities. FactoryFLOW always checks to see whether entity handles are turned on. If HANDLES are OFF, FactoryFLOW will prompt you to turn them on.

FactoryFLOW uses AutoCAD entity handles.
Press RETURN to turn HANDLES ON.

FACTFLOW
* * * *
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
ACAD

FactoryFLOW also checks to see whether AutoCAD's units are set to ENGINEERING. FactoryFLOW requires ENGINEERING UNITS when it performs its analysis. If your current drawing is not set to ENGINEERING UNITS, FactoryFLOW asks you to press <Return> to turn them on.

FactoryFLOW requires Engineering units.
Press RETURN to set Engineering units.

NOTE: AutoCAD's ENGINEERING UNITS are feet and inches, with the base unit inches. If you drew your layout with a base unit other than inches (for example, meters or feet), you may have to use AutoCAD's SCALE command to scale your drawing by the appropriate scale factor.

FactoryFLOW will display a new screen menu with the heading FACTFLOW. All FactoryFLOW commands can be accessed from this main FactoryFLOW menu and its

submenus.

AutoCAD commands you should know

The FactoryFLOW manual assumes you are familiar with the use of certain basic AutoCAD commands and techniques. If you are not familiar with the following AutoCAD commands and techniques, you may want to review the appropriate section of your *AutoCAD Reference Manual*.

- picking options from the screen menu
- basic drawing commands: LINE, CIRCLE, and so forth
- basic editing commands: ERASE, MOVE, ROTATE, and so forth
- ZOOM (with All, Previous, and Window options), PAN REDRAW
- SNAP, GRID, ORTHO, COORDS
- the concept of layers and the LAYER command

Many FactoryFLOW menus contain relevant AutoCAD for your convenience. You can access most AutoCAD commands from within FactoryFLOW in the normal manner.

You should also be aware of AutoCAD's method of correcting errors, Ctrl-C, which works similarly in FactoryFLOW. Ctrl-C will cancel any FactoryFLOW command and return you to the command prompt.

Conventions used in the FactoryFLOW manual

The FactoryFLOW manual uses several conventions. Reading the following paragraphs will help you use this manual.

Special keys

Special keys on the keyboard, such as the function keys, control key, backspace key, and so forth, are printed in <brackets>.

<Ctrl> <F1> <Return>

Your <Return> key may appear on your keyboard as Enter, or even just a bent arrow.

Prompts

While using FactoryFLOW, prompts for user input will appear on the AutoCAD command line. In the *FactoryFLOW Tutorial and Reference Manual*, prompts are printed as they appear on the command line. Frequently a prompt will include a list of options enclosed in (parenthesis). If the prompt has a default response, it is shown at the end of the prompt in <brackets>. Below is an example of a FactoryFLOW prompt:

Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>:

In this example, pressing <Return> will accept the default option, YEAR. Options other than the default may be specified by typing the portion of the option name which appears in upper case letters and then pressing <Return>. For example, typing W then pressing <Return> after the above example prompt would specify Week.

Responses to prompts occasionally appear on a screen menu and can be picked from the menu. When you are directed to pick something from the screen menu, the word to be picked will be preceded by an arrow, as shown below. An illustration of the screen menu will usually appear in the left margin with the word to be picked shaded.

```
FACTFLOW
* * * *
YEAR
MONTH
WEEK
DAY
SHIFT
```

—>WEEK

When you're directed to type a response, the keys to be pressed will appear in bold type after the prompt.

Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>: **W** <Return>

This completes *Getting Started*. Your next step in learning FactoryFLOW is to read the brief *Using FactoryFLOW* section and then go on to the *Tutorial*.

Using FactoryFLOW to Analyze Plant Layout and Material Handling Costs

Using FactoryFLOW explores the subject of plant layout and material handling analysis and how to use FactoryFLOW as an analysis tool. When you have completed reading this section, you will understand: 1) some of the history that led to FactoryFLOW's development, 2) the methodology FactoryFLOW uses to perform layout and handling analysis, and 3) how to best approach planning for and executing a project using FactoryFLOW. This section was designed to quickly and thoroughly prepare you to "get your hands on FactoryFLOW" which is exactly what you will do in the tutorial following *Using FactoryFLOW*.

The Plant Layout Problem

Plant layout and material handling cost analysis are two sides of the same coin. Efficient layouts keep non-value-adding material handling costs to a minimum. For the typical manufacturing company, "Plant and Equipment" represents one of the largest items on the Balance Sheet. It is no coincidence, then, that methods of analyzing the layout of that "Plant and Equipment" (i.e. the manufacturing facility) have been around for many years.

With the acceptance of the computer as a planning and analysis tool came a variety of software programs designed to help with the layout decision. Some programs recommended a "best" layout--at least given the limited parameters the program considered. Others calculated material handling costs for a given layout. Still others merely helped create drawings to visually aid in the analysis. None of these programs, however, met with great acceptance in the industrial marketplace.

A New Approach to the Layout Problem

FactoryFLOW is the first layout analysis tool that integrates actual facilities drawings and material flow paths with production and material handling data. FactoryFLOW is innovative in many ways:

1. analysis is done within the world's most popular CAD system, AutoCAD
2. data can be entered or edited interactively on low-cost hardware platforms
3. alternative layouts and handling systems can be analyzed iteratively (i.e. trial and error)
4. the impact of changes in either the drawing or the data can be calculated immediately in a powerful graphical "what if" decision-making tool
5. valuable output is produced both graphically (drawings, diagrams and charts) and in pre-designed or customized report formats

FactoryFLOW and Manufacturing Facilities Planning

FactoryFLOW is designed to analyze and improve plant layout based on product flow and/or material handling costs. Alternatively, FactoryFLOW is designed to analyze and improve material handling system costs and efficiency within a given plant layout. FactoryFLOW is an effective tool either for planning a new facility or for making changes to an existing one.

The objective of facilities planning in general is to effectively utilize buildings, equipment, people, space and energy at the lowest cost while maintaining safety, flexibility, cleanliness, etc. The general facilities planning problem includes many quantitative and qualitative dimensions.

FactoryFLOW is not intended to directly address all of these dimensions. However, since FactoryFLOW lets the analyst control all decisions, qualitative issues beyond FactoryFLOW's normal scope can be built into the FactoryFLOW analysis. By addressing the primary considerations in manufacturing facilities planning, product flow and handling costs, and by giving the analyst complete control over both layout and handling decisions, FactoryFLOW is a significant asset to the manufacturing facilities planner.

How FactoryFLOW Performs Layout and Material Handling Analysis

The two traditional elements of material handling analysis are **distance** and **intensity**. FactoryFLOW adds a third, very valuable element: **material handling cost**. The following is an "executive level" discussion of how FactoryFLOW works. This discussion is intended to help you understand FactoryFLOW's required input and interpret its output. For a more detailed discussion, including the actual formulas used in the program, see *Appendix E Draft of Technical Article*.

In FactoryFLOW, **distance** means the length of the travel path over which material is moved between a pair of workcenters. **Intensity** is simply the number of trips made over a single path. Traditionally, distance times intensity is used to calculate the total distance travelled by, for example, an individual part between a particular pair of workcenters (a move). The traditional goal of plant layout is to minimize the sum of all distances based upon the assumption that costs vary directly with distances.

FactoryFLOW makes the analysis more realistic. By assigning a defined material handling device to each move, FactoryFLOW can calculate both distances and costs. For each material handling device (or system), you are asked to provide performance and cost information including average speed, load and unload times, percentage of time spent on non-productive moves (e.g. travelling empty to pick up a load), and fixed and variable cost information.

Using this information, FactoryFLOW starts with distance times intensity, then computes **move times** which can be used to calculate the **variable cost** for each move. **Fixed costs** are then allocated to each move based upon the percentage of time spent on a single move out of the total busy time for that material handling device. FactoryFLOW reports all of these results, and summarizes the results in a variety of ways. For example, results for a single move can be reported for distance, time, or fixed, variable and total cost. Results can also be summarized by part, product, product group, etc.

FactoryFLOW uses this information to automatically generate Product Flow Diagrams and Composite Flow Diagrams. A FactoryFLOW Product Flow Diagram displays actual material handling paths overlaying the plant drawing. FactoryFLOW scales each path so that the path width reflects the cost/foot of each move. The Composite Flow Diagram shows cost/foot summarized for all moves between pairs of workcenters.

Using FactoryFLOW's diagrams and reports as tools, you can improve the layout and reduce handling system costs in several ways:

- Decrease distances for high cost/foot paths by:
 - a) changing workcenter location (layout)
 - b) altering travel paths between existing workcenters
- Improve handling systems use by:
 - a) eliminating under-utilized devices
 - b) altering average unit loads (intensity)
 - c) choosing alternate devices

FactoryFLOW lets you calculate the impact of any of these changes within your plant and handling system model before you go to the expense and effort of implementing the change on the shop floor. FactoryFLOW highlights absolute and relative improvement in cost and distance between alternatives.

Planning and Executing a FactoryFLOW Analysis

As with any problem you analyze, a little planning before you use FactoryFLOW can make the job much easier. An example of an organized implementation plan for a FactoryFLOW analysis is presented below followed by a brief discussion of each stage:

1. Determine the appropriate project scope (level of detail)
2. Adopt appropriate, understandable naming conventions for products, parts, material handling systems and workcenters
3. Gather and organize the input data
4. Produce an AutoCAD plant drawing
5. Enter the drawing and data into FactoryFLOW
6. Analyze the layout and material handling system

1. Project Scope

With FactoryFLOW, you can analyze the layout of any or all of the following:

- multiple buildings on a plant site
- areas within a building
- cells within an area
- machines within a cell

To be as accurate as possible, you could consider each of these levels simultaneously.

However, the problem can easily become too complex to allow effective interpretation. Therefore, it is usually best to analyze only one level at a time, and to start at the highest level of detail and then move down. For example, if you wanted to revise the layout of an area in your factory, we recommend that you first concentrate on cell location within the area, and then layout machines within the cells. In the first step, all moves within a cell could be ignored and all moves to (from) a cell would be considered to have the same destination (origin) regardless of the individual machines used within the cell. You may also choose to analyze only high-volume products, or specific areas, or expensive handling devices, etc. Each level of abstraction may make interpretation easier for your situation. Remember, however, that accuracy may suffer to some degree.

2. Adopt Data Naming Conventions

As with any software program, FactoryFLOW has certain restrictions on data format. (See *Appendix D File Formats* for complete specifications.) Field lengths for product names (14 characters), part names (14), workcenter names (10) and material handling device names (5) have been designed to allow you quite a bit of latitude and, in most cases, to let you use names that are already used in your plant.

It is especially important within FactoryFLOW that the names you choose be meaningful. For example, FactoryFLOW prompts you to specify the path between two named workcenters for a named part of a named product where each of the names is exactly what you input to FactoryFLOW.

3. Gather and Organize the Input Data

The best way to understand exactly what data FactoryFLOW requires is to do the tutorial which follows this section. The tutorial has been designed to quickly walk you through all aspects of entering data and analyzing it using FactoryFLOW. A complete description of FactoryFLOW's data files is included in *Appendix D File Formats*.

Appendix C Blank Forms includes some convenient data gathering forms. Duplicating and using these forms will make your job much easier both while gathering and then while entering data.

Data which already exists in computer format may be able to be transferred into FactoryFLOW. This is discussed in *Appendix D* and in the reference section under FFEDIT: and IN DATA: . You may also be able to use alternate conventions of data organization and interpretation as discussed in the following paragraphs.

Standard and Alternate Data Formats

Two methods of FactoryFLOW data organization are the Product Method and the Path Method.

The Product Method: The standard method of data organization within FactoryFLOW is the Product Method. The file and field names in the program were designed with this method in mind. The Product Method requires information on all products you wish to consider. For each product, you are then asked for all parts within the product, and for each part, from and to workcenters for all moves.

For many plants, data requirements using the Product Method may become very large. This can be managed in some cases by making appropriate decisions as discussed in Project Scope above. However, some other summarized or abbreviated method of data organization may yield satisfactory results in your situation. One such method we call the Path Method.

The Path Method: The Path Method is quite effective when you have a large number of products, or many parts within products, especially with varying levels of production. In such cases, historical data on loads moved between pairs of workcenters (perhaps from pick sheets) may be available.

In the Path Method, rather than considering products and parts, you can perform the analysis based on a summary of flows between a particular pair of workcenters (i.e. a particular path).

All parts moved between a unique pair of workcenters by a particular material handling device are summarized and entered as one line of data.

To do use the Path Method, enter only one product and give it a production volume of 1 per time unit. Then create "dummy" part names by concatenating the from and to workcenter names (and possibly the material handling device name) and complete the Parts file as shown below. Here, use intensity (number of trips over each path) in the Quantity/Product field and 1 as the Unit Load.

Following are example Products and Parts files entries using the Path Method.

Example Products file

```
YEAR
PATH 1.00 CYAN
```

Example Parts file

Part Name	Product Name	Qty/Prod	From WC	To WC	M.H. Equip	Unit Load
PATH	WCA_WCB	1000.000	WCA	WCB	MH1	1.00
PATH	WCD_WCA	100.000	WCD	WCA	MH1	1.00
PATH	WCF_WCJ	100.000	WCF	WCJ	MH1	1.00
PATH	WCA_WCD	400.000	WCA	WCD	MH1	1.00
PATH	WCC_WCB	3500.000	WCC	WCB	MH1	1.00
PATH	WCD_WCK	20000.000	WCD	WCK	MH1	1.00
PATH	WCL_WCM	4732.000	WCL	WCM	MH1	1.00
PATH	WCP_WCU	1680.000	WCP	WCU	MH1	1.00

4. Produce an AutoCAD Plant Drawing

FactoryFLOW requires an AutoCAD drawing of the facility or area you want to analyze. However, you do not need to create a drawing especially for FactoryFLOW. There are only a couple of requirements for the drawing that FactoryFLOW uses. First, the drawing must be actual size so that correct distances can be extracted. For the same reason, workcenter locations should be accurate, as should the location of relevant aisles or other obstacles that affect travel paths. Second, you need to clearly define each workcenter in the drawing so you can easily find and recognize it by name. It will be easier to edit your drawing if you use AutoCAD to "block" all of the drawing entities in each workcenter. When you move a blocked workcenter, you merely need to select (pick with the cursor) any part of the workcenter and all the drawing entities will be selected. To move an unblocked workcenter, you need to select each entity in the workcenter individually using AutoCAD's standard selection methods. See the AutoCAD reference manual for more information on blocking.

Detail can be quite valuable in interpreting the results and in being able to visualize flows as they actually appear in the plant. However, too much detail increases the size of the drawing file which increases loading time and execution time for many FactoryFLOW functions (due to increased screen regeneration time).

If you need to create a new AutoCAD plant drawing, FactoryCAD by CIMTECHNOLOGIES can help speed and simplify the process. FactoryCAD automates many complex AutoCAD

drawing functions, eliminates the need to create layer naming conventions and includes over 100 standard industrial symbols.

AutoCAD also allows you to import and translate drawings from another CAD system as well as to scan in paper drawings. Although either of these options may save time, there are limitations and problems to both, so be well informed. CIMTECHNOLOGIES technical support staff can give you more guidance and information.

5. Enter the Drawing and Data into FactoryFLOW

Drawing. Once you have an AutoCAD plant drawing, simply start FactoryFLOW and load the plant drawing.

Data. FactoryFLOW includes two methods for creating data files, FFEDIT: and IN DATA: . FFEDIT: is a windowing program designed especially to ease the entry and editing of FactoryFLOW data files. IN DATA: is a FactoryFLOW command used primarily to load existing FactoryFLOW files for use in the current FactoryFLOW session.

You may also create or edit your data files using a spreadsheet or word processing program and then import the files as space-delimited ASCII files into FactoryFLOW. See *Appendix D File Formats* for more information on importing and exporting data files. A word processor may be useful in performing global search and replace operations to rename data elements in pre-existing data files.

6. Analyze the Layout and Material Handling System

The first step in analyzing a layout is to use FactoryFLOW's CALC: command to calculate distances and costs and generate a Product Flow Diagram. When you do this for the first time in a new analysis, you are prompted to enter the flow paths.

FactoryFLOW is unique in that you can draw actual flow paths directly on the AutoCAD plant drawing and use the actual path distances for calculations. This gives you accuracy and the ability to visualize product flow using the Product Flow Diagram.

However, in the early stages of an analysis, or merely to save the time required to draw the paths, you may have FactoryFLOW calculate either rectilinear (x-axis and y-axis) or euclidean (straight line) distances between workcenters automatically, or you may enter a distance directly. To use rectilinear or euclidean paths, and later to generate Composite Flow Diagrams, you must specify a particular "workcenter point" within each workcenter that is used as the endpoint of the automatic paths.

From there you can use each of FactoryFLOW's diagrams, charts and reports to help you find areas of possible improvement. You can change workcenter locations, edit paths, or change any of the data in the Product, Part or Material Handling Equipment files and immediately calculate the impact. You can compare any number of alternate layouts and/or material handling systems. And you can use FactoryFLOW's output to help document and justify any recommendations you present to management.

FactoryFLOW can also be used to consider layout by itself before considering the material handling devices and their costs. To use FactoryFLOW to analyze the traditional layout considerations of distance and intensity alone, define only one material handling device and

assign it to all moves, give it a \$0 investment cost, a \$0 cost of hourly fuel, power and maintenance, a \$1 hourly labor cost, a 0 load and unload time, and an average speed of 1 foot/minute. FactoryFLOW's Product Flow and Composite Flow Diagrams will then be scaled to purely represent the intensity of each move. Once the best layout (lowest total distance) is chosen, simply add material handling information and use FactoryFLOW to make the most efficient, least-cost handling system choices.

Summary

In this section we looked at FactoryFLOW's role as a layout and material handling system decision-making tool. We discussed how FactoryFLOW works, and how to approach an analysis using FactoryFLOW. Now that you understand FactoryFLOW, it's time to learn exactly how to operate the program. Please turn to the tutorial, where you will quickly cover entering data and analyzing plant layout and material handling costs with FactoryFLOW.

Tutorial

Welcome to the FactoryFLOW tutorial. The tutorial uses the actual FactoryFLOW program to introduce you to the features of FactoryFLOW and to help you feel comfortable using FactoryFLOW to analyze your plant layout and material handling system.

The tutorial has three sections. The first section takes you step-by-step through a basic analysis of a simple ladder factory. The second section shows you how to make and save alternative layouts and material handling systems. The third section shows you how to generate several charts, selectively view paths, and generate a workcenter utilization report.

Before you start the tutorial, you must have installed the program; you should also have read the *Getting Started* and *Using FactoryFLOW* sections of the manual. When you've finished installing and reading, you're ready for the tutorial.

Repeating the Tutorial and Restoring the Tutorial files

The INSTALL program copies the files needed for the Tutorial to the USER directory on your hard disk. (If you named the directory something else during installation, substitute that name for USER when referring to your directory.) The files include drawing and data files used in the Tutorial. During the Tutorial you modify the original files and create new data files.

To do the Tutorial a second time, you'll need to restore the files to their original condition. You restore the files by deleting the new files and copying the needed files from your original FactoryFLOW diskette. Following are specific instructions for restoring the files.

To restore Tutorial Section 1 files, delete all ACME files in your USER directory, then copy the ACME drawing from the original FactoryFLOW diskette.

```
C:\USER> DEL ACME . *  
C:\USER> COPY A:\USER\ACME . DWG
```

To restore Tutorial Section 2 files, delete all LADDER files from your USER directory, then copy the LADDER1 files from the original FactoryFLOW diskette.

```
C:\USER> DEL LADDER* . *  
C:\USER> COPY A:\USER\LADDER1 . *
```

To restore Tutorial Section 3 files, delete all SAMPLE files from your USER directory, then copy the SAMPLE files from the original FactoryFLOW diskette.

```
C:\USER> DEL SAMPLE . *  
C:\USER> COPY A:\USER\SAMPLE . *
```


Tutorial: Section One

Welcome to the first of three sections in the FactoryFLOW tutorial. In this section you are going to analyze the layout and material handling system of a simple ladder manufacturing facility. You will start by entering all of your product and part information and finish by generating a Product Flow Diagram and a Material Handling Cost Report.

To make things a little more interesting, we'll call the ladder company Acme Ladders. Let's imagine you're an industrial engineer at Acme Ladders. Mr. Althep, plant manager, has assigned you the task of computing material handling costs and travelled distances between the different departments in order to improve plant layout.

You've been anticipating such an assignment, and you've been collecting data on part moves and material handling equipment at Acme. To help you visualize where everything goes, you created a full-scale AutoCAD layout drawing of Acme's production floor. Let's take a minute now to review what you know about Acme Ladders.

Acme Ladders

Acme Ladders manufactures 250,000 aluminum ladders per year. Each ladder is composed of 4 steps, 2 rails, and 12 screws. The finished product is packaged in a carton which is then sealed with 3 staples. The steps and rails are made at Acme Ladders. The screws, box and staples are purchased.

The steps and rails are extruded from aluminum. Aluminum billets are transported with a fork lift from the receiving dock to the extrusion workcenter. There, the aluminum is extruded into 48 foot sections, cut into 8 foot sections, and placed on a conveyor that feeds the oven. After heat treatment, the 8 foot sections are transported via fork lift to the step and rail workcenters.

In the step workcenter, the incoming 8-foot sections are sheared into 1 foot steps. The steps are then drilled and transported via fork lift to the assembly workcenter. The rails are produced by bending and drilling the 8-foot sections. The rails are transported to the assembly workcenter with a fork lift.

A hand truck is used to carry the screws to the assembly workcenter. The ladder is assembled there and sent to packaging via conveyor. The ladder is packed in the box and the box is then stapled. The finished product is taken to the shipping department by fork lift.

Stages of your Acme Analysis

In the past, even with the raw production data and a plant drawing in hand, there was no way to integrate the two to easily visualize and analyze the material handling process. You would have groaned (though not where Mr. Althep could hear) at the thought of making the hundreds of calculations necessary for a thorough analysis. But now you have a copy of FactoryFLOW, and you can simply and quickly produce the information Mr. Althep wants.

You're going to use FactoryFLOW to integrate your plant drawing and production data and then compute your material handling costs and distances. You have already read the *Using FactoryFLOW* section of your FactoryFLOW manual and are familiar with the stages in a FactoryFLOW analysis. Review the stages now and note the progress you've already made.

Stage	Your progress so far
1. Determine the level of detail for your analysis.	Mr. Althep has determined that for you. You're going to analyze the layout of workcenters on the production floor.
2. Decide on naming conventions for your products, parts, and workcenters.	Acme has had names for its product, parts, and workcenter areas for quite a while. Some of the names were formal, some were informal. You checked the names with the file format field definitions in Appendix D of the FactoryFLOW manual and discovered that with just a few modifications the existing names would work.
3. Collect and organize product, part, and material handling equipment data.	You used the blank forms from Appendix C of the FactoryFLOW manual to organize data as you collected it from information you already had in your office and from workers on the production floor. You learned a lot about your production by tracing each individual part's path from beginning to end.
4. Produce an AutoCAD drawing of the layout.	You were on the ball and drew the layout in AutoCAD weeks ago. You used FactoryCAD with AutoCAD to simplify drawing the layout.
5. Enter product, part, and material handling equipment data.	You'll use FactoryFLOW's FFEDIT: to load the data into FactoryFLOW. FFEDIT: is a windowing program which makes loading and editing this data a snap.
6. Define Paths, generate a Product Flow Diagram, and calculate material handling costs and distances.	By inspecting the shop floor, you have determined the actual paths travelled by the material handling equipment. You want your analysis to be as accurate as possible, and you want to present your results graphically, so you've decided to draw actual material handling paths. Keeping track of all the paths will be easy since FactoryFLOW will prompt you for the paths one by one. Once the paths are entered, FactoryFLOW will automatically calculate material handling costs and distances and generate scaled product flow lines.

- | | |
|--|---|
| 7. Create a Material Handling Cost Report | Mr. Althep will also want a Material Handling Cost Report which breaks down the distance and cost associated with each part move. You will use FactoryFLOW's GENEMHR: command to automatically generate the report. |
| 8. Save all the files before you exit FactoryFLOW. | You'll make sure to save all your work before leaving FactoryFLOW. The next time you need to work with your layout you can simply load the data files you saved. |

Boiling it down to what remains to be done, you're left with five steps:

1. Load the drawing using the FACTFLOW batch file and start FactoryFLOW.
2. Enter and save product, parts, and material handling equipment information with FFEDIT:, including the
 - a. Products file
 - b. Parts file
 - c. Material Handling Equipment file
3. Draw material handling paths and use FactoryFLOW to calculate material handling costs and distances and generate a scaled Product Flow Diagram.
4. Generate a simple Material Handling Cost Report and display it on the screen.
5. Save your layout drawing and material handling paths.

Step 1 Load the drawing and start FactoryFLOW

When you installed FactoryFLOW on your computer you created a user directory with the default name USER. (If you called the directory something else, you will have to substitute your directory name for the directory called USER in this manual). Go to that directory now to get started on your Acme Ladders analysis.

CD\USER <Return>

NOTE: Performing this Tutorial exercise changes drawing and data files. To repeat a Tutorial section, you must restore the files to their original condition by following the instructions on page 17.

The USER directory contains the batch file that sets up the operating environment for FactoryFLOW and starts AutoCAD. To run the batch file type FACTFLOW and press <Return>.

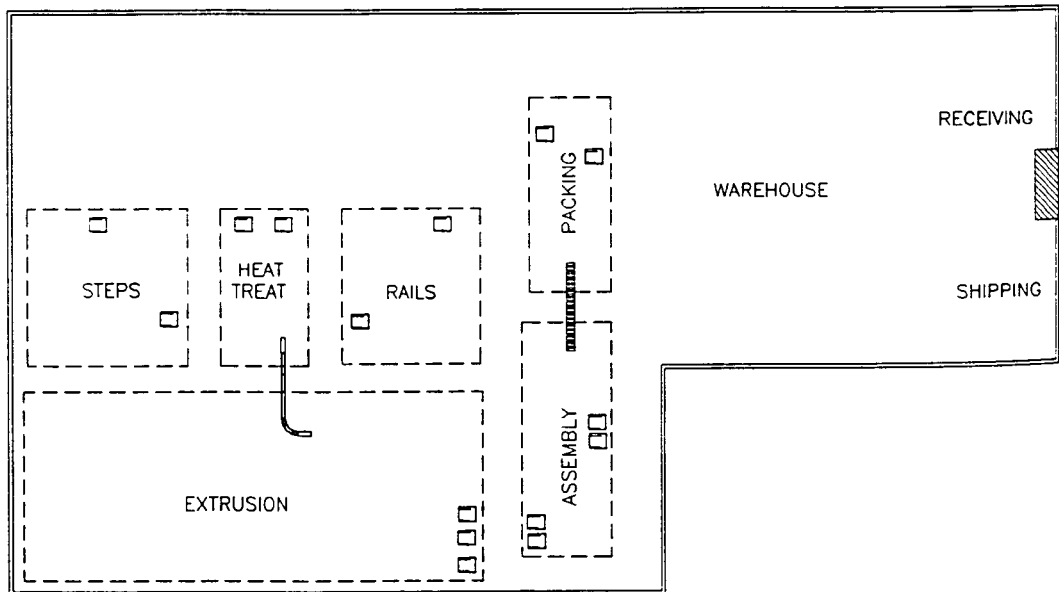
FACTFLOW <Return>

The AutoCAD Main Menu will be displayed. You want to load your Acme Ladders layout, which you called ACME, so type 2 to Edit an EXISTING drawing.

Enter selection: **2** <Return>

Enter NAME of drawing: **ACME** <Return>

Your layout drawing loads into the AutoCAD drawing editor and AutoCAD's screen menu is displayed.



So far you're just in AutoCAD, even though you used the FACTFLOW batch file to load AutoCAD. Now use AutoCAD's MENU command to load FactoryFLOW's screen menu.

Command: **MENU** <Return>

AutoCAD prompts you for the menu name. To call up the FactoryFLOW menu, type FACTFLOW.

Menu file name or . for none <acad>: **FACTFLOW** <Return>

```

AUTOCAD
* * * * *
SETUP

BLOCKS
DIM:
DISPLAY
DRAW
EDIT
INQUIRY
LAYER:
SETTINGS
PLOT
UCS:
UTILITY

FACTFLOW
3D
SAVE:

```

FactoryFLOW's screen menu will now appear. Notice that it looks similar to the standard AutoCAD screen menu except that FACTFLOW appears near the bottom of the menu. Pick FACTFLOW from the menu to load FactoryFLOW.

—>FACTFLOW

When the FactoryFLOW program is through loading you'll see the copyright line and a prompt to enter the time unit to analyze. The time unit refers to the period of time that the output reports will use to present distances, costs, and utilizations. Your production volumes for Acme are specified per year, so pick YEAR from the menu or press <Return> to select the default time unit, year.

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Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>: <Return>

```

AUTOCAD
* * * * *
YEAR

MONTH

WEEK

DAY

SHIFT

```

You're on your way, but one more thing needs to be set. FactoryFLOW keeps track of paths by using AutoCAD's HANDLES feature, so FactoryFLOW will prompt you to turn HANDLES on. The HANDLES ON setting will be saved with the drawing, so you won't have to turn them on again the next time you edit the drawing. But be careful: once the HANDLES are turned ON you must not turn them off or all path information will be lost, since path information is tied to the entity handles.

FactoryFLOW uses AutoCAD entity handles.
Press RETURN to turn HANDLES ON. <Return>

You have to press <Return> to continue. When you do, the entity handles are turned on and the FACTFLOW screen menu appears.

Step 2 Enter product, parts, and material handling equipment information.

```
FACTFLOW
*****
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
ACAD
```

Once the drawing is loaded and you're in FactoryFLOW, you have to enter the data you gathered on your products, parts, and material handling equipment. When you load the data, you're "setting up" the situation for analysis. To enter the data, pick FFSETUP from the menu.

--> FFSETUP

A new screen menu appears. The first two commands on the menu, IN DATA: and FFEDIT:, can be used to load data for an analysis. IN DATA: is a command line oriented program that is best for loading existing data files; FFEDIT: is a windowing program that is best for creating and editing data files. You will use FFEDIT: to create three new data files needed to analyze the layout, so pick FFEDIT: now.

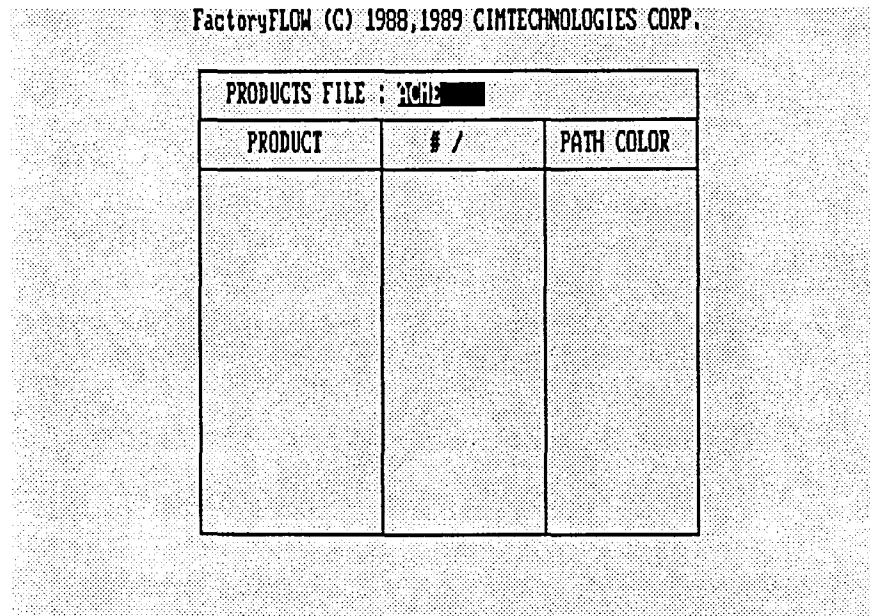
--> FFEDIT:

```
FACTFLOW
*****
IN DATA:
FFEDIT:
DEFVIEW:

ZOOM V:
ZOOM W:
ZOOM P:
PAN:
LAST
```

2.a. Products

After you pick FFEDIT: , a window for entering product information appears on the screen. The cursor will be in the PRODUCTS FILE field. The default file name is the name of the drawing you are in, which in this case is ACME. It's most convenient to name the data files with the same name as the drawing, so press <Return> to select the default.



<Return>

A new window appears and says the Products file ACME does not exist, and asks whether you wish to create it.

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PRODUCTS FILE : ACME		
PRODUCT	# /	PATH COLOR
Products file ACME does not exist. Do you wish to create it ? (Y/N) <input checked="" type="checkbox"/>		

You want to create the file so respond by pressing <Return> to accept the YES default.

<Return>

FFEDIT: will next return to the PRODUCTS FILE window and position your cursor in the quantity per time unit field heading (# /). You need to type a time unit (YEAR, MONTH, WEEK, DAY, or SHIFT) for the analysis.

You decided earlier to run the analysis on a yearly basis, so it would be simplest now to enter your product data per year. (FactoryFLOW can convert data file entries whose time unit is different from the analysis time unit. In that case you would have to supply a conversion factor.) Type YEAR in the heading.

YEAR <Return>

YEAR appears in the quantity field heading and the cursor jumps to the PRODUCT field.

You're now ready to start entering data. If you make a mistake as you follow the process below, don't worry--mistakes are easy to correct. Directions in the box on page 26 tell you how to make corrections.

Correcting a mistake in FFEDIT:

To make sure all required data is entered, FFEDIT: will force you to put a value in each successive field when you first enter a line of data. Once the whole line is entered you can use the arrow keys to move to any field on any line. If you make a mistake entering products or parts information you can easily correct it once you've completed the line.

To correct a field entry before you leave the field, press <BackSpace> to move back past the error, then type the correct entry.

To correct a mistake after you've left a field when first entering a line, continue entering the rest of the information on the line; then use the arrow keys to move the cursor back to the field containing the error and type the correct entry. If you want to start the line over before you finish entering all of the information, press <Esc> and then <Delete>. The line will now be deleted and you can press <Insert> to start over on a new line.

To delete a whole line, move your cursor to any field on the line and press <Delete>.

To insert a line, move your cursor to any field on the line before which your line should be inserted and press <Insert>.

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PRODUCTS FILE : ACME		
PRODUCT	# / YEAR	PATH COLOR
██████████		

Acme Ladders' only product is a ladder, so type LADDER and press <right arrow>.

LADDER <right arrow>

The cursor moves to the Quantity (#/YEAR) field. Acme Ladders' production is 250,000 ladders per year, so type 250000 in the quantity field. Do not include commas in your number.

250000 <right arrow>

Next, the path color menu will appear. FactoryFLOW allows you to assign any one of seven colors to every product so you can easily identify each product's paths in the layout.

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PRODUCTS FILE : ACME		
PRODUCT	# / YEAR	PATH COLOR
LADDER	250000	Path Color for LADDER <input type="checkbox"/> Red <input type="checkbox"/> Yellow <input type="checkbox"/> Green <input type="checkbox"/> Cyan <input type="checkbox"/> Blue <input checked="" type="checkbox"/> Magenta <input type="checkbox"/> White

To select a color use the arrow keys to move the check mark next to the color you want and press <Return>. Select magenta for the ladder paths.

<down arrow> <down arrow> <down arrow>
<Return>

And you're finished entering the product data for LADDER. That was easy, wasn't it? If you were producing another product, you would press <Insert> to move to a new line and continue entering products. In this case, though, Acme Ladders has only one product, so you're done entering product information. The next step in loading data is entering parts information.

2.b. Parts

Once you have entered the product information, you need to enter each product's part information. While the cursor is in the PRODUCT column, Press <F1> to bring up FFEDIT:'s PARTS FILE window.

<F1>

The PARTS FILE window pops up over the PRODUCTS FILE window, and the cursor is on the PARTS FILE field. The name you enter in this field will tell FFEDIT: which Parts file to load.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
PRODUCT : LADDER

PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD

You usually use the same name for your Parts file that you do for your Products file (the Parts file holds parts information for all of the products in the corresponding Products file; only one product's parts are displayed at a time). Press <Return> to accept the default name, ACME.

< Return >

Since you are creating a new file, FFEDIT: can't find an existing file to load. FFEDIT: gives you the option of creating a new file.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
PRODUCT : LADDER

PART	QTY /	FROM	TO	MAT'L	UNIT LOAD
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Parts file ACME does not exist. Do you wish to create it ? (Y/N) </div>					

You want to create the ACME Parts file, so respond by pressing <Return> to accept the YES default.

< Return >

The small window disappears and the cursor is now positioned on the PART field. You are now ready to begin entering the parts data. You used the parts data collection form from *Appendix C* of the FactoryFLOW manual when you collected your data, so the data fields are in the same order as they appear in the FFEDIT: PARTS FILE window. Here is your parts data:

PART	QTY	FROM	TO	MH DEV	UNIT LOAD
SCREW	12	RECEIVING	ASSEMBLY	HANDT	1000
ALUMINUM	.14	RECEIVING	EXTRUDE	FORK	20
RAIL	2	EXTRUDE	HEAT	CONV1	1
RAIL	2	HEAT	RAILS	FORK	50
RAIL	2	RAILS	ASSEMBLY	FORK	50
STEP	3	EXTRUDE	HEAT	CONV1	1
STEP	3	HEAT	STEPS	FORK	65
STEP	3	STEPS	ASSEMBLY	FORK	65
LADDER	1	ASSEMBLY	PACKING	CONV2	1
LADDER	1	PACKING	SHIPPING	FORK	25
BOX	1	RECEIVING	PACKING	FORK	100
STAPLES	3	RECEIVING	PACKING	HANDT	1500

NOTE: The quantity of aluminum per part is less than one because only a fraction of a billet is used in each ladder.

The first part is a screw. There are 12 screws per ladder, and the only routing for a screw is from the receiving workcenter to the assembly workcenter. A hand truck is used to move 1000 screws at a time.

Enter part information the same way you entered product information in the PRODUCTS FILE window.

SCREW <right arrow>

12 <right arrow>

RECEIVING <right arrow>

ASSEMBLY <right arrow>

HANDT

1000 <right arrow>

NOTE: You didn't have to press <right arrow> after typing HANDT since HANDT has five characters, the maximum length for an entry in the MAT'L HAND. field.

After you enter the information for one part, you can press <Insert> to begin a new line for another part.

<Insert>

Follow the table above and finish entering the rest of the part information. You will notice that some parts appear more than once. When a part travels to more than one workcenter, it

will have several entries in the Parts file. It doesn't matter in what order you enter part moves; every part move is treated independently by FactoryFLOW. However, entering part moves sequentially may make reading the Parts file easier. If you make a mistake, refer to the instructions on page 26 for help in making corrections.

2.c. Material Handling Equipment

Once you have entered all of your parts information, you need to enter your material handling equipment information. To call up FFEDIT's MATERIAL HANDLING EQUIPMENT FILE window, move the cursor to the MAT'L HAND. field for any part in the Parts window and press <F1>.

<F1>

A small box appears and tells you that changes have been made and asks whether you want to save your parts information.

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PRODUCTS FILE : ACME					
PARTS FILE : ACME PRODUCT : LADDER					
PART	QTY /	FROM	TO	MAT'L	UNIT LOAD
SCREW					1000.00
ALUMINUM					20.00
RAIL					1.00
RAIL					50.00
RAIL	2.000	RAILS	ASSEMBLY	FORK	50.00
STEP	3.000	EXTRUDE	HEAT	CONU1	1.00
STEP	3.000	HEAT	STEPS	FORK	65.00
STEP	3.000	STEPS	ASSEMBLY	FORK	65.00

Changes have been made...
Save parts information ? (Y/N)

You want to save the parts information, so press <Return> to accept the default YES response.

<Return>

A new prompt appears and asks what name to save the Parts file under. Press <Return> to accept the default file name ACME.

<Return>

FFEDIT: saves the Parts file and the MATERIAL HANDLING EQUIPMENT FILE window appears on top of the PRODUCTS FILE and PARTS FILE windows. The cursor will be on the file name field. Press <Return> to select the default name, ACME.

<Return>

A small window pops up and asks whether you want to create the file.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
 PRODUCT : LADDER

MATERIAL HANDLIN									
MATERIAL HANDLING	TYP	Q	Mat. hand. eq. file ACME does not exist. Do you wish to create it ? (Y/N) <input checked="" type="checkbox"/>					AVERAGE SPEED (FT/MIN)	EFFECT (%)

You want to create the file, so respond by pressing <Return> to accept the YES default.

<Return>

The cursor will be aligned on the investment cost per time unit field (INVEST. COST/). As with the Products file, the Material Handling Equipment file can have its own time unit. You have computed your material handling equipment information on a yearly basis, so type YEAR in the field and press <Return>.

YEAR <Return>

The cursor will now be positioned on the MATERIAL HANDLING field, and you are ready to begin entering your material handling equipment information. Once again you used a form from Appendix C of the FactoryFLOW manual to organize your material handling equipment data, so your data is in the same order as it appears on the FFEDIT: MATERIAL HANDLING EQUIPMENT FILE window. (And if you had saved it in an electronic text file, you could have loaded it directly. See Appendix D File Formats, for information on importing files). Here is your material handling equipment data:

MATERIAL HANDLING	TYPE	QTY	INVEST. COST /YEAR	HOURLY FP & M COST	HOURLY LABOR COST	AVAIL MINUTES /YEAR	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)
HANDT	1	1	100	0.0	10.00	115200	1.00	50.00	50
FORK	5	1	3500	1.0	15.00	115200	1.00	250.00	70
CONV1	7	**	1000	1.0	0.00	115200	***	***	**
CONV2	7	**	1500	1.0	0.00	115200	***	***	**

Enter material handling equipment data similarly to how you entered product and parts data. Instructions for correcting errors are on page 26.

The name of the first material handling system is HANDT, so type HANDT.

HANDT

Since HANDT is five characters long, the maximum length for a material handling system name, the cursor automatically jumps to the TYP field and the Material Handling Type window pops up. When the material handling system name is less than five characters long, you will need to press <right arrow> to move to the TYP field.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
PRODUCT : LADDER

MATERIAL HANDLING EQUIPMENT FILE : ACM

MATERIAL HANDLING	TYP	QTY	INVEST. COST /YEAR	HOURLY FP & M COST	ECT (%)
HANDT	5	1.00	3500	1.00	.00

Material Handling Type for HANDT

- 1. HAND_TRUCK
- 2. M.PALLET_TRUCK
- 3. P.PALLET_TRUCK
- 4. TRACTOR_TRAILER
- 5. LIFT_TRUCK
- 6. AGVS
- 7. CONVEYOR
- 8. SPECIAL

The Material Handling Type window lists eight types of material handling equipment. Your selection determines the algorithm FactoryFLOW will use for computing costs and distances made with the defined material handling system. Default values are given for each of the eight types of material handling devices. Your first material handling system, HANDT, is a hand truck so move the cursor to HAND_TRUCK and then press <right arrow>.

(move cursor to 1. HAND_TRUCK) <right arrow>

The Material Handling Type window disappears and the cursor is now in the QTY field. The default value is one. Since you have only one hand truck in your facility serving this area, you can simply press <right arrow> to accept the default value and move your cursor to the next field.

<right arrow>

The cursor is now in the INVEST. COST /YEAR field. Your heavy-duty hand truck cost Acme \$200 and its expected life is two years, so its amortized investment cost is \$100 per year. The default value is 100 so simply press <right arrow> to accept the default value and move to the next field.

<right arrow>

The cursor moves to the HOURLY FP & M COST (hourly fuel, power and maintenance cost) field. This field represents the cost added to the system for every hour the system is in use. You have no hourly fuel, power and maintenance for the hand truck, so press <right arrow> to accept the default value of 0.00 and move to the next field.

<right arrow>

The cursor moves to the HOURLY LABOR COST field. The hourly wage (including benefits) for the hand truck operator is \$10.00. Press <right arrow> to accept the default value 10.00 and move to the next field.

<right arrow>

The cursor is now in the AVAIL. MINUTES/YEAR field. This field tells FactoryFLOW how many minutes per time unit each piece of equipment in the system is available for use. With this information FactoryFLOW can calculate the utilization of the system. The hand truck has no scheduled maintenance or down time, so it has 115200 available minutes (240 days x 8 hours per day x 60 minutes per hour) each year. 115200 minutes is the default value, so once again simply move the cursor to the next field.

<right arrow>

The LOAD & UNLOAD field represents the time (in minutes) required to pick up a load plus the time to set the load down. The Load & Unload time is added to every move using the system. The default value for a hand truck is one minute, which is a typical Load & Unload time at Acme, so accept the default value and move to the next field by pressing <right arrow>.

<right arrow>

The AVERAGE SPEED field represents the average travel speed (in feet per minute) of the material handling equipment when loaded. Taking into account time turning and waiting during a move, hand truck operators at Acme move a loaded hand truck about 50 feet per minute, which is the default value for a hand truck. Accept the default value and move to the next field by pressing <right arrow>.

<right arrow>

The last field, EFFECT, represents the effectiveness of the material handling equipment. Effectiveness is the ratio of the distance travelled while carrying a load to the total distance travelled. If a device was always able to pick up a new load at the same place it set down a load, it would have an effectiveness of 100%. At Acme, the hand truck is empty for half of the total distance travelled, so it has an effectiveness of 50%. The default value for effectiveness is 70%, so type 50 in the field. At this point you have entered a value for each required field and can use <Enter> or any of the arrow keys to enter the value and continue. You can also press <Insert> to insert a new line or <Delete> to delete the line.

50 <Enter>

To add the other material handling devices, press <Insert> to move to the next line and begin entering the rest of the data listed below.

MATERIAL HANDLING	TYPE	QTY	INVEST. COST /YEAR	HOURLY FP & M COST	HOURLY LABOR COST	AVAIL MINUTES /YEAR	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)
HANDT	1	1	100	0.0	10.00	115200	1.00	50.00	50
FORK	5	1	3500	1.0	15.00	115200	1.00	250.00	70
CONV1	7	**	1000	1.0	0.00	115200	***	***	**
CONV2	7	**	1500	1.0	0.00	115200	***	***	**

When you select the CONVEYOR system type for the last two systems, FFEDIT: will automatically fill in the asterisks shown in the material handling equipment table and will not allow you to edit these fields (FactoryFLOW does not use these fields for conveyors).

Leaving FFEDIT: and saving the data files

You have finished entering all the product, parts, and material handling data and are ready to exit FFEDIT: . Press <Esc> to leave the material handling equipment table and save it.

<Esc>

A box pops up and asks whether you want to save the material handling information.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
PRODUCT : LADDER

MATERIAL HANDLIN									
MATERIAL HANDLING	TYP	Q	Changes have been made... Save mat. hand. eq. information ? (Y/N) Y					AVERAGE SPEED (FT/MIN)	EFFECT (%)
HANDT	1	1.00	100	0.00	10.00	115200	1.00	50.00	50.00
FORK	5	1.00	3500	1.00	15.00	115200	1.00	250.00	70.00
CONV1	7	***	1000	1.00	0.00	115200	***	***	***
CONV2	7	***	1500	1.00	0.00	115200	***	***	***

You want to save the data you just entered, so press <Return> to select the default, YES.

<Return>

A new prompt appears and asks what name to save the Material Handling Equipment file under. Press <Return> to accept the default file name ACME.

<Return>

FFEDIT: saves the Material Handling Equipment file and returns you to the PARTS FILE window. To leave the PARTS FILE window press <Esc>.

<Esc>

As you might expect, a box pops up and asks whether you want to save the parts information. Answer NO since you saved the Parts file when you entered the material handling equipment window. In this case NO is the default response since no changes have been made, so just press <Return>.

<Return>

The PARTS FILE window disappears and you are now back at the PRODUCTS FILE window. Press <Esc> to save the Products file and leave FFEDIT: .

<Esc>

When you press <Esc> a small window pops up and tells you that changes have been made, and asks whether you want to save the products information. Press <Return> to accept the default response YES, and press <Return> again to accept the default file name ACME.

<Return>

<Return>

The system will return to the drawing screen and the FFSETUP menu. Using FFEDIT: you created three new data files which FactoryFLOW uses in the analysis of the layout: the Products, Parts, and Material Handling Equipment files. When you leave FFEDIT:, FactoryFLOW automatically loads the three data files.

FACTFLOW
 * * * * *
 IN DATA:
 FFEDIT:
 DEFVIEW:

 ZOOM V:
 ZOOM W:
 ZOOM P:
 PAN:
 LAST

Reading products file ACME.
 Please wait.
 Reading parts file ACME.
 Please wait.
 Reading material handling equipment file ACME.
 Command:

You've finished setting up the analysis, so pick FACTFLOW to return to the main FACTFLOW screen menu.

-->FACTFLOW

Step 3 Draw material handling paths, calculate material handling costs and distances, and generate scaled product flow lines

```
FACTFLOW
*****
FFSETUP

RUN
CHARTS

LIST
PRINT
PLOT
SAVE:
END:
EXIT:
ACAD
```

When you picked FACTFLOW from the screen menu, the FACTFLOW Main Menu appeared. The next step is to define material handling paths and calculate costs and distances. Pick RUN from the FACTFLOW menu.

-->RUN

A new screen menu appears. This menu is the "workhorse" menu of FactoryFLOW. The first command on the menu, CALC:, allows you to initially define material handling paths. It then calculates material handling costs and distances and generates scaled product flow lines. CALC: also includes a routine for defining material handling equipment, but since you already defined the equipment with FFEDIT: in step 2.c., the material handling equipment routine won't be called. Pick CALC: from the screen menu.

-->CALC:

```
FACTFLOW
*****
CALC:
ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

CALC: will load and ask whether you wish to enter ACTUAL material handling paths (an actual path follows the actual transport route of your material handling device). Drawing actual paths will allow CALC: to generate a Product Flow Diagram (scaled product flow lines) for Mr. Althep, so choose YES.

```
Loading...
Enter actual material handling paths <YES>: <Return>
```

You should toggle ORTHO ON to make it easier to draw straight paths (AutoCAD's ORTHO feature can be toggled ON or OFF with <F8> or Ctrl-O).

If you make a mistake drawing a path, just keep on going until you are through specifying all your paths. You can easily edit paths later with EDTPATH: . If you need to, you can enter a Ctrl-C key sequence at any time to cancel the current command in the normal AutoCAD fashion. FactoryFLOW will prompt you for any missing paths the next time you select CALC: .

CALC: will begin prompting you to draw the paths. CALC: first identifies the path to be drawn, then tells you to enter the first point of the path.

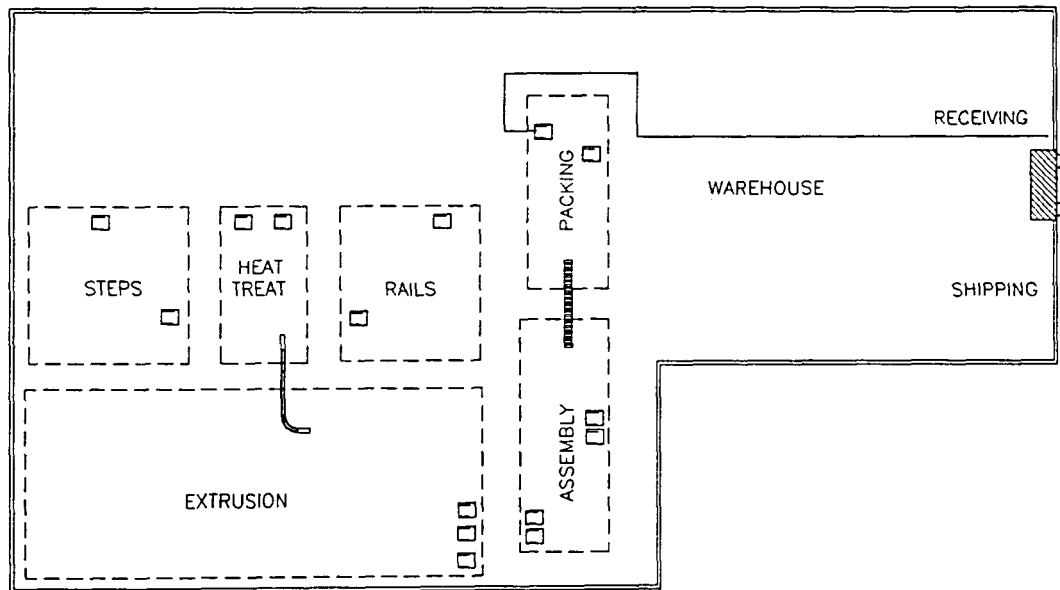
```
Enter product: LADDER path from RECEIVING to PACKING:
Enter first point of Path [Return = None]
```

At Acme Ladders, the RECEIVING and SHIPPING departments share the same loading dock. Incoming material is dropped off in the RECEIVING department where it is stored. So, pick a point in RECEIVING as shown in the following illustration. After you pick the first point, CALC: will ask for the next point.

Enter next point of path [Return = Done]

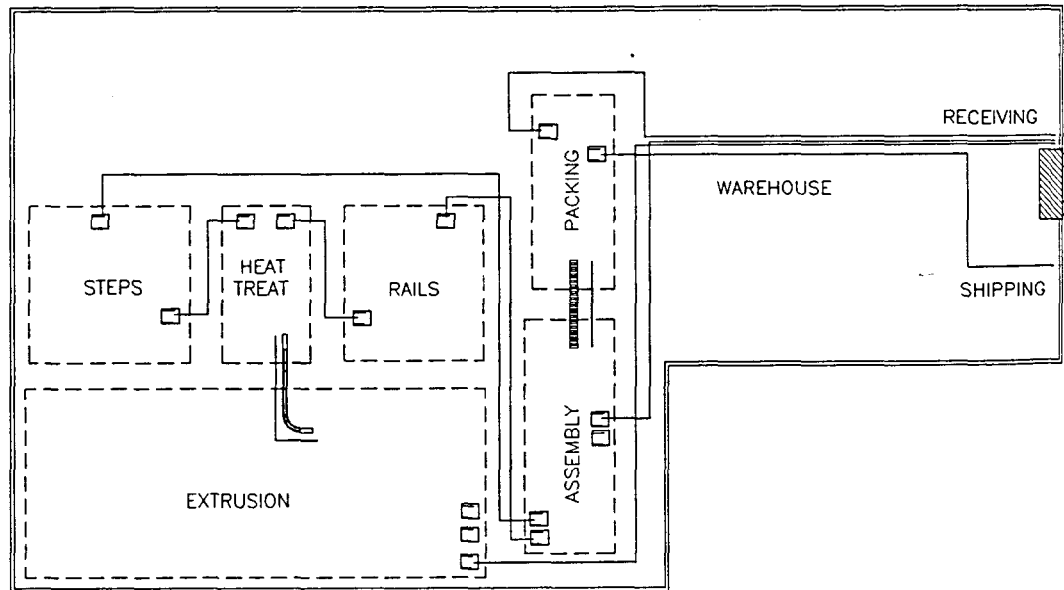
Pick your second point just to the right of the PACKING workcenter as shown in the illustration below. Keep on picking points until you've drawn a path around the top of PACKING and to the pallet on the left side, as shown in the following illustration. Press <Return> when you have picked the last point.

Material handling path from RECEIVING to PACKING.



FactoryFLOW will prompt you for every unique interworkcenter path that has parts flowing along it. Don't neglect to draw paths for the two conveyors--FactoryFLOW reads the paths, not the layout drawing. You can draw paths for conveyors right on top of or along the side of the conveyor. When you have specified all of the paths, your layout should look similar to the following illustration.

Material handling paths for LADDER.



When you have specified all of the paths, CALC: loads the data and algorithms and computes material handling distances and costs. CALC: will then prompt you for the path thickness scale.

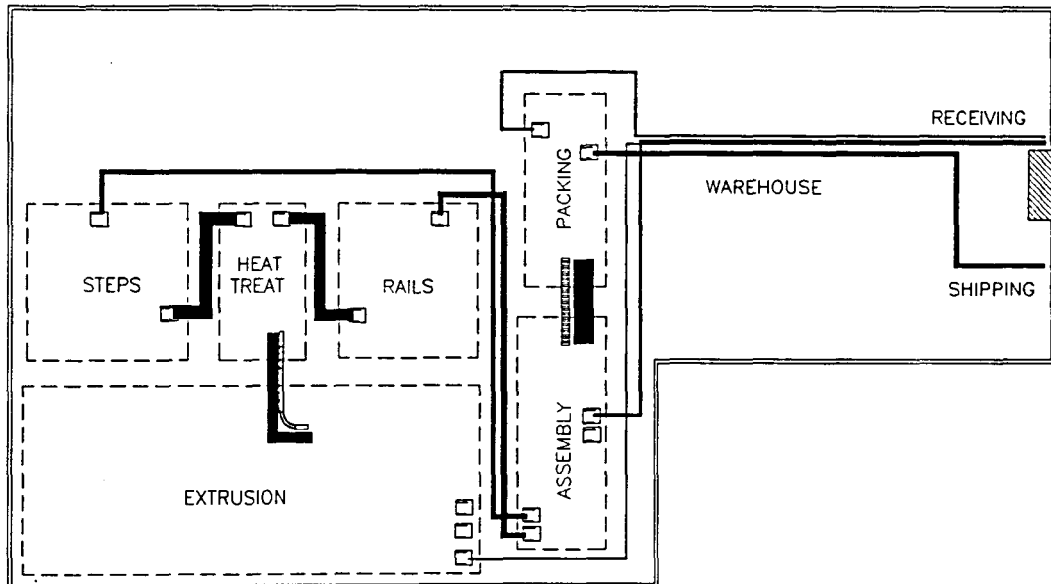
Loading...
 Working....
 Path thickness scale (Dollars/Foot/Inch) <100> :

The path thickness scale determines how wide the scaled product flow lines will appear in the drawing. Depending on the time unit, the cost of material handling, and the path thickness scale, product flow line thickness will vary greatly from one analysis to another. For this example, an appropriate scale factor is 3. With a scale factor of 3 a material handling cost of \$3 per foot travelled will be represented by a 1-inch thick product flow line, and a \$6 per foot travelled cost would be represented by a two-inch thick line. Type 3 and press <Return>.

3 <Return>

CALC: now applies the scale factor to your material handling paths to create scaled product flow lines. Together, the resulting product flow lines are called a Product Flow Diagram.

Product Flow Diagram for LADDER.



In an ideal layout, high cost per foot moves (represented by thick product flow lines) are short; long moves should have a low move cost per foot (represented by thin product flow lines). The Product Flow Diagram shows you at a glance how close your layout is to approaching the ideal.

CALC: also displays the total travel distance for all of your parts as well as the cost for this travel. Your numbers may vary slightly from the ones given below because you probably selected pick up and set down points as well as actual paths that weren't exactly the same as the example points and paths. You can see how important it is to be consistent when you specify actual paths.

New Total Travelled Distance (Ft)/ YEAR: 53,726,563
 New Total Material Handling Cost/ YEAR: \$39,224

Congratulations! You have completed the bulk of your first FactoryFLOW analysis. There are just a couple more things you'd like to do to finish up: put arrows on the product flow lines, generate a simple report, and, of course, save the drawing with the product flow lines.

Putting arrows on the product flow lines

FACTFLOW
* * * *

CALC:

ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
_ LAST _

To make your drawing more informative for Mr. Althep, you've decided to put arrows on the end of your product flow lines so he can easily determine the direction of material flow. To generate arrows, select ARROWS: from the RUN menu.

-->ARROWS:

Loading...

Sometimes the last line segment in a product flow line is shorter than its arrow head would be long, so ARROWS: isn't able to put an arrow head on the end of the line. When this happens, ARROWS: will tell you which segment is too short.

Last path segment of product LADDER between HEAT and STEPS is too short for the display of an arrow. Press Return to continue.

You will need to press <Return> to complete the ARROWS: command. When all of the arrowheads are drawn ARROWS: returns you to the command prompt.

Step 4 Generate a Material Handling Cost Report

FACTFLOW
* * * *

CALC:

ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
_ LAST _

While the Product Flow Diagram shows at a glance the material handling distances and relative costs, you know that Mr. Althep will also want a Material Handling Cost Report containing the distance and cost numbers. To generate the report pick REPORTS from the screen menu.

-->REPORTS


```

FACTFLOW
* * * *
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_

```

When the new menu appears, pick GENEMHR: .

--> GENEMHR:

GENEMHR: will ask you what type of report you wish to generate. There are two types of material handling reports: SIMPLE and ADVANCED (an example of each report is in Appendix F). In this case, all the information you need to give Mr. Althep can easily be found in the simple report, so press <Return> to accept the default response, Simple.

Generate Simple or Advanced material handling report (S/A) <S>: <Return>

GENEMHR: asks whether you want to include all products. Acme only has one product anyway, so press <Return> to accept the default response, YES.

Include all products <YES>: <Return>

GENEMHR: asks for the file name to save the report in. You're keeping everything simple, so press <Return> to accept the default response, ACME.

Material handling report file <ACME>: <Return>

You can generate the report by products or by workcenters. You only have one product, so a report by workcenters would be a more informative choice. Press W, then <Return>.

Generate report by Products or Workcenters (P/W) <P>: W <Return>

GENEMHR: will report the total distance travelled in feet or in miles. Acme's travel distances are not all that large, so you choose feet. Press <Return> to select the default response, Feet.

Total travelled distance unit (Feet/Miles) <Feet>: <Return>

GENEMHR: asks for information to include in the report heading. Type ACME for the company name and press <Return>.

Company name <NONE>: ACME <Return>

The next heading item is the project name. Type LADDER and press <Return>.

Project name <NONE>: LADDER <Return>

The next two prompts have your computer's current date and time as the default responses. Press <Return> for each of them.

Date <system date>: <Return>

Time <system time>: <Return>

Please wait...

GENEMHR: does not automatically list the report on the screen; rather, GENEMHR: saves the report as an ASCII text file under the name you specified above plus the file extension .MHR. The complete file name for your report is ACME.MHR. After GENEMHR: finishes saving the report, the command prompt returns.

FACTFLOW
* * * * *
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

You can treat the saved material handling report file as you would any ASCII text file. You can list the file from within FactoryFLOW by picking LISTMHR: from the REPORTS menu. You're anxious to see the report, so pick LISTMHR: now.

-->LISTMHR:

LISTMHR: asks for the name of the file to display. As usual, the default name is the name of the drawing. You saved the file with the name ACME, so press <Return> to accept the default response.

File name <ACME>: <Return>

LISTMHR: will switch to the text screen and your report will scroll onto the screen. Your report should look similar to the one below.

COMPANY NAME: ACME
PROJECT NAME: LADDER
DATE: 07/17/1989
TIME: 11:06

MATERIAL HANDLING REPORT

By Workcenters

	Distance	Cost
Between RECEIVING and PACKING	673,238 Ft.	\$ 1,987
Between PACKING and SHIPPING	1,924,107 Ft.	\$ 5,381
Between ASSEMBLY and PACKING	3,468,750 Ft.	\$ 3,420

Press RETURN when ready . . . <Return>

Press <Return> when you've finished looking at the first screen of the report. The remainder of the report will then scroll up.

Between STEPS and ASSEMBLY	3,112,981 Ft.	\$ 7,295
Between HEAT and STEPS	571,429 Ft.	\$ 4,204

Between EXTRUDE and HEAT	40,078,125 Ft.	\$ 2,920
Between RAILS and ASSEMBLY	1,627,679 Ft.	\$ 5,021
Between HEAT and RAILS	687,202 Ft.	\$ 3,877
Between RECEIVING and EXTRUDE	603,177 Ft.	\$ 1,266
Between RECEIVING and ASSEMBLY	979,875 Ft.	\$ 3,853
Grand Total	53,726,563 Ft.	\$ 39,224

Press RETURN when ready . . .

Wow, this report is just what Mr. Althep was looking for. The complete report has been displayed, so when you press <Return> LISTMHR: will switch back to the graphics screen and the command prompt. You're done looking for now, so press <Return>.

<Return>

You could print the report as easily as you just listed it. (See the reference section for information on how to print report files.) Just now, though, your printer isn't available, so you're just going to save the drawing and product flow lines and leave FactoryFLOW.

Step 5 Saving the drawing and product flow lines and exiting FactoryFLOW

```
FACTFLOW
*****
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_
```

You have finished generating the material handling costs and distances and saved them in a report file. Your Products, Parts, and Material Handling Equipment files have already been saved, but you need to save your actual material handling paths definitions. You'll need to pick the SAVE: command from the FACTFLOW menu, so pick FACTFLOW now.

-->FACTFLOW

```

FACTFLOW
* * * * *
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT
SAVE:
END:

EXIT:
ACAD

```

FactoryFLOW's SAVE: command actually saves three things: the drawing, the paths (in a file with an .EDG extension), and, when they've been defined, the workcenter points (in a file with a .WCP extension). You want to save the drawing and the paths, so when the FACTFLOW menu appears pick SAVE: .

-->SAVE:

The SAVE: routine will load and ask you for the name of the file in which to save the drawing, paths, and workcenter points (actually three files with different extensions). You want to save the file with the name ACME, so press <Return> to accept the default response.

```

Loading...
File name <ACME>: <Return>

```

Since the drawing file ACME already exists, SAVE: asks whether you want to overwrite the file. You do want to overwrite it, so type Y and press <Return>. SAVE: will then save the files.

```

File ACME already exists! Overwrite file (Yes/No): Y <Return>

```

```

Saving paths file ACME.
Please wait ....
Saving drawing file ACME.

```

```

FACTFLOW
* * * * *
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT
SAVE:
END:
EXIT:
ACAD

```

You have finished saving your files, so you're ready to quit the program. Pick END: from the menu.

-->END:

Since there are no unsaved changes, END: takes you out of FactoryFLOW and the drawing editor, and you're back at the AutoCAD main menu. You're through with AutoCAD, so type 0 and press <Return> to quit.

```

Enter selection: 0 <Return>

```

You should now be back at your system prompt, and feeling pretty proud of yourself.

Looking back at what you've done, you can see that you've accomplished quite a bit. Chiefly, you have now successfully done the following:

- used FFEDIT: to create Products, Parts and Material Handling Equipment files
- defined actual material flow paths and generated a Product Flow Diagram
- calculated material handling costs and distances
- generated a Material Handling Report and listed it to the screen
- saved all of your data files and exited the FactoryFLOW program

Good work! The reports and diagrams you've generated are useful to you and Mr. Althep. You can examine the Product Flow Diagram to check for long paths with high cost per foot moves. And you can use the Material Handling Cost Report to examine the particular parts or paths the diagram points you to. Finally, since you've saved the files, you can continue your analysis later. You've accomplished quite a bit in a short period of time!

But there's more to come. Take a break, and then on to Section Two.

Tutorial: Section Two

Welcome to the second of three sections of the FactoryFLOW tutorial. In this tutorial you will learn how to go about improving your layout and material handling system. You will start by loading the drawing and data files, then using CALC: to create a Product Flow Diagram and calculate material handling costs and distances. Next you will make several changes to your layout and Material Handling Equipment file. Later you will use CALC: again to learn the effects of the changes.

Once again you are working for Acme Ladders. You still make just one product, a ladder, but this time the ladder is more complex with more component parts. There are also additional manufacturing steps needed to produce a ladder in this example. The plant includes several new workcenters not included in Tutorial Section 1.

Again we will assume you have already created your plant layout drawing. We are also assuming you have added your product flow paths and workcenter points before saving the drawing to a file called LADDER1. The detailed layout is shown on page 54. You also entered and saved your production data in your Product, Parts, and Material Handling Equipment files using FFEDIT: . Mr. Althep wants you to experiment with developing an improved layout to cut costs. You believe that material handling costs could be reduced by rearranging workcenters in your layout and fine tuning your material handling system.

This project would have been complex, but with FactoryFLOW, making changes and recalculating the distances and costs will be easy. You've outlined ten steps to improving your layout and are ready to begin. Just to keep organized, let's review the ten steps you've come up with.

1. Load the layout drawing, FactoryFLOW, and data files.
2. Compute the current material handling costs and distances and generate a Product Flow Diagram.
3. Generate a Composite Flow Diagram.
4. Change the layout by moving some workcenters.
5. Edit a product flow path.
6. Recompute material handling costs and distances.
7. Compute material handling system utilizations.
8. Edit product, part, and material handling equipment information.
9. Generate a Material Handling Equipment Utilizations Report.
10. Save your new layout and data files.

These few steps may result in thousands of dollars of cost savings. With FactoryFLOW, it'll be a snap. Let's get going.

Step 1 Load the layout drawing, FactoryFLOW, and data files

The first step is to go to the USER directory you created when you installed FactoryFLOW. (If you called the directory something other than USER, substitute that name when USER appears.)

CD\USER <Return>

NOTE: Performing this Tutorial exercise changes drawing and data files. To repeat a Tutorial section, you must restore the files to their original condition by following the instructions on page 17.

The USER directory contains the batch file that sets up the operating environment for FactoryFLOW and starts AutoCAD. To run the batch file, type FACTFLOW and press <Return>.

FACTFLOW <Return>

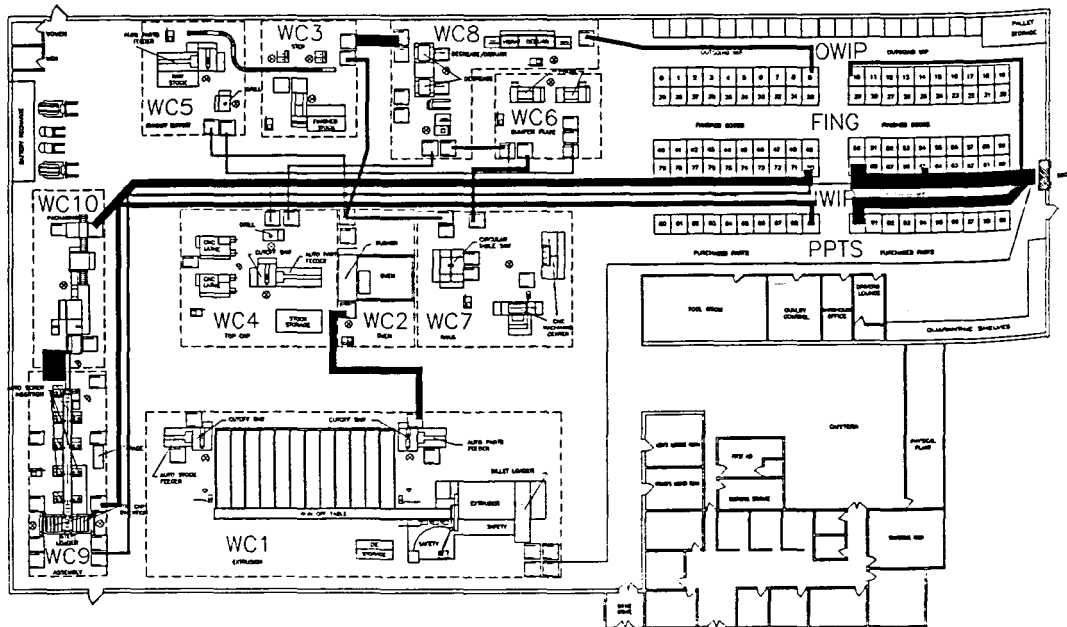
The AutoCAD Main Menu will appear. You want to load your detailed plant layout, so when you're prompted to enter a selection, type 2 to edit an existing drawing.

Enter selection: **2 <Return>**

The name of the layout drawing is LADDER1, so type that name now.

Enter NAME of drawing: **LADDER1 <Return>**

The layout drawing now loads.



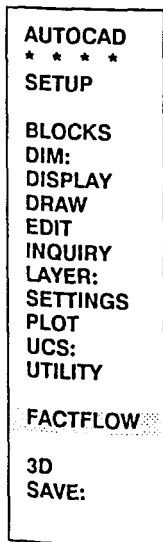
Remember, for this tutorial we are assuming that you've already accomplished several things:

- you drew a detailed layout
- entered your products, parts, and material handling equipment data
- drew your material handling paths

- defined some reference points called workcenter points
- used CALC: to calculate costs and distances
- saved your layout and its associated data files

The layout and data files were saved under the file name LADDER1.

In the first section of the tutorial it was necessary to load the FACTFLOW menu using AutoCAD's MENU command and to turn on HANDLES before you could use FactoryFLOW's commands. When the LADDER1 layout was saved, the menu was saved with the drawing and the handles were turned on. Therefore, when the layout drawing LADDER1 is loaded, the FACTFLOW menu is automatically loaded.



Pick FACTFLOW from the screen menu now to load FactoryFLOW.

-->FACTFLOW

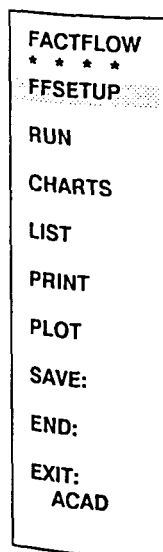
When the FactoryFLOW program is through loading, the copyright line and time period prompt appear. You want to analyze distances and costs on an annual basis, so pick YEAR from the menu or press <Return> to select the default time unit, year.

Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>: <Return>

FactoryFLOW now loads the Path and Workcenter Points files automatically.

Please wait.....

Loaded paths file LADDER1.
Loaded workcenter points file LADDER1.



The main FACTFLOW screen menu now appears. You still have to load the Products, Parts, and Material Handling Equipment files. Pick FFSETUP from the menu.

-->FFSETUP

FACTFLOW
 * * * * *
 IN DATA:
 FFEDIT:
 DEFVIEW:
 ZOOM V:
 ZOOM W:
 ZOOM P:
 PAN:
 __LAST__

You can use IN DATA: to simply load the existing files rather than using FFEDIT: to create new ones. Pick IN DATA: now.

-->IN DATA:

The IN DATA: prompt and screen menu appear, listing the choices of loading each file independently or loading all files sequentially. You want to load all files, so choose ALL now. You can either type A and press <Return> or pick ALL from the screen menu.

All/PRoducts/PArts/MatIhand/<X>: A <Return>

You want to read information from your existing Products, Parts, and Material Handling Equipment files. All of the files are named LADDER1, so in this case you may simply press <Return> to accept the defaults for the prompts to read each of your data files.

Loading ...
 Read products information from a file <YES>: <Return>
 Products file <LADDER1>: <Return>
 Please wait .
 Loading ...
 Read parts information from a file <YES>: <Return>
 Parts file <LADDER1>: <Return>
 Please wait

Loading ...
 Material handling equipment file <LADDER1>: <Return>
 Loading ...

FACTFLOW
 * * * * *
 IN DATA:
 FFEDIT:
 DEFVIEW:
 ZOOM V:
 ZOOM W:
 ZOOM P:
 PAN:
 __LAST__

After the Material Handling Equipment file is read, the original IN DATA: prompt returns. You're finished with IN DATA:, so press <Return> to accept the default response, eXit.

All/PRoducts/PArts/MatIhand/eXit <X>: <Return>

Now you're ready to perform your analysis, so pick FACTFLOW to go back to the main FACTFLOW screen menu.

-->FACTFLOW

Step 2 Compute material handling costs and distances and generate a Product Flow Diagram

```

FACTFLOW
* * * * *
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
  ACAD
    
```

The next thing you need to do is run FactoryFLOW's CALC: command. The CALC: command will compute the current material handling costs and distances and generate a scaled Product Flow Diagram. Later, FactoryFLOW will use the data to create a Composite Flow Diagram. FactoryFLOW will also use the initial costs and distances to compute and report the percentage change after you make changes to your current layout.

To run CALC:, pick RUN from the screen menu, then pick CALC: .

```
--> RUN
```

```
--> CALC:
```

```

Loading ...
Working ...
    
```

All the data CALC: needs to compute distances and costs is present, so CALC: automatically reads the data, performs the computations, and then asks for the path thickness scale. A path thickness scale of \$2 per foot per inch works well for this layout and time period, so type 2 and press <Return> .

```

FACTFLOW
* * * * *
CALC:
ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:
EDIT
REPORTS
COMPANAL
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
  _LAST_
    
```

```
Path thickness scale (Dollars/Foot/Inch) <100>: 2 <Return>
```

```
Working ...
```

```

New Total Travelled Distance (Ft)/ YEAR: 11,559,466
New Total Material Handling Cost/ YEAR: $46,609
    
```

Now that you have calculated your initial costs and distances and generated a Product Flow Diagram, you can generate a Composite Flow Diagram.

Step 3 Generate a Composite Flow Diagram

FACTFLOW

* * * *

CALC:
**ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:**
**EDIT
REPORTS
COMPANAL**
ZOOM V:
**ZOOM W:
ZOOM P:
PAN:
__LAST__**

A Composite Flow Diagram is an effective tool for visually understanding the total cost of moving materials between pairs of workcenters. FactoryFLOW's DRWCOMP: command draws Composite Flow Diagrams by computing the total move costs between workcenters one product at a time, adding the costs for all included products, and then drawing euclidean (direct from workcenter point to workcenter point) composite product flow lines. To generate the Composite Flow Diagram, first pick COMPANAL (composite analysis) from the screen menu.

-->COMPANAL

The appropriate FactoryFLOW functions will load and a new screen menu will be displayed. Pick DRWCOMP: from the new menu to draw the Composite Flow Diagram.

-->DRWCOMP:

DRWCOMP: first checks for existing composite flow lines. If you already have composite flow lines, DRWCOMP: will ask you whether you want to erase them. Since in this case there are none, DRWCOMP: immediately asks whether you want to include all products in the composite flow computations. Your factory only produces one product, a ladder, and your Products file contains data only on your single product, so press <Return> to accept the default response, YES.

Include all products <YES>: <Return>

DRWCOMP: allows you to choose a color for the Composite Flow Diagram. The default color is fine, so press <Return>.

Color for COMPOSITE flow diagram <GREEN>: <Return>

DRWCOMP: uses "workcenter points" as endpoints of the Composite Flow Diagram. You defined and saved the workcenter points when you drew the detailed layout. The workcenter points were automatically loaded from a file when you picked FACTFLOW from the opening menu. DRWCOMP: gives you the option of redefining the workcenter points now. (If you hadn't already defined the points, DRWCOMP: would prompt you for each required workcenter point. Refer to DRWCOMP: in the reference section for more information.) You're happy with your old workcenter points as well as the thickness scale you used before, so press <Return> to keep them.

Redefine workcenter points <NO>: <Return>

Path thickness scale (Dollars/Foot/Inch) <2>: <Return>

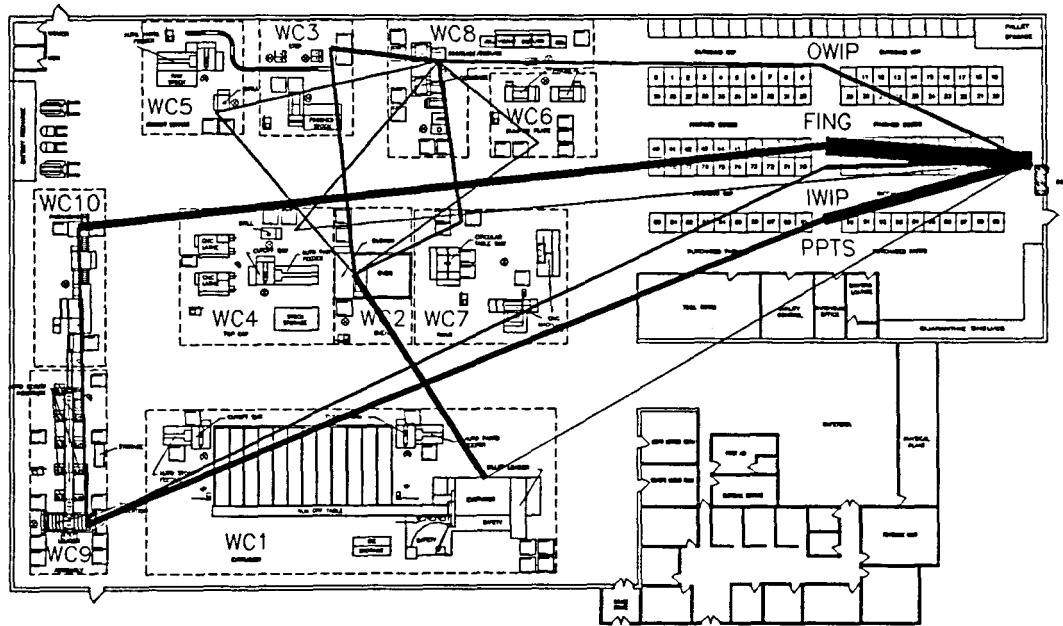
The Composite Flow Diagram now generated on your screen should appear similar to the one in the illustration below. To make this illustration more readable, only the composite flow

FACTFLOW

* * * *

DRWCOMP:**DELCOMP:****REDRAW:****ZOOM V:**
**ZOOM W:
ZOOM P:
PAN:
__LAST__**

lines are shown. Your screen will show both the product flow lines and the composite flow lines. You can easily tell them apart because they are displayed in different colors. If you want to view only the green composite flow lines, you can turn off the yellow product layer. Since your only product is LADDER, turning the LADDER layer off will give you the same view as in the illustration below.



- FACTFLOW
- *****
- DRWCOMP:
- DELCOMP:
- REDRAW:
-
- ZOOM V:
- ZOOM W:
- ZOOM P:
- PAN:
- __LAST__

Notice that there are long thick lines between the warehouse area on the far right side of the plant and the assembly (WC9) and packing (WC10) workcenters on the opposite side of the plant. The thick lines represent a high cost/foot relative to the thinner lines, thus indicating that it would be advantageous to move these workcenters closer to one another. You're hot on the trail of a more efficient plant layout!

Remember, the Composite Flow Diagram is a tool to help you visualize the relative costs of moving material between workcenters. When you're through looking at the Composite Flow Diagram, pick DELCOMP: to delete the composite flow lines.

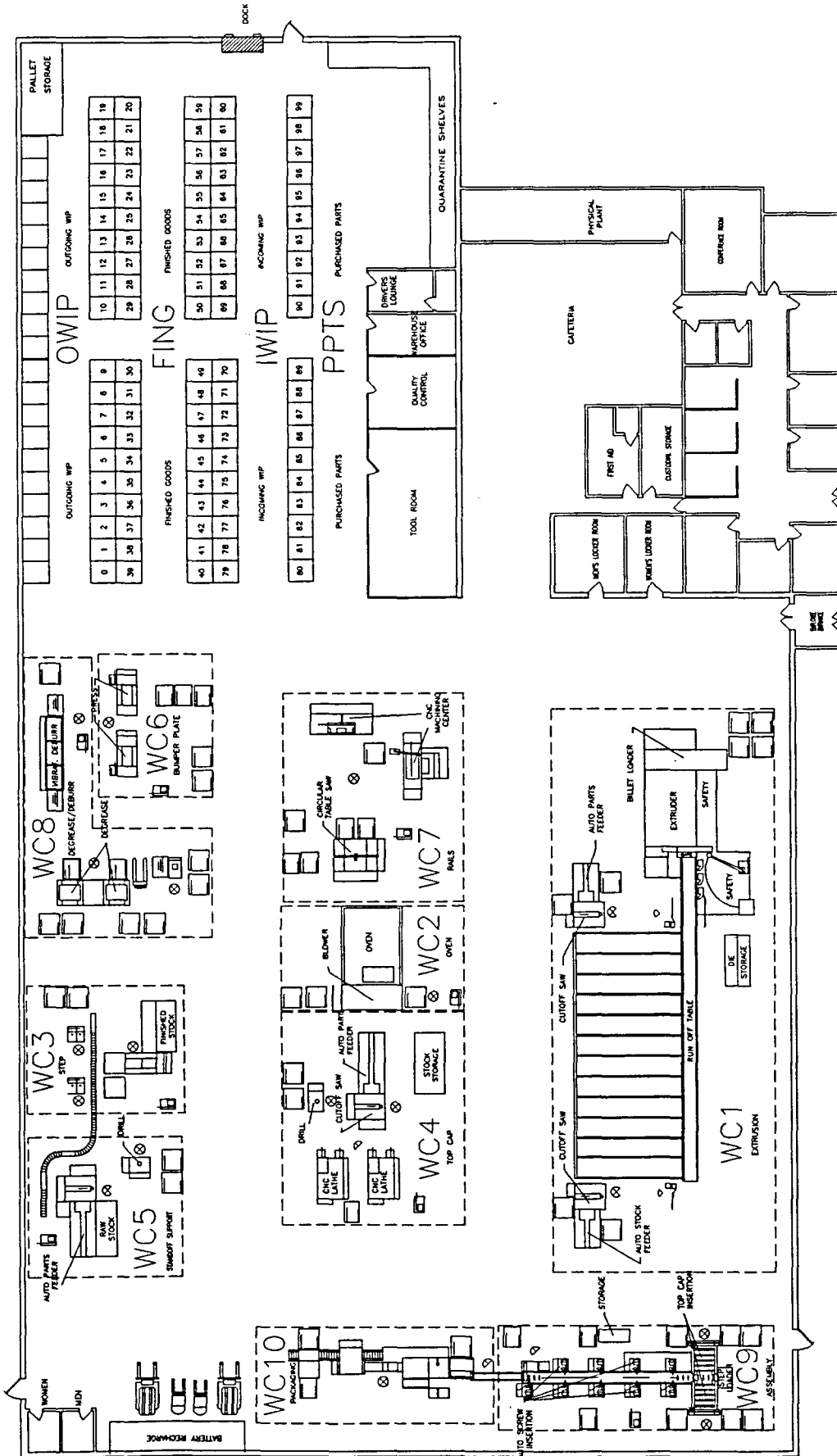
--> DELCOMP:

Once the lines are gone, pick REDRAW: to generate a fresh display.

--> REDRAW:

Finally, pick __LAST__ to go back to the previous screen menu.

--> __LAST__



OWIP

OUTGOING WIP										OUTGOING WIP									
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	28	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20

FING

FINISHED GOODS										FINISHED GOODS									
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61	60

IWIP

INCOMING WIP										INCOMING WIP									
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99

PPTS

PURCHASED PARTS										PURCHASED PARTS									
-----------------	--	--	--	--	--	--	--	--	--	-----------------	--	--	--	--	--	--	--	--	--

Step 4 Change the layout by moving some workcenters

By viewing the Composite Flow Diagram, you noticed the relatively high cost per foot of material handling between the warehouse and the assembly and packing workcenters. "What if" you changed the layout? What effect would that have on the material handling costs? You've decided to use FactoryFLOW's MOVEWC: command to move the assembly and packing workcenters closer to the warehouse, and to use CALC: to see what effect this would have on material handling costs.

FACTFLOW

* * * *

CALC:

ARROWS:

SAVE DC:

PRODFW:

LSTPATH:

EDIT

REPORTS

COMPANAL

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

MOVEWC: works like the standard AutoCAD move command except that MOVEWC: will also delete all paths going to and from the workcenters you move. Deleting the paths is important because once you move a workcenter the old paths are invalid. To get to the MOVEWC: command, pick EDIT from the screen menu.

--> EDIT

Before you start moving workcenters, take a few minutes to review the plant layout drawing on page 54. You can also, of course, zoom in on your on-screen drawing to view any part of the plant layout.

Moving the WC9 (assembly) and WC10 (packaging) workcenters closer to the warehouse will involve several steps. First, you'll temporarily move WC9 and WC10 outside the plant to make room. Next, you'll move WC1 (extrusion) and WC7 (rails) to the left. Finally, you'll move WC9 and WC10 to the new space next to the warehouse. Got it? Don't worry, we'll go one step at a time.

Go ahead and pick MOVEWC: now to start moving workcenters.

FACTFLOW

* * * *

MOVEWC:

FFEDIT:

EDTPATH:

DELPATH:

LSTPATH:

TIMUNIT:

CHTUNIT:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

--> MOVEWC:

Loading ...

MOVEWC: first asks you for the name of the workcenter you want to move. When you entered the parts data earlier, you gave each workcenter a name. You've assigned the name WC10 to packaging, so type WC10 and press <Return>.

Workcenter name: WC10 <Return>

MOVEWC: next asks you to select the objects which make up the workcenter you've named. Knowing that you would be moving workcenters, you BLOCKed each workcenter earlier to speed up the editing process. You can pick any part of the workcenter to select the entire workcenter. (If the workcenters were not blocked, you would have to select all entities in the workcenter with the regular AutoCAD selection methods.) Pick an object in WC10 (packaging) to select the packaging workcenter.

Select WC10 workcenter:

MOVEWC: continues to prompt you to select the objects to be moved. Since the workcenter is a block reference, all objects are selected with one pick. Press <Return> to continue
MOVEWC: .

Select objects: 1 selected, 1 found.
Select objects: <Return>

MOVEWC: asks for a base point for the move. Select a point in WC10.

Base point:

MOVEWC: asks for a second point. Pick a point to the far right of the screen outside the plant.

Second point:

MOVEWC: will now move the packaging workcenter to the new location and erase all material handling path definitions for paths to or from the packaging workcenter.

Please wait

MOVEWC: asks whether you want to redefine the workcenter point. Since you're not through moving the workcenter yet, type N and press <Return>.

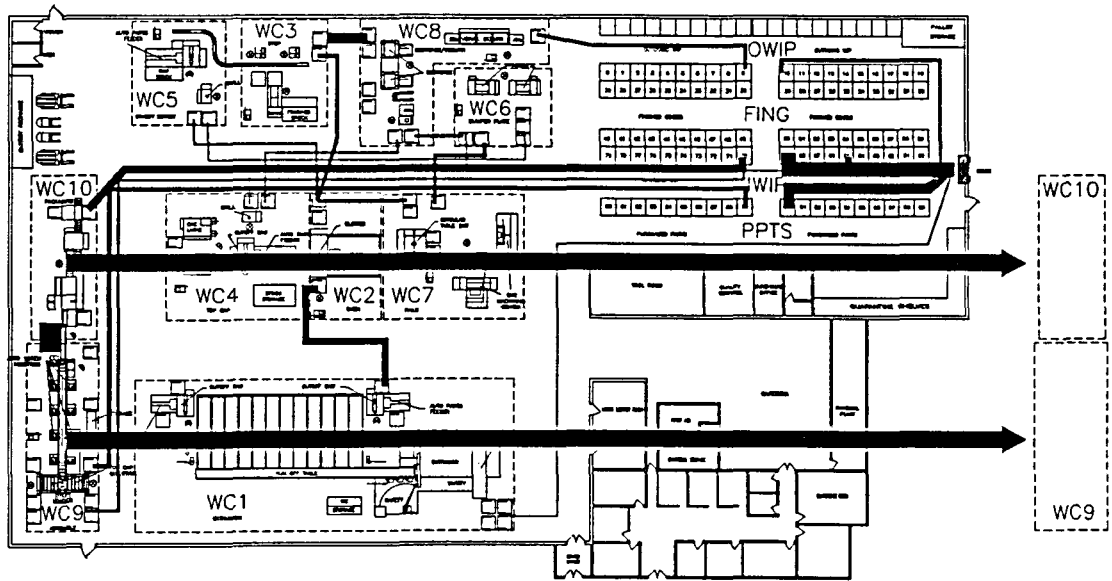
Redefine workcenter point for WC10 <YES>: N <Return>

MOVEWC: asks whether you want to move another workcenter. You do, so press <Return> to accept the default response, YES.

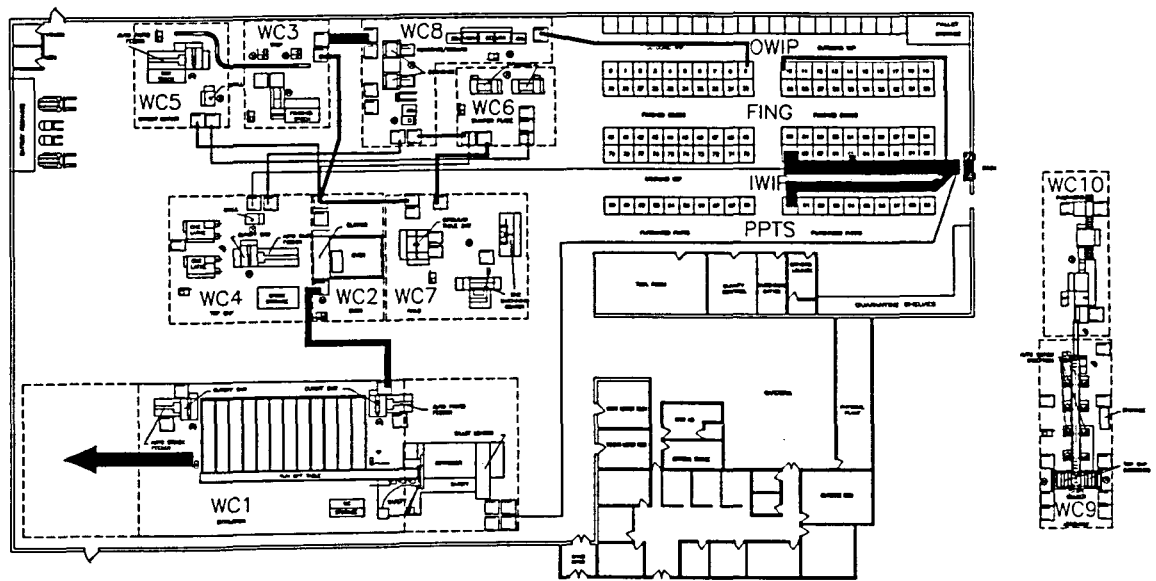
Move another workcenter <YES>: <Return>

Refer to the following illustrations and move the other workcenters as shown.

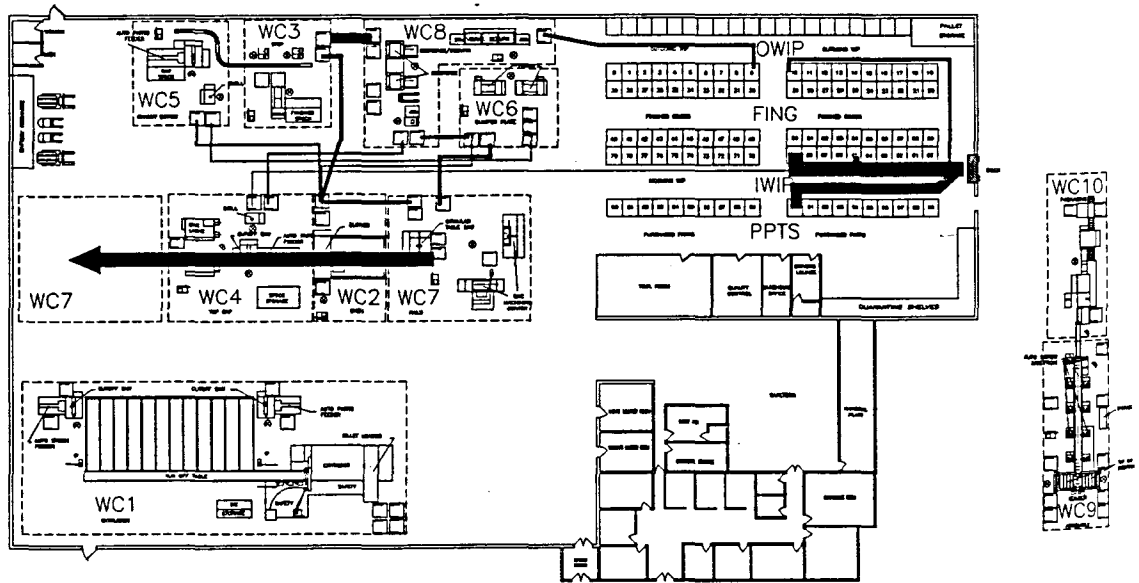
Move WC9 (assembly) next to WC10 (packaging).



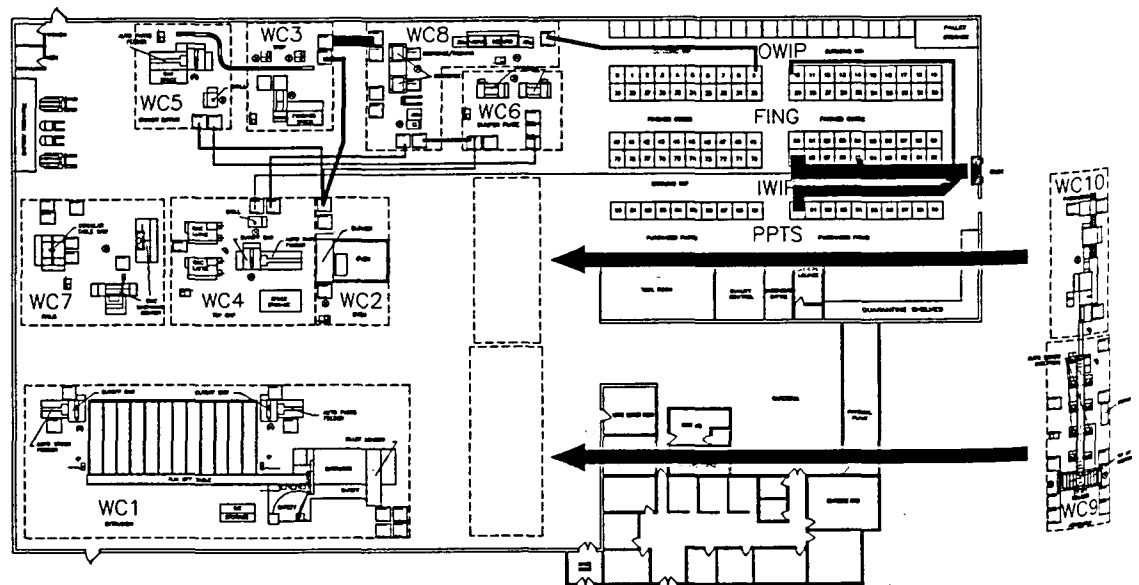
Move WC1 (extrusion) to the left.



Move WC7 (rails) to the left.



Lastly, move WC10 and WC9 to their new locations back in the factory.



When you have finished moving all of the workcenters, answer **NO** to the move another workcenter prompt. In this tutorial section you should not redefine workcenter points: you won't need to use them again for this example. However, if you picked a **FactoryFLOW** command that uses workcenter points, **FactoryFLOW** would give you a chance to redefine workcenter points at that time.

You've accomplished your goal of moving **WC9** and **WC10** nearer the warehouse. At this point, you could run **CALC:** to see what effect the move has had, but for now you decide to edit a product flow path before running **CALC:** .

Step 5 Edit a path

While you were collecting path data, one of the production workers suggested that production would be smoother if material from **WC3** (step) was dropped off at a different location in **WC8** (degrease/deburr). You passed the suggestion along and it has now been implemented, so you need to make the change in your material handling path from **WC3** to **WC8**.

You note that the production worker's suggestion results in a longer path, which means an increase in material handling costs. The reason the worker suggested the change is because it will result in smoother production within **WC8** itself. A later project might be to analyze the flow of material within **WC8** and try to modify the layout of that workcenter to improve flow in the workcenter as well as between workcenters. Since the drop off location in **WC8** has already been changed out on the shop floor, you need to edit the path in your current layout drawing.

You can use **FactoryFLOW**'s **EDTPATH:** command to edit paths. Pick **EDTPATH:** from the screen menu.

```
FACTFLOW
*****
MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__
```

```
-->EDTPATH:
```

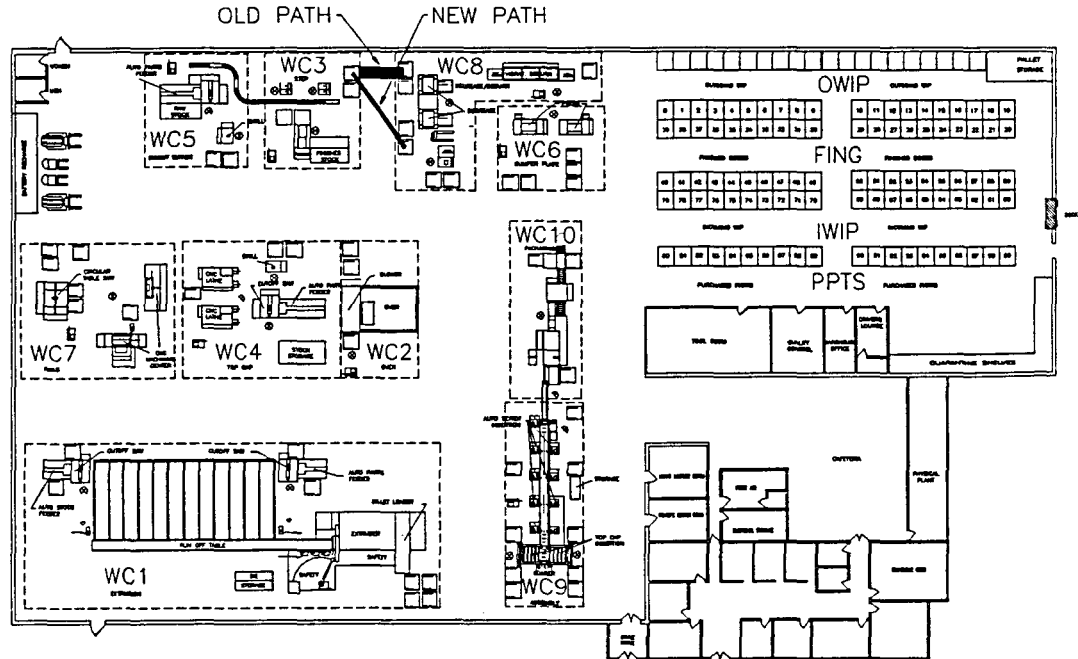
```
Loading ...
```

EDTPATH: first prompts for the path to edit. You can specify the path either by typing the product name and then the from and to workcenters, or by selecting an actual path from the drawing. Since you can easily pick the path you want from the drawing, press **<Return>** to select a path. (If you turned off the **LADDER** layer, you will need to turn it on.)

```
Product name or RETURN to select path: <Return>
```

EDTPATH: asks you to select a path to edit. Pick the "old path" shown in the following illustration.

Select path to edit:



Once you've selected the path, EDTPATH: erases the old definition, then takes you through the same path definition routine you used before in CALC: . Press <Return> to enter an actual material handling path.

Enter actual material handling paths <YES>: <Return>

Enter product: LADDER path from WC3 to WC8:
Enter first point of path [Return = None]:

Pick the point in WC3 shown above for the beginning of "new path." (You will need to toggle ORTHO OFF to draw the diagonal path.) When you're prompted for the next point, pick the end point of "new path" in WC8. Then press <Return> to accept the default response, Done.

Once you've finished editing the path, EDTPATH: asks whether you want to edit another. You don't, so type N and press return to end EDTPATH: and return to the command prompt.

Edit another path <YES>: N <Return>

Step 6 Recompute material handling costs and distances

You've finished moving workcenters and editing paths, so now it's time to run CALC: to see what effect these changes have had on material handling distances and costs. Pick LAST to go back to the previous screen menu, then pick CALC: .

--> LAST

-->CALC:

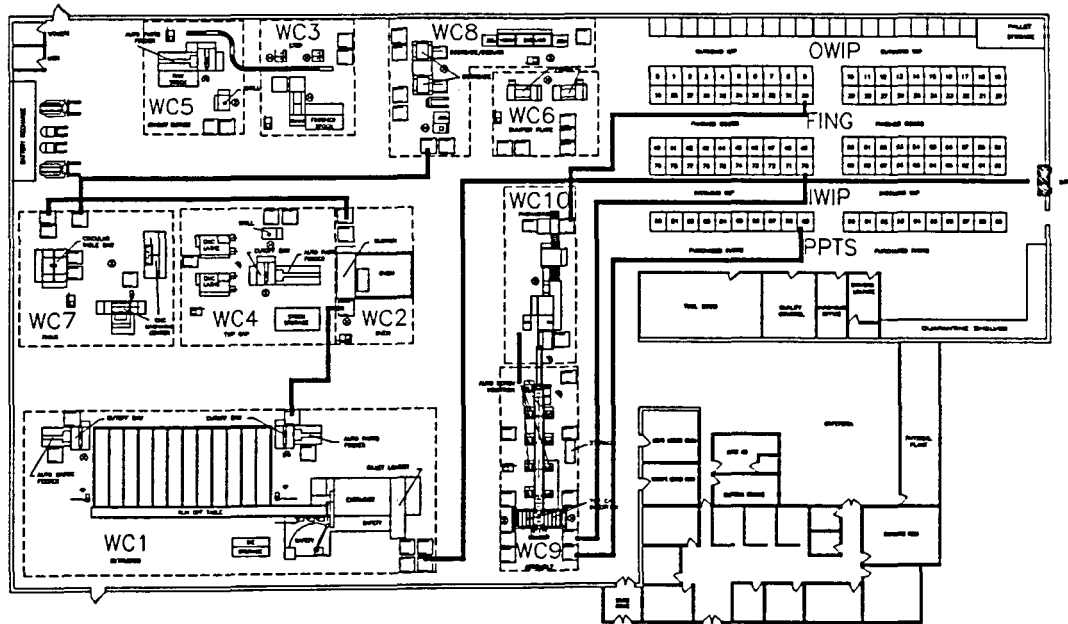
CALC: will load and begin computing travel distances. The following messages will scroll by:

Loading ...

Travel-distance for part: STSCREW of product: LADDER

Travel-distance for part: STSCREW of product: LADDER

When CALC: encounters a move whose path was deleted when you moved workcenters, CALC: will ask you to define the path. Press <Return> to define actual paths. A diagram showing the new paths appears below.



Enter actual material handling paths <YES>: <Return>
 Enter product: LADDER path from PPTS to WC9:
 Enter first point of path [Return=None]:

Draw the new material handling paths as shown in the illustration above. CALC: will prompt you for the paths it needs one at a time. NOTE: the path from WC9 to WC10 follows the short conveyor (shown in yellow on your screen) connecting the two workcenters.

When you're through entering paths, CALC: asks you for the thickness scale. Press <Return> to keep the previous value, 2.

Loading ...
 Working ...
 Path thickness scale (Dollars/Foot/Inch) <2>: <Return>

CALC: will change the new paths to scaled product flow lines and report the previous and new costs and distances along with percentage of improvement. Switch to the text screen to see the complete report, which should have results similar to those in the report below.

Working ...

Percent Travelled Distance Improvement: 34
Previous Total Travelled Distance (Ft) / YEAR: 11,559,466
New Total Travelled Distance (Ft) / YEAR: 7,602,778

Percent Material Handling Cost Improvement: 12
Previous Total Material Handling Cost / YEAR: \$46,609
New Total Material Handling Cost / Year: \$41,086

The report shows that there has been a large reduction in total distance travelled, but not as great a reduction of cost. (If you ran CALC: between the first report and this report, your previous cost and distance as well as your percentages may differ from the example.)

Now, Mr. Althep will be thrilled with a 12% reduction in cost, but you suspect you can do even better. Here's how. Much of the material handling cost is due to fixed costs of material handling equipment. With the large reduction in total distances travelled, there is a strong possibility you now have more material handling equipment than you need. You decide to find out by using FactoryFLOW to calculate your Material Handling Equipment Utilizations.

Step 7 Compute Material Handling Equipment Utilizations

```
FACTFLOW
*****
CALC:

ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

You can use FactoryFLOW's DISPMHU: command to compute your Material Handling Equipment Utilizations. DISPMHU: is found under REPORTS, so pick REPORTS then pick DISPMHU: .

-->REPORTS

-->DISPMHU:

DISPMHU: will compute the utilizations and display the material handling utilizations on the text screen.

Loading ...

MATERIAL HANDLING UTILIZATIONS

Material handling system name: LFTRK
 Available minutes / equipment / YEAR: 100000.00
 Busy minutes / system / YEAR: 82785.00
 Quantity: 1.00
 Utilization (%): 82.78

Material handling system name: CONVY

Material handling system name: PPTRK
 Available minutes / equipment / YEAR: 100000.00
 Busy minutes / system / YEAR: 11041.74
 Quantity: 5.00
 Utilization (%): 2.21

Press RETURN to continue.

Wow, in the new layout the power pallet trucks (PPTRK) are only 2.21% utilized. (Your numbers may differ slightly, depending on exactly where you drew your material handling paths.) You thought you were hot on the trail before; now you're smokin'! Your next step is to edit the material handling equipment information. When you're through looking at the Material Handling Equipment Utilizations, press <Return> to return to the command prompt.

<Return>

```
FACTFLOW
*****
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

Step 8 Edit product, part, and material handling equipment information

Acme currently has five power pallet trucks, and they are listed as parallel servers in the PPTRK material handling system. With the new layout, only one server is necessary. You will simply change the number of pallet trucks in your Material Handling Equipment file using FFEDIT: . FactoryFLOW gives you two different ways to edit your material handling

quantities, CHGEMHU: and FFEDIT: . In Tutorial Section 1, you used FFEDIT: to create a new Material Handling Equipment file. Now you will use FFEDIT: to edit an existing file. Pick FACTFLOW, FFSETUP, then FFEDIT: or FACTFLOW, RUN, EDIT, then FFEDIT: to get to FFEDIT: .

```

FACTFLOW
* * * *
MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
  _LAST_
    
```

-->FACTFLOW

-->RUN

-->EDIT

-->FFEDIT:

When you pick FFEDIT:, the PRODUCTS FILE window is displayed with the cursor on the default file name LADDER1. Press <Return> to load your LADDER1 Products file.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1		
PRODUCT	# /	PATH COLOR

<Return>

The LADDER1 Products file will load and the cursor will jump down to the product name field and highlight LADDER. Press <F1> to display the PARTS FILE window.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1		
PRODUCT	# / YEAR	PATH COLOR
LADDER1	100000.00	YELLOW

<F1>

The PARTS FILE window will pop up and the cursor will be in the PARTS FILE name field. Press <Return> to accept your default Parts file name, LADDER1.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1					
PARTS FILE : LADDER1					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD

<Return>

FFEDIT: will display your LADDER1 Parts file. Move the cursor to the MAT'L HAND. field and press <F1> to display the MATERIAL HANDLING EQUIPMENT window.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1 PRODUCT : LADDER					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD
LADDER	1.000	FING	DOCK	LFTRK	8.00
LADDER	1.000	WC10	FING	LFTRK	8.00
LADDER	1.000	WC9	WC10	CONVY	8.00
RTRAIL	1.000	IWIP	WC9	LFTRK	200.00
LFRAIL	1.000	IWIP	WC9	LFTRK	200.00
RAIL	2.000	DOCK	IWIP	LFTRK	200.00
RAIL	2.000	OWIP	DOCK	LFTRK	250.00
RAIL	2.000	WC8	OWIP	LFTRK	250.00

<right arrow> <right arrow> <right arrow> <right arrow> <right arrow>

<F1>

FFEDIT: will ask whether you want to save the Parts file information before moving on to the Material Handling Equipment file. You haven't made any changes, so press <Return> to accept the default response, NO.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1 PRODUCT : LADDER					
PART	QTY /	FROM	TO	MAT'L	UNIT LOAD
LADDER					8.00
LADDER					8.00
LADDER					8.00
RTRAIL					200.00
LFRAIL	1.000	IWIP	WC9	LFTRK	200.00
RAIL	2.000	DOCK	IWIP	LFTRK	200.00
RAIL	2.000	OWIP	DOCK	LFTRK	250.00
RAIL	2.000	WC8	OWIP	LFTRK	250.00

<Return>

Your MATERIAL HANDLING EQUIPMENT window will be displayed with the cursor in the MATERIAL HANDLING EQUIPMENT name field. Press <Return> to accept your default file name, LADDER1.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1
PRODUCT : LADDER

MATERIAL HANDLING EQUIPMENT FILE : LADDER1

MATERIAL HANDLING	TYP	QTY	INVEST. COST /	HOURLY FP & M COST	HOURLY LABOR COST	AVAIL. MINUTES /	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)

<Return>

This displays the data you wish to edit. You want to change the quantity of powered pallet trucks from 5 to 1. Move the cursor down to the PPTRK line, then move the cursor over to the QTY field. The current QTY (number of pallet trucks) is 5. Type 1 and press <Return> to change the number of power pallet trucks to one.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1
PRODUCT : LADDER

MATERIAL HANDLING EQUIPMENT FILE : LADDER1

MATERIAL HANDLING	TYP	QTY	INVEST. COST /YEAR	HOURLY FP & M COST	HOURLY LABOR COST	AVAIL. MINUTES /YEAR	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)
LFTRK	5	1.00	3000	1.00	20.00	100000	1.00	250.00	70.00
CONVY	7	***	1000	1.00	0.00	10000	***	***	***
PPTRK	3	1.00	1000	1.00	15.00	100000	1.00	150.00	70.00

1 <Return>

That is the only change you're going to make to the Material Handling Equipment file, so press <Esc> to leave the window.

<Esc>

A small window will pop up to warn you that changes have been made and ask whether you want to save the information. You do want to save it (though you will save the data to a new file), so press <Return> to accept the default response, Y.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1
PRODUCT : LADDER

MATERIAL HANDLIN										
MATERIAL HANDLING	TYP	Q	Changes have been made... Save mat. hand. eq. information ? (Y/N) Y						AVERAGE SPEED (FT/MIN)	EFFECT (%)
LFTRK	5	1.00	3000	1.00	20.00	100000	1.00	250.00	70.00	
CONUY	7	***	1000	1.00	0.00	10000	***	***	***	
PPTRK	3	1.00	1000	1.00	15.00	100000	1.00	150.00	70.00	

<Return>

The prompt changes and asks for the file name to save the information in. You want to keep the original data file as it was, so type a new name, LADDER2, and press <Return> to save the revised data.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1
PRODUCT : LADDER

MATERIAL HANDLIN										
MATERIAL HANDLING	TYP	Q	Mat. hand. equipment file : LADDER2						AVERAGE SPEED (FT/MIN)	EFFECT (%)
LFTRK	5	1.00	3000	1.00	20.00	100000	1.00	250.00	70.00	
CONUY	7	***	1000	1.00	0.00	10000	***	***	***	
PPTRK	3	1.00	1000	1.00	15.00	100000	1.00	150.00	70.00	

LADDER2 <Return>

Now that you're back in the PARTS FILE window, you can make two other changes that you've thought of. The other day while gathering information, you noted that if you used the lift truck instead of the powered pallet truck to move your ladder topcaps from WC4 (topcap) to WC8 (degrease/deburr), you could move twice as many parts in one trip. This increase would accomplish the parts move in half as many trips. You also discovered that with just a little better scheduling you could avoid storing the ladder rails in the OWIP (outgoing work in process) workcenter and just move the rails directly from WC8 to the DOCK. You will make the changes in FFEDIT: .

To make the change from power pallet truck to lift truck, move the cursor down to the line in your Parts file which represents moving the TOPCAP from WC4 to WC8, then move the cursor to the MAT'L HAND. field and type LFTRK.

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PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1 PRODUCT : LADDER					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD
RAIL	2.000	WC1	WC2	PPTRK	400.00
SRAIL	0.030	DOCK	WC1	LFTRK	30.00
RTOPCAP	1.000	OWIP	WC9	LFTRK	400.00
LTOPCAP	1.000	OWIP	WC9	LFTRK	400.00
TOPCAP	2.000	DOCK	OWIP	LFTRK	400.00
TOPCAP	2.000	OWIP	DOCK	LFTRK	500.00
TOPCAP	2.000	WC8	OWIP	LFTRK	500.00
TOPCAP	2.000	WC4	WC8	LFTRK	500.00

< arrow keys >

LFTRK

Since you can move 1000 parts with the fork lift truck, change the number of parts in the UNIT LOAD field from 500 to 1000. You're already in the UNIT LOAD field, so simply type 1000.

1000

That's one more change accomplished. Now make the other change, moving rails directly from WC8 to the DOCK. First move the cursor up to the line in your Parts file which represents moving the RAIL from WC8 to OWIP, then place the cursor in the TO CELL field and type DOCK.

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PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1 PRODUCT : LADDER					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD
RAIL	2.000	WC8	OWIP	LFTRK	250.00
RAIL	2.000	WC7	WC8	PPTRK	250.00
RAIL	2.000	WC2	WC7	PPTRK	400.00
RAIL	2.000	WC1	WC2	PPTRK	400.00
SRAIL	0.030	DOCK	WC1	LFTRK	30.00
RTOPCAP	1.000	IWIP	WC9	LFTRK	400.00
LTOPCAP	1.000	IWIP	WC9	LFTRK	400.00
TOPCAP	2.000	DOCK	IWIP	LFTRK	400.00

<arrow keys>
DOCK

Since you are not going to store the rails in OWIP, you can delete the line in your Parts file which represents moving the RAIL from OWIP to DOCK. To delete the line, move the cursor up one line and press <Delete>.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1 PRODUCT : LADDER					
PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD
RAIL	2.000	OWIP	DOCK	LFTRK	250.00
RAIL	2.000	WC8	DOCK	LFTRK	250.00
RAIL	2.000	WC7	WC8	PPTRK	250.00
RAIL	2.000	WC2	WC7	PPTRK	400.00
RAIL	2.000	WC1	WC2	PPTRK	400.00
SRAIL	0.030	DOCK	WC1	LFTRK	30.00
RTOPCAP	1.000	IWIP	WC9	LFTRK	400.00
LTOPCAP	1.000	IWIP	WC9	LFTRK	400.00

<up arrow>
<Delete>

You have finished making changes to the Parts file, so press <Esc> to exit the PARTS FILE window. Once again, you will save the changes to a new file and keep a copy of the existing data. When you are prompted for the Parts file name, type LADDER2 and press <Return>.

<Esc>

<Return>

LADDER2 <Return>

FFEDIT: saves the Parts file and returns you to the PRODUCTS FILE window. You have one change to make in the Products file. Marketing has informed you that Acme will be producing 95,000 ladders per year instead of the 100,000 you were planning for. Move to the #/YEAR field and type 95000, then press <Return>.

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PRODUCTS FILE : LADDER1		
PRODUCT	# / YEAR	PATH COLOR
LADDER	100000	YELLOW

<right arrow>

95000 <Return>

You have finished editing your Products file and you're ready to save the data to a new file and leave FFEDIT: . Press <Esc> to display the prompt to save the changes. The now familiar window pops up warning you that changes have been made and prompting you to save the Products file information. Remember, you want to save the new file under the name LADDER2.

<Esc>

<Return>

LADDER2 <Return>

FFEDIT: saves the Products file and returns you to your layout drawing. FactoryFLOW automatically reads the new Products, Parts, and Material Handling Equipment files, and returns you to the command prompt.

Reading products file LADDER2.
 Please wait
 Reading parts file LADDER2.
 Please wait
 Reading material handling equipment file LADDER2.

Step 9 Generate a Material Handling Equipment Utilizations Report

FactoryFLOW read your three LADDER2 data files when you left FFEDIT:, but has not yet computed distances and costs based on the new information. To see how your changes have affected distances and costs, pick FACTFLOW, RUN, CALC: from the screen menu to run the CALC: command.

-->FACTFLOW

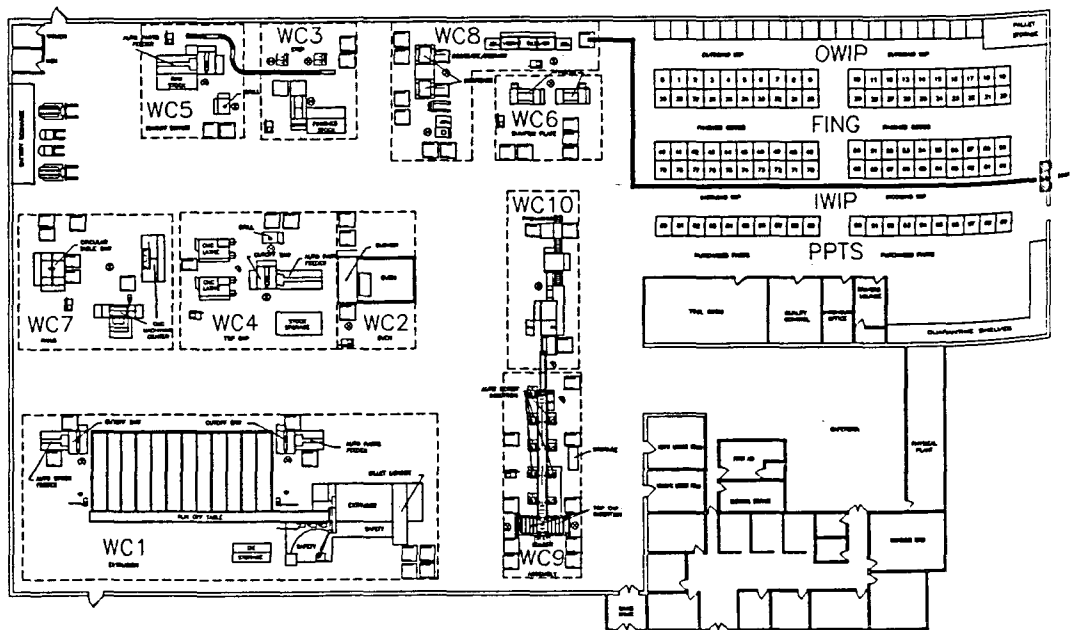
-->RUN

-->CALC:

CALC: will load, then begin to read path data. CALC: will pause when it reaches the path you added (remember, you added a move from WC8 to DOCK). Press <Return> to enter an actual material handling path.

Loading ...
 Enter actual material handling paths <YES>: <Return>

As you expected, you're prompted for the path from WC8 to DOCK. Draw the path from WC8 to the DOCK as shown in the illustration below.



Enter product: LADDER path from WC8 to DOCK:
Enter first point of path [Return = None]:

CALC: will finish making calculations and ask you for the path thickness scale. Press
<Return> to keep the same scale, 2.

Working ...
Path thickness scale (Dollars/Foot/Inch) <2>: <Return>
Working ...

When CALC: is through drawing the scaled product flow lines, switch to the text screen to see
the complete distance and cost report.

Percent Travelled Distance Improvement: 5
Previous Total Travelled Distance (Ft) / YEAR: 7,602,778
New Total Travelled Distance (Ft) / YEAR: 7,223,845

Percent Material Handling Cost Improvement: 14
Previous Total Material Handling Cost / YEAR: \$41,086
New Total Material Handling Cost / Year: \$35,246

Well, those material handling costs came right down, didn't they! The improvement was
mainly as a result of reducing the number of powered pallet trucks, although the other changes
that you made also affected your distances and costs. Since you made all of the changes at
once, you don't know exactly what effect each change had. Of course, if you were concerned
with each independent effect, you would change only one item at a time and rerun CALC: .

```
FACTFLOW
*****
CALC:

ARROWS:
SAVE DC:
PRODFW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

Now let's take a look at material handling equipment utilizations for the new layout. Instead of simply displaying a report, as you did earlier with DISPMHU:, this time you want to actually write the report to a file. To generate a Material Handling Utilization Report and write it to a file, pick REPORTS from the screen menu, then pick GENEMHU: .

-->REPORTS

-->GENEMHU:

GENEMHU: will load, then ask for a file name to save the utilization data in. GENEMHU: uses data from the latest CALC: to generate the report. The latest CALC: used the LADDER2 Products, Parts, and Material Handling Equipment files, so type LADDER2 and press <Return> .

Loading ...
Material handling utilizations file <LADDER1>: LADDER2 <Return>

```
FACTFLOW
*****
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

GENEMHU: will add a simple header on the report using the company and project names you supply. The header will also include the date and time. GENEMHU: will prompt you to enter the header information. Type the responses as shown below.

Company name <NONE>: ACME LADDERS <Return>
Project name <NONE>: LAYOUT2 <Return>
Date <SYSTEMDATE>: <Return>
Time <SYSTEMTIME>: <Return>

GENEMHU: saves the report in the file LADDER2.MHU (GENEMHU: adds the MHU extension). You can access the file as you would any ASCII text file. You can list the file without leaving FactoryFLOW by using another command on this screen menu, LISTMHU: . Pick LISTMHU: now.

-->LISTMHU:

When LISTMHU: asks for the file name, type LADDER2 then press <Return> .

File name <LADDER1>: LADDER2 <Return>

LISTMHU: then lists the material handling utilizations for LADDER2 on the text screen. The report shows that the one remaining powered pallet truck is approximately 10% utilized. Your new layout eliminated the need for four of the trucks with plenty of capability left in the one truck to perform all necessary moves.

```
FACTFLOW
*****
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
```

COMPANY NAME: ACME LADDERS
PROJECT NAME: LAYOUT2
DATE: 07/17/1989
TIME: 16:44

MATERIAL HANDLING UTILIZATION

Material handling system name: LFTRK
Available minutes / equipment / YEAR: 100000.00
Busy minutes / system / YEAR: 78393.12
Quantity: 1.00
Utilization (%): 78.39

Material handling system name: CONVY

Material handling system name: PPTRK
Available minutes / equipment / YEAR: 100000.00
Busy minutes / system / YEAR: 9905.40
Quantity: 1.00
Utilization (%): 9.91

Press RETURN when ready . . .

When you're through looking at the report, press <Return> to continue.

<Return>

Step 10 Save your new layout and data files and end FactoryFLOW

Well, you've really made some progress with the new layout and material handling equipment configuration. You've accomplished enough for now, so it's time to end your FactoryFLOW session. Use FactoryFLOW's END: command to finish the session. The FactoryFLOW END: command is not the same as AutoCAD's END command. When you pick END: from the FACTFLOW screen menu, END: will attempt to save your paths and workcenter points as well as your drawing. END: is on the main FACTFLOW screen menu, so pick FACTFLOW, then pick END: .

```
FACTFLOW
* * * *
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST _
```

-->FACTFLOW

-->END:

Loading ...

END: will load and check for unsaved changes to the Paths, Workcenter Points, and Drawing files. END: warns you that there are unsaved changes and asks whether you really want to end without saving changes. You do want to save the changes, so press <Return> to accept the default response, NO.

There are some unsaved changes !!!
Do you really want to end without saving changes <NO>: <Return>

END: asks for the name of the file in which to save the paths, workcenter points, and drawing. You want to save the new files with the name LADDER2, so type LADDER2 and press <Return>.

```
FACTFLOW
* * * *
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT

SAVE:

END:
EXIT:
  ACAD
```

File name <LADDER1>: LADDER2 <Return>
Please wait
Saving paths file LADDER2.
Please wait
Saving workcenter points file LADDER2.
Saving drawing file LADDER2.

END: saves the files and leaves the drawing editor, returning you to AutoCAD's Main Menu. You're through with AutoCAD, so type 0 and press <Return> to quit.

Enter selection: 0 <Return>

You've learned a lot while going through your ten steps. Let's step back a bit and review your progress. Among other things, you have now successfully done the following:

- loaded an existing layout with its corresponding data files and computed its costs and distances
- generated a Composite Flow Diagram
- rearranged a group of workcenters
- edited a path
- generated a Material Handling Equipment Utilizations Report
- edited Products, Parts, and Material Handling Equipment files with FFEDIT:
- saved an alternative layout and material handling system design

You're well on your way to mastering FactoryFLOW. But yes, you guessed it, there's more to come. Take a break now, then come back to Section Three.

Tutorial: Section Three

Welcome to the third and last section in the FactoryFLOW tutorial. We'll leave Acme Ladders and Mr. Althep behind and take a quick look at three more of FactoryFLOW's tools using a fictitious plant called SAMPLE. You'll load the drawing and data files and then generate Distance-Intensity and Product-Quantity Charts, selectively view product flow paths, and generate a Workcenter Utilizations Report.

The SAMPLE plant produces three products: PROD1, PROD2, and PROD3 (what else would you expect from a plant called SAMPLE?). SAMPLE has seven workcenters: RECEIVING, LATHE, ROBOT, MILL, BROACH, ASSEMBLY, and SHIPPING. There are eight parts moves for PROD1, four for PROD2, and six for PROD3. The SAMPLE plant has two material handling systems, called MH1 and MH2. That's a pretty sketchy overview of SAMPLE, but it's enough to get you going. An illustration of the SAMPLE plant is on page 78.

You have six steps to complete in section three:

1. Load the drawing and FactoryFLOW
2. Load the data files using FFEDIT:
3. Generate a Distance-Intensity Chart
4. Generate a Product-Quantity Chart
5. Selectively view product flow paths
6. Calculate workcenter utilizations

Step 1 Load the drawing and FactoryFLOW

Go to the USER directory. (If you called the directory something other than USER, substitute that name when USER appears.)

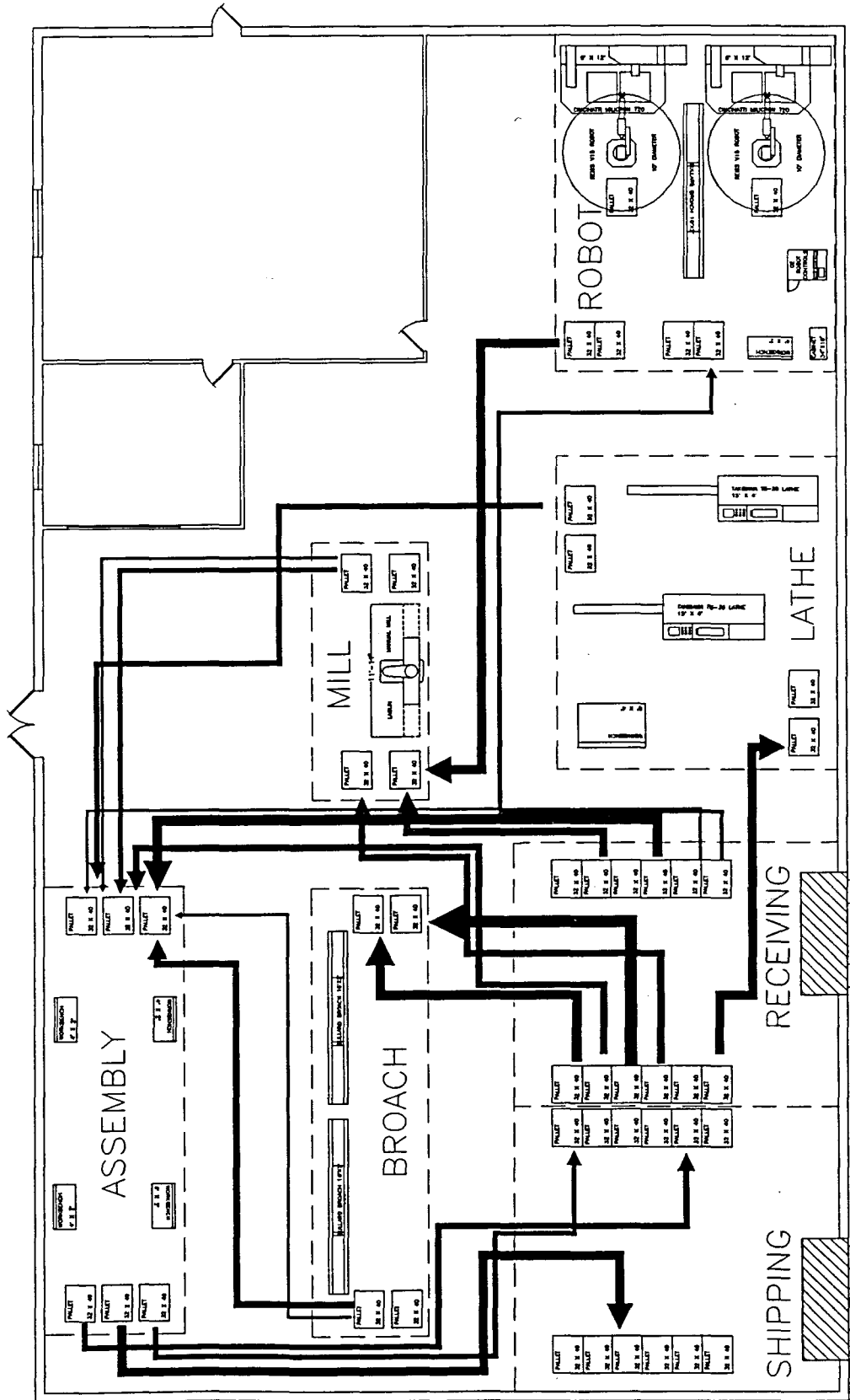
```
CD \USER <Return>
```

NOTE: Performing this Tutorial exercise changes drawing and data files. To repeat a Tutorial section, you must restore the files to their original condition by following the instructions on page 17.

To run the FactoryFLOW program, you will use the FACTFLOW batch file in a new way. The FACTFLOW batch file saves several DOS environment variables, then resets the variables for FactoryFLOW. The batch file also prepares the system to use Extended AutoLISP, then automatically loads AutoCAD.

The FACTFLOW batch file also has a feature which allows you to pass the name of your drawing to AutoCAD. To start FactoryFLOW with a default drawing name, type the drawing name after FACTFLOW. You will use this feature now. To start FactoryFLOW for the SAMPLE drawing, type FACTFLOW SAMPLE and press <Return>.

```
FACTFLOW SAMPLE <Return>
```



When AutoCAD's Main Menu is displayed, select option 2 to edit an existing drawing.

Enter selection: **2** <Return>

SAMPLE appears as the default drawing name, so simply press <Return> to load SAMPLE.

Enter NAME of drawing <SAMPLE>: <Return>

AUTOCAD
* * * *
SETUP

BLOCKS
DIM:
DISPLAY
DRAW
EDIT
INQUIRY
LAYER:
SETTINGS
PLOT
UCS:
UTILITY

FACTFLOW

3D
SAVE:

The SAMPLE layout has already been through a FactoryFLOW analysis during which actual paths were defined. Pick FACTFLOW from the screen menu to start FactoryFLOW.

-->FACTFLOW

When the time unit prompt appears, press <Return> to accept the default response, YEAR.

* FactoryFLOW (C) 1989 CIMTECHNOLOGIES CORP. *
Time unit to analyze (Year/Month/Week/Day/Shift) <YEAR>: <Return>

FactoryFLOW searches for and finds SAMPLE's Paths and Workcenter Points files and automatically loads them.

Loaded paths file SAMPLE.
Loaded workcenter points file SAMPLE.

The next step is to load your three data files. You used IN DATA: to load your data files in section two of the tutorial. This time you'll use FFEDIT: .

Step 2 Load the data files using FFEDIT:

IN DATA: can read only fixed field format files. FFEDIT: can read both fixed format and space delimited files. FFEDIT:'s ability to read space delimited files enables you to import files that have been created in a text editor or spreadsheet program and printed to an ASCII text file. When you save files with FFEDIT:, the new files will be saved in a fixed format that can later be read by IN DATA: . A discussion of how to import and export files is included at the end of *Appendix D File Formats*.

```

FACTFLOW
*****
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
  ACAD
    
```

The procedure for loading data files into FFEDIT: is the same for fixed format and space delimited files. When you save the files and leave FFEDIT:, FactoryFLOW automatically loads the files and will be "set up" for your analysis. Pick FFSETUP from the main FACTFLOW screen menu, then pick FFEDIT: .

-->FFSETUP

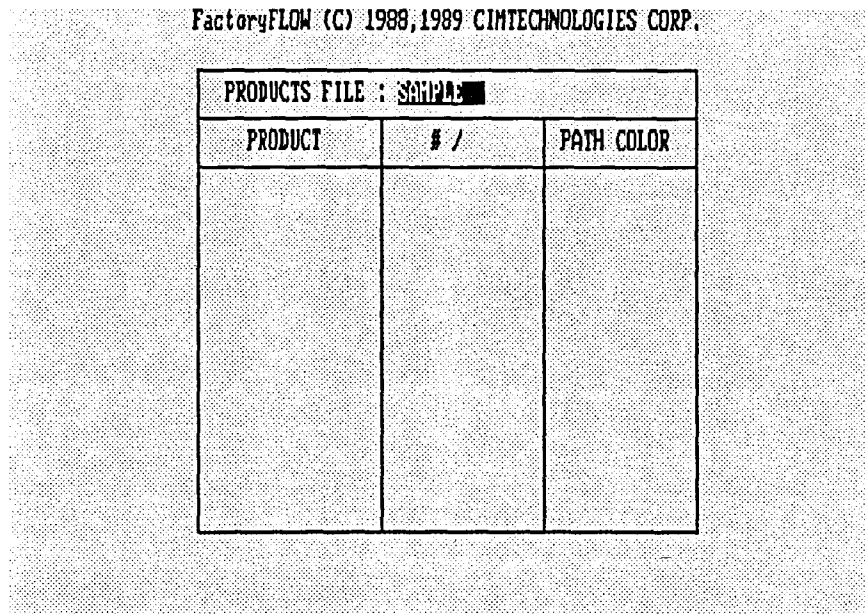
-->FFEDIT:

When the FFEDIT: PRODUCTS FILE window appears, press <Return> to accept the default Products file name, SAMPLE.

```

FACTFLOW
*****
IN DATA:
FFEDIT:
DEFVIEW:

ZOOM V:
ZOOM W:
ZOOM P:
PAN:
  _LAST_
    
```



<Return>

The SAMPLE Products file will load and your cursor will be on PROD1. Press <F1> to bring up the PARTS FILE window for product PROD1.

<F1>

FFEDIT:'s PARTS FILE window will pop up. Press <Return> to accept the default Parts file name, SAMPLE.

<Return>

The SAMPLE parts file will load and the cursor will jump to the part name field. (Since the cursor was on PROD1 when you pressed <F1> in the PRODUCTS FILE window, only the

parts for PROD1 will be displayed. The SAMPLE parts file, though, actually contains all the parts for PROD1, PROD2, and PROD3.) Move the cursor to the MAT'L HAND. field and press <F1> to go to the MATERIAL HANDLING EQUIPMENT FILE window.

<right arrow> <right arrow> <right arrow> <right arrow>
<F1>

A small box will pop up and ask whether you want to save the parts information. You don't want to save it right now, so press <Return> to accept the default response, NO.

<Return>

FFEDIT:'s MATERIAL HANDLING EQUIPMENT FILE window will pop up. Press <Return> to accept the default Material Handling Equipment file name, SAMPLE.

<Return>

The SAMPLE Material Handling Equipment file will load and the cursor will jump to the material handling name field.

You have loaded all three data files into FFEDIT:, but now you must save the files. Even though you haven't made any changes to the files, saving them will accomplish two things. First, if the files are currently space delimited, FFEDIT: will convert them to a fixed format that IN DATA: can read. Second, when you save the files, you will trigger FactoryFLOW to load the files so you can use them for your analysis. Press <Esc> to save the Material Handling Equipment data and leave the MATERIAL HANDLING EQUIPMENT FILE window.

<Esc>

The familiar small window will pop up asking whether you want to save the information. Type Y and press <Return>.

Y <Return>

Another prompt line appears asking for the name of the file to save the information in. Press <Return> to accept the default response, SAMPLE.

<Return>

FFEDIT: will save the Material Handling Equipment file and then return you to the PARTS FILE window.

The procedure for saving and exiting the PARTS FILE and PRODUCTS FILE windows is the same as for the MATERIAL HANDLING EQUIPMENT FILE window. Press <Esc> to leave, type Y and press <Return> to save the file, and press <Return> to accept the default file name, SAMPLE.

<Esc>
 Y
 <Return>

```

FACTFLOW
*****
IN DATA:

FFEDIT:
DEFVIEW:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_
  
```

After you leave the PRODUCTS FILE window (which takes you out of FFEDIT:), FactoryFLOW will automatically read the Products, Parts, and Material Handling Equipment files and return you to the command prompt.

```

Loading ...
Reading products file SAMPLE.
Please wait ...
Reading parts file SAMPLE.
Please wait .....
Reading material handling equipment file SAMPLE.
Command:
  
```

Now that FactoryFLOW has read the data files, you're finished setting up. Pick FACTFLOW to return to the main FACTFLOW screen menu.

-->FACTFLOW

Step 3 Generate a Distance-Intensity Chart

```

FACTFLOW
*****
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
  ACAD
  
```

You're ready now to generate a Distance-Intensity Chart (you do not need to run CALC: first). FactoryFLOW's Distance-Intensity Chart graphically represents with points on a graph the path distances between workcenters and their intensities (number of moves along the path). In an optimal layout where material handling devices have been selected, points will be close to the x and y axes. That is, high intensity moves will have short travel distances, and long distance moves will be reserved for moves with low intensity.

Generating the chart takes two steps: first, generate the Distance-Intensity data file, and second, generate the chart. The GEN DI: command generates the Distance-Intensity data. Pick CHARTS, then pick GEN DI: .

-->CHARTS

-->GEN DI:

GEN DI: will load and ask you for the data file names. Press <Return> each time to accept the default name, SAMPLE.

```

Products file <SAMPLE>: <Return>
Parts file <SAMPLE>: <Return>
Paths file <SAMPLE>: <Return>
  
```

GEN DI: will also ask you what file to save the Distance-Intensity information in. Again, press <Return> to accept the default name, SAMPLE.

Distance-intensity file <SAMPLE>: <Return>

GEN DI: will allow you to specify which products you want to include. GEN DI: first asks, though, whether you simply want to include all products. Press <Return> to accept the default response, YES.

Include all products <YES>: <Return>

GEN DI: will create and save the Distance-Intensity information file.

Now that the data for the DI Chart has been created and saved, pick PLT DI: to generate the chart itself.

-->PLT DI:

PLT DI: will ask you for the name of the Distance-Intensity information file. Press <Return> to accept the default response, SAMPLE.

Loading ...
Distance-intensity file <SAMPLE>: <Return>

FactoryFLOW draws the DI Chart right on the graphics screen as part of your drawing. PLT DI: will ask you to pick a start point for the origin of the chart. Pick a point in the empty area above the upper right corner of the facility.

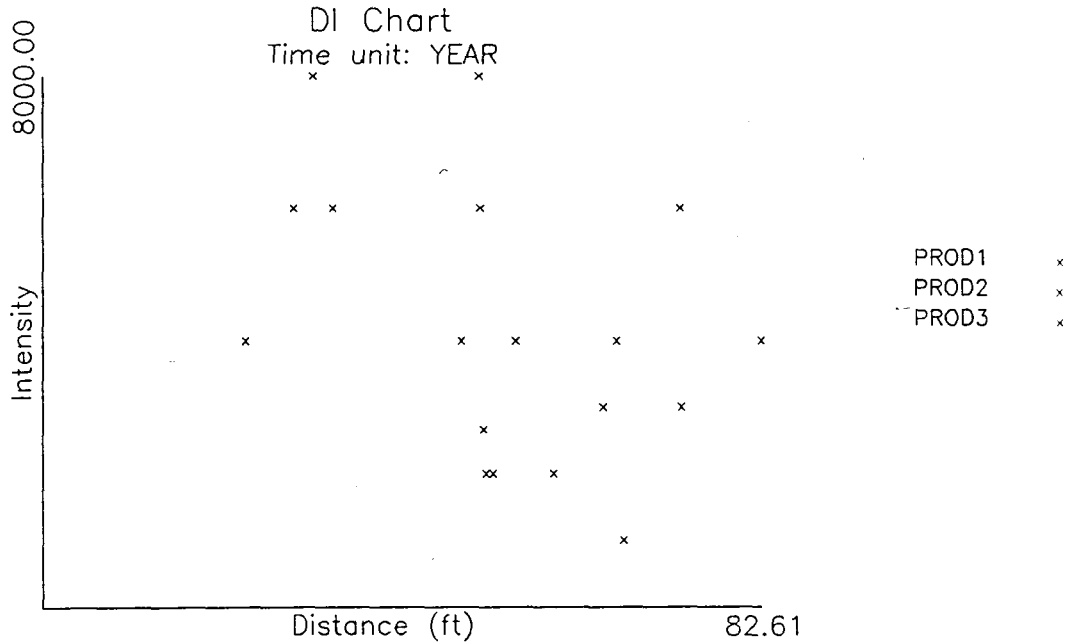
Select start point for distance-intensity graph:

After you pick the starting point, GEN DI: will create a chart sized to fill an 8½ x 11 sheet of paper. Use ZOOM W: from the screen menu to view the chart. (You may have to zoom in several times to get close enough to the plot to view it.) Your chart will look similar to the following illustration.

-->ZOOM W:

FACTFLOW

PQCHART
GEN PQ:
PLT PQ:
DICHART
GEN DI:
PLT DI:
PT ATT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__



```

FACTLOW
*****
PQCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_
    
```

The points are color coded by product with the same colors as the product flow lines. The PT ATT: command on the CHARTS menu allows you to query the point attributes of a point on the DI Chart and display the data associated with it. Pick PT ATT: now.

-->PT ATT:

Pick any point on the chart once you have selected the PT ATT: command.

Select distance-intensity point to query:
Select object:

Pick any point in the chart. Once you have selected the point, you should see a report similar to the one below on your text screen.

Product: PROD3
Part: PART33
From Workcenter: RECEIVING
To Workcenter: ASSEMBLY
Material Handling Device: MH1

Distance (ft): 64.35
Intensity: 3000.00

Press RETURN to continue. <Return>

PT ATT: asks whether you want to query another point. You don't want to query another point right now, so type N and press <Return> to end PT ATT: .

Query another distance-intensity point <YES>: N <Return>

Pick ZOOM P: from the screen menu to zoom back to the full plant drawing. (You may have to pick ZOOM P: more than once to get all the way back to the view you were in prior to looking at the DI Chart.)

-->ZOOM P:

Step 4 Generate a Product-Quantity Chart

FACTFLOW
Q C * *
POCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
_ LAST _

FactoryFLOW's Product-Quantity (PQ) Chart is a bar graph that shows the relative quantity of products produced. Like the DI Chart, generating the PQ Chart takes two steps: first generate the data file, then plot the chart. GEN PQ: gets its information directly from the Products file. Pick GEN PQ: to generate the information file.

-->GEN PQ:

GEN PQ: prompts you for the Products file to read and the name of the Product-Quantity file to save the information in. Press <Return> in both cases to accept the default name, SAMPLE.

Products file <SAMPLE>: <Return>
Product-quantity file <SAMPLE>: <Return>

GEN PQ: generates and saves the Product-Quantity information file. Now pick PLT PQ: to generate the chart.

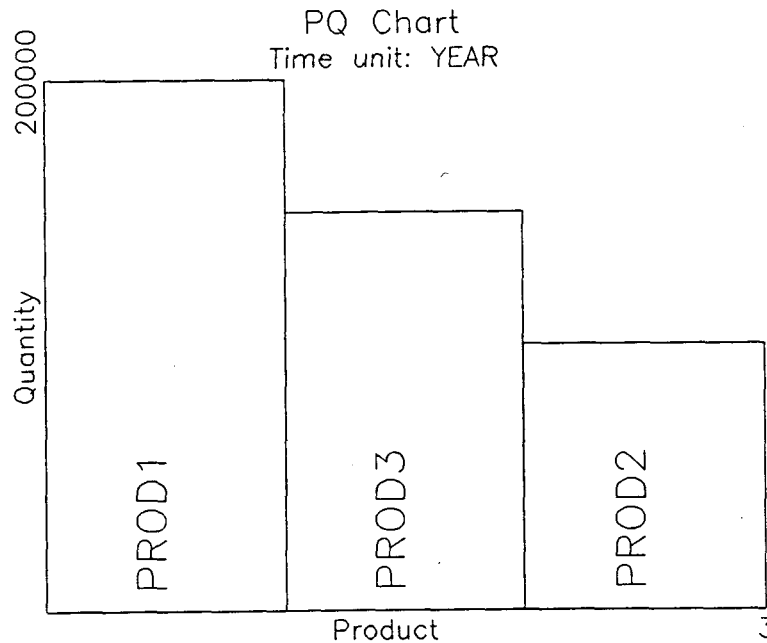
-->PLT PQ:

PLT PQ: prompts for the name of the file to read. Press <Return> to accept the default name, SAMPLE. Then PLT PQ: asks you to select a start point for the origin of the PQ Chart. Pick a point above and to the right of the drawing, next to where you put the DI Chart.

Product-quantity file <SAMPLE>: <Return>
Select start point for product-quantity graph:

After you pick a point, PLT PQ: will plot the chart. As before, the chart is sized to fit an 8½ x 11 inch sheet of paper, so you will need to use the ZOOM W: to get close enough to the chart to see it. The chart should look similar to the one below.

-->ZOOM W:



The Product-Quantity Chart is useful for grouping products into similar-volume categories. Different volume categories tend to require different methods of plant layout. High-volume products lend themselves to a mass production type of layout; that is, a production line. Low-volume products lend themselves to a process or job-shop type of layout.

When you're through looking at the chart, pick ZOOM P: to return to the full plant drawing.

-->ZOOM P:

Step 5 Selectively view product flow paths

With a large number of product flow paths between workcenters shown in a Product Flow Diagram, concentrating on just one flow path or group of paths coming from or going to any particular workcenter can be difficult. The PRODFLOW: command gives you two methods for isolating a particular path or group of paths: 1) by changing the color of selected product flow paths, or 2) by turning off non-selected paths.

FACTFLOW
* * * *
CALC:

ARROWS:
SAVE DC:
PRODFW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

Let's use PRODFW: to turn off all but a single product flow path. PRODFW: is found by picking RUN from the main menu, so pick FACTFLOW, RUN, PRODFW: .

-->FACTFLOW

-->RUN

-->PRODFW:

Loading ...

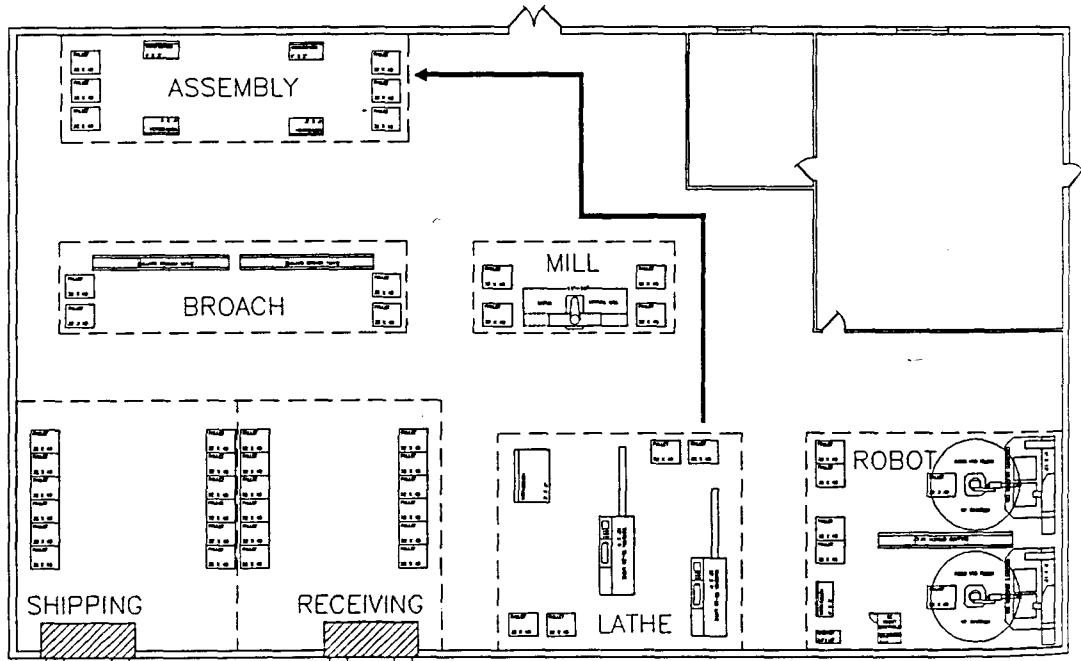
PRODFW: will load and ask you for the product, from workcenter, and to workcenter names. The default response, * (asterisk), is a wildcard character. When you're prompted for the product, answering * tells PRODFW: to use all products. If you want to specify one specific product, you type the product name. In our example, you wish to isolate the path that PROD3 parts travel from the LATHE workcenter to the ASSEMBLY workcenter. Type PROD3 then press <Return> to specify PROD3 paths; type LATHE and press <Return> to select the paths that originate in LATHE; type ASSEMBLY and press <Return> to select only those paths that end in ASSEMBLY.

Product <*>: PROD3 <Return>
From workcenter <*>: LATHE <Return>
To workcenter <*>: ASSEMBLY <Return>

You have now specified which product flow path you want to concentrate on. To make the selected path easier to see, you can turn off all other paths. Your other option is to change the color of the selected path to make it stand out. For now, you will display only the selected paths. When PRODFW: asks whether you want to display paths not selected, type N and press <Return>.

Display paths not selected <YES>: N <Return>

PRODFW: will turn off all non-selected paths. Your plant should now look like the following illustration.



If you had chosen to keep displaying non-selected paths, PRODFLW: would have asked you for the color to use for the selected paths.

The product flow paths you turned off have information associated with them, so PRODFLW: will restore them to their original status before ending. In case you want to keep a copy of your layout displaying your selected paths, PRODFLW: gives you several options. You can save the drawing to a file, save the current graphics screen as a slide, or create a hard copy by plotting or printer plotting. See PRODFLW: in the reference section for more information on these options. For now, press <Return> after each prompt to accept the default response, NO.

Save product flow diagrams <NO>: <Return>
 Make a slide of product flow diagrams <NO>: <Return>
 Plot or printer-plot product flow diagrams <NO>: <Return>

PRODFLW: will now restore the drawing to its original condition and return you to the command prompt.

Step 6 Calculate Workcenter Utilizations

Calculating Workcenter Utilizations (the percentage of busy time for servers within a workcenter) is particularly important when you're considering a change in the production volume and want to make sure the servers are neither overloaded nor underutilized. Making the calculation requires taking into account production volumes, setup times, machining times, lot sizes, scrap rates, and number of servers within the workcenter.

FactoryFLOW's FFEDIT: program has the ability to quickly calculate Workcenter Utilizations if you include the setup times, machining times, lot sizes and scrap rates information in your Parts file. The SAMPLE Parts file does include this information; the figure below shows the information for PROD3 as displayed in FFEDIT's pop-up workcenter data window (you can reach the window by pressing <F1> when the cursor is in the PARTS FILE window's FROM CELL field).

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PRODUCTS FILE : SAMPLE

PARTS FILE : SAMPLE PRODUCT : PROD3						
PART	QTY / PRODUC	WORK CENTER	SETUP TIME (MIN)	LOT SIZE	CYCLE TIME (MIN)	SCRAP RATE (%)
PART3	1.	ASSEMBLY	20.00	1000.00	0.50	3.00
PART31	4.	LATHE	20.00	300.00	0.25	4.00
PART32	2.	BROACH	20.00	300.00	0.25	2.00
PART33	1.	RECEIVING	0.00	1.00	0.00	0.00
PART311	4.	RECEIVING	0.00	1.00	0.00	0.00
PART321	2.	RECEIVING	0.00	1.00	0.00	0.00

The line for PART31 shows that each PROD3 requires four PART31's, which are machined in the LATHE workcenter. It takes 20 minutes to set up a lathe to machine PART31, and 300 PART31s are run in a lot. It takes .25 minutes to machine each PART31, and 4% of the lot is scrapped.

To compute workcenter utilizations, pick EDIT to go to the EDIT menu and select FFEDIT: .

--> EDIT

--> FFEDIT:

FFEDIT: loads and the PRODUCTS FILE window appears with the highlight in the file name field. Press <Return> to select the default Products file name, SAMPLE.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : SAMPLE		
PRODUCT	# /	PATH COLOR

<Return>

The SAMPLE Products file will load and the cursor will move to the Product field. Press <F2> to display the WORKCENTER UTILIZATIONS FILE window. A small window will pop up and ask whether you want to save the Products file. Press <Return> to accept the default response, NO.

<F2>

<Return>

The WORKCENTER UTILIZATIONS FILE window is displayed. Enter the name of the Products, Parts, and Workcenter Utilizations files. In each case press <Return> to accept the default response, SAMPLE.

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PRODUCTS FILE : SAMPLE				
PRODUCTS FILE : SAMPLE PARTS FILE : SAMPLE WC UTILIZATIONS FILE : SAMPLE				
WORK CENTER	# OF SERV /	AVAIL MIN /	BUSY MIN /	UTIL. (%)

<Return>
 <Return>
 <Return>

FFEDIT: loads the files and computes the workcenter utilizations. FFEDIT: will compute the number of busy minutes per year and workcenter utilizations, then display the information in the WORKCENTER UTILIZATIONS FILE window.

FactoryFLOW (C) 1988,1989 CIMTECHNOLOGIES CORP.

PRODUCTS FILE : SAMPLE				
PRODUCTS FILE : SAMPLE PARTS FILE : SAMPLE WC UTILIZATIONS FILE : SAMPLE				
WORK CENTER	# OF SERV /	AVAIL MIN / YEAR	BUSY MIN / YEAR	UTIL. (%)
ASSEMBLY	4.00	115200	346631	75.22
MILL	1.00	115200	97258	84.43
BROACH	2.00	115200	169184	73.40
ROBOT	2.00	115200	169697	73.65
LATHE	2.00	115200	197917	85.90

You can change the information in two fields of the WORKCENTER UTILIZATIONS FILE window: the number of servers (# OF SERV) and the available minutes per time unit (AVAIL MIN / time unit specified in the Products file). Changing the values in these fields causes the UTIL. % field to update automatically. For example, assume the SAMPLE plant

maintenance supervisor tells you that he wants to schedule more time for servicing the broach machines. You know from your WORKCENTER UTILIZATIONS FILE window that the broach machines are 73.40% busy, so you decide that you can afford to schedule more service time. To make the change to the data file, move the cursor to the BROACH line's AVAIL MIN / YEAR field and type 110000 then press <Return>.

<down arrow> <down arrow> <right arrow>
110000 <Return>

FFEDIT: will automatically recompute the utilization percentage. Your change in the available minutes increases the busy time to about 76%, which you feel is still an acceptable value. When you are done looking at the WORKCENTER UTILIZATIONS FILE window, press <Esc> to leave. FFEDIT: will automatically save the change you made, and then will ask whether you want a Workcenter Utilizations Report. You don't want a report just now, so type N and press <Return>.

<Esc>

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PRODUCTS FILE : SAMPLE				
PRODUCTS FILE : SAMPLE				
PARTS FILE : SAMPLE				
WC UTILIZATIONS FILE : SAMPLE				
Do you want a workcenters utilizations report ? (Y/N) ↓				
ROBOT	2.00	115200	169697	73.65
LATHE	2.00	115200	197917	85.90

N <Return>

FFEDIT: will take you back to the PRODUCTS FILE window. To leave FFEDIT: and return to the drawing and the command prompt, press <Esc>.

<Esc>

FFEDIT: will ask whether you want to save the products information. Press <Return> to accept the default response, NO.

<Return>

```
FACTFLOW
* * * *
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT

SAVE:

END:
EXIT:
ACAD
```

You've completed the last step of tutorial section three, so pick **FACTFLOW** to go back to the main **FACTFLOW** menu, then pick **END:** to leave **FactoryFLOW** and return to the **AutoCAD** Main Menu.

-->**FACTFLOW**

-->**END:**

To review, in part three of the tutorial you accomplished five new tasks:

- loaded data files using **FFEDIT:**
- generated a **Distance-Intensity Chart**
- generated a **Product-Quantity Chart**
- selectively viewed a product flow path
- modified the workcenter utilization data and calculated workcenter utilizations

Congratulations! By completing the three sections of the **FactoryFLOW** tutorial you are now familiar with most of **FactoryFLOW**'s functions and how to use them. It's now time to put **FactoryFLOW** to work on a project at your plant.

For more information on how to use **FactoryFLOW**, refer to *Using FactoryFLOW* and *Reference--FactoryFLOW Menus and Commands* in this manual. Registered **FactoryFLOW** users can call **CIMTECHNOLOGIES** for further assistance. **CIMTECHNOLOGIES**' engineers are dedicated to helping you use **FactoryFLOW** successfully to improve your factory layouts.

Reference--FactoryFLOW Menus and Commands

The reference section is organized according to the order in which FactoryFLOW commands appear on the menus. Check the menu tree diagram in *Appendix A* to see the complete hierarchical organization at a glance. Check the table of contents or the index to quickly find the menu item you're interested in. Commands appearing on more than one menu are documented only on the first menu on which they appear.

Menus

AutoCAD

AutoCAD

Setup

BLOCKS
DIM:
DISPLAY
DRAW
EDIT
INQUIRY
LAYER:
SETTINGS
PLOT
UCS:
UTILITY

FACTFLOW

3D
SAVE:

FactoryFLOW Main Menu

FACTFLOW

FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT

SAVE:

END:

EXIT:
ACAD

FFSETUP

FACTFLOW

IN DATA:

FFEDIT:

DEFVIEW:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

RUN

FACTFLOW

CALC:

ARROWS:
SAVE DC:
PRODFW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

EDIT

FACTFLOW

MOVEWC:

FFEDIT:

EDTPATH:
DELPATH:
LSTPATH:

TIMUNIT:
CHTUNIT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

REPORTS

FACTFLOW

DISPMHU:
CHGEMHU:

GENEMHU:
LSTMHU:

GENEMHR:
LSTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

COMPANAL

FACTFLOW

DRWCOMP:
DELCOMP:

REDRAW:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

CHARTS

FACTFLOW

POCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

LIST

FACTFLOW

LIST

PRODUCT:
PART:
MH EQU:
PATH:
WCP:

MH REP:
MH UTL:
WC REP:
DC REP:
PQ:
DI:

__LAST__

PRINT

FACTFLOW

PRINT

PRODUCT:
PART:
MH EQU:
PATH:
WCP:

MH REP:
MH UTL:
WC REP:
DC REP:
PQ:
DI:

__LAST__

PLOT

FACTFLOW

PLOTING

PLOT:

PRPLOT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

FactoryFLOW Main Menu

FACTFLOW
* * * *
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
ACAD

The FactoryFLOW Main Menu provides access to all of the FactoryFLOW menus and commands. FACTFLOW and * * * * appear on all FactoryFLOW menus.

FACTFLOW returns you to the FactoryFLOW Main Menu.

* * * * displays the AutoCAD object snap overrides menu.

FFSETUP, RUN, CHARTS, LIST, PRINT, and PLOT display their respective menus.

SAVE: saves the files and continues.

END: saves the files and ends the session.

EXIT: saves the files and exits FactoryFLOW but leaves you in the AutoCAD drawing editor.

ACAD displays the AutoCAD menu without exiting FactoryFLOW.

FFSETUP Menu

FACTFLOW

* * * *

IN DATA:

FFEDIT:

DEFVIEW:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

Commands on the FFSETUP menu are used to set up the FactoryFLOW analysis. That is, you use FFSETUP's commands IN DATA: and FFEDIT: to provide FactoryFLOW with information on products, parts, and material handling equipment.

Several other commands that appear first on the FFSETUP menu help you view selected parts of your drawing.

DEFVIEW: defines a view.

ZOOM V: displays a view.

ZOOM W: zooms to a selected window.

ZOOM P: zooms to the previous display

PAN: and __LAST__ work as they do in AutoCAD.

IN DATA: and FFEDIT: can be used to load data in either of two ways: 1) by reading previously created Products, Parts, and Material Handling Equipment files, or 2) by creating new data files. (A description of the Products, Parts, and Material Handling Equipment files and their fields is in *Appendix D File Formats*.)

FFEDIT: is the recommended method for entering and editing FactoryFLOW data files.

After a file is saved with FFEDIT:, it is automatically loaded for use by FactoryFLOW.

IN DATA: is the recommended method for loading existing FactoryFLOW data files when no changes or additions are needed. The differences between the two commands are summarized below.

FFEDIT:

Reads both space-delimited files (that is, files in which field entries on a line are separated simply by a space) and fixed-format files.

Can be used to create and modify data files.

Provides interactive data entry windows.

Saves data in a fixed format.

Converts a space-delimited data file to a fixed-format file.

Can be run outside of FactoryFLOW from the operating system.

IN DATA:

Only reads fixed format files (that is, files in which field entries occupy a specific position on a line).

Can be used to create (but not modify) data files.

Provides sequential command line prompts for data entry.

Saves data in a fixed format.

Cannot convert a space-delimited file to a fixed-format file.

Can be run only within FactoryFLOW.

IN DATA:

FACTFLOW
* * * *
IN DATA:
FFEDIT:
DEFVIEW:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

IN DATA: brings data into FactoryFLOW in one of two ways: 1) by reading previously created Products, Parts, or Material Handling Equipment files, or 2) by prompting you for the information required to build a Products or Parts file (IN DATA: does not include a routine to build a Material Handling Equipment file; CALC: does include that routine). IN DATA: is normally used to read existing data files, and not to create files. (See comparison between IN DATA: and FFEDIT: on page (?).) FFEDIT: is the easiest way to enter or edit FactoryFLOW data.

If you want to bring data into FactoryFLOW by using IN DATA:, pick IN DATA: from the FFSETUP menu.

—>IN DATA:

A list of choices appears on the screen menu; the prompt line lists the same choices.

All/PRoducts/PArts/Matlhand/eXit <X>:

The choices give you the option of reading (or of creating Products and Parts files) all or any one of the Products, Parts, or Material Handling Equipment files. Choosing eXit will end IN DATA: and return you to the FFSETUP menu.

ALL

Choosing ALL is similar to choosing PProducts, PArts, and Matlhand in succession. The prompts are effectively the same as for the individual functions. To load products, parts, and material handling equipment data using ALL, type A and press <Return> (or pick ALL from the menu).

All/PRoducts/PArts/Matlhand/eXit <X>: A <Return>

Many combinations of responses to the prompts are possible; the various prompts and responses are described in PRODUCTS, PARTS, and MATLHAND below. The typical use for IN DATA:, though, is simply to load existing data files which have the same name as the drawing (DEFAULT). In that case, the sequence of prompts and replies is this:

```

Read products information from a file <YES>: <Return>
Products file <DEFAULT>: <Return>
Please wait . . .
Read parts information from a file <YES>: <Return>
Parts file <DEFAULT>: <Return>
Please wait . . .
Material handling equipment file <DEFAULT>: <Return>
Please wait . . .
All/PRoducts/PArts/Matlhand/eXit <X>: <Return>

```

PRODUCTS

PRODUCTS reads an existing Products file or will help you create a new Products file by prompting for the product names, production volumes, and product path colors. Refer to *Appendix D File Formats* for a description of valid names and volumes.

Reading an existing Products file

To read an existing Products file, pick PRODUCTS from the menu or type PR (the capitalized letters in the prompt) and press <Return>.

```
All/PRoducts/PARts/MatIhand/eXit <X>: PR <Return>
Loading . . .
Read products information from a file <YES>: <Return>
```

After you press <Return> to accept the YES default, you're prompted for the file name.

```
Products file <DEFAULT>:
```

Press <Return> to accept the default name or type a Products file name and press <Return>. Once you designate the file name, PRODUCTS reads the file and then returns to the initial prompt.

```
Please wait . . .
All/PRoducts/PARts/MatIhand/eXit <X>:
```

Creating a new Products file

The recommended method for creating data files is the FFEDIT: command. However, INDATA: may be used to create files as shown below. To create a new Products file, pick PRODUCTS from the menu or type PR (the capitalized letters in the prompt) and press <Return>. Then type N and press <Return> to tell PRODUCTS that you want to create a file.

```
All/PRoducts/PARts/MatIhand/eXit <X>: PR <Return>
Loading . . .
Read products information from a file <YES>: N <Return>
```

To create a Products file, PRODUCTS will ask for product names, production volumes, and path colors.

```
Product name <DONE>: PRODUCTNAME <Return>
```

Type the name of your product and press <Return> (the default response, DONE exits the PRODUCTS routine).

```
Production of PRODUCTNAME per (TIME UNIT):
```

PRODUCTS asks for the quantity of the product produced per the current FactoryFLOW time unit. Type the number produced and press <Return>.

Path color for PRODUCTNAME <GREEN>:

The third item in the Products file is the color FactoryFLOW will use for the product's path in the drawing. Color choices are listed on the screen menu. Enter one of the color choices. After you pick a color, PRODUCTS will ask you for the next product name. Enter another product or press <Return> to accept the default response DONE when you're finished entering products.

Product name <DONE>: <Return>
Press RETURN to save products information. <Return>

You must press <Return> to save and continue. When you press <Return>, PRODUCTS will ask you for the name of the Products file you want to save.

Products file <DEFAULT>:

Press <Return> to accept the default name or type a file name and press <Return>. If a Products file with the name you specified already exists, PRODUCTS will ask you whether you want to overwrite it. Type Y to say yes or N to say no, then press <Return>.

Products file FILENAME already exists! Overwrite file (Yes/No):

If you say No, the data you entered will not be saved in a file, but will be the active data for the current FactoryFLOW session until you load a new Products file. After saving the products data (or not saving it, as the case may be), PRODUCTS will end and the original IN DATA: prompt will reappear. (If you originally chose ALL, PARTS will begin immediately.)

Please wait . . .
All/PProducts/PARts/Matlhnd/eXit <X>:

PARTS

PARTS reads an existing Parts file or will help you create a new Parts file by prompting for the required information. Required information includes product components, and process routings (group codes, quantities of parts per product, starting and ending points of parts moves, material handling system names, and quantities of parts moved at one time). If you want to compute workcenter utilizations, PARTS will also ask you for setup times, manufacturing lot sizes, cycle times, and scrap rates. Considering the complexity of the Parts file, you can easily see why it's easier to create a Parts file using FFEDIT's windows than IN DATA's prompts. Refer to *Appendix D File Formats* for a description of valid names and volumes.

Reading an existing Parts file

To read an existing Parts file, pick PARTS from the menu or type PA and press <Return>.

```
All/PRoducts/PARts/Matlhand/eXit <X>: PA <Return>
Loading . . .
Read parts information from a file <YES>: <Return>
```

After you press <Return> to accept the YES default, you're prompted for the file name.

```
Parts file <default>:
```

Press <Return> to accept the default name or type a Parts file name and press <Return>. Once you designate the file name, PARTS reads the file and then returns to the initial IN DATA: prompt.

```
Please wait . . .
All/PRoducts/PARts/Matlhand/eXit <X>:
```

Creating a new Parts file

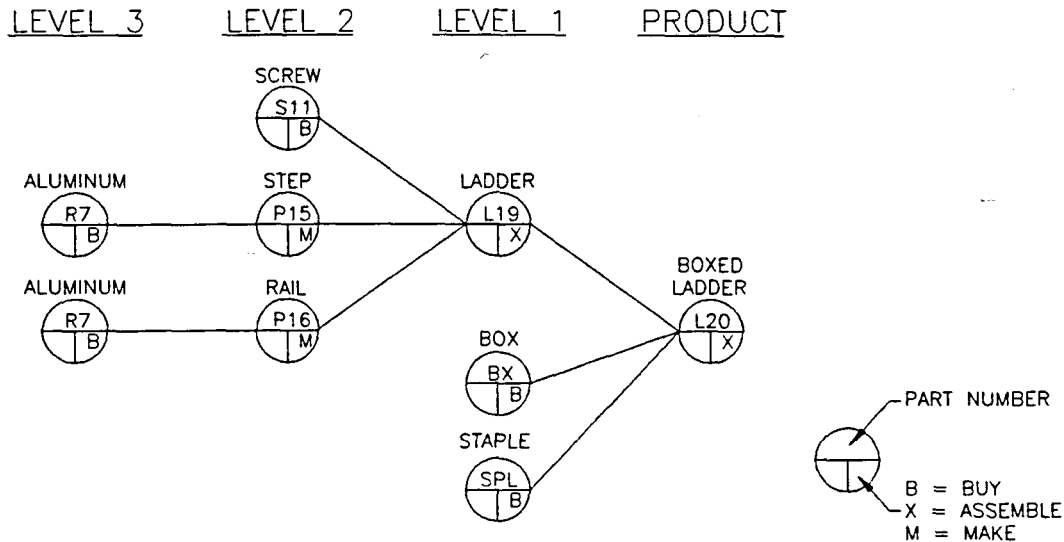
Again, FFEDIT: is the recommended method for creating files. To create a new Parts file for the products listed in your Products file (the Products file must have already been read or created), pick PARTS from the menu or type PA (the capitalized letters in the prompt) and press <Return>. Then type N and press <Return> to tell PARTS that you want to create a file.

```
All/PRoducts/PARts/Matlhand/eXit <X>: PA <Return>
Loading . . .
Read parts information from a file <YES>: N <Return>
```

PARTS will display prompts on the text screen, and take you step by step through creating a Parts file. PARTS uses the concept of a part explosion diagram to organize the prompts. A part explosion diagram is a tree-like structure that starts with the product (on the right in the following figure), then branches out to components and subcomponents until all the parts are included.

PART EXPLOSION DIAGRAM

BOXED LADDER L20



PARTS checks the Products file for the names of the products. PARTS will then ask you for the main components of the first product in the Products file. The following example uses the boxed ladder as the product. PARTS will display the product for which you will enter the components, and then ask you for the first main component.

Part Explosion diagram: BOXEDLADDER
 Component used in BOXEDLADDER <DONE>: LADDER <Return>

Type the name of a first level component (LADDER, BOX, and STAPLE in the diagram above). PARTS will keep prompting for first level components until you accept the default response, DONE. Once you've accepted DONE, PARTS will prompt you for second level components.

Component used in LADDER <DONE>: SCREW <Return>

PARTS continues this process until the part explosion diagrams of all products have been described (that is, until all the parts required for the finished product have been named). Next you're prompted for the process routing data of each part. Refer to *Appendix D File Formats* for information on valid entries.

Process Routing: BOXEDLADDER
 Enter group code for LADDER of BOXEDLADDER <0>: <Return>
 Enter quantity of LADDER per BOXED LADDER <1.0>: <Return>
 Enter workcenter name from which path of LADDER starts: ASSEMBLY
 <Return>
 Enter workcenter name at which path of LADDER ends: PACKING <Return>

Enter material handling system name for LADDER: HANDT <Return>
Enter quantity of LADDER per unit load <1.0>: <Return>

When you've completed entering process routing data, PARTS asks you whether you want to specify setup and cycle times for the part. This information is necessary only if you want FactoryFLOW to compute workcenter utilizations.

Workcenter utilizations desired

If you want to have FactoryFLOW compute workcenter utilizations, type Y and press <Return>.

Do you wish to specify setup and cycle times for LADDER in ASSEMBLY <NO>: Y
<Return>

PARTS will ask you for the setup and cycle time data of each part. Refer to *Appendix D File Formats* for information on valid entries.

Enter setup time for LADDER in ASSEMBLY (min) <0.0>: 40 <Return>
Enter manufacturing lot size of LADDER in ASSEMBLY <1.0>: 500 <Return>
Enter cycle time of LADDER in (min) <0.0>: 1 <Return>
Enter scrap rate of LADDER in ASSEMBLY (%) <0.0>: 2 <Return>

Workcenter utilizations not desired

If you do not want to have FactoryFLOW compute workcenter utilizations, press <Return> to accept the default response, NO.

Do you wish to specify setup and cycle times for LADDER in ASSEMBLY <NO>:
<Return>

Once you have finished entering data for one part, PARTS will ask you for the process routing data of the next part, repeating the process until all parts data is entered.

After you have completed entering the parts data, PARTS prompts you to save the parts information.

Press RETURN to save parts information.

You must press <Return> to continue. After you press <Return>, PARTS asks for the name of the Parts file you want to save.

Parts file <DEFAULT>:

Press <Return> to accept the default name or type a file name and press <Return>. If a Parts file with the name you specified already exists, PARTS will ask you whether you want to overwrite it. Type Y to say yes or N to say no, then press <Return>.

Parts file FILENAME already exists! Overwrite file (Yes/No):

If you say No, the data you entered will not be saved in a file, but will be the active data for the current FactoryFLOW session until you load a new Parts file. After saving the parts data (or not saving it, as the case may be); PARTS will end and the original IN DATA: prompt will reappear. (If you originally chose ALL, MATLHAND will begin immediately.)

Please wait . . .
All/PRoducts/PARts/Matlhand/eXit <X>:

MATLHAND

MATLHAND reads the material handling equipment information from an existing file. There is no IN DATA: routine for creating a Material Handling Equipment file. (As with all the data files, material handling equipment data can be entered using FFEDIT: . CALC: includes a command prompt routine for entering material handling equipment information; the routine is invoked if required material handling equipment data is not present. See Situation 3 on page 130.)

To read an existing Material Handling Equipment file, pick MATLHAND from the menu or type M and press <Return>.

All/PRoducts/PARts/Matlhand/eXit <X>: **M** <Return>

Material Handling Equipment file <DEFAULT>:

Press <Return> to accept the default name or type a Material Handling Equipment file name and press <Return>. Once you designate the file name, MATLHAND reads the file and then returns to the initial IN DATA: prompt.

EXIT

EXIT returns you to the command prompt and takes you back to the FFSETUP menu. To leave IN DATA: and go back to the FFSETUP menu, pick EXIT from the menu or press <Return> to accept the default response, X.

All/PRoducts/PARts/Matlhand/eXit <X>:

FFEDIT:

FACTFLOW

IN DATA:
FFEDIT:
DEFVIEW:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

FFEDIT: is a pop-up windowing program used to create and edit data files and to compute workcenter utilizations. FFEDIT: can also read ASCII files created with another application (such as a spreadsheet or word processor) and save the file in a format usable by FactoryFLOW.

FFEDIT: can be started from within FactoryFLOW or from the system prompt.

From within FactoryFLOW

To start FFEDIT: from within FactoryFLOW, simply pick FFEDIT: from the FFSETUP menu. (The FFEDIT: command also appears on the EDIT menu.)

—>FFEDIT:

FFEDIT: will load and the PRODUCTS FILE window will appear. The file name field will be highlighted and will contain the name of the current drawing as the default Products file name.

From the system prompt

FFEDIT: can load and save files only from the current directory. The FFEDIT: program is in your FACTFLOW directory. (If you named your FactoryFLOW program directory something other than FACTFLOW, substitute that name for FACTFLOW) Before running FFEDIT:, you will need to set the ACAD variable to your FactoryFLOW directory.

```
C:\USER> SET ACAD=C:\FACTFLOW <Return>
```

Since FFEDIT: is in the FACTFLOW directory, you must include the path to that directory when calling FFEDIT: .

```
C:\USER> C:\FACTFLOW\FFEDIT <Return>
```

NOTE: If you have included the FACTFLOW directory in your DOS search path, or copied FFEDIT: to another directory on your path, you will not need to enter the path.

```
C:\USER> FFEDIT <Return>
```

If you wish, you can specify a default Products file by typing a space and the name of the Products file you wish to edit (do not specify any file extensions) before pressing <Return> .

```
C:\USER> C:\FACTFLOW\FFEDIT PRODFILE <Return>
```

-or-

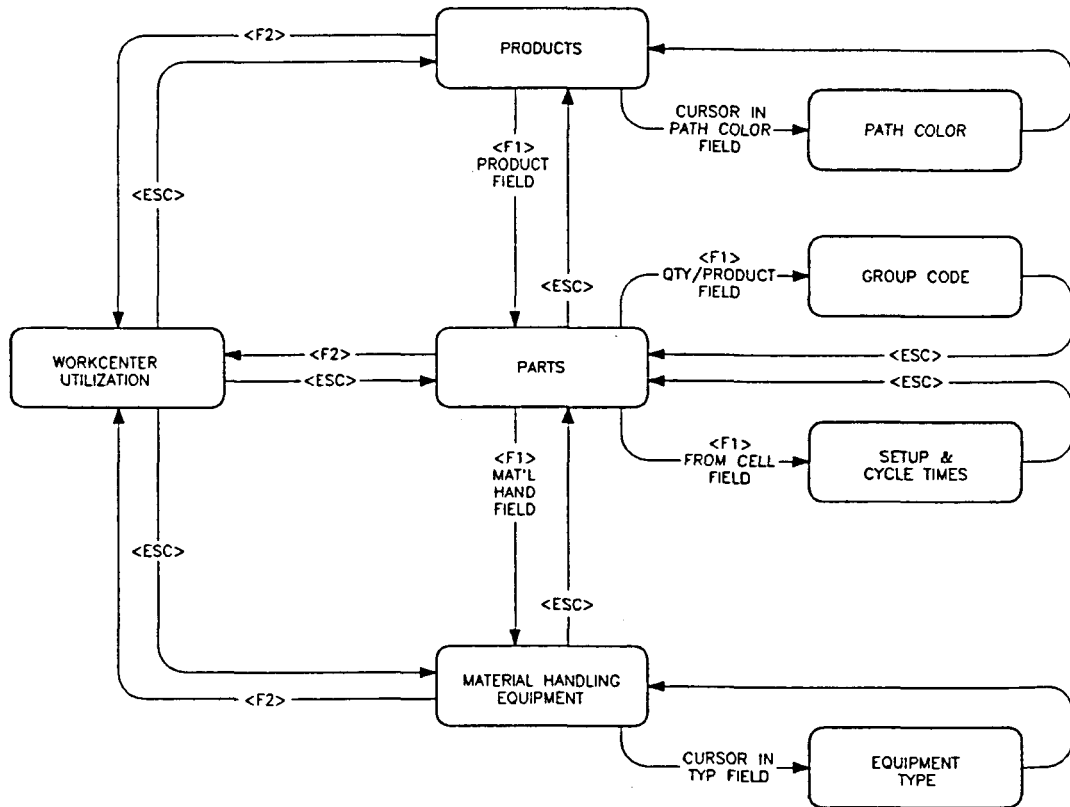
```
C:\USER> FFEDIT PRODFILE <Return>
```

FFEDIT: will load and the PRODUCTS FILE window will appear. The file name field will be highlighted and will be blank if no product file was specified; if a product file was specified, that name will appear in the field.

Moving between FFEDIT: windows

Products, Parts, and Material Handling Equipment file windows are opened consecutively in FFEDIT: . The WORKCENTER UTILIZATIONS FILE window can be reached from any other FFEDIT: window. The following diagram shows the sequence of windows and the keystrokes required to open successive windows. Keys must be pressed when the cursor is on the specified field of the previous window, except when going to the WORKCENTER UTILIZATIONS FILE window.

Except for the PATH COLOR and EQUIPMENT TYPE windows, press <Esc> to go back to the previous window. Pressing <Esc> while in the PRODUCTS window will end FFEDIT: and return you to either FactoryFLOW or the operating system prompt (depending on how you started FFEDIT:).



Entering and Editing Data in FFEDIT:

In FFEDIT: you can edit any field by moving the highlight cursor to the field with your arrow keys. The instructions in the following shaded box describe how to enter and edit data in the fields.

Entering and Editing Data in FFEDIT:

To enter data in a field, simply type the data using the keyboard. Use the arrow keys to move from field to field. To make sure all required data is entered, FFEDIT: will force you to put a value in each successive field when you first enter a line of data. Once the whole line is entered you can use the arrow keys to move to any field on any line.

To start a line over before you finish entering all of the information, press <Esc> and then <Delete> to delete the line. Then, press <Insert> to insert a new line.

To correct an entry before you leave it's field, press <BackSpace> to move back past the error. Then, type the correct entry.

To correct a field entry on a complete line of data, use the arrow keys to move the cursor to the field. Then, type the correct entry.

To delete a line, move your cursor to any field on the line and press <Delete>.

To insert a line, move your cursor to any field on the line before which your line should be inserted and press <Insert>.

Moving the cursor

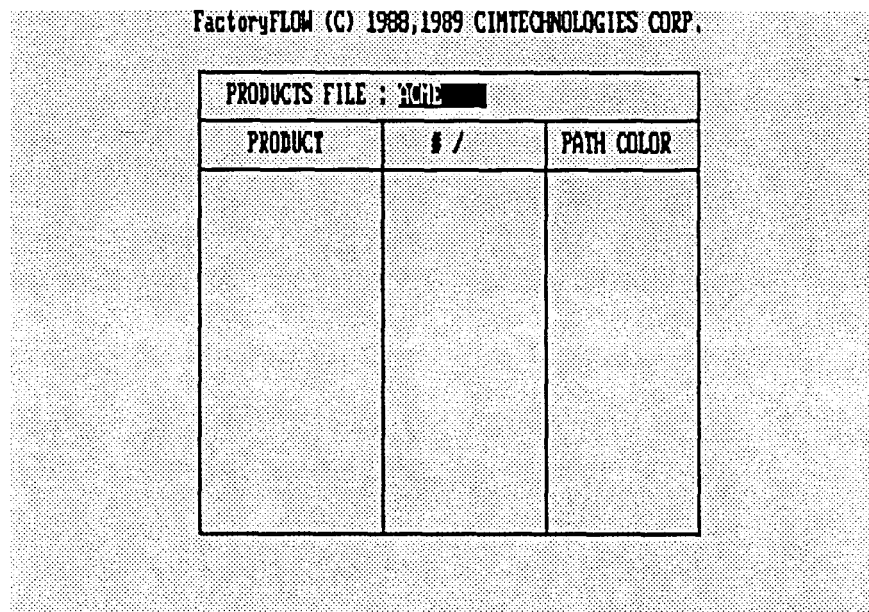
To move between lines and fields, use the special keys as described below.

- <up arrow> Up one line.
- <down arrow> Down one line
- <right arrow> Right one field.
- <left arrow> Left one field.
- <Page Up> One screen up.
- <Page Down> One screen down.
- <Home> To the first line in the file.
- <End> To the last line in the file.

Specific instructions for using FFEDIT:'s PRODUCTS, PARTS, MATERIAL HANDLING EQUIPMENT, and WORKCENTER UTILIZATIONS WINDOWS follow.

PRODUCTS FILE window

The PRODUCTS FILE window appears automatically when FFEDIT: is started. When the PRODUCTS FILE window appears, the PRODUCTS FILE field is highlighted. If you run FFEDIT: from within FactoryFLOW, the current drawing name will be the default file name. If you run FFEDIT: from the operating system prompt and specify a file name, that name will appear. Otherwise the field will be blank.



Loading a Products file

To create or edit a Products file, type the name of the Products file you wish to create or edit and press <Return>. If a default name is in the field, you can simply press <Return> to accept it.

After you press <Return>, FFEDIT: will search for the file in the current directory.

FFEDIT: finds the named Products file

If FFEDIT: finds the file, FFEDIT: reads the file and displays it in the window. The first product name will be highlighted.

FFEDIT: does not find the named Products file

If FFEDIT: does not find the file, a small window pops up and asks whether you wish to create the file.

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PRODUCTS FILE : ACME		
PRODUCT	# /	PATH COLOR
Products file ACME does not exist. Do you wish to create it ? (Y/N) <input type="checkbox"/>		

If you want to create the file, press <Return> to accept the default response, YES. FFEDIT: will create the file and the quantity per time unit (# /) field will be highlighted. Type the time unit you want to use for your input data (YEAR, MONTH, WEEK, DAY, or SHIFT) and press <Return>. The product name field will then be highlighted. NOTE: Once the time unit is entered, FFEDIT: will not allow you to change it.

If you do not want to create the file, type N and press <Return>. FFEDIT: will return the cursor to the file name field.

Entering or editing products data

General instructions on how to enter or edit data are in the box on page 107. Descriptions of valid entries are in *Appendix D File Formats*.

When you move to the path color field in the PRODUCTS FILE window, a color choice window pops up. Use <up arrow> and <down arrow> to move the check mark to the color you want, then press <Return> or <left arrow> to choose the color.

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PRODUCTS FILE : ACME		
PRODUCT	# / YEAR	PATH COLOR
LADDER	250000	Path Color for LADDER <input type="checkbox"/> Red <input type="checkbox"/> Yellow <input type="checkbox"/> Green <input type="checkbox"/> Cyan <input type="checkbox"/> Blue <input checked="" type="checkbox"/> Magenta <input type="checkbox"/> White

PARTS FILE window

The PARTS FILE window is reached from the PRODUCTS FILE window. To open the PARTS FILE window to create or edit parts data for a particular product, move the highlight to the product name and press <F1>. The PARTS FILE window pops-up with the Parts file name field highlighted. Although a single Parts file can contain parts data for many products, FFEDIT: only displays the parts data for one product at a time.

Loading a Parts file

To create or edit a Parts file, type the name of the Parts file you wish to create or edit and press <Return>. If a default name is in the field, you can simply press <Return> to accept it.

After you press <Return>, FFEDIT: will search for the file in the current directory.

FFEDIT: finds the named Parts file

If FFEDIT: finds the file, FFEDIT: reads the file and displays it in the window, and the first part name will be highlighted.

FFEDIT: does not find the named Parts file

If FFEDIT: does not find the file, a small window pops up and asks whether you wish to create the file.

If you want to create the file, press <Return> to accept the default response, YES. FFEDIT: will create the file and the highlight will jump to the part name field.

If you do not want to create the file, type N and press <Return>. FFEDIT: will return the cursor to the file name field.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
 PRODUCT : LADDER

PART	QTY / PRODUCT	FROM CELL	TO CELL	MAT'L HAND.	UNIT LOAD

Entering or editing parts data

The Parts file contains the parts information for all of the products in the associated Products file. However, even though the file actually contains the information for all the products, the PARTS FILE window will display only the parts information for the selected product. To display the parts data for another product without exiting the PARTS FILE window, press <F3> to move the cursor to the product name field, then type the product name and press <Return>.

General instructions on how to enter or edit data are in the box on page 107. Descriptions of valid entries are in *Appendix D File Formats*.

Group code and Setup and cycle times windows

The Parts file includes some optional data fields: group code and setup and cycle times. The group code can be used to identify certain categories of moves, parts, or products for summarization and reporting purposes. The setup and cycle times are used to calculate workcenter utilizations. The optional fields are displayed in two sub-windows of the PARTS FILE window: the group code window and the setup and cycle times window.

To move to the group code window, position your cursor in the quantity/product column on any line and press <F1>.

To move to the setup and cycle times window, position your cursor in the from workcenter column on any line and press <F1>.

MATERIAL HANDLING EQUIPMENT FILE window

The MATERIAL HANDLING EQUIPMENT FILE window is reached from the PARTS FILE window. To open the MATERIAL HANDLING EQUIPMENT FILE window, move the highlight to the material handling device column on any line and press <F1>.

Next, a small window will pop up and ask whether you want to save the parts information. Depending on your response, FFEDIT: will save the parts information or not and then will open the MATERIAL HANDLING EQUIPMENT FILE window. The file name field will be highlighted.

Loading a Material Handling Equipment file

To create or edit a Material Handling Equipment file, type the name of the file you wish to create or edit and press <Return>. If a default name is in the field, you can simply press <Return> to accept it.

After you press <Return>, FFEDIT: will search for the file in the current directory.

FFEDIT: finds the named Material Handling Equipment file

If FFEDIT: finds the file, FFEDIT: reads the file and displays it in the window, and the first material handling system name field will be highlighted.

FFEDIT: does not find the named Material Handling Equipment file

If FFEDIT: does not find the file, a small window pops up and asks whether you wish to create the file.

If you want to create the file, press <Return> to accept the default response, YES. FFEDIT: will create the file and the highlight will jump to the investment cost per time unit (INVEST. COST /) field. Type the time unit you want to use for your input data (YEAR, MONTH, WEEK, DAY, or SHIFT) and press <Return>. The time unit will be entered in both the investment cost field heading and the available minutes field heading and the first material handling system name field will be highlighted.

If you do not want to create the file, type N and press <Return>. FFEDIT: will return the highlight to the file name field.

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PRODUCTS FILE : LADDER1

PARTS FILE : LADDER1
PRODUCT : LADDER

MATERIAL HANDLING EQUIPMENT FILE : LADDER1

MATERIAL HANDLING	TYP	QTY	INVEST. COST /	HOURLY FP & M COST	HOURLY LABOR COST	AVAIL. MINUTES /	LOAD & UNLOAD (MIN)	AVERAGE SPEED (FT/MIN)	EFFECT (%)

Entering or editing material handling equipment data

General instructions on how to enter or edit data are in the box on page 107. Descriptions of valid entries are in *Appendix D File Formats*.

When you move to the TYP field in the MATERIAL HANDLING EQUIPMENT FILE window, a material handling type window pops up. Use the arrow keys to move the check mark to the material handling equipment type you want and press <right arrow> to move to the next field.

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PRODUCTS FILE : ACME

PARTS FILE : ACME
PRODUCT : LADDER

MATERIAL HANDLING EQUIPMENT FILE : ACM

MATERIAL HANDLING	TYP	QTY	INVEST. COST /YEAR	HOURLY FP & M COST					EFFECT (%)
HANDT	5	1.00	3500	1.00					.00

Material Handling Type for HANDT

- 1. HAND TRUCK
- 2. M.PALLET TRUCK
- 3. P.PALLET TRUCK
- 4. TRACTOR TRAILER
- 5. LIFT TRUCK
- 6. AGUS
- 7. CONVEYOR
- 8. SPECIAL

WORKCENTER UTILIZATIONS FILE window

The WORKCENTER UTILIZATIONS FILE window is used to calculate the utilization of workcenters. FFEDIT: calculates the workcenter utilizations by taking into account production volumes (from the Products file), setup times, cycle times, lot sizes, scrap rates (from the Parts file), and numbers of servers and their available minutes per time unit (from the Workcenter Utilizations file). The WORKCENTER UTILIZATIONS FILE window can be accessed from any of the products, parts, and material handling equipment windows.

To pop-up the WORKCENTER UTILIZATIONS FILE window from anywhere in -- FFEDIT: , press <F2>. In some cases FFEDIT: will ask whether you want to save the information from the current window before moving to the WORKCENTER UTILIZATIONS FILE window; if you have made changes you want to keep, you should type Y and press <Return>. If you don't want to save, type N and press <Return>. After the current file is saved (or not saved), the WORKCENTER UTILIZATIONS FILE window will pop up and Products file name field will be highlighted.

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PRODUCTS FILE : LADDER1						
PARTS FILE :	PRODUCTS FILE	:	LADDER1			
PRODUCT : LAD	PARTS FILE	:				
	WC UTILIZATIONS FILE	:				
PART	WORK CENTER	# OF SERV	AVAIL MIN /	BUSY MIN /	UTIL. (%)	UNIT LOAD
RAIL						250.00
RAIL						250.00
RAIL						400.00
RAIL						400.00
SRAIL						30.00
RTOPCAP						400.00
LTOPCAP						400.00
TOPCAP						400.00

Loading workcenter utilizations files

FFEDIT: needs information from three files to compute workcenter utilizations: a Products file, its associated Parts file, and a Workcenter Utilizations file.

Products and Parts files

The Products and Parts files must already exist in the current directory. When the WORKCENTER UTILIZATIONS FILE window pops up, the highlight is in the Products file name field. Type the name of the desired Products file and press <Return>. The highlight will jump to the Parts file name field. Type the name of the desired Parts file and press <Return>. The highlight will then jump to the WC UTILIZATIONS FILE field. If default file names are displayed, you may accept them by pressing <Return>.

Workcenter Utilizations file

To create or edit a Workcenter Utilizations file, type the desired file name in the WC UTILIZATIONS FILE field or accept the default by pressing <Return>. FFEDIT: will search for the named file in the current directory.

If FFEDIT: finds the file, FFEDIT: reads the file then calculates utilizations and displays them in the window.

If FFEDIT: does not find the file, FFEDIT: creates the file and inserts a default value of one for the number of servers. For available minutes, FFEDIT: uses the time unit in the Products file and inserts a default value for the number of available minutes based on this time unit. FFEDIT: then calculates utilizations and displays them in the window.

Entering or editing workcenter utilizations data

Only two fields in the WORKCENTER UTILIZATIONS FILE window can be edited: the number of servers (# OF SERV) and the available minutes per time unit. (AVAIL MIN/TIMEUNIT). WORKCENTER names come from the Parts file, and busy minutes per time unit (BUSY MIN/TIMEUNIT) and percentage of workcenter utilization are the results of calculations.

General instructions on how to enter or edit data are in the box on page 107. Descriptions of valid entries are in *Appendix D File Formats*.

One thing to note about the values in the fields: AVAIL MIN/TIMEUNIT expresses the available minutes per server, while the BUSY MIN/TIMEUNIT expresses the total busy minutes for all servers in a workcenter.

Generating a Workcenter Utilizations Report

When you press <Esc> to leave the WORKCENTER UTILIZATIONS FILE window, FFEDIT: gives you the option of generating a Workcenters Utilizations Report.

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PRODUCTS FILE : SAMPLE				
PRODUCTS FILE : SAMPLE				
PARTS FILE : SAMPLE				
WC UTILIZATIONS FILE : SAMPLE				
Do you want a workcenters utilizations report ? (Y/N) Y				
ROBOT	2.00	115200	169697	73.65
LATHE	2.00	115200	197917	85.90

If you want a Workcenter Utilizations Report, press <Return> to accept the YES default. FFEDIT: will then ask for a report file name to save the report in (the report will be saved in an ASCII text file with a .UTR extension). Type the name of the file and press <Return>. FFEDIT: will next ask for information to include in a report header. The header includes company and project names and the date and time. Once you've responded to the prompts, FFEDIT: will save the report file and the Workcenter Utilizations file and take you back to the previous window.

If you don't want a Workcenter Utilizations Report, type N and press <Return>, and FFEDIT: will save the Workcenter Utilizations file and take you back to the previous window.

Displaying and printing a Workcenter Utilization Report

See the WC REP: command on the LIST and PRINT menus for information on how to display and print the Workcenters Utilizations Report. Following is a sample Workcenters Utilizations Report.

COMPANY NAME: ACME
 PROJECT NAME: LADDERS
 DATE: 10/16/89
 TIME: 08:49

WORKCENTERS UTILIZATIONS

Workcenter name: ASSEMBLY
 Available minutes / server / YEAR : 115200
 Busy minues / workcenter / YEAR: 1336001
 Number of servers: 15
 Utilization (%): 77.31

Workcenter name: MILL
 Available minutes / server / YEAR : 115200
 Busy minues / workcenter / YEAR: 982143
 Number of servers: 11
 Utilization (%): 77.501

Workcenter name: BROACH
 Available minutes / server / YEAR : 115200
 Busy minues / workcenter / YEAR: 743162
 Number of servers: 8
 Utilization (%): 80.64

DEFVIEW:

FACTFLOW
 * * * * *
 IN DATA:
 FFEDIT:
 DEFVIEW:
 ZOOM V:
 ZOOM W:
 ZOOM P:
 PAN:
 _ LAST _

DEFVIEW: defines a view in your drawing. Once you've defined a view, you can zoom to it at any time using ZOOM V: . To define a view, pick DEFVIEW: from the FFSETUP menu.

-->DEFVIEW:

DEFVIEW: will load and ask you to name the view. Type a name and press <Return>.

View name: VIEWNAME <Return>

If the view name you specify has already been defined, DEFVIEW: will ask whether you want to redefine it. If you say yes, or if it is a new view name, DEFVIEW: will ask you to place a window around the area you want defined as a view.

Place a window around VIEWNAME:

After you're through placing the window, DEFVIEW: ends and returns you to the command prompt.

ZOOM V:

FACTFLOW

IN DATA:
FFEDIT:
DEFVIEW:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

ZOOM V: zooms to a defined view in the drawing. **ZOOM V:** will also allow you to define a view at the same time you zoom to it. To zoom to a defined view or to define a view and zoom to it, pick **ZOOM V:** from the menu.

-->**ZOOM V:**

ZOOM V: asks for the view name. Type the name and press <Return>.

View name: **VIEWNAME** <Return>

If the named view has been defined, **ZOOM V:** zooms to it. If the named view has not been defined, **ZOOM V:** will ask you whether you would like to define it. If you say **NO**, **ZOOM V:** ends. If you say **YES**, **ZOOM V:** asks you to place a window around the view you want to define, then saves your definition and zooms to the view.

ZOOM W:, ZOOM P:, PAN:

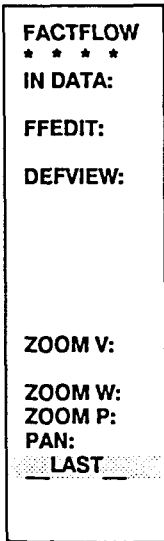
FACTFLOW

IN DATA:
FFEDIT:
DEFVIEW:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

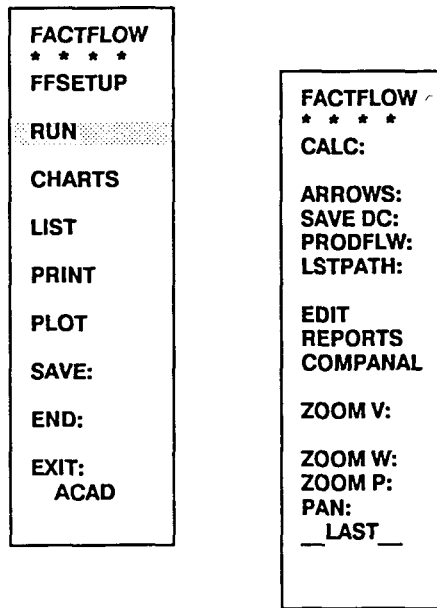
ZOOM W:, **ZOOM P:**, and **PAN:** are available in most FactoryFLOW menus. They perform the AutoCAD **ZOOM WINDOW**, **ZOOM PREVIOUS**, and **PAN** commands just as in AutoCAD. These commands are transparent, that is, they can be called while executing another command. For more information on **ZOOM** and **PAN**, see the AutoCAD Reference Manual.

LAST

Picking LAST from any FactoryFLOW menu returns you to the previous menu.



RUN Menu



The RUN menu is the heart of FactoryFLOW. Once your Products and Parts files are loaded, options on the RUN menu allow you to analyze your plant layout and material handling system, create alternative designs, and generate reports and diagrams.

CALC: calculates distances and costs using information from the drawing and the data files, then scales the product flow lines to generate a Product Flow Diagram.

ARROWS: puts arrowheads on the ends of product flow lines in the Product Flow Diagram to show direction of travel.

SAVE DC: saves the distance and cost data of alternative layouts to a file.

PRODFW: displays selected product flow lines in the Product Flow Diagram.

LSTPATH: lists the distance and cost data associated with a path on the Product Flow Diagram.

EDIT, REPORTS, and COMPANAL display their respective menus.

CALC:

FACTFLOW

* * * *

CALC:ARROWS:
SAVE DC:
PRODFW:
LSTPATH:EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
LAST

CALC: calculates material handling distances and costs. CALC: gives you several ways to specify the material flow paths which it requires to calculate distances and costs. If you specify Actual paths, CALC: generates scaled product flow lines to create a Product Flow Diagram. CALC: also includes routines for entering product information and material handling equipment information.

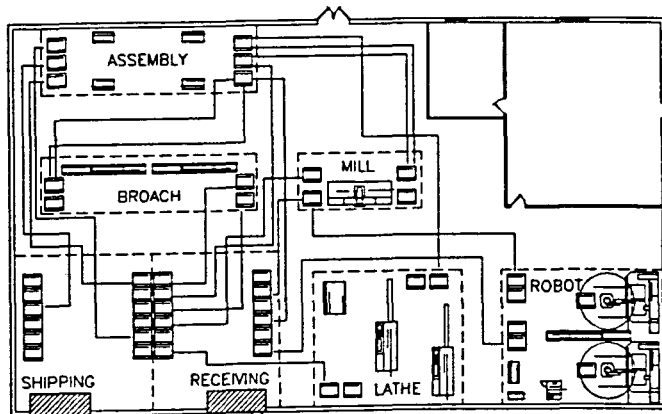
CALC: reports the total travelled distances and costs in the command prompt area. If you have already run CALC: in the current session, CALC: will also report the previous distances and the percent improvement. In this case, you'll have to view the text screen to see the whole report, since only part of the report will be visible in the command prompt area.

Example: Total Distances and Costs Report

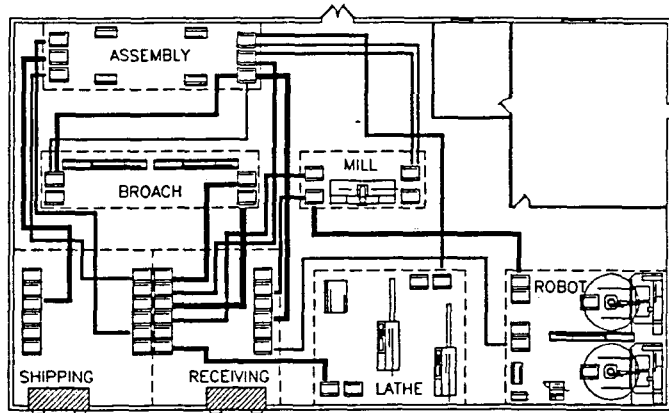
Percent Travelled Distance Improvement:	34
Previous Total Travelled Distance (Ft) / time unit:	11,559,466
New Total Travelled Distance (Ft) / time unit:	7,602,778
Percent Material Handling Cost Improvement:	12
Previous Total Material Handling Cost / time unit:	\$46,609
New Total Material Handling Cost / time unit:	\$41,086

About the Product Flow Diagram

A Product Flow Diagram is a commonly used tool in analyzing plant layout. FactoryFLOW's Product Flow Diagrams highlight potential areas of layout improvement (cost savings) with scaled lines which follow Actual flow paths. The lines are scaled based on the cost of performing that move with the specified material handling device. The cost per foot of a move determines the thickness of a flow line in the diagram. Thicker lines (higher cost per foot moves) represent the areas of greatest potential cost savings.



Actual material handling paths before CALC: .

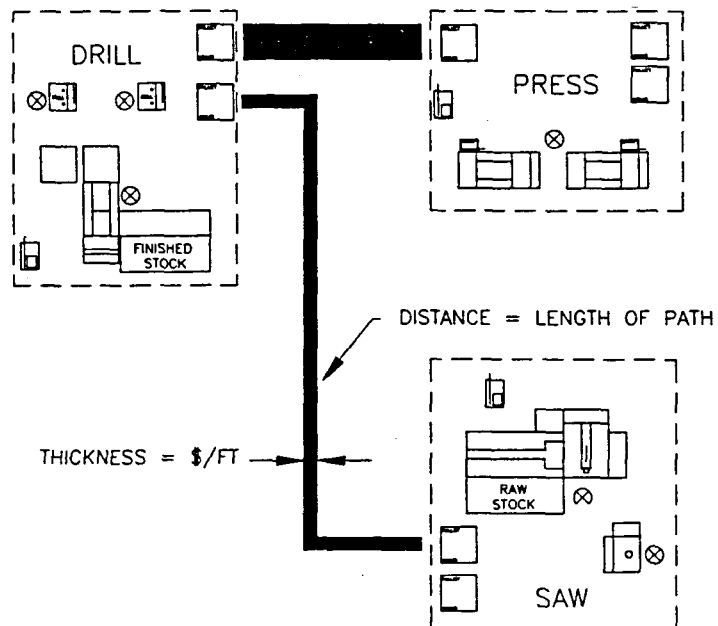


Actual material handling paths after CALC: has scaled them, creating the Product Flow Diagram.

In order to create a Product Flow Diagram, CALC: will prompt you for a path thickness scale. The path thickness scale determines the appearance of the Product Flow Diagram, but does not affect the calculations in any way. CALC: determines the total material handling cost for each move, then divides that total cost by the path length to determine cost per foot.

The thickness scale you provide merely tells FactoryFLOW how thick to draw the lines for a given cost per foot of the move. The lower the scale value, the thicker all lines will appear relative to your AutoCAD plant drawing. Lower scale values (thicker lines) also make it easier to see the contrast between path costs. A scale of 100 Dollars/Foot/Inch means a \$1,200 per foot move will appear in your drawing as a 12-inch thick product flow line.

The Product Flow Diagram shows you at a glance the relative cost per foot of various moves. The total area of the path (length x thickness) represents the total move cost. For example, in the following drawing the path from DRILL to PRESS is thick, but very short; the path from DRILL to SAW is thin, but quite long. Thus the total cost of material handling along the two paths may actually be close to equal, since the areas are similar. However, a small change in the distance between DRILL and SAW would not affect the total cost much, but a small change in the distance between DRILL and PRESS would affect the total cost significantly.

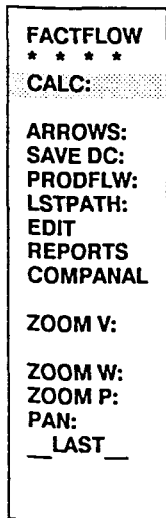


TOTAL MOVE COST = THICKNESS X DISTANCE

How to use CALC:

CALC: behaves differently in different situations. CALC: is described on the following pages according to three situations:

1. **All Data Loaded and All Paths Defined.** You've loaded your drawing and Products, Parts, and Material Handling Equipment files. All required paths were defined in a previous CALC:. You want to recalculate material handling distances and costs and generate a Product Flow Diagram. (This is the typical situation when you're modifying a layout you've analyzed before.)
2. **All Data Loaded, Some or All Paths Not Defined.** You've loaded your data but some or all of your paths are not defined. (This is the situation the first time you run a FactoryFLOW analysis on a plant drawing.)
3. **Parts Data Loaded, Products or Material Handling Equipment not loaded.** You've loaded the Parts file but not all products or material handling equipment data is defined. Paths may or may not be defined. (This situation is unusual, but could occur if you decide to add a material handling system or simply didn't bother to load the Products and Material Handling Equipment files.)

Situation 1: Data Loaded and Paths Defined

In this situation you have loaded Products, Parts, and Material Handling Equipment files and have defined paths for all required moves in a previous CALC:. Pick CALC: to calculate material handling distances and costs and generate a Product Flow Diagram.

--> CALC:

CALC: searches for data and paths.

Loading . . .

Travel-distance for part: PART1 of product: PROD1

Travel-distance for part: PART2 of product: PROD1

CALC: checks for unused paths and for not utilized or overutilized material handling systems.

Unused Paths

If there is an unused path, CALC: asks whether you want to erase it.

Path for product: PRODUCT from FROMWORKCENTER to TOWORKCENTER is not needed!

Erase path <YES>:

If you want to erase the path, press <Return> to accept the default response, YES. If you do not want to erase the path, type N and press <Return>.

CALC: will erase (or not erase) the path.

Material handling system utilization

If a material handling system is not utilized, CALC: warns you.

Material handling MHSYSNAME is not utilized!
Press RETURN to continue. <Return>

You must press <Return> to continue.

CALC: will also check for overutilized equipment. If there is equipment with a utilization of 100% or more, CALC: warns you and asks whether you want to increase the number of servers in the system.

Material handling MHSYSNAME is over 100% utilized!
Increase number of equipment to decrease utilization <YES>:

If you do not want to increase the number of servers, type N and press <Return>. If you do want to increase the number of servers, press <Return> to accept the default response, YES. When you respond YES, CALC: tells you the minimum number of servers required to bring utilization below 100% and asks you to enter a new quantity.

Quantity of material handling MHSYSNAME equipment should be larger than
QUANTITY
Enter new quantity of MHSYSNAME <DEFAULT>:

Type a quantity and press <Return>, or simply press <Return> to accept the default response. CALC: then requires you to press <Return> to save the material handling equipment information, and asks for the file name to save to.

Press RETURN to save material handling equipment information. <Return>
Material handling equipment file <DEFAULT>:

Type a name for the file and press <Return>, or simply press <Return> to accept the default file name.

Path thickness scale and distance/cost reports

After calculating the distance and cost of all moves, CALC: prompts you for the path thickness scale. (If you have only Rectilinear or Euclidian paths, the path thickness scale prompt will not appear.)

Path thickness scale (Dollars/Foot/Inch) <DEFAULT>:

Enter a thickness scale factor and press <Return> or press <Return> to accept the default.

Once all computations are complete and CALC: has checked paths and material handling system utilizations, CALC: scales product flow lines on the drawing to create a Product Flow Diagram and reports the distances and costs.

Situation 2: All Data Loaded, Some or All Paths Not Defined

FACTFLOW

* * * *

CALC: _____

 ARROWS:
 SAVE DC:
 PRODFLOW:
 LSTPATH:

 EDIT
 REPORTS
 COMPANAL

ZOOM V:

 ZOOM W:
 ZOOM P:
 PAN:
 _ LAST _

In this situation you have loaded Products, Parts, and Material Handling Equipment files, but some or all required paths are not defined. Pick CALC: to define material handling paths, calculate material handling distances and costs, and generate the scaled product flow lines of a Product Flow Diagram.

→ CALC:

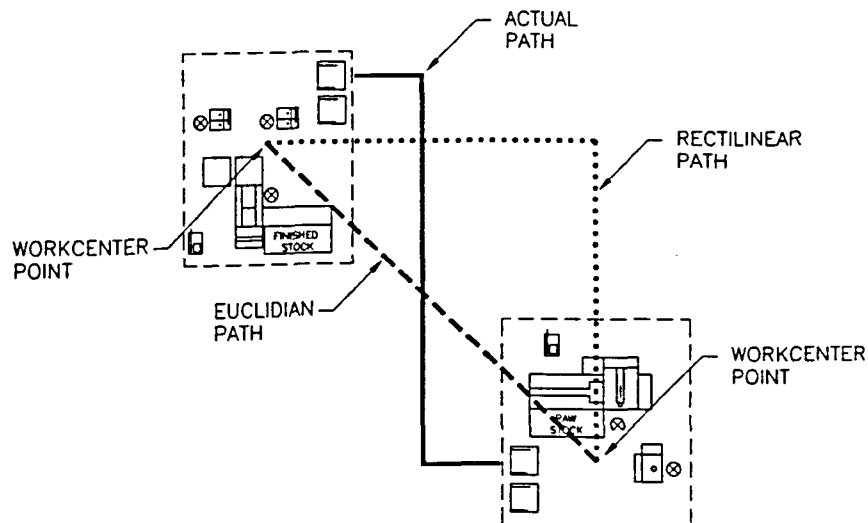
CALC: searches for data and paths and computes travel distances for those moves whose material handling paths are defined. When CALC: encounters a material move whose path is not defined, it asks you to specify a path definition.

FactoryFLOW allows for five types of material handling path definitions:

- Actual path
- Path Length
- Null path
- Euclidian
- Rectilinear

You specify Actual paths by drawing them on the plant drawing. They are the only ones that allow the generation of a Product Flow Diagram. The remaining four types of definitions are specified by responses entered at the keyboard. When null paths are specified, material handling along the null path is not included in the analysis.

Examples of Actual, Euclidian, and Rectilinear paths are shown in the following illustration. NOTE: Only Actual paths are displayed on the drawing; Rectilinear and Euclidian paths are stored in the paths file but are not displayed.



Specifying path definitions

CALC: first checks for existing Actual paths for other products moved between the same pair of workcenters. NOTE: You specify a path between two given workcenters only once per direction per product, even though there may be several parts for a product that travel between the two workcenters.

Existing Actual path between workcenters

If CALC: finds one or more Actual paths, you have the option of copying the path definition.

Define product: PRODUCTNAME path from FROMWORKCENTER to TOWORKCENTER to be identical to another product path <NO>:

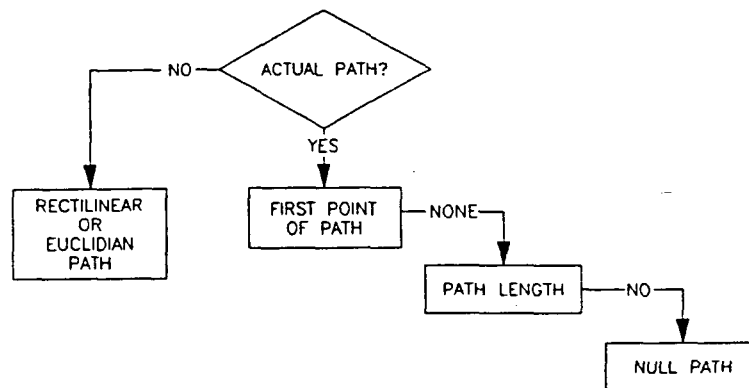
If you want to copy a material handling path definition, choose YES. CALC: will name the products which have defined Actual paths and ask you to pick one of them by typing the product name. If there is only one product with the same path, CALC: will name the product and tell you to press <Return> to continue. CALC: will then begin the routine again with the next required path definition.

If you do not want to copy a material handling path definition, choose NO and continue as if there were no existing path between workcenters.

No existing Actual path between workcenters.

If there are no existing Actual paths between the required workcenters, or if you did not want to copy a material handling path, CALC: will ask how you want to define paths.

The following chart shows the sequence of the path definition prompts and responses.



Below are descriptions of how to specify each type of path. When you choose to enter an Actual, Rectilinear, or Euclidian path, CALC: will assume you want to specify all remaining undefined paths with the same type of definition.

Once you have specified a path, you can leave CALC: and use EDTPATH: to edit the definition. You can also use DELPATH: to delete the path.

Specifying Actual material handling paths

If CALC: does not find a required material handling path and no other products have an Actual path defined between the required workcenters, CALC: asks how you want to enter paths.

Enter actual material handling paths <YES> :

To specify an Actual path definition, press <Return> to accept the default response, YES. CALC: will tell you which product path you need to specify and ask you to enter the first point of the path.

Enter product: PRODUCTNAME path from FROMWORKCENTER to
TOWORKCENTER:
Enter first point of path [Return=None]:

To draw the path, pick a starting point in the from workcenter. CALC: then asks you for the next point.

Enter next point of path [Return=Done]:

Continue picking a series of points ending at the drop-off point in the to workcenter. (NOTE: You need to draw paths for conveyors as well as for the mobile equipment. You can draw the path right on top of a conveyor pictured in your drawing or along the side.) Accuracy is important, since the path determines the distance travelled. Use aisles and other landmarks in your drawing to accurately draw the paths. When you have finished drawing the path, press <Return> to complete the path definition. CALC: continues to prompt for the paths until all the paths have been entered. CALC: will assume that you want to enter Actual paths for all remaining undefined paths.

When all paths have been specified, CALC: computes distances and costs. CALC: then continues with the path thickness scale prompt as described in Situation 1, page 124.

Specifying path length

If CALC: does not find a required material handling path and no other products have a path defined between the required workcenters CALC: asks how you want to enter paths. To specify a path length directly, press <Return> to accept the first two default responses, YES and None.

Enter actual material handling paths <YES>: <Return>
Enter product: PRODUCTNAME path from FROMWORKCENTER to
TOWORKCENTER:
Enter first point of path [Return=None]: <Return>

CALC: will then ask whether you want to enter a path length.

Enter path length <YES>: <Return>

Press <Return> to accept the default response, YES. CALC: will then ask you for the length.

Enter path length (Inch) <0.0>:

Enter the path length by typing the length in inches (or feet and inches) or by picking two points on the drawing (FactoryFLOW will calculate the distance between the two points and enter that length).

CALC: continues to prompt for the paths until all the paths have been specified. CALC: will assume that you want to continue to specify Actual paths for all remaining undefined paths.

When all paths have been specified, CALC: computes distances and costs. CALC: then continues with the path thickness scale prompt as described in Situation 1, page 124.

Specifying a null path

If CALC: does not find a required material handling path and no other products have an Actual path defined between the required workcenters, CALC: asks how you want to enter paths. To specify a null path definition, press <Return> to accept the first two default responses, YES and None.

Enter actual material handling paths <YES>: <Return>
Enter product: PRODUCTNAME path from FROMWORKCENTER to
TOWORKCENTER:
Enter first point of path [Return=None]: <Return>

CALC: will then ask whether you want to enter a path length.

Enter path length <YES>: N <Return>

To enter a null path, type N and press <Return>. CALC: will then ignore the current product's Parts file entries with the specified path and moves along the path will not be included in the analysis. CALC: will display the message:

No material handling activity exists for product: PRODUCTNAME from
FROMWORKCENTER workcenter to TOWORKCENTER workcenter.
Press RETURN to continue.

CALC: continues to prompt for the paths until all the paths have been entered. CALC: will assume that you want to continue to enter Actual paths for all remaining undefined paths.

When all paths have been specified, CALC: computes distances and costs. CALC: then continues with the path thickness scale prompt as described in Situation 1, page 124.

Specifying Rectilinear or Euclidian Paths

If CALC: does not find a required material handling path and no other products have a path defined between the required workcenters, CALC: asks how you want to enter paths.

Enter actual material handling paths <YES>:

If you want to enter Rectilinear or Euclidian paths, type N and press <Return>. CALC: then prompts you to choose Rectilinear or Euclidian.

Rectilinear or Euclidian (R/E) <R>:

Enter R if you want to use Rectilinear paths; enter E if you want to use Euclidian paths. CALC: will compute distances between workcenters based on the type of path you choose. CALC: will not draw the Rectilinear or Euclidian path on the drawing. If you have already defined the workcenter points, you're asked whether you want to redefine them.

Redefine workcenter points <NO>:

If you choose YES or if you have not defined the workcenter points, CALC: prompts you to pick a workcenter point.

Pick workcenter point in WORKCENTER:

A workcenter point is an arbitrary point you specify which FactoryFLOW uses as the endpoint of Rectilinear or Euclidian paths, and also to generate Composite Flow Diagrams.

CALC: will assume that you want to enter Rectilinear or Euclidian paths for the remaining undefined paths. CALC: continues to prompt for workcenter points until all required workcenter points have been entered.

When all paths have been specified, CALC: computes distances and costs. CALC: then continues with the path thickness scale prompt as described in Situation 1, page 124.

Situation 3: Data Loaded Except for Products or Material Handling Equipment

```

FACTFLOW
*****
CALC:
ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_

```

In this situation you've loaded the Parts file but not all products or material handling equipment referenced in the Parts file are defined. Paths may or may not be defined. Product information and material handling equipment is most easily defined in FFEDIT; but CALC: does include products and material handling equipment data entry routines. Pick CALC: to define products and material handling equipment information (and material handling paths if necessary), calculate material handling distances and costs, and generate scaled product flow lines.

--> CALC: _

CALC: starts by computing travel distances, if at least some material handling equipment has been defined. (If no material handling equipment has been defined, CALC: immediately displays prompts on the text screen as described below prompting for material handling equipment information.)

```

Loading . . .
Travel-distance for part: PART1 of product: PROD1
Travel-distance for part: PART2 of product: PROD1
      .
      .
      .
Travel-distance for part: PART5 of product: PROD3

```

Defining material handling equipment

If a material handling system has not been defined, CALC: displays the name of the material handling system, and begins prompting for material handling equipment information. (See *Appendix D File Formats* for descriptions of valid entries.)

Material handling name: MHSYSNAME

Material handling equipment:

1. Hand truck
2. Manual pallet truck
3. Powered pallet truck
4. Fork-lift truck
5. Tractor-trailer system
6. Automated guided vehicle system
7. Conveyor
8. None of the above

Enter choice <4>:

Enter the number corresponding to the type of material handling device. CALC: next asks for the quantity of that material handling device used to move the parts you have loaded for analysis. (Some of the following prompts do not apply to a conveyor and will not appear when a conveyor is being defined.)

Enter quantity <1.00>:

The quantity is the number of identical pieces of equipment per system (for example, the number of fork-lift trucks in a system). If a material handling device is shared with another part of production not included in the analysis, you can enter a decimal quantity such as .50. CALC: next asks for investment cost.

Enter investment cost per equipment per TIMEUNIT <DEFAULT>:

Investment cost represents the fixed cost, and is the rental cost or the depreciation per piece of material handling equipment per time unit. If your labor is a fixed cost (that is, if your equipment operators are dedicated to the material handling equipment), then include your labor cost here.

Next are the hourly costs (fuel, power, maintenance, and labor), which represent the variable costs.

Enter hourly fuel, power, and maintenance cost per equipment <DEFAULT>:

Enter the hourly fuel, power, and maintenance cost for one piece of material handling equipment.

Enter hourly labor cost per equipment <DEFAULT>:

Don't forget to include fringe benefits in the labor rate.

The next prompt asks how many minutes each piece of equipment is available for use in a time unit.

Enter available minutes per equipment per TIMEUNIT <DEFAULT>:

Enter the number of available minutes. For example, if a device was available one eight-hour shift per day, and your time unit was SHIFT, you would enter 480. Next CALC: asks for the load and unload time.

Enter Load + Unload time (min) <DEFAULT>:

CALC: adds the load and unload time to every move using the material handling system. The load AND unload time need to be added together and then entered. Next you're prompted for the average material handling equipment speed.

Enter average speed (ft/min) <DEFAULT>:

Enter the average travel speed of the material handling device. The average speed should account for accelerating/decelerating and for turning. Finally, CALC: asks for the material handling system effectiveness. -

Enter material handling effectiveness (%) <DEFAULT>:

Enter the effectiveness ratio. See the glossary or *Appendix D File Formats* for an explanation of material handling effectiveness.

If there are more material handling systems that need to be defined, CALC: begins the material handling system definition prompts again. When all the information has been entered, CALC: prompts you to save the Material Handling Equipment file.

Press RETURN to save material handling equipment information.

You must press <Return> to continue. CALC: will ask for the name of the file you want to save the information in.

Material handling equipment file <DEFAULT>:

If a file with that name already exists, CALC: warns you and asks whether you want to overwrite the file.

Material handling equipment file FILENAME already exists!
Overwrite file (Yes/No):

If you choose YES, CALC: overwrites the file. If you choose NO, CALC: will use the information just entered to compute distances and costs for this iteration of CALC: only and will not save the new material handling equipment definition.

CALC: next searches for paths. If there are undefined paths, CALC: continues as from the beginning of Situation 2 (page 125). If all paths are defined, CALC: computes travel distances and costs and continues with the path thickness scale prompt as in Situation 1 (page 124).

ARROWS:

FACTFLOW

CALC:

ARROWS:

SAVE DC:

PRODFLOW:

LSTPATH:

EDIT

REPORTS

COMPANAL

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

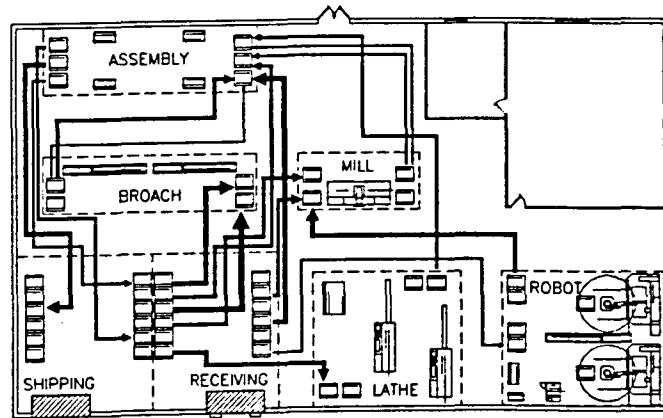
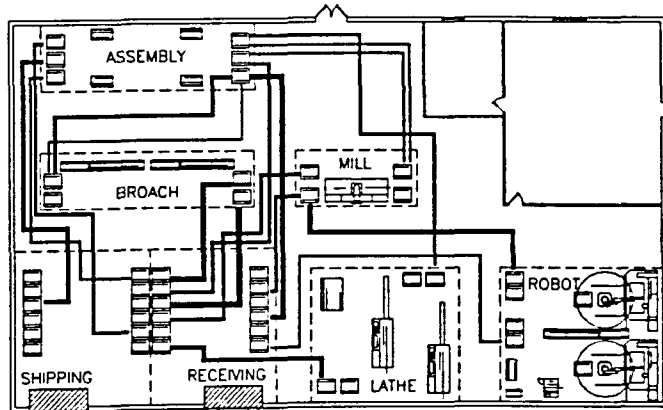
_ LAST _

ARROWS: places an arrowhead at the end of each scaled product flow line in the Product Flow Diagram to indicate direction of product flow. The size of the arrowhead varies with the thickness of the product flow lines (that is, with the cost per foot of material handling). After each time you use **CALC:**, you'll need to pick **ARROWS:** to adjust the size of the arrowheads and to add arrowheads to new or changed paths.

-> ARROWS:

After you pick it from the menu, **ARROWS:** draws the arrowheads. An example of product flow lines with and without arrowheads is shown below.

Example: Product flow lines before and after **ARROWS:**.



If the last line segment in a path is shorter than the arrowhead, ARROWS: will not be able to put an arrowhead on the path. In this case, ARROWS: tells you it cannot add an arrowhead and prompts you to press <Return> to continue.

Last path segment of product: PRODUCTNAME between FROMWORKCENTER and TOWORKCENTER is too short for the display of an arrow. Press RETURN to continue.

You must press <Return> to continue. When ARROWS: is complete, you are returned to the command prompt.

SAVE DC:

FACTFLOW
* * * *

CALC:

ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
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ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

SAVE DC: saves the most recently calculated total distance and cost in an ASCII Distance-Cost file. SAVE DC: also allows you to save the current layout under a new drawing file name. Together, the Distance-Cost file and the saved drawing record a particular design alternative. You may want to keep copies of the Products, Parts, and Material Handling Equipment files also. You can append each design alternative's total travelled distance and total material handling cost to a single Distance-Cost file, then later list the file with DC REP: to compare alternatives.

To save the distance and cost, pick SAVE DC: from the menu.

--> SAVE DC:

SAVE DC: will ask you for the file name to save to.

File name <DEFAULT>:

SAVE DC: looks in the current directory for a file with the name you enter.

New file

If the file name you enter is new, SAVE DC: asks for the file header:

Company name <NONE>:
Project name <NONE>:

Existing file

If the file exists, SAVE DC: asks whether you want to append to it.

File FILENAME already exists. Append to it <YES>:

If you choose NO, SAVE DC: will ask for the file header as in New file above, write over the existing file, then continue below. If you choose YES, SAVE DC: will append the information to the existing file.

Next SAVE DC: asks for a layout name with which to associate the distance and cost.

Layout name:

NOTE: The name you enter here will be used to name this layout drawing if you choose to save it later in this command. If you enter the name of an existing drawing, SAVE DC: will overwrite the existing drawing.

SAVE DC: then asks for the date and time.

Date <DEFAULT>:

Time <DEFAULT>:

SAVE DC: saves the distance and cost to a Distance-Cost file with an .LDC extension. The example file below shows the structure for presenting distances and costs for two alternative layouts, A and B.

Example: LADDER1.LDC

COMPANY NAME: ACME LADDERS
PROJECT NAME: LAYOUT OPTIMIZATION

DISTANCE AND COST REPORT

LAYOUT NAME: A DATE: 10/17/1989 TIME: 9:46

PATH THICKNESS SCALE (DOLLARS/FOOT/INCH): 2

TOTAL TRAVELLED DISTANCE (FT.)/YEAR: 11,559,466

TOTAL MATERIAL HANDLING COST/YEAR: \$46,609

LAYOUT NAME: B DATE: 10/17/1989 TIME: 10:12

PATH THICKNESS SCALE (DOLLARS/FOOT/INCH): 2

TOTAL TRAVELLED DISTANCE (FT.)/YEAR: 7,602,778

TOTAL MATERIAL HANDLING COST/YEAR: \$41,086

SAVE DC: will next ask whether you want to save the layout.

Save layout <YES>:

If you choose YES, the layout is saved as a drawing under the layout name you used to identify the distance and cost. SAVE DC: then returns you to the command prompt.

If you choose NO, SAVE DC: returns you to the command prompt.

PRODFW:

FACTFLOW

* * * *

CALC:

ARROWS:

SAVE DC:

PRODFW:

LSTPATH:

EDIT

REPORTS

COMPANAL

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

PRODFW: highlights a selected set of product flow paths from a Product Flow Diagram. PRODFW: also allows you to save the resulting diagram as a file, to make a slide of the diagram, or to plot or printer-plot the diagram. You have the option of displaying only the selected set of paths, or displaying the selected set in a special color to set it apart from the other paths.

Using PRODFW: to display selected sets of paths is particularly useful if there are many paths in the full Product Flow Diagram, or if you want to analyze a particular product, handling system, etc.

Selecting product flow paths.

If you want to display a specific set of paths, pick PRODFW: from the RUN menu.

--> PRODFW:

Loading . . .
Product <*>:

PRODFW: asks you for the product name. The default response * is a wildcard character which will select all products. Enter the product name or * for all products. You are then prompted for specific path origins and destinations.

From workcenter <*>:
To workcenter <*>:

Again, the default response is *, which will select all workcenters. You can select any combination of products, from workcenters, and to workcenters.

Once your paths are selected, you have the option of displaying only selected paths or of displaying all paths but changing the color of the selected paths. PRODFW: asks whether you want to continue displaying the non-selected paths.

Display paths not selected <YES>:

If you want to produce a black and white plot of the paths, you probably would not want to display all paths. However, if you just want to highlight a select group of paths, changing their color is much faster than turning off all of the unselected paths. If you choose NO, PRODFW: will turn off all unselected paths. If you choose YES, all paths are displayed and PRODFW: asks for a color for the selected paths.

Color for selected paths <GREEN>:

Saving the selected Product Flow Diagram

After the selected product flow paths are displayed, you have the option of saving, making a slide of, or plotting the Product Flow Diagram. PRODFW: asks first whether you want to save the diagram in a drawing file.

Save product flow diagrams <NO>:

If you choose YES, PRODFW: asks for a drawing name to save to. Make sure that you do not specify your current drawing name, or you will overwrite your original layout drawing. If you choose NO, PRODFW: goes immediately to the next prompt:

Make a slide of the product flow diagrams <NO>:

If you choose YES, PRODFW: asks for the AutoCAD slide file name to save to. If you choose NO, PRODFW: goes immediately to the next prompt:

Plot or printer-plot product flow diagrams <NO>:

If you choose NO, PRODFW: restores the original paths display and returns you to the command prompt. If you choose YES, PRODFW: warns you that plotting will return you to the main AutoCAD screen menu.

Plotting will return you to the AutoCAD main menu.
You MUST pick FACTFLOW from AutoCAD main menu after plotting.
If you wish to abort this operation, pick either FACTFLOW or LAST in next menu.

Press RETURN to continue.

You must press <Return> to continue. When you press <Return>, PRODFW: returns to the graphics screen and displays a plotting options menu. To abort this operation, pick either FACTFLOW or LAST from the screen menu to restore the original paths display and return to the command prompt.

To plot or printer-plot, pick PLOT: or PRPLOT: from the menu. These commands will function exactly as they do in AutoCAD. You must pick FACTFLOW after the plot is done to restore the Product Flow Diagram to its original state and return to your FactoryFLOW analysis.

LSTPATH:

FACTFLOW

CALC:

ARROWS:

SAVE DC:

PRODFLW:

LSTPATH:

EDIT

REPORTS

COMPANAL

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

LSTPATH: lists the cost and distance data associated with a specific product flow path in your layout drawing. LSTPATH: uses the results of the latest CALC: command, so CALC: must already have been run in the current session. To list the data, pick LSTPATH: from the RUN menu.

-->LSTPATH:

LSTPATH: will load and ask you to select a path to query.

Select path to query:

Pick a path on the drawing. LSTPATH: will display the associated data. The data fields are shown in the example below.

Example: LSTPATH: display

PRODUCT FLOW PATH

Product: PROD1

From Workcenter: MILL

To Workcenter: ASSEMBLY

Total Cost: \$1170.07

Distance (ft): 48.31

Cost (\$/ft): 24.22

Press RETURN to continue.

When you are ready to continue, press <Return>. LSTPATH: will ask whether you want to query another path.

Query another path <YES>:

If you choose YES, LSTPATH: repeats. If you choose NO, LSTPATH: returns you to the command prompt.

NOTE: The entity selected must be a product flow path. If you pick another type of entity, LSTPATH: will warn you that the entity is not a path, and ask whether you want to list another path.

Entity selected is not a path!
Query another path <YES>:

EDIT Menu

```

FACTFLOW
*****
CALC:

ARROWS:
SAVE DC:
PRODFLW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST _

```

```

FACTFLOW
*****
MOVEWC:

FFEDIT:

EDTPATH:
DELPATH:
LSTPATH:

TIMUNIT:
CHTUNIT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST _

```

The EDIT menu contains commands you can use to make changes to your drawing and data files. This lets you do "what if" analysis by creating alternative layouts, material handling systems, etc.

MOVEWC: is used to change workcenter locations.

FFEDIT: is used to enter and edit data files (and compute workcenter utilizations).

(FFEDIT: is explained on page 105.)

EDTPATH: is used to edit or redefine material handling paths.

DELPATH: is used to delete existing paths.

LSTPATH: is used to list data associated with an actual path (LSTPATH: is explained on page 138).

TIMUNIT: is used to list the default time unit for analysis for the current analysis session.

CHTUNIT: is used to change the time unit for analysis.

MOVEWC:

FACTFLOW

MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

MOVEWC: is used to move workcenters in the layout. **MOVEWC:** is similar to the AutoCAD **MOVE** command, but **MOVEWC:** also erases paths going to and from a moved workcenter, thereby ensuring only valid paths will be used in calculating distances and costs. To move a workcenter, pick **MOVEWC:** from the **EDIT** menu.

--> **MOVEWC:**

Loading . . .
Workcenter name:

MOVEWC: first asks you for the name of the workcenter you want to move. **MOVEWC:** will use the name you provide to access the Paths file and delete paths going to and from the workcenter.

Select **WORKCENTERNAME** workcenter:

MOVEWC: asks you to select entities that make up the workcenter. The workcenter can be selected with a window, a crossing window, by picking entities with the cursor, or any other method, exactly as in AutoCAD's **MOVE** command. Refer to the AutoCAD Reference Manual for information on the **MOVE** command.

Select objects: 1 selected, 1 found.
Select objects:

MOVEWC: asks you to select objects to be moved. (If you have used AutoCAD's **BLOCK** command to block the objects in the workcenter, the workcenter can be selected with one pick.) When all of the objects in the workcenter are selected, press <Return>. **MOVEWC:** then asks for the base point and second point for the move.

Base point:
Second point:

MOVEWC: moves the workcenter and erases the paths going from and to the moved workcenter. If a workcenter point exists, **MOVEWC:** asks whether you want to redefine it.

Redefine workcenter point for **WORKCENTER** <YES>:

If you do want to redefine the workcenter point, press <Return> to accept the default response, **YES**. **MOVEWC:** will ask you to select a new workcenter point in the moved workcenter. After you select a new point, **MOVEWC:** will ask whether you want to move another workcenter.

If you do not want to redefine the workcenter point, type N and press <Return>. The workcenter point will be deleted. NOTE: The next time FactoryFLOW needs to use a missing workcenter point, you will be prompted to redefine it. MOVEWC: will then ask whether you want to move another workcenter.

Move another workcenter <YES>:

If you choose YES, MOVEWC: begins again. If you choose NO, MOVEWC: returns you to the command prompt.

FFEDIT:

Refer to FFEDIT: on page 105.

EDTPATH:

FACTFLOW
* * * *
MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

EDTPATH: edits a material handling path by erasing an existing path definition and then allowing you to define a new path exactly as when paths are first defined in CALC: . If you want to edit a path definition (redefine the Actual path, switch from Actual to Rectilinear or vice versa, and so forth), pick EDTPATH: from the EDIT menu.

--> EDTPATH:

Loading . . .
Product name or <Return> to select path:

EDTPATH: asks you to identify the path you want to edit. You can identify the path by supplying path data (product name, from workcenter, and to workcenter) or simply by picking the Actual path on the drawing. If the path you want to edit has been defined by length or as Rectilinear or Euclidian, you must supply path data to identify the path, since only Actual paths are displayed in the drawing.

To identify a path by supplying path data, type the product name and press <Return>. EDTPATH: then asks for the workcenter names.

From workcenter name:
To workcenter name:

To identify a path by selecting it on the drawing, press <Return>. EDTPATH: asks you to select a path to edit. Select the path by picking it with the pointing device.

Select a path to edit:

After you've identified the path to be edited, EDTPATH: erases the old path definition and starts the same path definition routine used when paths are first defined in CALC: . See CALC: Situation Two on page-125 for an explanation of defining paths.

After you finish redefining the path, EDTPATH: asks whether you want to edit another path.

Edit another path <YES>:

If you want to edit another path, press <Return> to accept the default response YES; EDTPATH: will repeat. If you don't want to edit another path, pick NO from the screen menu, or type N and press <Return>; EDTPATH: will then return you to the command prompt.

DELPATH:

FACTFLOW

MOVEWC:

FFEDIT:

EDTPATH:

DELPATH:

LSTPATH:

TIMUNIT:

CHTUNIT:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__ LAST __

DELPATH: deletes a path from the drawing and from the Path file. NOTE: paths must not be deleted using the AutoCAD ERASE command. To delete a path, pick DELPATH: from the menu.

--> DELPATH:

Loading . . .

Product name or RETURN to select path:

DELPATH: asks you to identify the path you want to delete. You can identify the path by supplying path data (product name, from workcenter, and to workcenter) or simply by selecting an Actual path on the drawing. If the path you want to delete has been defined by length, or as Rectilinear or Euclidian, you must supply path data to identify the path, since only Actual paths are displayed in the drawing.

To identify a path by supplying path data, type the product name and press <Return>. You can also type an asterisk (*) to delete all paths in your drawing. If you enter an asterisk (*) for the product name, DELPATH: erases all the paths and returns you to the command prompt. If you enter a product name, DELPATH: then asks for the path name. You can specify one path or all paths for the selected product.

Path name (From workcenter/To workcenter) <*>: FROMWC/TOWC
<Return>

Type the from workcenter name, a slash (/), and the to workcenter name to identify the path. You can also simply press <Return> to accept the default response, *, which will include all paths for the selected product.

To identify a path by selecting it on the drawing, press <Return>. DELPATH: asks you to select the path to erase. Select the path by picking it with the pointing device.

Select path to erase:

After you identify the path(s) to be deleted, DELPATH: erases the path definition(s) and erases any actual paths from the drawing. DELPATH: next asks whether you want to erase another path.

Erase another path <YES>:

If you want to delete another path, press <Return> to accept the default response, YES; DELPATH: will then begin again. If you do not want to delete another path, type N and press <Return>; DELPATH: will then return you to the command prompt.

LSTPATH:

Refer to LSTPATH: on page 138.

TIMEUNIT:

TIMEUNIT: displays the current time unit for analysis. To display the time unit, pick TIMEUNIT: from the RUN menu.

--> TIMEUNIT:

TIMEUNIT: displays the current time unit for analysis in the command area.

Time unit: CURRENT TIME UNIT

FACTFLOW
* * * *
MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
LAST

CHTUNIT:

```

FACTFLOW
*****
MOVEWC:
FFEDIT:
EDTPATH:
DELPATH:
LSTPATH:
TIMUNIT:
CHTUNIT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
  _LAST_

```

CHTUNIT: changes the time unit for analysis of the current session, and gives you the option of updating your Products and Material Handling Equipment files to reflect the new time unit. To change the time unit for analysis, pick CHTUNIT: from the EDIT menu.

-->CHTUNIT:

Loading . . .

This command changes the time unit of analysis and adjusts the production volumes, material handling investment costs, and available minutes per time unit. Do you want to continue <NO>:

A time unit change affects all of the time-dependent data, so CHTUNIT: asks whether or not you want to continue with this change.

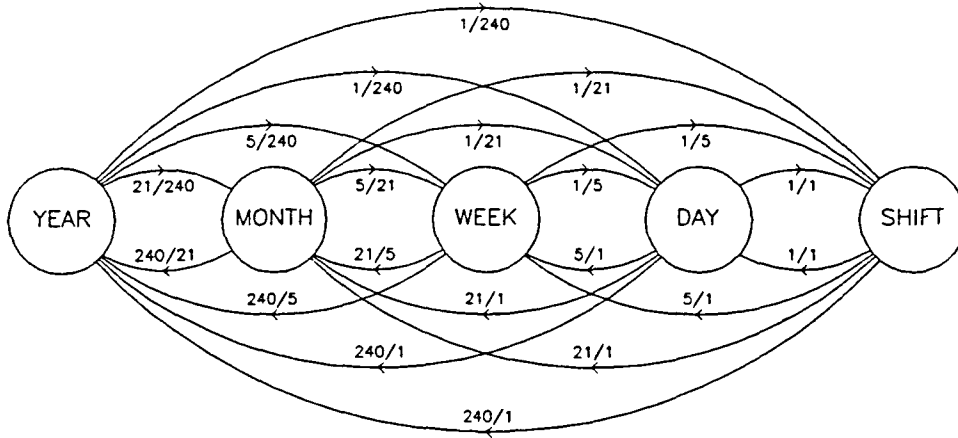
If you do not want to continue with the change, press <Return> to accept the default response, NO; CHTUNIT: will then end and return you to the command prompt.

If you want to continue with the change, type Y and press <Return>. CHTUNIT: then asks for the new time unit.

Time unit to change to (Year/Month/Week/Day/Shift) <TIMEUNIT>:

Type Y, M, W, D, or S and press <Return>. The current time unit is displayed as the default. Pressing <Return> to accept the current time unit as the new time unit will return you to the command prompt.

Once you select a new time unit, CHTUNIT: will ask you to supply multipliers for changing the production volumes, material handling equipment investment costs, and material handling equipment available minutes. The default conversion factor values assume one shift per day, five days per week, 21 days per month, and 240 days per year. The default values for the various time unit changes are illustrated in the following figure.



MULTIPLIERS

Change from OLDTIME to NEWTIME unit basis:
 Production volumes multiplier <DEFAULT> :

Type any positive real number and press <Return>, or simply press <Return> to accept the default value. Fractions must be entered as a decimal number. CHTUNIT: will then ask for investment costs and available minutes multipliers.

Material handling investment costs multiplier <DEFAULT> :
 Material handling available minutes multiplier <DEFAULT> :

After you have entered the multiplier values, CHTUNIT: adjusts the data files and asks whether you want to save the adjustments, first to the Products file and then to the Material Handling Equipment file.

Production volumes have been changed. Save products information <YES>:

If you do not want to save products information, type N and press <Return>; the new values will then be used for the current session only. CHTUNIT: will next ask whether you want to save material handling equipment information.

If you want to save products information, press <Return> to accept the default response, YES; CHTUNIT: then asks for the name of the file to save.

Products file <DEFAULT>:

Type the name of the file to save and press <Return>, or simply press <Return> to accept the default response. CHTUNIT: will save the file.

After the products information has been saved (or not saved), CHTUNIT: asks whether you want to save the adjusted material handling equipment information.

Material handling equipment investment costs and available minutes have been changed. Save material handling equipment information <YES>:

If you do not want to save material handling equipment information, type N and press <Return>; the new values will then be used for the current session only. CHTUNIT: will return you to the command prompt.

If you want to save material handling equipment information, press <Return> to accept the default response, YES. CHTUNIT: then asks for the name of the file to save.

Material Handling Equipment file <DEFAULT>:

Type the name of the file to save and press <Return>, or simply press <Return> to accept the default response. CHTUNIT: will save the file, then return you to the command prompt.

REPORTS Menu

```

FACTFLOW
*****
CALC:

ARROWS:
SAVE DC:
PRODFW:
LSTPATH:

EDIT
REPORTS
COMPANAL

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST _
    
```

```

FACTFLOW
*****
DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST _
    
```

The REPORTS menu contains commands you can use to generate and list both Material Handling Equipment Utilizations Reports and Material Handling Cost Reports, as well as display material handling equipment utilizations and quickly change the number of servers in a material handling system.

DISPMHU: displays material handling utilizations.

CHGEMHU: changes the number of servers in the material handling system.

GENEMHU: generates a Material Handling Equipment Utilizations Report file.

LISTMHU: lists the Material Handling Utilizations Report file.

GENEMHR: generates simple and advanced Material Handling Cost Reports.

LISTMHR: lists Material Handling Cost Reports.

LSTPATH: lists the data associated with an actual path (see LSTPATH: on page 138).

DISPMHU:

FACTFLOW
* * * *

DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:

__LAST__

DISPMHU: displays material handling equipment utilizations. To display material handling equipment utilizations, pick DISPMHU: from the REPORTS menu.

-->DISPMHU:

DISPMHU: displays the material handling utilizations on the text screen. Below is a sample display:

MATERIAL HANDLING UTILIZATIONS

Material handling system name: MH1
Available minutes / equipment / YEAR: 105000.00
Busy minutes / system / YEAR: 42975.56
Quantity: 0.50
Utilization (%): 81.86

Material handling system name: MH2
Available minutes / equipment / YEAR: 95000.00
Busy minutes / system / YEAR: 3697.67
Quantity: 1.0
Utilization (%): 72.49

Press RETURN to continue.

Press <Return> to continue. DISPMHU: will return you to the command prompt.

CHGEMHU:

FACTFLOW
* * * *

DISPMHU:
CHGEMHU:

GENEMHU:
LISTMHU:

GENEMHR:
LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:

__LAST__

CHGEMHU: lets you change the number of servers in a material handling system and saves the change. (You can also change the number of servers using FFEDIT:'s MATERIAL HANDLING UTILIZATIONS WINDOW, but CHGEMHU: is more efficient if the number of servers is all you need to change.) To change the number of servers in a material handling system, pick CHGEMHU: from the REPORTS menu.

-->CHGEMHU:

CHGEMHU: first asks for the name of the material handling system whose number of servers you want to change.

Material handling system name to change quantity:

Type the name of the material handling system and press <Return> (the system must already be defined).

Enter new quantity of MHSNAME <DEFAULT>:

The default value is the current number of servers. Type a new number and press <Return>, or simply press <Return> to keep the same number of servers. CHGEMHU: then asks whether you want to change another material handling system's number of servers.

Change another material handling system's quantity <YES>:

If you want to change another system's quantity, press <Return> to accept the default response, YES. CHGEMHU: will begin again.

If you do not want to change another system's quantity, type N and press <Return> to tell CHGEMHU: you're through making changes. CHGEMHU: then prompts you to press <Return> to save the changes. You must press <Return> to continue.

Press RETURN to save the material handling equipment information.

CHGEMHU: then asks for the name of the file to save.

Material handling equipment file <DEFAULT>:

Type the name of the file and press <Return>, or press <Return> to accept the default name. The most recently saved file will become the file used in the current analysis.

After the file is saved, CHGEMHU: asks you to press <Return> to display the new material handling utilizations. When you're through looking at the display, press <Return>. CHGEMHU: will then return you to the command prompt.

GENEMHU:

FACTFLOW

DISPMHU:

CHGEMHU:

GENEMHU:

LISTMHU:

GENEMHR:

LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

GENEMHU: generates the Material Handling Utilizations Report file. To generate the Material Handling Utilizations Report file, pick GENEMHU: from the REPORTS menu.

-->GENEMHU:

GENEMHU: first asks for the name of the Material Handling Utilizations Report file you want to generate.

Material handling utilizations file <DEFAULT>:

Type the name of the file and press <Return>, or simply press <Return> to accept the default file name. GENEMHU: then asks for information to include in the report heading.

Company name <NONE>:

Project name <NONE>:

Date <SYSDATE>:

Time <SYSTIME>:

Type the header information and press <Return> after each prompt, or simply press <Return> to accept the default responses. GENEMHU: generates the report file, then returns you to the command prompt.

LISTMHU:

FACTFLOW

DISPMHU:

CHGEMHU:

GENEMHU:

LISTMHU:

GENEMHR:

LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

LISTMHU: displays the Material Handling Utilizations Report file on the screen. To list the file, pick LISTMHU: from the menu.

-->LISTMHU:

LISTMHU: asks you for the name of the report file to list.

File name <DEFAULT>:

Type the file name and press <Return>, or simply press <Return> to accept the default file name. LISTMHU: then displays the report file on the text screen. Following is an example file.

COMPANY NAME: ACME LADDERS
 PROJECT NAME: ACME
 DATE: 04/06/1989
 TIME: 15:49

MATERIAL HANDLING UTILIZATIONS

Material handling system name: MH1
 Available minutes / equipment / YEAR: 105000.00
 Busy minutes / system / YEAR: 42975.56
 Quantity: 0.50
 Utilization (%): 81.86

Material handling system name: MH2
 Available minutes / equipment / YEAR: 95000.00
 Busy minutes / system / YEAR: 3697.67
 Quantity: 1.0
 Utilization (%): 72.49

Press RETURN when ready . . .

Press <Return> to continue. LISTMHU: then returns you to the command prompt.

GENEMHR:

FACTFLOW

DISPMHU:
CHGEMHU:
GENEMHU:
LISTMHU:
GENEMHR:
LISTMHR:
LSTPATH:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
LAST
__

GENEMHR: generates a wide variety of simple and advanced Material Handling Cost Reports. The simple Material Handling Cost Report groups material handling information either by products or by workcenters. The advanced Material Handling Cost Report uses various standard or custom report formats. Sample Material Handling Cost Reports are included beginning on page 159. If you have made changes to your design (moved workcenters, changed paths or data files), you must recalculate material handling distances and costs with CALC: before running GENEMHR: . To generate a Material Handling Cost Report, pick GENEMHR: from the REPORTS menu.

—> GENEMHR:

GENEMHR: first asks whether you want to generate a simple or advanced report.

Generate Simple or Advanced material handling report (S/A) <S>:

To generate a simple report, press <Return> to accept the default response, S. To generate an advanced report, pick ADVANCED from the screen menu or type A and press <Return>. Simple and advanced reports are described separately below.

SIMPLE reports

Generate Simple or Advanced material handling report (S/A) <S>: <Return>

When you choose SIMPLE, GENEMHR: first asks whether you want to include all products.

Include all products <YES>:

If you want to include all products, press <Return> to accept the default response, YES. GENEMHR: then asks for the report file name.

If you do not want to include all products, type N and press <Return>. GENEMHR: then asks for the product names to include in the report.

Product name <DONE>:

Type each product name you want included, pressing <Return> after each name. When you're through entering product names, press <Return> to accept the default response, DONE. GENEMHR: then asks for the report file name.

Material handling report file <DEFAULT>:

Type the name of the file and press <Return>, or simply press <Return> to accept the default response, which is the current drawing name. GENEMHR: then asks whether you want to generate the report by products or workcenters.

Generate report by Products or Workcenters (P/W) <P>:

After you choose products or workcenters, GENEMHR: asks whether you want total travelled distance reported in feet or miles.

Total travelled distance unit (Feet/Miles) <Feet>:

Last, GENEMHR: asks you for report header information.

Company name <NONE>:
Project name <NONE>:
Date <DEFAULT>:
Time <DEFAULT>:

After you enter the header information, GENEMHR: generates the report and writes it to a file with an .MHR extension. You can display the file on the screen with LISTMHR: .

ADVANCED reports

Generate Simple or Advanced material handling report (S/A) <S>: A <Return>

When you choose ADVANCED, GENEMHR: first asks for report header information.

Company name <NONE>:
 Project name <NONE>:
 Date <DEFAULT>:
 Time <DEFAULT>:

After you enter the header information, GENEMHR: writes the material handling information to a work file whose name is the current drawing name with a .DAT extension, then displays the Advanced Report Generator windowing program. The Advanced Report Generator uses information in this .DAT file to produce an advanced report.

Using the Advanced Report Generator

The Advanced Report Generator (REPGEN) windowing program enables you to generate the Material Handling Cost Report in a variety of formats.

REPGEN has two main windows: the report selection window and the format options window. The report selection window appears when GENEMHR: calls REPGEN; the format options window appears when you press <F2> to edit a highlighted report format or <F3> to create a new report format. Subsidiary printer options windows can be reached from the format options window.

Report selection window

The first window is the report selection window. The window has two boxes in it; the upper box shows standard report formats and the lower box shows the custom report formats. When the window appears, one report format will be highlighted.

Report Generator		Material handling source file: exan
Select the type of report to generate		
Standard Reports	<div style="border: 1px solid black; padding: 5px;"> Move Frequency Total Distance Total Time Total Cost </div>	
Custom Reports	<div style="border: 1px solid black; padding: 5px;"> WC : Work Centers MDIST : Move Distance PRODPART : Products Parts MHE : Material Handling Equipment GCODE : Group Code </div>	
Press <F1> to print highlighted report, <F2> to edit highlighted report format, (space) to switch boxes, <F3> to create a new report format, <ESC> to exit.		

The instructions in the following box describe how to choose options in the report selection window.

Options in the report selection window

You can print the highlighted report by pressing <F1>. You can open the format options window to edit a highlighted report by pressing <F2>. To create a new report format from scratch, press <F3> to open a cleared format options window.

To switch between boxes, press <space bar>. The <up-arrow> and <down-arrow> keys move between choices within a box (choices will scroll if there are more choices than can appear at one time). Pressing <Esc> in the report selection window will close the REPGEN window, end GENEMHR:, and return you to the command prompt.

Printing a report

When you are in the first window of REPGEN, pressing <F1> on a highlighted format will open a window with the following prompt:

Enter selection:

- (S) - Screen
- (F) - File
- (P) - Printer

Press the appropriate key for your choice.

Printing to the screen will show you roughly what the report will look like on paper. Anything beyond screen width will not be displayed, but you can press any key but <Esc> to scroll down the length of the report one screen at a time; <Esc> will take you back to the last menu.

Printing to a file will print the report to a text file in the current directory. If you print to a file, REPGEN will ask you for a file name. REPGEN will add an .MHR extension to the file name. The report title and header will be printed only once.

Printing to a printer will send the report to a printer device. REPGEN will ask you for the print device, then ask you to specify single or double spacing.

Enter Printer Device <DEFAULT>:
Single or Double spaced (S/D):

Press either S or D. The printer will print the Material Handling Cost Report in the highlighted format.

To stop the print, press a key at any time during printing. A small window will appear and ask if you wish to abort the print. Press <Esc> to abort the print or any other key to continue printing.

Editing or creating a report format

Report formats can be edited or created in REPGEN's format options window. The format options window is reached by pressing <F2> or <F3> in the report selection window. Press <F2> to edit the options for an existing report; press <F3> to bring up a cleared format options window. The format options window has five major parts:

- Print Fields
- Sort Parameters (Primary and Secondary levels)
- Units for Total Distance field
- Units for Total Time field
- Subtotal printing selection field

Print Fields	Sort Parameters (A or D)		Length of print line: 73	
	Primary	Secondary	Total Dist.	Total Time
(X) Product Name	()	()	() miles	() hours
(X) Part Name	()	()	(J) feet	(J) minutes
() Group Code	()	()		
(X) From Work Center	()	()		
(X) To Work Center	()	()		
(X) Material Handling	()	()		
() Move Distance				
() Total Move Dist.				
() Total Move Time				
() Fixed Move Cost				
() Variable Move Cost				
() Total Move Cost				
(X) Move Frequency	(D)	()		
() Total Distance	()	()		
() Total Time	()	()		
() Total Cost	()	()		

()	ON	()
(J)	OFF	(J)

Press (F1) to set printer options
 (- -) to move between columns and boxes
 (ESC) to return to previous menu

<Enter> or <space> to select/unselect. A - Ascending
 D - Descending

Print Fields. The large box on the left side lists all of the fields available to print. You can select which fields you want to appear in the report by moving the highlight box up and down with the arrow keys, then pressing <Return> or <space bar> when the highlight box is on the desired field. An x will appear next to a field when it is selected. Pressing either <Return> or <space bar> will also unselect a field if it has been previously selected.

The current length of the print line is printed in the upper right-hand corner of the screen; the length is updated whenever print fields are selected or unselected.

Sort Parameters. FactoryFLOW will sort the report according to the parameters you enter in the primary and secondary sort fields. Move the cursor to the sort field of a selected print field and press A for an ascending sort or D for a descending sort. Pressing <space bar> when the highlight is on a sort field which has been selected will clear the selected sort.

Units for Total Distance field. You can choose either miles or feet for the total distance. When the cursor is in the Total Distance units selection box, press <Return> or <space bar> to toggle between miles and feet.

Print Fields	Sort Parameters (A or D)		Length of print line: 73		
	Primary	Secondary	Total Dist.	Total Time	
(X)	Set Printer Options				hours
(X)	Enter selection:				minutes
()	(S) - Setup codes (sent before report)				condary
(X)	(C) - Clear codes (sent after report)				
(X)	(L) - Length of printed page				()
()	Hexadecimal or Decimal entry (H/D):				(J)
()					ons
()					etween
()					boxes
(X)	(Enter) or (space) to select/unselect.		A - Ascending D - Descending	(ESC) to return to previous menu	

Type H or D and press <Return>. The printer options window will then display hexadecimal and decimal values for various special and normal characters as an aid to entering these codes.

Print Fields	Sort Parameters (A or D)		Length of print line: 73		
	Primary	Secondary	Total Dist.	Total Time	
(X)	Set Printer Options				hours
(X)	Setup codes -- Decimal entry				minutes
()	Please enter all codes as 2-digit numbers separated by spaces (i.e. l = 01, F = 0F, etc.)				condary
(X)	[Redacted]				
(X)					()
()					(J)
()					ons
()					etween
()					boxes
(X)	(Enter) or (space) to select/unselect.		A - Ascending D - Descending	(ESC) to return to previous menu	

Consult your printer manual to find the desired codes, and then enter each character of the code as a two-digit number. Separate each number by a space. REPGEN will check for correct entry and warn you if the entry isn't right. When you're through entering codes, press <Esc> to go back to the original printer options window.

If you use printer setup codes when printing reports, it is a good idea to also include clear codes to reset the printer to a normal state. If you don't reset the printer, later printer output may not be what you expect (for example, text rotated on the page instead of printed normally).

Length of printed page. If you use setup codes to alter the number of lines per inch or rotate the print direction on a printer, it may be necessary to change the length of a printed page. To change the length of the printed page, press L while in the printer options window. REPGEN will ask for the new number of lines per page. The minimum number of lines is 15.

Print Fields	Sort Parameters (A or D)		Length of print line: 73	
	Primary	Secondary	Total Dist.	Total Time
(X)	Set Printer Options			hours
(X)	Enter selection:			minutes
()	(S) - Setup codes (sent before report)			Secondary
(X)	(C) - Clear codes (sent after report)			
()	(L) - Length of printed page			totals
()	New number of lines per page: 32			()
()	(minimum 15, default = 60)			(↓)
(X)				ons
()				etween
()				boxes
()				
(Enter) or (space) to select/unselect.		A - Ascending D - Descending	(ESC) to return to previous menu	

Enter the new desired value and press <Return>.

When you are finished selecting printer options, press <Esc> to return to the format options window.

Once you are finished setting format options, press <Esc> to exit the format options window. If you have made any changes to the report format, a window will appear and ask whether you want to save the new format.

If you want to save the report format, type Y and press <Return>. REPGEN will ask you for a report format name and report format description. If you originally selected a standard report format and made changes, the changed format will be saved under the new name as a custom format. Standard formats cannot be changed.

If you do not want to save the report format, type N and press <Return>. REPGEN will display an unnamed report format with the description "unsaved new report format" in the custom format box on the first screen. You can print the new format, but the description will disappear when you leave REPGEN or if you press either <F2> to edit another report or <F3> to create a new report.

Sample Material Handling Reports

Simple Report by Workcenters

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: SAMPLE REPORTS
 DATE: 10/31/1989
 TIME: 09:59

MATERIAL HANDLING REPORT

By Workcenters

Time unit: YEAR

	Distance	Cost
Between RECEIVING and ROBOT	550,722 Ft.	\$ 1,498
Between RECEIVING and BROACH	705,278 Ft.	\$ 3,481
Between RECEIVING and MILL	336,163 Ft.	\$ 2,827
Between ROBOT and MILL	672,200 Ft.	\$ 2,380
Between RECEIVING and ASSEMBLY	636,871 Ft.	\$ 5,832
Between BROACH and ASSEMBLY	678,563 Ft.	\$ 2,390
Between MILL and ASSEMBLY	492,261 Ft.	\$ 1,767
Between ASSEMBLY and SHIPPING	807,992 Ft.	\$ 6,734
Between RECEIVING and LATHE	334,458 Ft.	\$ 1,538
Between LATHE and ASSEMBLY	734,336 Ft.	\$ 2,117
Grand Total	5,948,843 Ft.	\$ 30,564

Simple Report by Products

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: SAMPLE REPORTS
 DATE: 10/31/1989
 TIME: 09:58

MATERIAL HANDLING REPORT

By Products

Product name: PROD1 Production volume: 200000 / YEAR

	Distance	Cost
Between RECEIVING and ROBOT	550,722 Ft.	\$ 1,498

Between RECEIVING and BROACH	416,244 Ft.	\$ 2,008
Between RECEIVING and MILL	155,739 Ft.	\$ 929
Between ROBOT and MILL	672,200 Ft.	\$ 2,380
Between RECEIVING and ASSEMBLY	290,520 Ft.	\$ 2,876
Between BROACH and ASSEMBLY	173,225 Ft.	\$ 603
Between MILL and ASSEMBLY	322,562 Ft.	\$ 1,170
Between ASSEMBLY and SHIPPING	157,692 Ft.	\$ 1,465
Total	2,738,903 Ft.	\$ 12,929

Product name: PRO02 Production volume: 100000 / YEAR

	Distance	Cost
Between RECEIVING and MILL	180,424 Ft.	\$ 1,899
Between RECEIVING and ASSEMBLY	88,941 Ft.	\$ 742
Between MILL and ASSEMBLY	169,699 Ft.	\$ 597
Between ASSEMBLY and SHIPPING	355,295 Ft.	\$ 2,993
Total	794,359 Ft.	\$ 6,231

Product name: PRO03 Production volume: 150000 / YEAR

	Distance	Cost
Between RECEIVING and BROACH	289,033 Ft.	\$ 1,473
Between RECEIVING and LATHE	334,458 Ft.	\$ 1,538
Between RECEIVING and ASSEMBLY	257,410 Ft.	\$ 2,213
Between BROACH and ASSEMBLY	505,338 Ft.	\$ 1,787
Between LATHE and ASSEMBLY	734,336 Ft.	\$ 2,117
Between ASSEMBLY and SHIPPING	295,005 Ft.	\$ 2,276
Total	2,415,581 Ft.	\$ 11,405
Grand Total	5,948,843 Ft.	\$ 30,564

Advanced Material Handling Report

COMPANY NAME: ABC CORPORATION

PROJECT NAME: SAMPLE REPORTS

DATE: 10/31/1989

TIME: 10:35

MATERIAL HANDLING REPORT

PRODUCT	PART	FROM	TO	TOTAL MOVE DISTANCE (FT.)	TOTAL COST (\$/YEAR)
PROD1	PART1	ASSEMBLY	SHIPPING	78.25	1,465.09
PROD1	PART11	MILL	ASSEMBLY	80.52	1,170.07
PROD1	PART111	ROBOT	MILL	83.86	2,379.84
PROD1	PART1111	RECEIVING	ROBOT	137.68	1,497.66
PROD1	PART112	RECEIVING	MILL	38.93	928.71
PROD1	PART12	BROACH	ASSEMBLY	86.40	602.59
PROD1	PART121	RECEIVING	BROACH	52.03	2,008.33
PROD1	PART13	RECEIVING	ASSEMBLY	72.63	2,876.26
PROD2	PART2	ASSEMBLY	SHIPPING	87.94	2,993.09
PROD2	PART21	MILL	ASSEMBLY	84.72	597.16
PROD2	PART211	RECEIVING	MILL	67.66	1,898.69
PROD2	PART22	RECEIVING	ASSEMBLY	88.94	742.22
PROD3	PART3	ASSEMBLY	SHIPPING	97.84	2,275.93
PROD3	PART31	LATHE	ASSEMBLY	122.08	2,116.98
PROD3	PART311	RECEIVING	LATHE	55.74	1,538.33
PROD3	PART32	BROACH	ASSEMBLY	84.01	1,787.12
PROD3	PART321	RECEIVING	BROACH	48.17	1,472.90
PROD3	PART33	RECEIVING	ASSEMBLY	85.80	2,213.29
Grand total				=====	30,564.26

LISTMHR:

FACTFLOW

* * * *

DISPMHU:

CHGEMHU:

GENEMHU:

LISTMHU:

GENEMHR:

LISTMHR:

LSTPATH:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

LISTMHR: displays the Material Handling Cost Report on the screen. To list the report, pick LISTMHR: from the REPORTS menu.

-->LISTMHR:

LISTMHR: first asks for the name of the file to list.

File name <DEFAULT>:

Type the file name and press <Return>, or simply press <Return> to accept the default file name. LISTMHR: will then switch to the text screen and display the report one page at a time. Press <Return> to scroll to successive pages. Following is an example report.

COMPANY NAME: ABC CORP.
 PROJECT NAME: SAMPLE REPORTS
 DATE: 04/06/1989
 TIME: 15:50

MATERIAL HANDLING REPORT

By Product

Product name: PROD1 Production volume: 100000 / YEAR

	Distance	Cost
Between RECEIVING and ROBOT	278,333 Ft.	\$ 842
Between RECEIVING and BROACH	310,000 Ft.	\$ 1,325
Between RECEIVING and MILL	143,889 Ft.	\$ 646
Between ROBOT and MILL	298,541 Ft.	\$ 1,317
Between RECEIVING and ASSEMBLY	453,333 Ft.	\$ 4,462
Between BROACH and ASSEMBLY	20,342 Ft.	\$ 250
Between MILL and ASSEMBLY	120,370 Ft.	\$ 617
Between ASSEMBLY and SHIPPING	215,986 Ft.	\$ 1,814
Total	1,840,796 Ft.	\$ 11,273

Product name: PROD2 Production volume: 50000 / YEAR

	Distance	Cost
Between RECEIVING and MILL	54,762 Ft.	969
Between RECEIVING and ASSEMBLY	25,893 Ft.	\$ 377
Between MILL and ASSEMBLY	69,304 Ft.	\$ 322
Between ASSEMBLY and SHIPPING	168,610 Ft.	\$ 1,695
Total	318,569 Ft.	\$ 3,363

Product name: PROD3 Production volume: 80000 / YEAR

	Distance	Cost
Between RECEIVING and BROACH	65,778 Ft.	\$ 795
Between RECEIVING and LATHE	61,778 Ft.	\$ 789
Between RECEIVING and ASSEMBLY	123,619 Ft.	\$ 1,308
Between BROACH and ASSEMBLY	127,048 Ft.	\$ 891
Between LATHE and ASSEMBLY	575,533 Ft.	\$ 1,544
Between ASSEMBLY and SHIPPING	72,036 Ft.	\$ 817
Total	1,025,792 Ft.	\$ 6,143

GRAND TOTAL 3,185,157 Ft. \$ 20,779

Press RETURN when ready . . .

At the end of the report, press <Return> to continue. LISTMHR: returns you to the command prompt.

LSTPATH:

Refer to LSTPATH: on page 138.

COMPANAL Menu

```
FACTFLOW
*****
CALC:

ARROWS:
SAVE DC:
PRODFW:
LSTPATH:

EDIT
REPORTS
COMPANAL
ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_
```

```
FACTFLOW
*****
DRWCOMP:

DELCOMP:

REDRAW:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
  _LAST_
```

The COMPANAL menu contains commands you can use to generate and clear a Composite Flow Diagram. A Composite Flow Diagram uses scaled thickness lines between pairs of workcenters to show the combined material handling costs of selected product moves between the workcenters. The thicker the composite line between two workcenters, the greater the cost per foot of material handling. As an analysis and improvement tool, the diagram indicates to the user which workcenters should be close to each other, based on the composite material handling cost between them.

DRWCOMP: draws composite flow lines for selected products.

DELCOMP: deletes the composite flow lines.

REDRAW: executes the AutoCAD REDRAW command.

DRWCOMP:

FACTFLOW *****
DRWCOMP:
DELCOMP:
REDRAW:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

DRWCOMP: draws composite flow lines between workcenters for selected products to create a Composite Flow Diagram. The Composite Flow Diagram is a graphical presentation of the material handling costs between workcenters. The composite flow line is a scaled thickness line that represents the material handling cost per foot between workcenters: the thicker the line, the greater the cost per foot. Composite flow lines are particularly helpful when paths have not been defined as Actual paths, since other types of path definitions are not graphically represented on the drawing. **DRWCOMP:** can be invoked multiple times to highlight composite flow lines for multiple products.

To draw composite flow lines, pick **DRWCOMP:** from the COMPANAL menu.

-->**DRWCOMP:**

When first invoked, **DRWCOMP:** checks for existing composite flow lines. If there are any existing lines, **DRWCOMP:** gives you the option of clearing the composite layer.

Do you want to clear COMPOSITE layer <YES>:

If you choose **YES**, existing composite flow lines will be erased. If you choose **NO**, nothing is erased and you can proceed to place new composite flow lines on the composite layer. Whether you choose yes or no, **DRWCOMP:** will next ask whether you want to include all products in the analysis.

Include all products <YES>:

If you choose **YES**, all products will be included in the analysis. **DRWCOMP:** will continue by asking for the color for the Composite Flow Diagram. If you choose **NO**, **DRWCOMP:** asks for the products to be included.

Product name <DONE>:

Type the names of the products you wish to include, pressing <Return> after each product name. When you're through entering product names, press <Return> to accept the default response, **DONE**. **DRWCOMP:** will then ask for the color for the flow lines in the Composite Flow Diagram.

Color for COMPOSITE flow diagram <GREEN>:

Enter the color of the lines for this Composite Flow Diagram. Your choices are **RED**, **YELLOW**, **GREEN**, **CYAN**, **BLUE**, **MAGENTA**, and **WHITE**.

If the workcenter points have not been defined, **DRWCOMP:** next asks you to pick them.

Pick workcenter point in WORKCENTER:

DRWCOMP: then asks for the path thickness scale.

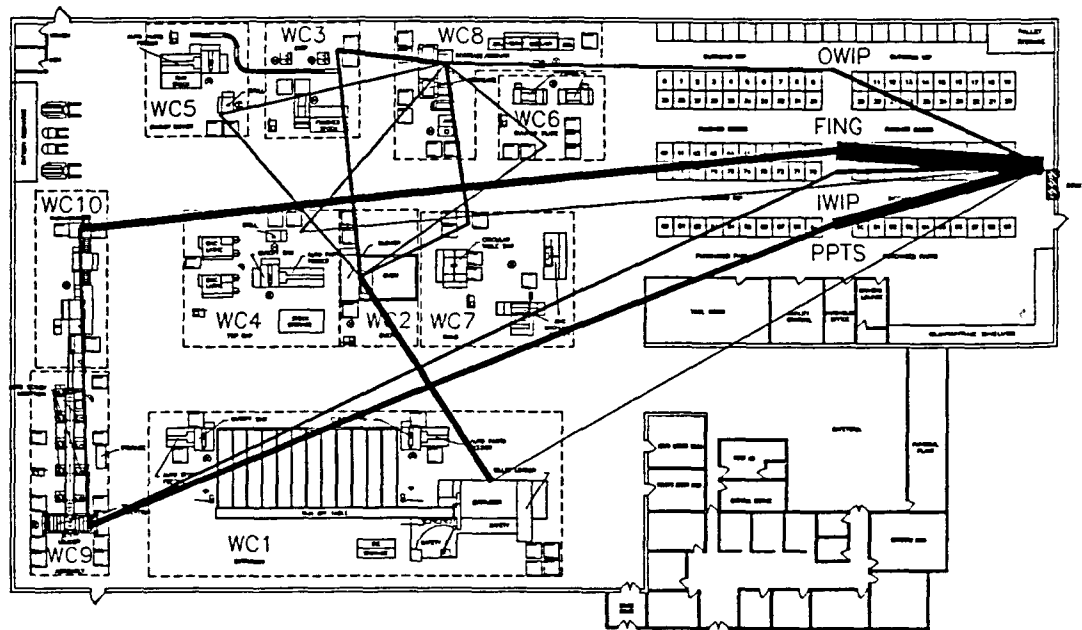
If the workcenter points have been defined, DRWCOMP: asks whether you want to redefine them.

Redefine workcenter points <NO>:

If you choose yes, DRWCOMP: will ask you to pick workcenter points, then ask for the path thickness scale. If you choose no, DRWCOMP: immediately asks for the path thickness scale.

Path thickness scale (Dollars/Foot/Inch) <DEFAULT>:

Type a value for the the scale and press <Return>, or simply press <Return> to accept the default value. See the CALC: command on page 121 for a discussion of the path thickness scale. PRODFLOW: will then draw the product flow lines. The example below shows a Composite Flow Diagram.



By examining the relative thickness of the composite product flow lines, you can determine high cost per foot product flows. The thicknesses indicate which workcenters should be close to each other based on the material handling cost between them.

DELCOMP:

FACTFLOW
* * * * *
DRWCOMP:
DELCOMP:
REDRAW:

ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

DELCOMP: deletes all the composite flow lines from the composite layer. To clear the composite layer, pick DELCOMP: from the COMPANAL menu.

-->DELCOMP:

DELCOMP: deletes the composite flow lines and returns you to the command prompt.

REDRAW:

FACTFLOW
* * * * *
DRWCOMP:
DELCOMP:
REDRAW:

ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

REDRAW: executes the AutoCAD REDRAW command. REDRAW: cleans up the screen by removing unwanted "blips" and by redrawing objects that were partially erased due to editing of other objects. To redraw the screen, pick REDRAW: from the COMPANAL menu.

-->REDRAW:

REDRAW: redraws the screen and returns you to the command prompt.

CHARTS Menu

```
FACTFLOW
*****
FFSETUP

RUN

CHARTS
-----
LIST

PRINT

PLOT

SAVE:

END:

EXIT:
  ACAD
```

```
FACTFLOW
*****
PQCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

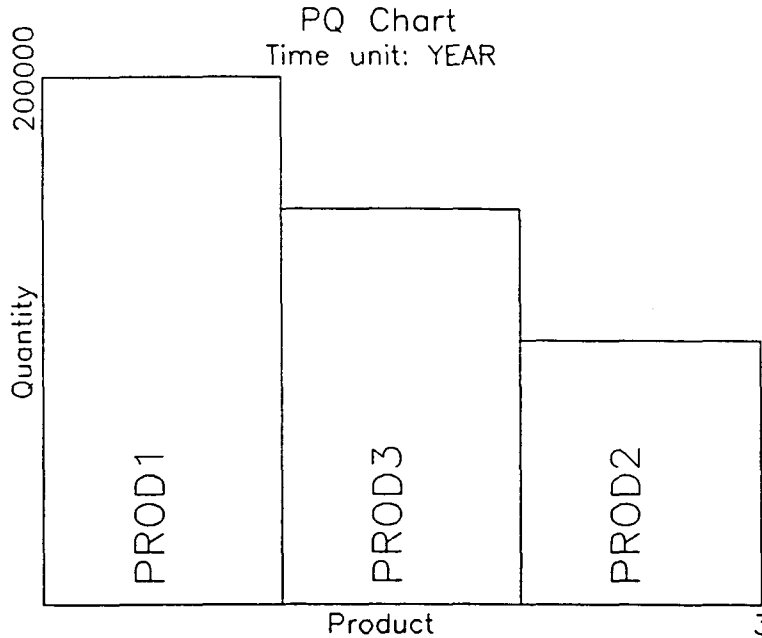
ZOOM W:
ZOOM P:
PAN:
  _LAST_
```

The CHARTS menu contains commands you can use to create Product-Quantity (PQ) and Distance-Intensity (DI) charts. A PQ Chart is a bar chart of your products versus their production quantities per unit time. A DI Chart is an xy graph with data points showing material handling paths' distances versus their intensities. PT ATT: allows you to look at the data behind each point on the DI Chart.

PQCHART is only a label, not a command or the name of a menu.
GEN PQ: generates a Product-Quantity file.
PLT PQ: draws the Product-Quantity Chart.
DICHART is only a label, not a command or the name of a menu.
GEN DI: generates a Distance-Intensity file.
PLT DI: draws the Distance-Intensity Chart.
PT ATT: allows you to look at the data behind each point on the DI Chart.

PQCHART

PQCHART is only a label, not a command or the name of a menu. If you pick PQCHART from the menu, you'll be prompted to pick GEN PQ: or PLT PQ: . Below is an example of a Product-Quantity Chart.



GEN PQ:

```

FACTLOW
*****
PQCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__
    
```

GEN PQ: generates a Product-Quantity file. You must create the Product-Quantity file before picking PLT PQ: to produce a Product-Quantity Chart. To generate a Product-Quantity file, pick GEN PQ: from the CHARTS menu.

-->GEN PQ:

GEN PQ: first asks for the name of the Products file you want to use.

Products file <DEFAULT>:

Type the name of the file you want and press <Return>, or simply press <Return> to accept the default file name. GEN PQ: next asks for the name you want to assign to the Product-Quantity file. GEN PQ: will automatically add a .PQC file name extension.

Product-quantity file <DEFAULT>:

GEN PQ: then generates the file. Below is an example of a PQ file.

```

BAR
PQ Chart
Time unit: YEAR
Product
Quantity
3
100000.00
PROD1 100000.00
PROD3 80000.00
PROD2 50000.00

```

After generating the file, GEN PQ: returns you to the command prompt.

PLT PQ:

```

FACTFLOW
*****
PQCHART
GEN PQ:
PLT PQ:

```

```

DICHART
GEN DI:
PLT DI:
PT ATT:

```

```
ZOOM V:
```

```
ZOOM W:
ZOOM P:
PAN:
```

```
__LAST__
```

PLT PQ: draws the Product-Quantity Chart and places it on your drawing. A Product-Quantity Chart is a bar chart of your products versus their production quantities per unit time. You must have created a PQ file with GEN PQ: before you can use PLT PQ: . To draw the Product-Quantity Chart, pick PLT PQ: from the CHARTS menu.

--> PLT PQ:

PLT PQ: first asks for the name of the Product-Quantity file.

Product-quantity file <DEFAULT>:

Type the name of a Product-Quantity file created with GEN PQ: and press <Return>, or simply press <Return> to accept the default response.

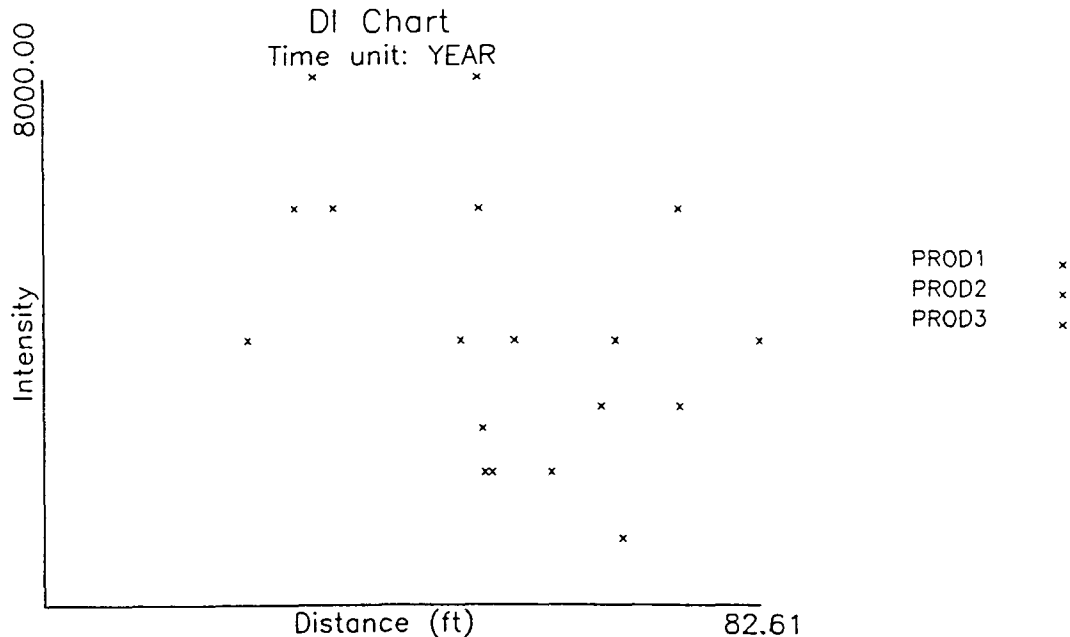
PLT PQ: prompts you to pick a point on your drawing for the start point of the chart. The chart will be drawn to a size which will let you plot FULL scale to an 8½x11 inch sheet. The start point is 0.5 inches left and 0.5 inches below the origin of the chart.

Select start point for product-quantity graph:

PLT PQ: draws the chart. You will probably need to zoom up on the graph to be able to read it.

DI CHART

DI CHART is only a label, not a command or the name of a menu. If you pick DI CHART from the menu, you'll be prompted to pick GEN DI: or PLT DI: . Below is an example of a Distance-Intensity Chart.



GEN DI:

FACTLOW

PQCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

GEN DI: generates the Distance-Intensity file. You must create the Distance-Intensity file before picking PLT DI: to produce a Distance-Intensity Chart. To generate a Distance-Intensity file, pick GEN DI: from the CHARTS menu.

—>GEN DI:

GEN DI: first checks for unsaved path changes. If you have unsaved path changes when you pick GEN DI:, GEN DI: will tell you to go to the FactoryFLOW Main Menu and pick SAVE: before using GEN DI:. If there have been no changes since you last saved, GEN DI: asks for the name of the data files.

Products file <DEFAULT>:
Parts file <DEFAULT>:
Paths file <DEFAULT>:

Type the names of the files and press <Return>, or simply press <Return> to accept default names. GEN DI: next asks for the name you want to assign to the Distance-Intensity file.

Distance-intensity file <DEFAULT>:

Type the name of the file and press <Return>, or simply press <Return> to accept the default response. GEN DI: will add a .DIC extension to the file name.

GEN DI: next asks whether you want to include all products in the Distance-Intensity file.

Include all products <YES>:

If you choose YES, all products will be included in the DI Chart. If you choose NO, GEN DI: will ask you for the products you want to include.

Product name <DONE>:

Type the product names, pressing <Return> after each name. GEN DI: will keep asking for product names until you accept the default response, DONE.

Once you've designated which products to include, GEN DI: generates the Distance-Intensity file, then returns you to the command prompt. Following is an example of a Distance-Intensity file.

```
XY
DI Chart
Time unit: YEAR
Distance
Intensity
PROD1 CYAN
58.69 2000.00 PART1 ASSEMBLY SHIPPING MH1
48.31 4000.00 PART11 MILL ASSEMBLY MH2
51.84 2000.00 PART12 BROACH ASSEMBLY MH2
54.47 4000.00 PART13 RECEIVING ASSEMBLY MH1
50.31 8000.00 PART111 ROBOT MILL MH2
23.36 4000.00 PART112 RECEIVING MILL MH2
31.22 8000.00 PART121 RECEIVING BROACH MH2
82.61 4000.00 PART1111 RECEIVING ROBOT MH2
PROD2 WHITE
65.95 4000.00 PART2 ASSEMBLY SHIPPING MH1
51.04 2000.00 PART21 MILL ASSEMBLY MH2
66.71 1000.00 PART22 RECEIVING ASSEMBLY MH1
50.74 2666.67 PART211 RECEIVING MILL MH1
PROD3 MAGENTA
73.38 3000.00 PART3 ASSEMBLY SHIPPING MH1
73.25 6000.00 PART31 LATHE ASSEMBLY MH2
50.41 6000.00 PART32 BROACH ASSEMBLY MH2
64.35 3000.00 PART33 RECEIVING ASSEMBLY MH1
33.45 6000.00 PART311 RECEIVING LATHE MH2
28.90 6000.00 PART321 RECEIVING BROACH MH2
82.61
8000.00
```

PLT DI:

FACTFLOW

PQCHART
GEN PQ:
PLT PQ:

DICHART
GEN DI:
PLT DI:
PT ATT:

ZOOM V:

ZOOM W:
ZOOM P:
PAN:
__LAST__

PLT DI: draws the Distance-Intensity Chart. The DI Chart is an xy chart with data points showing material handling distances versus material handling intensities. You must have generated the Distance-Intensity file with GEN DI: before using PLT DI: . To draw the Distance-Intensity Chart, pick PLT DI: from the CHARTS menu.

-->PLT DI:

PLT DI: first asks for the name of the Distance-Intensity file.

Distance-intensity file <DEFAULT>:

Type the name of the Distance-Intensity file and press <Return>, or simply press <Return> to accept the default response.

PLT DI: prompts you to pick a point on your drawing for the start point of the chart. The chart will be drawn to fit an 8½ x 11 inch sheet when plotted FULL scale. The start point is 0.5 inches left and 0.5 inches below the origin of the chart.

Select start point for distance-intensity graph:

Select a point on the drawing for the chart. After you select a point, PLT DI: draws the chart, then returns you to the command prompt. You will probably need to zoom up on the chart to be able to read it.

PT ATT:

FACTFLOW

* * * *

PQCHART

GEN PQ:

PLT PQ:

DICHART

GEN DI:

PLT DI:

PT ATT:

ZOOM V:

ZOOM W:

ZOOM P:

PAN:

__LAST__

PT ATT: shows you the point attribute data associated with points on a DI Chart. To display data associated with a point on a DI Chart, pick PT ATT: from the CHARTS menu.

-->PT ATT:

PT ATT: first asks you to select a point to query.

Select distance-intensity point to query:

After you pick a point, PT ATT: displays data associated with the point. Following is an example data display.

Product: PROD 2
 Part: PART21
 From Workcenter: MILL
 To Workcenter: ASSEMBLY
 Material Handling Device: MH2

Distance (ft): 50.83
 Intensity: 2000.00

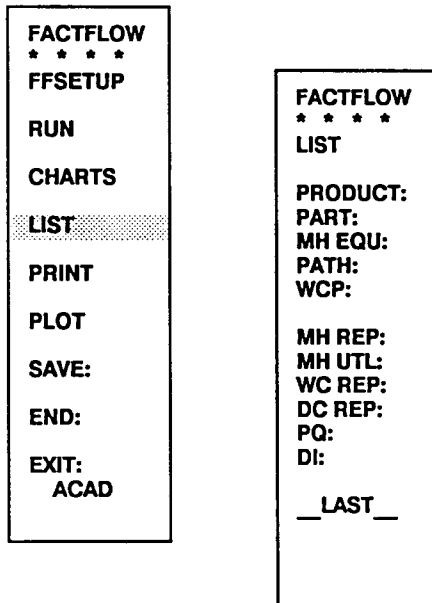
Press RETURN to continue.

Press <Return> when you're through looking at the display. PT ATT: then asks whether you want to query another point.

Query another distance-intensity point <YES>:

If you choose YES, PT ATT: begins again. If you choose NO, PT ATT: returns you to the command prompt.

LIST Menu



The LIST menu contains commands that list (display) FactoryFLOW files on the text screen.

LIST is only a label, not a command.

PRODUCT: lists a Products file.

PART: lists a Parts file.

MH EQU: lists a Material Handling Equipment file.

PATH: lists a Paths file.

WCP: lists a Workcenter Points file.

MH REP: lists a Material Handling Cost Report file.

MH UTL: lists a Material Handling Utilizations file.

DC REP: lists a Distance-Cost Report file.

PQ: lists a Product-Quantity file.

DI: lists a Distance-Intensity file.

FACTFLOW
* * * *
LIST
PRODUCT:
PART:
MH EQU:
PATH:
WCP:
MH REP:
MH UTL:
WC REP:
DC REP:
PQ:
DI:
__LAST__

To display a file, pick its respective command from the LIST menu.

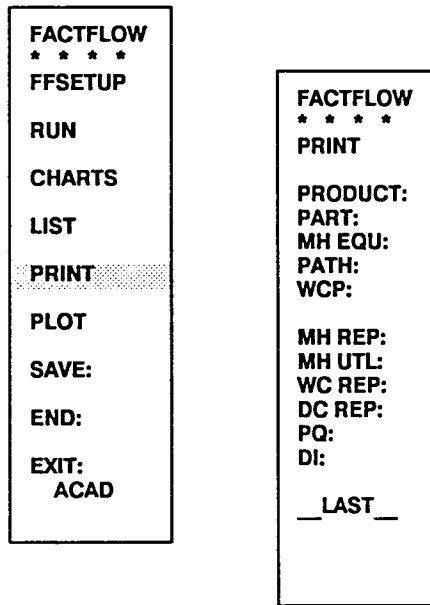
-->PRODUCT: (or any LIST Menu command)

The LIST command will ask for the name of the file to display.

File name <DEFAULT>:

After you name the file, FactoryFLOW displays the requested file one page at a time. Press <Return> to go to the next page. After the last page of the file has been displayed, pressing <Return> will return you to the command prompt.

PRINT Menu



The PRINT menu contains commands that print FactoryFLOW files.

PRINT is only a label, not a command.

PRODUCT: prints a Products file.

PART: prints a Parts file.

MH EQU: prints a Material Handling Equipment file.

PATH: prints a Paths file.

WCP: prints a Workcenter Points file.

MH REP: prints a Material Handling Cost Report file.

MH UTL: prints a Material Handling Utilizations file.

DC REP: prints a Distance-Cost Report file.

PQ: prints a Product-Quantity file.

DI: prints a Distance-Intensity file.

```
FACTFLOW
*****
PRINT
PRODUCT:
PART:
MH EQU:
PATH:
WCP:

MH REP:
MH UTL:
WC REP:
DC REP:
PQ:
DI:

  _LAST_
```

To print a file, pick its respective command from the PRINT menu.

--> **PRODUCT:** (or any PRINT Menu command)

The PRINT command will ask for the name of the file to print.

File name <DEFAULT>:

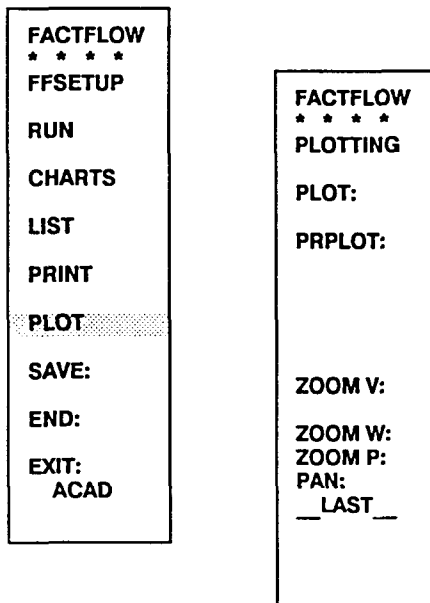
FactoryFLOW will next ask you to enter the printer device.

Enter Printer Device <LPT1:>

Type the name of your printer device and press <Return>, or press <Return> to accept the default response, LPT1. If your printer is connected to your first parallel port, then the device name should be LPT1. If you have a serial printer connected to your first serial port, then device name will be COM1.

After sending the file to the printer device, the PRINT command will return you to the command prompt.

PLOT Menu



When you pick PLOT from the FactoryFLOW Main Menu, FactoryFLOW warns you that plotting will return you to the AutoCAD Menu. After plotting, you must pick FACTFLOW from the AutoCAD menu to return to FactoryFLOW.

Plotting will return you to the AutoCAD main menu.
 You **MUST** pick FACTFLOW from AutoCAD main menu after plotting.
 If you wish to abort this operation, pick either FACTFLOW or LAST in next menu.

Press RETURN to continue

Press <Return> to continue. FactoryFLOW will then display the PLOT menu.

The PLOT menu contains commands that plot or printer plot the drawing.

PLOTTING is only a label, not a command.

PLOT: is the same as the AutoCAD PLOT command.

PRPLOT: is the same as the AutoCAD PRPLOT command.

To abort the plotting operation, pick FACTFLOW or __LAST__ from the PLOT menu.

PLOT: and PRPLOT:

FACTFLOW * * * * PLOTTING
PLOT:
PRPLOT:
ZOOM V:
ZOOM W:
ZOOM P:
PAN:
__LAST__

PLOT: and PRPLOT: execute AutoCAD's PLOT and PRPLOT commands. Refer to the AutoCAD manual for information on the PLOT and PRPLOT commands.

SAVE:

FACTFLOW
* * * *
FFSETUP
RUN
CHARTS
LIST
PRINT
PLOT
SAVE:
END:
EXIT:
ACAD

SAVE: saves the Material Handling Paths, Workcenter Points, and Drawing files. The three files are saved under the same name but with different extensions; this way each filename set represents a layout/material handling design alternative. To save the Material Handling Paths, Workcenter Points, and Drawing files, pick SAVE: from the FACTFLOW menu.

--> SAVE:

SAVE: loads and asks for the name to save the files under.

File name <DEFAULT>:

Type a name and press <Return>, or simply press <Return> to accept the default response. SAVE: checks the current directory to see whether a drawing file with the name already exists.

If the file does not already exist, SAVE: saves the Paths, Workcenter Points, and drawing files, and returns you to the command prompt.

Saving paths file FILENAME.
 Saving workcenter points file FILENAME.
 Saving drawing file FILENAME.

If the file already exists, SAVE: warns you and asks whether you want to overwrite the file.

File FILENAME already exists! Overwrite file (Yes/No):

If you choose YES, SAVE: saves the Paths, Workcenter Points, and Drawing as above. If you choose NO, nothing is saved and you're returned to the command prompt

END:

```
FACTFLOW
*****
FFSETUP
```

```
RUN
```

```
CHARTS
```

```
LIST
```

```
PRINT
```

```
PLOT
```

```
SAVE:
```

```
END:
```

```
EXIT:
ACAD
```

END: saves the current drawing and exits FactoryFLOW and AutoCAD. If you have unsaved changes to the Paths, Workcenter Points, or drawing files, **END:** asks you for a file name to save the changes to.

--> **END:**

END: first checks for unsaved changes to the Paths, Workcenter Points, and Drawing files.

If there are no unsaved changes, END: ends the session with the AutoCAD **END** command. That is, **END:** saves the drawing and quits the drawing editor; the Paths and Workcenter Points files remain unchanged.

If there are unsaved changes, FactoryFLOW warns you and asks whether you really want to end without saving changes.

There are some unsaved changes!!!
Do you want to end without saving changes <NO>:

If you choose **YES**, **END:** ends the session as if there were no unsaved changes. If you choose **NO**, **END:** asks you for the file name.

File name <DEFAULT>:

Type the file name and press <Return>, or simply press <Return> to accept the default response. **END:** then checks the current directory for a drawing file with the same name.

If no other drawing file with the same name exists, END: saves the Paths, Workcenter Points, and Drawing files, then quits the drawing editor.

Saving paths file FILENAME.
Saving workcenter points file FILENAME.
Saving drawing file FILENAME.

If a drawing file with the same name exists, END: warns you and asks whether you want to overwrite the file.

File FILENAME already exists! Overwrite file (YES/NO):

If you choose **YES**, **END:** saves the three files as above. If you choose **NO**, **END:** asks whether you want to try saving the changes again.

Do you want to try saving changes again <YES>:

If you choose YES, END: starts the save procedure again by asking for the file name as above.
If you choose NO, END: ends the session with the AutoCAD END command without saving the Paths and Workcenter Points files.

If you want to discard all changes, use the AutoCAD QUIT command.

EXIT:

```
FACTFLOW
*****
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT

SAVE:

END:

EXIT:
ACAD
```

EXIT: checks for unsaved changes, allows you to save changes if any, then exits FactoryFLOW; you remain in the AutoCAD drawing editor. To exit the FactoryFLOW session but stay in the drawing editor, pick EXIT: from the FACTFLOW screen menu.

-->EXIT:

EXIT: first checks for unsaved changes to the Paths, Workcenter Points, and Drawing files.

If there are no unsaved changes, EXIT: exits FactoryFLOW but stays in the drawing editor.

If there are unsaved changes, EXIT: warns you and asks whether you want to exit without saving changes.

```
There are some unsaved changes!!!
Do you want to exit without saving changes <NO>:
```

If you choose YES, EXIT: exits FactoryFLOW without saving the changes. If you choose NO, END: asks you for the file name.

File name <DEFAULT>:

Type the file name and press <Return>, or simply press <Return> to accept the default response. EXIT: then checks the current directory for a drawing file with the same name.

If no other drawing file with the same name exists, EXIT: saves the Paths, Workcenter Points, and Drawing files, then exits FactoryFLOW.

```
Saving paths file FILENAME.
Saving workcenter points file FILENAME.
Saving drawing file FILENAME.
```

If a drawing file with the same name exists, EXIT: warns you and asks whether you want to overwrite the file.

File FILENAME already exists! Overwrite file (YES/NO):

If you choose YES, EXIT: saves the three files as above. If you choose NO, EXIT: asks whether you want to try saving the changes again.

Do you want to try saving changes again <YES>:

If you choose YES, EXIT: starts the save procedure again by asking for the file name as above. If you choose NO, EXIT: exits FactoryFLOW without saving the changes; you remain in the AutoCAD drawing editor.

ACAD

```

FACTFLOW
*****
FFSETUP

RUN

CHARTS

LIST

PRINT

PLOT

SAVE:

END:

EXIT:
ACAD
    
```

ACAD takes you to the main AutoCAD screen menu. To go to the AutoCAD menu, pick ACAD from the FACTFLOW menu.

-->ACAD

The AutoCAD menu is displayed, and a message appears reminding you to pick FACTFLOW to return to the FactoryFLOW Main Menu.

When done using the AutoCAD menu, please pick FACTFLOW.

```

AUTOCAD
*****
SETUP

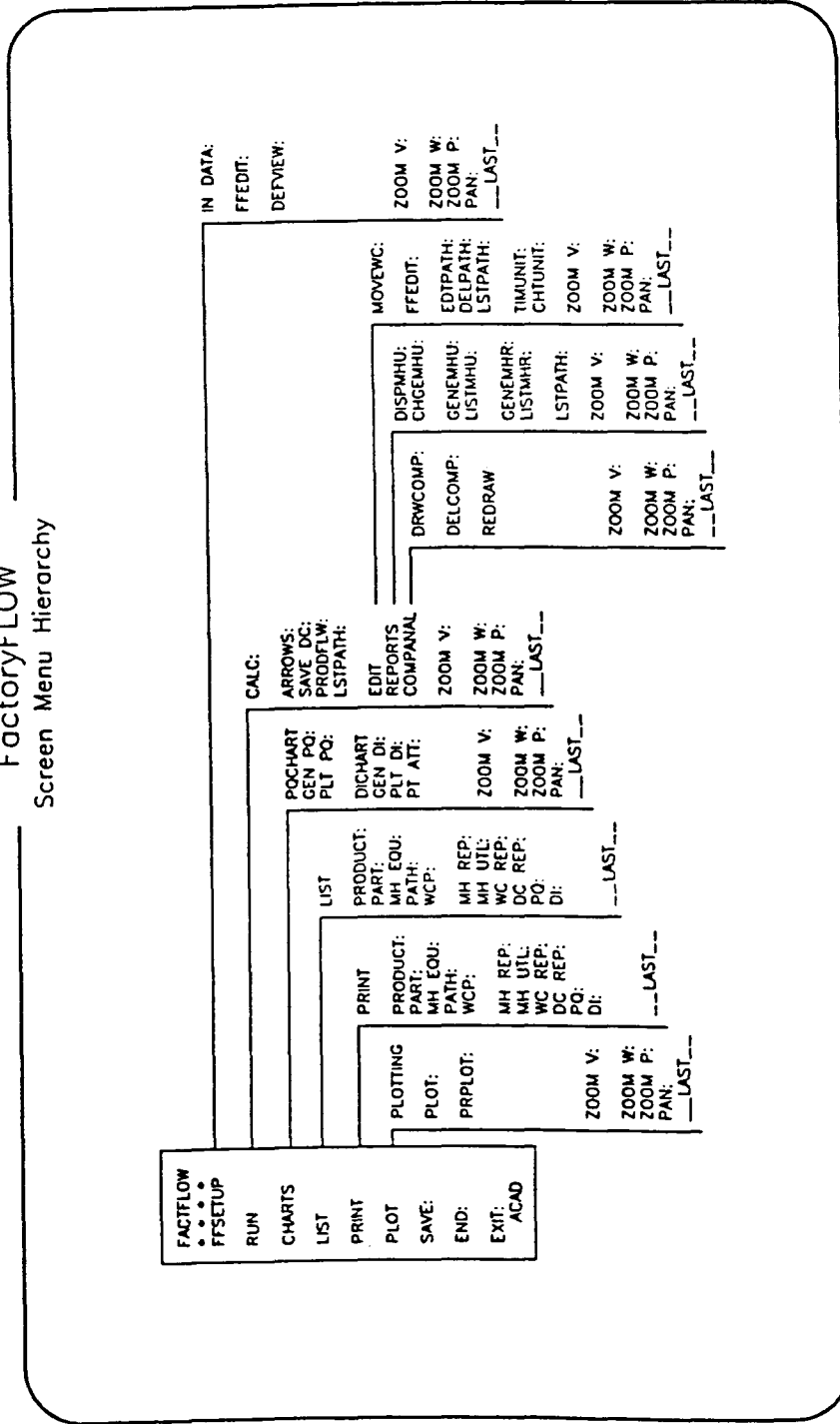
BLOCKS
DIM:
DISPLAY
DRAW
EDIT
INQUIRY
LAYER:
SETTINGS
PLOT
UCS:
UTILITY

FACTFLOW

3D
SAVE:
    
```


Appendix A FactoryFLOW Menu Tree Diagram

FactoryFLOW
Screen Menu Hierarchy



Appendix B Technical Information

Technical information provided in this appendix is separated into three categories: How FactoryFLOW interacts with your computing environment, How FactoryFLOW interacts with AutoCAD, and a List of FactoryFLOW program and data files. The three categories are subdivided as shown below.

How FactoryFLOW interacts with your computing environment

- FactoryFLOW batch file FACTFLOW.BAT
- Program Parameters file ACAD.PGP
- Configuration file CONFIG.SYS
- Using ACAD.LSP and other AutoLISP programs with FactoryFLOW

How FactoryFLOW interacts with AutoCAD

- AutoCAD system variables and undefined commands in FactoryFLOW
- Entity handles with FactoryFLOW
- FactoryFLOW layer specifications

List of FactoryFLOW program and data files

- FactoryFLOW program files
- FactoryFLOW data, drawing, and report files

How FactoryFLOW interacts with your computing environment

When you install FactoryFLOW, the INSTALL program creates a batch file called FACTFLOW.BAT, adds five external commands to the ACAD.PGP file, and adds two configuration commands to the CONFIG.SYS file if you accept the option to update your CONFIG.SYS file.

FactoryFLOW Batch File FACTFLOW.BAT

The FACTFLOW.BAT file is used for starting FactoryFLOW. The INSTALL program creates and places one copy of this file in the USER file directory and another copy in a directory on your DOS search path. To start FactoryFLOW type FACTFLOW and press <Return> or type FACTFLOW followed by the drawing name and press <Return>. Specifying a drawing name is optional.

```
C:\USER> FACTFLOW [default drawing name] <Return>
```

Since FACTFLOW.BAT is in a directory on your search path, DOS will find FACTFLOW.BAT from any directory. However, FactoryFLOW searches only the current directory for drawing and data files. Therefore, you need to make the directory containing your drawing and data files your current directory before you type FACTFLOW.

The INSTALL program customizes the FACTFLOW batch file for your system. AutoCAD 386 and DOS AutoCAD require very different versions of FACTFLOW.BAT.

Below are the two versions of the FACTFLOW.BAT file. Please note that any word in parenthesis represents a path. For example, (AutoCAD) represents a path to AutoCAD like C:\ACAD.

FACTFLOW.BAT for AutoCAD 386

```
(FactoryFLOW)\ffsv386 (FactoryFLOW)
SET PATH=(Path at installation)+(FactoryFLOW)
SET ACAD=(FactoryFLOW)
(AutoCAD)\acad %1 %2
(FactoryFLOW)\savenv
```

FACTFLOW.BAT for DOS AutoCAD

```
(FactoryFLOW)\ffsvenv (FactoryFLOW)
SET LISPHEAP=
SET LISPSTACK=20000
SET ACADFREERAM=24
SET PATH=(Path at installation)+(FactoryFLOW)
SET ACAD=(FactoryFLOW)
(AutoCAD)EXTLISP
(AutoCAD)\ACAD %1 %2
(FactoryFLOW)\savenv
```

When you start FactoryFLOW, the FACTFLOW batch file calls the FFSV386 or FFSVENV program in the FactoryFLOW program directory. These programs read the current value of the DOS environment variables used by FactoryFLOW and saves them in the batch file SAVENV. These variables are LISPHEAP, LISPSTACK, ACADFREERAM, ACAD, and PATH.

FACTFLOW.BAT then sets the DOS variables LISPHEAP, LISPSTACK, ACADFREERAM, ACAD, and PATH to the required FactoryFLOW values. LISPHEAP, LISPSTACK, or ACADFREERAM are not used or set for the AutoCAD 386 version FactoryFLOW. Following is an explanation of each environment variable.

LISPHEAP and **LISPSTACK** reserves memory for use by AutoLISP programs on a standard DOS AutoCAD system. Since DOS FactoryFLOW requires Extended AutoLISP, the **LISPHEAP** variable is removed from the environment. The **LISPSTACK** variable is set to 20000 bytes. If, while running FactoryFLOW, you are receiving a "LISPSTACK overflow" error, you should edit the FACTFLOW.BAT file with a text editor to increase the **LISPSTACK** variable. **LISPSTACK** must be set before loading EXTLISP.

ACADFREERAM controls the size of the space reserved for working storage in memory if you are using standard DOS AutoCAD.

ACAD tells AutoCAD which drive and directory to search for FactoryFLOW files. It is important that your AutoCAD support files are in the AutoCAD program directory since FactoryFLOW needs the **ACAD** variable to point to the FactoryFLOW program and support files.

PATH sets a DOS search path to include the path to FactoryFLOW files in addition to your path at the time of installation.

On standard DOS AutoCAD systems, FACTFLOW.BAT then loads Extended AutoLISP by calling the EXTLISP program. Again, LISPSTACK must be set before loading EXTLISP. AutoCAD 386 does not use Extended AutoLISP.

FACTFLOW.BAT then starts AutoCAD from the current directory. You have the option of passing in a drawing name and a script name.

When exiting AutoCAD, FACTFLOW.BAT resets all environment variables to your original settings by calling the SAVENV batch file before returning you to the DOS system prompt.

Program Parameters File ACAD.PGP

The INSTALL program defines five FactoryFLOW external commands by adding the following lines to your ACAD.PGP file in your AutoCAD program directory. For an explanation of the programs, refer to the FactoryFLOW program files section in this appendix. For a complete explanation of external commands, refer to Appendix B.9 in the AutoCAD reference manual.

```
FFEDIT,FFEDIT,200000,File name: ,4
PQCHART,PQCHART,150000,File name: ,4
DICHART,DICHART,150000,File name: ,4
VPRINT,VPRINT,150000,File to print: ,4
REPGEN,REPGEN,150000,File name: ,4
```

These five external commands are added to your ACAD.PGP file every time you install FactoryFLOW. If you have installed FactoryFLOW more than once, you may use a text editor to delete the extra lines from your ACAD.PGP file.

Reinstalling AutoCAD will overwrite your ACAD.PGP file. You will need to add these five lines to your ACAD.PGP file by reinstalling FactoryFLOW (or by using a text editor).

Configuration File CONFIG.SYS

If you choose the option to update your CONFIG.SYS file at the time of installation, INSTALL will add the two configuration commands SHELL and FILES. If you chose not to have INSTALL modify CONFIG.SYS, you must insure that these configuration commands are set to at least the following values:

```
SHELL=C:\COMMAND.COM /p /e:512
FILES=40
```

SHELL is used to tell DOS to expand its environment space beyond its default size. The environment space is used to store the DOS path and other set statements you make. AutoCAD and FactoryFLOW require the use of several set statements. This SHELL line in your CONFIG.SYS file establishes an environment of 512 bytes to be sure that you have enough room for all of the set statements. NOTE: if you are using DOS version 3.0 or 3.1, the number 512 should be changed to 32.

FILES is used to tell DOS the maximum number of files that can be opened concurrently. The setting should be 40 for AutoCAD386 and 20 for DOS AutoCAD.

These settings for **SHELL** and **FILES** should be considered minimum. If your system already sets **SHELL** and **FILES** to larger values, you do not need to update your **CONFIG.SYS** file.

If you edit **CONFIG.SYS**, either with **INSTALL** or by another method, you must reboot your computer to accept the new configuration. The **CONFIG.SYS** file is read each time you boot your computer.

Using **ACAD.LSP** and Other AutoLISP Programs with **FactoryFLOW**

If you are loading AutoLISP programs, either automatically with **ACAD.LSP** or manually, you must make sure they do not use the **VMON** function. Any AutoLISP file containing **VMON** (virtual function paging) will conflict with **FactoryFLOW**. You can easily remove all the **VMON** calls with a text editor or a word processor. Since **FactoryFLOW** requires Extended memory, **VMON** is not needed. You can still use your customized AutoLISP functions (without **VMON**) if they are defined before starting **FactoryFLOW**.

FactoryFLOW uses three memory cleaning routines. Each **CLEAN** routine removes from the **ATOMLIST** all functions and variables defined after it. The **CLEAN** routines work on different levels. For example, **CLEAN1** removes all the **FactoryFLOW** functions and variables.

VMON can not be used in any AutoLISP programs that run concurrently with **FactoryFLOW**. This is because **VMON** rearranges the **ATOMLIST**, making it impossible for the cleaning functions to operate properly.

How **FactoryFLOW** interacts with AutoCAD

FactoryFLOW sets specific AutoCAD system variables, undefines some commands, and uses entity handles and layers.

AutoCAD system variables and undefined commands

When you start **FactoryFLOW** by picking **FACTFLOW** from the screen menu, **FactoryFLOW** sets some AutoCAD system variables and undefines some AutoCAD commands. The system variables need to be set for the proper operation of **FactoryFLOW**. The following is a listing of the AutoCAD system variables used by **FactoryFLOW**, including their values, and meanings.

Variable	Value	Meaning
CMDECHO	0	Command echo OFF.
MENUECHO	5	Menu echo OFF and ^P disabled.
DRAGMODE	2	Auto dragging.
COORDS	2	Distance and angle from last point displayed.

SNAPMODE	1	Snap ON.
LIMCHECK	0	Limits checking OFF.
EXPERT	2	Suppress certain "are you sure" prompts.
LUPREC	2	2 decimal places for linear units.
BLIPMODE	0	Marker blips off.
HIGHLIGHT	1	Object selection highlighting ON.
FLATLAND	1	Set FLATLAND ON.
HANDLES	1	Entity handles ON.
CECOLOR	"BYLAYER"	Entity color BYLAYER.
CELTYPE	"BYLAYER"	Entity linetype BYLAYER.
LUNITS	3	Engineering linear units.

Some of the AutoCAD commands might cause serious problems if used with FactoryFLOW. An example is AutoCAD's END command. AutoCAD's END command will save the drawing but will NOT save any changes affecting the paths and workcenter points, resulting in a drawing that does not match the paths and workcenter points files. To protect the user from committing such an error, the AutoCAD END command is undefined. The AutoCAD commands that are undefined while in FactoryFLOW are: PLOT, PRPLOT, SAVE, END, and MENU.

Entity Handles with FactoryFLOW

FactoryFLOW uses AutoCAD entity handles to link the polylines representing the material handling paths to the Paths file. Each material handling path is an AutoCAD polyline with thickness proportional to the cost per foot of material handling.

When a material handling path is generated with the CALC: command, a polyline is drawn and its entity name is stored in the EDGELIST. The EDGELIST is an AutoLISP list containing the path entity name, path distance, from and to workcenters, and product names.

The material handling paths must not be deleted with the AutoCAD ERASE command; the FactoryFLOW DELPATH: command should be used instead. This is because deleting a material handling path with the AutoCAD ERASE command deletes the entity from the drawing database but does NOT remove it from the EDGELIST.

When leaving FactoryFLOW, the EDGELIST is saved to the Path file. The Path file contains the same information as the EDGELIST except the entity names are substituted for the entity handles.

The next time FactoryFLOW is called, the Path file is read automatically and the polylines are directly linked to their corresponding material handling paths.

FactoryFLOW layer specifications

FactoryFLOW uses AutoCAD layers to organize the information in your drawing. The layers are added to the drawing as needed. You can take advantage of the FactoryFLOW layers organization to display different information. For example, you can look at a Product Flow Diagram one product at a time by turning all product flow layers OFF except the layer

corresponding to the desired product. Refer to the AutoCAD manual if you are unfamiliar with the LAYER command.

Each product's material handling paths are placed on a separate layer; the name of the layer is the same as the product name, and the layer color is the product path color.

All Composite Flow Diagrams are placed on the COMPOSITE layer. It is possible to have more than one Composite Flow Diagram displayed at the same time. Each diagram has its own color specification.

The elements of the Product-Quantity (PQ) and Distance-Intensity (DI) Charts are placed on specific layers.

The x and y axes and chart headings of both PQ and DI Charts are placed on the CHART layer, whose color is red.

The bars of the PQ Chart are placed on the DATA layer, whose color is yellow.

The data points of the DI Chart are placed on individual layers, each layer containing the points for only one product. The layer name is C followed by the name of the product (for example, CPROD1). The layer color is the same as the product path color.

List of FactoryFLOW program and data files

The source code for FactoryFLOW's AutoLISP routines and menus have been included unprotected to help you understand how the program works and to enable you to make changes if you wish. Following is a list of the program files and an explanation of what they are. A list of FactoryFLOW data, drawing, and report file extensions concludes the technical information appendix.

FactoryFLOW program files

The FactoryFLOW program is written mostly in AutoLISP. Some of the input and output areas have been coded in C as listed below. All AutoLISP routines have the prefix VAL.

Files in the program directory (default=C:\FACTFLOW):

FACTFLOW.MNU	FactoryFLOW menu.
FACTFLOW.MNX	Compiled FactoryFLOW menu.
VAL21.LSP	Product-Quantity and Distance-Intensity Chart routines. Defined functions: POCHART, GENDI, DICHART, OFFSET, and PATT.
VAL300.LSP	Start routine.
VAL301.LSP	Memory cleaning routine. Defined function: CLEAN1.

VAL311.LSP	Set-up, read paths and workcenter points routines. Defined functions: PARTSTRING, *ERROR*, READDATA, CLEAN2, CLEAN3, SETUP, READPATH, and READWCP.
VAL3211.LSP	Define and zoom view routines. Defined functions: DEFVIEW and SEEVIEW.
VAL3212.LSP	Read, input and save products routines. Defined functions: CLEAN3, A5, PSPROD, A1, A6, ADSPC, and INPROD.
VAL3214.LSP	Read material handling equipment routine. Defined functions: CLEAN3, READMH, and PSMH.
VAL3215.LSP	Read products, parts, and material handling equipment routines. Defined functions: CLEAN3, TA5, PSPROD, TREADPART, PSPART, TREADMH, PSMH, and READTBS.
VAL322.LSP	Read, input, and save parts routines. Defined functions: CLEAN3, PRODS, PED, GOZINTO, CONV1, CONV2, CONV3, ROUTING1, ROUTING2, ROUTING3, PARTS, READPART, PSPART, SAVEPART, ADSPC, and INPART.
VAL3310.LSP	First part of CALC: command. Calculate total distance and time, input material handling equipment, paths, and products, save material handling equipment and products routines. Defined functions: CLEAN3, TOTAL, GETMH, GETPATH, DPLINE, ADPROD, A6, SAVEMH, and ADSP.
VAL3311.LSP	Second part of CALC: command. Calculate total cost, adjust Product Flow Diagrams, and save material handling equipment routines. Defined functions: CLEAN3, CALC, DOLLAR, FT, SAVEMH, and ADSP.
VAL3312.LSP	Arrows routine. Defined functions: CLEAN3, AARROW, and ARROW.
VAL3313.LSP	Display a set of Product Flow Diagrams routine. Defined functions: CLEAN3, PRODFLOW, and PFLOWB.
VAL3314.LSP	Save total travelled distance, total material handling cost, and layout routines. Defined functions: CLEAN3, SAVELAYOUT, DOLLAR, FT, and SVLAYOUT.
VAL3315.LSP	List path routines. Defined functions: CLEAN3, LISTPATH, and APATH.
VAL341.LSP	Move workcenters routine. Defined functions: CLEAN3 and MOVIT.

VAL344.LSP	Edit and erase paths routines. Defined functions: CLEAN3, EDPATH, GETPATH, DPLINE, and ERASEPATH.
VAL345.LSP	Change time unit routines. Defined functions: CLEAN3, CHTIME, A6, SAVEMH, ADSPC, and SAVEPMH.
VAL3513.LSP	Display, change, save, and list material handling utilizations routines. Defined functions: CLEAN3, DMHUTL, CMHUTL, SMHUTL, TYPEDATA, SAVEMH, and ADSPC.
VAL3514.LSP	Simple and advanced material handling reports routines. Defined functions: CLEAN3, GENEMHR1, ADDSPC, TYPEDATA, COMPOSITE, MHCGEN, MHLINE, DOLLAR, FT, GENEMHR2, and GENEMHR.
VAL361.LSP	Composite Flow Diagrams routine. Defined functions: CLEAN, COMPOSITE, DRAWCOMP, DELCOMP, and DRWCOMP.
VAL371.LSP	Plotting routine. Defined functions: CLEAN3, VPLOT, and PLOTBACK.
VAL3710.LSP	Type and print data routines. Defined functions: CLEAN3, TYPEDATA, and PRINTDATA.
VAL3711.LSP	Save paths, workcenter points, and drawing routines. Defined functions: CLEAN3, SAVEPATH, SAVEWCP, SAVEDWG, and SAVEALL.
VAL381.LSP	Ending and exiting routines. Defined functions: CLEAN3, SAVEPATH, SAVEWCP, SAVEDWG, SAVEALL, SETDOWN, and FEND.
VAL3315.LSP	List path routines. Defined functions: CLEAN3, LISTPATH, APATH
FFEDIT.EXE	C program to create and edit Products, Parts, and Material Handling Equipment files.
PQCHART.EXE	C program to create the Product-Quantity file.
DICHART.EXE	C program to create the Distance-Intensity file.
VPRINT.EXE	C program to print files.
REPGEN.EXE	C program to generate advanced material handling reports.
FREQ.SRF	Standard material handling report formats.
TDIST.SRF	
TTIME.SRF	

TCOST.SRF

WC.RPF Custom material handling report formats.

MDIST.RPF

PRODPART.RPF

MHE.RPF

GCODE.RPF

VALDEP.DMH Default material handling equipment parameters.

XPT.DWG Distance-Intensity block symbol.

SVENV.EXE C program to save the current environment variables.

Files in the user directory (default=C:\USER):

ACADADD.PGP External commands added to ACAD.PGP

FACTFLOW.BAT Batch file to start FactoryFLOW.

The following files are used in the FactoryFLOW tutorial.

Tutorial 1. ACME.DWG

Tutorial 2. LADDER1.DWG
 LADDER1.MHE
 LADDER1.PRD
 LADDER1.WCP
 LADDER1.PRT
 LADDER1.PTH

Tutorial 3. SAMPLE.PTH
 SAMPLE.WCP
 SAMPLE.MHU
 SAMPLE.PRT
 SAMPLE.DIC
 SAMPLE.MHE
 SAMPLE.UTL
 SAMPLE.UTR
 SAMPLE.LDC
 SAMPLE.PRD
 SAMPLE.PQC
 SAMPLE.MHR
 SAMPLE.DWG
 SAMPLE.DAT

FactoryFLOW File Extensions

The following is a listing and explanation of the file extensions in FactoryFLOW.

File Extension	Explanation
DWG	Drawing file.
BAK	Backup drawing file.
PRD	Products file.
PRT	Parts file.
MHE	Material Handling Equipment file.
PTH	Paths file.
WCP	Workcenter Points file.
DAT	Intermediate material handling file.
MHR	Material Handling Cost Report file.
MHU	Material Handling Equipment Utilizations file.
UTL	Intermediate Workcenter Utilizations file.
UTR	Workcenter Utilizations file.
LDC	Distance and Cost report file.
PQC	Product-Quantity file.
DIC	Distance-Intensity file.

Appendix D File Formats

FactoryFLOW data is saved in ASCII text files which contain fixed length fields. FactoryFLOW uses five types of files for holding analysis data:

File type	File Name Extension
PRODUCTS	.prd
PARTS	.prt
MATERIAL HANDLING EQUIPMENT	.mhe
PATHS	.pth
WORKCENTER POINTS	.wcp

Each record in the file is on its own line. FFEDIT: can be used to convert files in space delimited format (fields separated by one or more space characters) to the fixed field length format by simply reading the files in and then saving them. The format of the fixed length field format is described in detail below.

In the following file specifications, each file type is described in terms of its file name extension, an example of the data, the fixed length field format, and field descriptions. Each field description contains lines describing the field name and format, description of the contents, and notes on what the field can contain.

NOTE: Each field described below is followed by a space except the last field of each line.

Products File Format - file extension .prd

Example:

```
YEAR
PROD1      10000.00 CYAN
PROD2      50000.00 WHITE
PROD3      80000.00 MAGENTA
```

The first line contains the time unit. The second and all subsequent lines contain three fields, product name, production volume, and path color.

```

      1          2          3          4
1234567890123456789012345678901234567890
Product Name  Volume    Path Color
-----
XXXXXXXXXXXXX 9999999.99 XXXXXXXX
```

Time unit - YEAR, MONTH, WEEK, DAY, or SHIFT

The time unit is the time period that the data in the file represents.

The time unit must be in all capital letters.

Product name - alphanumeric 14 characters maximum

This field is the name of the product.

This field is left justified and may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

Product volume - numeric 10.2 (9999999.99 maximum)

Product volume is the number of this product produced per time unit.

This field contains a number with 2 decimal places right justified in 10 character places.

Product path color - RED, YELLOW, GREEN, CYAN, BLUE, MAGENTA, or WHITE

Path color is the color in which paths for this product will be shown.

Path color must be in all capital letters.

Parts File Format - file extension .prt

Example:

PROD1	PART1	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	50.00	2.00	3.00	C20
PROD1	PART11	2.000	MILL	ASSEMBLY	MH2	100.00	50.00	100.00	1.00	4.00	C20
PROD1	PART1111	4.000	RECEIVING	ROBOT	MH2	200.00	0.00	1.00	0.00	0.00	C21
PROD2	PART2	1.000	ASSEMBLY	SHIPPING	MH1	25.00	100.00	50.00	2.00	5.00	C20
PROD2	PART211	2.000	RECEIVING	MILL	MH1	75.00	0.00	1.00	0.00	0.00	C21
PROD3	PART3	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	80.00	2.00	3.00	C20

NOTE: This file can contain parts in any order but all the parts for a given product must be together as in the example above.

1	2	3	4	5	6	7	8	9	0	1	
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234	Product Name	Part Name	Quantity	From WC	To WC	M.H.	Unit	Lot	Setup	Scrap	Group
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXX	999999.999	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	999999.99	999.99	999999.99	999.99	99.99	XXXXXX

Product name - alphanumeric 14 characters maximum

Product name is the name of the product to which the part belongs.

This field is left justified and may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

Part name - alphanumeric 14 characters maximum

Part name is the name of the part.

This field is left justified and may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

Quantity of parts per product - numeric 10.3 (999999.999 maximum)

Quantity of parts per product is the quantity of the part required to assemble one finished product.

This field is a number with 3 decimal places right justified in 10 character places.

From workcenter - alphanumeric 10 characters maximum

From workcenter is the workcenter the part moves from.

This field is left justified and may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

To workcenter - alphanumeric 10 characters maximum

The to workcenter is the workcenter that the part is moved to.

This field is left justified and may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

Material handling device name - alphanumeric 5 characters maximum

Material handling device name is the name of the material handling device used to move the part.

This field is left justified and may not contain embedded spaces, ", *, or other special characters.

It may contain _, -, and \$.

Number of parts per unit load - numeric 9.2 (999999.99 maximum)

Number of parts per unit load is the quantity of the part moved between workcenters at one time.

This field is a number with 2 decimal places right justified in 9 character places.

NOTE: You may choose not to enter actual data in the next five fields unless you wish to do a workcenter utilizations analysis. However, the fields cannot be blank. If you do not choose to enter actual data, then you must enter dummy values in the fields. If you enter your data with FFEDIT: , the dummy values will be entered for you.

Workcenter setup time - numeric 6.2 (999.99 maximum) dummy value 000.00

Workcenter setup time is the length of time in minutes required to setup the from workcenter to run the part.

This field is a number with 2 decimal places right justified in 6 character places.

Lot size per run - numeric 10.2 (999999.99 maximum) dummy value 0000001.00

Lot size per run is the number of parts produced per run.

This field is a number with 2 decimal places right justified in 10 character places.

Cycle time per part - numeric 6.2 (999.99 maximum) dummy value 000.00

Cycle time is the amount of time in minutes required to machine one part.

This field is a number with 2 decimal places right justified in 6 character places.

Scrap rate - numeric 5.2 (99.99 maximum) dummy value 00.00

Scrap rate is the number of unacceptable parts per run divided by the lot size per run expressed as a percentage.

This field is a number with 2 decimal places right justified in 5 character places.

Group code - alphanumeric 6 characters maximum dummy value 0

Group codes are used to classify paths in order to group them for cost accounting or user-defined purposes in the generated reports.

This field is left justified and may not contain embedded spaces; ", *, or other special characters.

It may contain _, -, and \$.

Material Handling Equipment File Format - file extension .mhe

Example:

```
YEAR
MH1 LIFT_TRUCK      3500  1.00 25.00 100000  1.00 250.00  1.00 70.00
MH2 P.PALLET_TRUCK  1500  1.00 10.00 900000  1.00 150.00  1.00 60.00
```

The first line contains only the time unit for this data. The second and all subsequent lines contain 10 fields, material handling system name, equipment type, investment cost, fuel power and maintenance cost, labor cost, available minutes per time unit, load and unload time, speed, quantity of systems, and the effectiveness percentage.

```

      1         2         3         4         5         6         7         8
1234567890123456789012345678901234567890123456789012345678901234567890
M.H. Device Type   Invest F.P.M.Labor Avail. L & U Speed Qty. Effectiveness
-----
XXXXX XXXXXXXXXXXXXXXX 999999 99.99 99.99 999999 99.99 999.99 99.99 99.99
```

Time unit - YEAR, MONTH, WEEK, DAY, or SHIFT
 Time unit is the unit of time that the data in the file represents.
 This field must be in all capital letters.

Material handling system name - alphanumeric 5 characters maximum
 Material handling system name is the name of the material handling system.
 This field may not contain embedded spaces, ", *, or other special characters. It may contain _, -, and \$.

Material handling equipment type - HAND_TRUCK, M.PALLET_TRUCK, P.PALLET_TRUCK, TRACTOR_TRAILER, LIFT_TRUCK, AGVS, CONVEYOR, or SPECIAL
 Material handling equipment type specifies the type of equipment used for material handling into one of eight pre-defined categories. These categories are hand truck, manual pallet truck, powered pallet truck, tractor trailer, lift truck, automatically guided vehicle, conveyor, or special.
 This field must be in all capital letters and left justified in 15 character places.

Investment cost per time unit - numeric 6.0 (999999 maximum)
 Investment cost is the fixed or investment cost of the material handling equipment per time unit.
 This cost may include operator salaries if the operators are dedicated to this device full time.
 This field is a number with no decimal places right justified in 6 character places.

Hourly fuel, power, and maintenance cost - numeric 5.2 (99.99 maximum)
 Hourly fuel, power, and maintenance cost is the incremental cost in these areas incurred for each hour of use of the material handling system.
 This field is a number with 2 decimal places right justified in 5 character places.

Hourly labor cost - numeric 5.2 (99.99 maximum)
 Hourly labor cost is the cost of labor for 1 hour of use of the material handling system.
 This field is a number with 2 decimal places right justified in 5 character places.

Available minutes per time unit- numeric 6.0 (999999 maximum)

Available minutes is the number of minutes this material handling system will be available per time unit.

This field is a number with no decimal places right justified in 6 character places.

Load and unload time per move - numeric 5.2 (99.99 maximum)

Load and unload time is the sum of the load and unload times in minutes for each move.

This field is a number with 2 decimal places right justified in 5 character places.

Average speed - numeric 6.2 (999.99 maximum)

Average speed is the average speed in feet per minute of the material handling system. Average speed should be calculated to allow for starting, stopping, turning, etc.

This field is a number with 2 decimal places right justified in 6 character places.

Quantity of material handling system - numeric 5.2 (99.99 maximum)

Quantity of material handling system is the number of identical devices of this type in use in this system.

This field is a number with 2 decimal places right justified in 5 character places.

Material handling effectiveness - numeric 5.2 (99.99 maximum)

Material handling effectiveness is the percentage of total distance travelled by this material handling system accounted for by "productive moves. Effectiveness is a ratio which accounts for distance travelled empty while going to pick up a load. For example, if for every 10 feet of "productive" moves, the system must travel another 10 feet unloaded, the effectiveness would 50%; $[(10 \div (10 + 10)) \times 100]$.

This field is a number with 2 decimal places right justified in 5 character places.

Paths File Format - file extension .pth

The paths file is ALWAYS created and maintained by the FactoryFLOW program. You need not be concerned with its structure, or how to create it from a word processor or spreadsheet.

Example:

```
PRODUCT: PROD1
-PATH: RECEIVING ROBOT AEB 1002.00
-PATH: RECEIVING BROACH AF4 558.00
-PATH: RECEIVING MILL AFB 518.00
-PATH: ROBOT MILL B02 532.00
-PATH: RECEIVING ASSEMBLY BOA 714.00
-PATH: BROACH ASSEMBLY B11 145.00
-PATH: MILL ASSEMBLY B16 429.00
-PATH: ASSEMBLY SHIPPING B1C 889.00
PRODUCT: PROD2
-PATH: RECEIVING MILL B25 345.00
-PATH: RECEIVING ASSEMBLY B2C 435.00
-PATH: MILL ASSEMBLY B33 494.00
-PATH: ASSEMBLY SHIPPING B39 694.00
PRODUCT: PROD3
-PATH: RECEIVING BROACH B42 148.00
-PATH: RECEIVING LATHE B47 139.00
-PATH: RECEIVING ASSEMBLY B4C 649.00
-PATH: BROACH ASSEMBLY B55 283.00
-PATH: LATHE ASSEMBLY B5C 1282.00
-PATH: ASSEMBLY SHIPPING B65 593.00
```

Workcenter Points File Format - file extension .wcp

The Workcenter Points file is ALWAYS created and maintained by the FactoryFLOW program when you pick workcenter points during the DRWCOMP: or CALC: commands. You need not be concerned with its structure, or how to create it from a word processor or spreadsheet.

Example:

```
RECEIVING 533.00 274.00
ROBOT 1272.00 281.00
BROACH 345.00 573.00
MILL 839.00 581.00
ASSEMBLY 382.00 851.00
SHIPPING 154.00 274.00
LATHE 894.00 255.00
```

Importing Products, Parts, and Material Handling Equipment files from a spreadsheet

FactoryFLOW's FFEDIT: program was designed to accept information from a spreadsheet or word processing program. If you have some or all of your data in computer format, an electronic spreadsheet such as Lotus 1-2-3 or Microsoft Excel makes an excellent tool for editing and assembling the data for the Products, Parts, and Material Handling Equipment files since it is very easy to move columns of data and to copy fields in a spreadsheet. There are only four rules you must follow to successfully load your spreadsheet file into FactoryFLOW.

1. The files must be in ASCII format.
2. There must be no blank lines at the beginning or end of the files.
3. All fields must be separated by AT LEAST one space.
4. You must load the Part and Product files in FFEDIT: , and then save them with FFEDIT: before loading them into FactoryFLOW with the IN DATA: command.

NOTE: The following instructions refer specifically to Lotus 1-2-3. You need only translate these commands into your own spreadsheet program to perform the following functions.

Use the File Import Text command to load ASCII data files into 1-2-3. When you import columns of data into 1-2-3, they will all be read into one column. Use the Data Parse command to break this one column into separate columns. Once your files are in the spreadsheet, use the Move and Copy commands to organize the fields into the proper order as described elsewhere in *Appendix D*. Make certain that none of the data in any of the fields exceeds the maximum length.

FFEDIT: requires that there is at least one space between each field. To ensure that this will always be the case, insert a blank column one or two characters wide between every data column. Once all of your data is in the proper format in 1-2-3 and you have a blank column between every data column, use the Print File command to make a new ASCII data file. Make certain that your margins on the top, bottom, and left sides are set to zero and that your right margin is set to 240 (the maximum width).

After you print your file, save the spreadsheet and then go to DOS and change the print file extension .prn to .prd for Product files, to .prt for Part files, and to .mhe for Material Handling Equipment files. You can use the DOS command RENAME to rename your files.

If you are creating a Product file or a Material Handling Equipment file, you must also add the time unit to the beginning of the file. This time unit is the unit of time that all the data in the file represents and must be YEAR, MONTH, WEEK, DAY, or SHIFT. You should use an editor or word processor to insert a line at the beginning of the file and enter the time unit in all capital letters followed by a carriage return.

Now that you have created the Product, Part, or Material Handling Equipment file, run the FFEDIT: program inside or outside of AutoCAD and load the files that you have just created. When you press <esc> to leave FFEDIT: you will be asked whether you wish to save the files. Respond Y (for yes) to this prompt, and the files will be saved in a format compatible with FactoryFLOW.

Exporting FactoryFLOW files to a spreadsheet
Products, Parts, and Material Handling Equipment files from a spreadsheet

All the FactoryFLOW files are ASCII files, except the drawing files. Refer to *Appendix B* for a listing of the FactoryFLOW File Extensions.

Sometimes you may wish to make major changes to your Products, Parts, or Material Handling Equipment files, or you may wish to further process FactoryFLOW's output. In either case, follow the instructions below to transfer these files from FactoryFLOW to the spreadsheet.

NOTE: The following instructions refer specifically to Lotus 1-2-3. You need only translate these commands into your own spreadsheet program to perform the following functions.

Use the File Import Text command to load ASCII files from any program into 1-2-3. Give 1-2-3 the filename, including the file extension, to import the file.

When you import columns of data into 1-2-3, they will all be read into one column. Use the Data Parse command to break this one column into separate columns. Once in separate columns, you can treat the file as a normal spreadsheet.

Appendix E Draft of Technical Article

Appendix E is an unpublished draft of a technical article on FactoryFLOW. The article briefly reviews the history of computer aided facilities layout programs, discusses the role of FactoryFLOW, outlines how to use FactoryFLOW, and lists the formulas used in FactoryFLOW. A bibliography and seven figures referenced in the article are included at the end of the article.

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PLANT LAYOUT AND MATERIAL HANDLING ANALYSIS USING INTERACTIVE GRAPHICS

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Abstract

In the methods for the analysis of manufacturing plant layout and material handling systems commonly used today, the production data (products, parts, and routings), the facility layout drawings, and other data and calculations are in separate software or paper embodiments. The time and effort to calculate useful results by conventional means is usually prohibitive. Hence the need for an unconventional tool--FactoryFLOW. FactoryFLOW is a micro-computer-based iterative, interactive program which integrates the graphics of a CAD system with the analysis of plant layout and material handling systems. The program enables the user to alter production volumes, part routings, material handling methods, or storage and machine locations and then receive automatic cost and distance calculations. The material handling costs are listed in management reports and highlighted graphically by the thickness of the actual material handling paths overlayed on the plant drawing. The authors believe this is the first microcomputer program with these capabilities. This paper describes the FactoryFLOW program in detail.

Keywords

CAD, Plant Layout, Material Handling Analysis, Material Flow Diagrams, Layout Evaluation, FactoryFLOW, AutoCAD, Computer Aided Facilities Layout (CAFL)

Previous Computer Aided Facilities Layout Programs

A recent review by Oriscoll and Sangi of 56 CAFL software packages from all over the world stated that many first generation lineprinter-oriented layout programs are still used, but their ability to tackle real world problems is very limited. Computer aided facilities layout programs like CRAFT, COFAD, PLANET, CORELAP, and ALDEP are only marginally successful at generating usable layouts, and are not used much by industry.

These programs are difficult to use, run in batch mode often on mainframe computers, and have no graphics capabilities.

Oriscoll and Sangi also stated that for a CAFL software package to be successful it would have to be interactive, iterative, and tie into a popular proprietary CAD system to allow high quality graphics input and output.

The authors have developed FactoryFLOW, a microcomputer program written in a popular CAD system that meets the above criteria, and that is useful to both the typical and more advanced industrial facilities planner.

Why FactoryFLOW?

The authors saw the need for an interactive CAD-based system that could calculate the material handling costs and distances within a factory. To be effective, the system needed to allow the user to easily move workcenters or storage areas in a CAD drawing of their facility, or change production volumes, part routings, material handling systems or material handling paths, then easily recalculate the costs and material handling distances of that revised layout during the design process. Ideally, the actual CAD layout should be used to support rapid prototyping and the material handling cost should be represented graphically. The purpose of this system would be to allow the facilities planner to quickly and quantitatively evaluate a set of layouts based on material flow, and to create a set of graphical diagrams and reports that would allow for easy and informative presentations to management.

This program is FactoryFLOW. FactoryFLOW allows the user to interactively change production levels, part routings, material flow paths, storage and workcenter locations, unit loads, material handling devices, and other key information. Once the user enters the appropriate data, FactoryFLOW calculates the total material handling cost and the total travel distance, generates the Product Flow Diagram (fig. 1), the Composite Flow Diagram (fig. 2), the Distance-Intensity Chart (fig. 3), and the Product-Quantity Chart (fig. 4), the Material Handling Report (fig. 5), and the Material Handling Equipment Utilization Report (fig. 6).

In addition to analyzing material handling and workcenter/storage locations, FactoryFLOW computes operator/machine/workcenter utilizations. This analysis shows the user the effect of routing and layout changes on the work load of all of the machines, workcenters, and operators included in the analysis (fig. 7).

FactoryFLOW runs in the AutoCAD environment. The authors chose AutoCAD because it is both the most programmable PC CAD system available, and the most sold and used CAD system in the world. Its reasonable price and availability make it a good CAD system for use in facilities planning departments, as well as in schools and universities.

How to use FactoryFLOW

Graphical Input

To begin the analysis, the user must first draw the plant, or the relevant production or storage areas, using the AutoCAD CAD system. If the plant drawing already exists in another CAD system, it can be transferred to AutoCAD using the IGES or DXF format. The plant drawing must be drawn to size. FactoryFLOW does not actually try to interpret the drawing; however, it will prompt the user either to enter the **actual** material handling path between any two workcenters, or to accept automatically generated Rectilinear or Euclidian distances between all workcenters. In either case, the path distances are calculated from the CAD drawing. Hence, the drawing only needs to be detailed enough for the user to recognize the location of workcenters, storage areas, and aisles.

Alphanumeric Input

In order to determine which workcenters have material flows either in or out, and what the costs and intensities of these flows are, the user needs to input either the actual paths of the flows and their respective intensities (referred to as the PATH method), or to specify the part routings for all the parts in the products being analyzed (referred to as the PRODUCT method). Either data set can be added directly with the pop-up windows of FactoryFLOW, or can be imported from an external ASCII file.

The data input is provided by the user in three files: the Products file, the Parts file, and the Material Handling Equipment file.

Products File

The Products file includes the product names, their production volumes, and a unique color selected to represent a product's material flow paths in the subsequent flow diagrams. The Products file format is as follows:

TIME UNIT - Period of time in which production quantities are produced (year, month, week, day, or shift).

PRODUCT - Name of product.

PRODUCTION - Production volume of product per time unit.

COLOR - Path color of product.

Example:

YEAR		
PROD1	200000.00	CYAN
PROD2	100000.00	WHITE
PROD3	150000.00	MAGENTA

Parts File

The Parts file contains routing and production information for all parts in all products. There is one entry for each move a part makes. The Parts file format is as follows:

PRODUCT - Name of product this part is associated with.

PART - Name of part.

QUANTITY/PROD - Quantity of parts per product.

FROM WORKCENTER - Workcenter or storage area that part moves from.

TO WORKCENTER - Workcenter or storage area that part moves to.

MATERIAL HANDLING SYSTEM - Name of the material handling system for moving/handling part.

UNIT FACTOR - Average number of parts moved in one trip.

SETUP TIME - Time it takes to set up the FROM workcenter to produce a part.

CYCLE TIME - Average cycle time to produce one part.

LOT SIZE PER RUN - Average number of parts produced per setup.

SCRAP RATE % - Scrap rate in the FROM workcenter.

GROUP CODE - Organizational code assigned to move (used to account for costs).

Example:

PROD NAME	PART NAME	QTY/ PROD	FROM WC	TO WC	MH SYST	UNIT FACT	SETUP TIME	CYCLE TIME	LOT SIZE	SCRP RATE	GRP CODE
PROD1	PART1	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	50.00	2.00	3.00	C20
PROD1	PART11	2.000	MILL	ASSEMBLY	MH2	100.00	50.00	100.00	1.00	4.00	C20
PROD1	PART12	1.000	BROACH	ASSEMBLY	MH2	100.00	60.00	100.00	1.00	3.00	C20
PROD1	PART13	4.000	RECEIVING	ASSEMBLY	MH1	100.00	0.00	1.00	0.00	0.00	C20
PROD1	PART111	4.000	ROBOT	MILL	MH2	100.00	70.00	500.00	1.00	1.00	C21
PROD1	PART112	2.000	RECEIVING	MILL	MH2	100.00	0.00	1.00	0.00	0.00	C21
PROD1	PART121	4.000	RECEIVING	BROACH	MH2	100.00	0.00	1.00	0.00	0.00	C20
PROD1	PART1111	4.000	RECEIVING	ROBOT	MH2	200.00	0.00	1.00	0.00	0.00	C21
PROD2	PART2	1.000	ASSEMBLY	SHIPPING	MH1	25.00	100.00	50.00	2.00	5.00	C20
PROD2	PART21	2.000	MILL	ASSEMBLY	MH2	100.00	75.00	100.00	1.00	2.00	C21
PROD2	PART22	1.000	RECEIVING	ASSEMBLY	MH1	100.00	0.00	1.00	0.00	0.00	C20
PROD2	PART211	2.000	RECEIVING	MILL	MH1	75.00	0.00	1.00	0.00	0.00	C21
PROD3	PART3	1.000	ASSEMBLY	SHIPPING	MH1	50.00	100.00	80.00	2.00	3.00	C20
PROD3	PART31	4.000	LATHE	ASSEMBLY	MH2	100.00	40.00	100.00	1.00	4.00	C21
PROD3	PART32	2.000	BROACH	ASSEMBLY	MH2	50.00	70.00	200.00	1.00	2.00	C21
PROD3	PART33	1.000	RECEIVING	ASSEMBLY	MH1	50.00	0.00	1.00	0.00	0.00	C20
PROD3	PART311	4.000	RECEIVING	LATHE	MH2	100.00	0.00	1.00	0.00	0.00	C21
PROD3	PART321	2.000	RECEIVING	BROACH	MH2	50.00	0.00	1.00	0.00	0.00	C20

Material handling equipment file

The Material Handling Equipment file contains the material handling system names and each named system's type, quantity, fixed cost, variable cost, load and unload time, average speed, and effectiveness. The Material Handling Equipment file format is as follows:

TIME UNIT - Period of time for investment cost and available minutes (year, month, week, day, shift).

MATERIAL HANDLING SYSTEM - Name of material handling system.

MATERIAL HANDLING TYPE - Type of material handling system.

INVESTMENT COST - Investment cost per piece of equipment per time unit.

FUEL, POWER, AND MAINTENANCE COST - Hourly fuel, power, and maintenance cost per piece of equipment.

LABOR COST - Hourly labor rate per piece of equipment.

AVAILABLE MINUTES - Available minutes per piece of equipment per time unit.

LOAD PLUS UNLOAD TIME - Load plus unload time per move in minutes.

SPEED - Average speed of material handling system in feet per minutes.

QUANTITY - Quantity of equipment in material handling system.

EFFECTIVENESS - Material handling system effectiveness in percent.

Example:

	YEAR								
MH1	LIFT_TRUCK	4503	2.54	19.75	105000	1.40	310.00	0.50	75.00
MH2	P.PALLET_TRUCK	1300	0.45	12.50	95000	0.75	163.00	1.00	60.00

Program Execution

The user first loads AutoCAD and the plant layout drawing, then calls the FactoryFLOW program and menu under the AutoCAD umbrella. FactoryFLOW reads the products, parts, and material handling files, then prompts for the inter-workcenter paths. All the user must do is draw a series of straight line segments in the CAD plant drawing to specify the actual paths through the aisles from the originating workcenters/storage areas to the destination workcenters/storage areas. Alternately, FactoryFLOW will generate euclidian or rectilinear paths automatically. FactoryFLOW calculates the distance of the paths, adds up all of the paths for a particular material handling system, and amortizes the fixed costs over the time used. The variable costs are then added to the fixed costs to get the move costs for each path. The move distances, times, and costs are multiplied by the move frequency to get the total move distances, times, and costs. The total material handling cost and travel distance are obtained by adding the total move costs and distances.

FactoryFLOW computes the travel costs and distances for the interworkcenter/storage distances, then scales the width of the paths in the drawing to give the user a visual presentation of the associated handling costs. This Product Flow Diagram is a tool which enables the engineer to visualize the material handling costs within the plant, recognize problem areas, and present alternatives to management. Fig. 1. shows the Product Flow Diagram of a plant with seven workcenters. The relative thickness of the paths shows that the material flow between receiving and assembly is expensive and perhaps a change in location or material handling method is needed.

After the user makes one or more changes to the layout drawing or to the handling information, the program can calculate new material handling costs and travel distances and also present cost and distance changes from the previous layout. The user can then generate new Material Handling Cost Reports and flow diagrams.

In addition to the flow diagrams, FactoryFLOW also creates Distance-Intensity Charts and Product-Quantity Charts. The Distance-Intensity (DI) Chart is helpful when trying to determine which class of material handling equipment to use for specific interworkcenter moves, and also in determining the quality of the current layout. When the DI chart is used with material handling equipment and unit factors already selected, all the moves (represented as one point on the chart) should be close to the axes. A move falling in the middle of the chart indicates that this move has a high distance and high frequency and should be adjusted either by decreasing the distance or frequency. If many moves fall in the middle of the chart, the layout should probably be altered. Fig 3. shows a DI chart of the previous example.

The Product Flow Diagram for each product is automatically generated on a separate CAD layer and Composite Flow Diagrams can be generated on a special Composite Flow Diagram layer. The Composite Flow Diagram can consist of any combination of products. Product flow diagrams for different products are given different colors so one can easily look at the level of material handling activity in an area for any products. Layers can be turned on and off to highlight individual products. Fig. 2 shows the Composite Flow Diagram of the same plant presented in Fig. 1.

By including machine and workcenter utilizations in the same CAD database as the plant drawing, it becomes possible to review the relationships of part routings to workcenter utilizations. These workcenter utilizations are calculated using a simple analytical model and do not simulate the work loading on the machine.

The Formulas Behind FactoryFLOW

FactoryFLOW calculates the material handling costs using formulas similar to those in COFAD. Material handling equipment is classified as either fixed path or mobile. The fixed path equipment includes all types of conveyors. Mobile equipment is not restricted to a path, and includes forklift trucks, pallet trucks, AGVS and tractor-trailers.

Similar material handling equipment is grouped together to form a material handling system. Each system is defined with a fixed and variable system cost. The fixed cost is the investment cost, and includes the depreciation or rental cost per piece of equipment.

The variable cost is composed of power, fuel, maintenance, and labor costs, or the overhead costs of the equipment. The available time per piece of equipment is also defined.

For mobile material handling equipment, the load and unload times, average speed, equipment effectiveness, and quantity of equipment per system are also needed. The **material handling effectiveness** is the ratio of the distance travelled while carrying a load to the total distance travelled to accomplish a move, including distance travelling empty, as shown below:

Let:

- L_1 = distance travelled empty to workcenter 1
- L_2 = distance travelled carrying load from workcenter 1 to 2
- L_3 = distance travelled empty from workcenter 2

Then the material handling effectiveness is:

$$E = [L_2 / (L_1 + L_2 + L_3)]$$

The **material handling cost** of transporting material from workcenter i to workcenter j using material handling system k is:

$$C_{ijk} = M_{ijk} \cdot F_{ijk}$$

Where:

M_{ijk} = move cost from workcenter i to workcenter j using system k

F_{ijk} = frequency of material flow from workcenter i to workcenter j using system k

For Mobile Equipment:

$$M_{ijk} = [(T_{ijk} / \text{SUM}T_k) \cdot N_k \cdot C_k] + [T_{ijk} \cdot O_k]$$

$$T_{ijk} = A_k + B_k \cdot (D_{ijk} / E_k)$$

Where:

T_{ijk} = move time from workcenter i to workcenter j using system k

$\text{SUM}T_k$ = sum of transportation times using system k

N_k = number of equipment type in system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per equipment type per unit time in system k

A_k = load and unload time per move in system k

B_k = inverse of average transportation speed of equipment in system k

D_{ijk} = distance from workcenter i to workcenter j using system k

E_k = material handling effectiveness of system k

For Fixed Path Equipment:

$$M_{ijk} = (D_{ijk} / \text{SUM}D_k) \cdot (C_k + O_k)$$

D_{ijk} = distance from workcenter i to workcenter j using system k

$\text{SUM}D_k$ = sum of transportation distances using system k

C_k = investment cost per piece of equipment in system k

O_k = fuel, power, maintenance, and labor costs per piece of equipment per unit time in system k

The move frequency F_{ijk} is expressed in terms of the production volume, quantity of parts per product, unit load size, and scrap rate. The move frequency for part y of product x is:

$$F_{ijk} = [P_x \cdot Q_{xy}] / [U_{xy} \cdot (1 - (SR_{xy}/100))]$$

Where:

P_x = production volume of product x

Q_{xy} = number of parts of y per product x

U_{xy} = unit load size of part y

SR_{xy} = scrap rate in producing part y

The **utilization of material handling** equipment is calculated for mobile equipment. The utilization of material handling system k is:

$$U_k = \text{SUMT}_k / (A_k \cdot N_k)$$

Where:

SUMT_k = sum of transportation times using system k

A_k = available time per piece of equipment of system k

N_k = quantity of equipment type per system

The **workcenter utilization** is also calculated. The utilization of workcenter k is:

$$U_k = B_k / (A_k \cdot N_k)$$

Where:

$$B_k = \text{SUM} [(P_k \cdot Q_y \cdot (\text{SU}_y/\text{LOT}_y + \text{CT}_y)) / (1 - (\text{SR}_y/100))]$$

B_k = busy time in workcenter k

P_k = production volume of product x

Q_y = quantity of parts y in product x

SU_y = set-time for part y in product x

LOT_y = manufacturing lot size of part y in product x

CT_y = cycle time per part y of product x

SR_y = scrap rate in producing part y of product x

A_k = available time per machine/server in workcenter k

N_k = number of machines/serves in workcenter k

Conclusion

FactoryFLOW provides a unique method of analyzing plant layout, material handling activity, and machine utilization, and their interrelation in the context of facility planning. By combining a standard CAD system with FactoryFLOW's ability to analyze what has been drawn, the user can now efficiently compare layout alternatives for production and storage areas based on the flow of materials, the material handling utilizations, and the workcenter utilizations during the design process.

FactoryFLOW's development owes much to the research conducted in the Industrial Engineering Department at Iowa State University, as well as to the assistance that many facility planners have provided in refining the user interface and overall effectiveness of the program.

Factory FLOW is under continuing development. Currently FactoryFLOW can run a complete analysis of up to 30 workcenters and 400 parts in about 3 minutes on an 80386-based microcomputer running at 16MHz. In the future the authors plan to speed up execution time to allow larger data sets to be analyzed. The authors also intend to add time-based algorithms to the program to allow for simulation. Currently the program runs with AutoCAD under DOS, but conversions to engineering workstations are planned.

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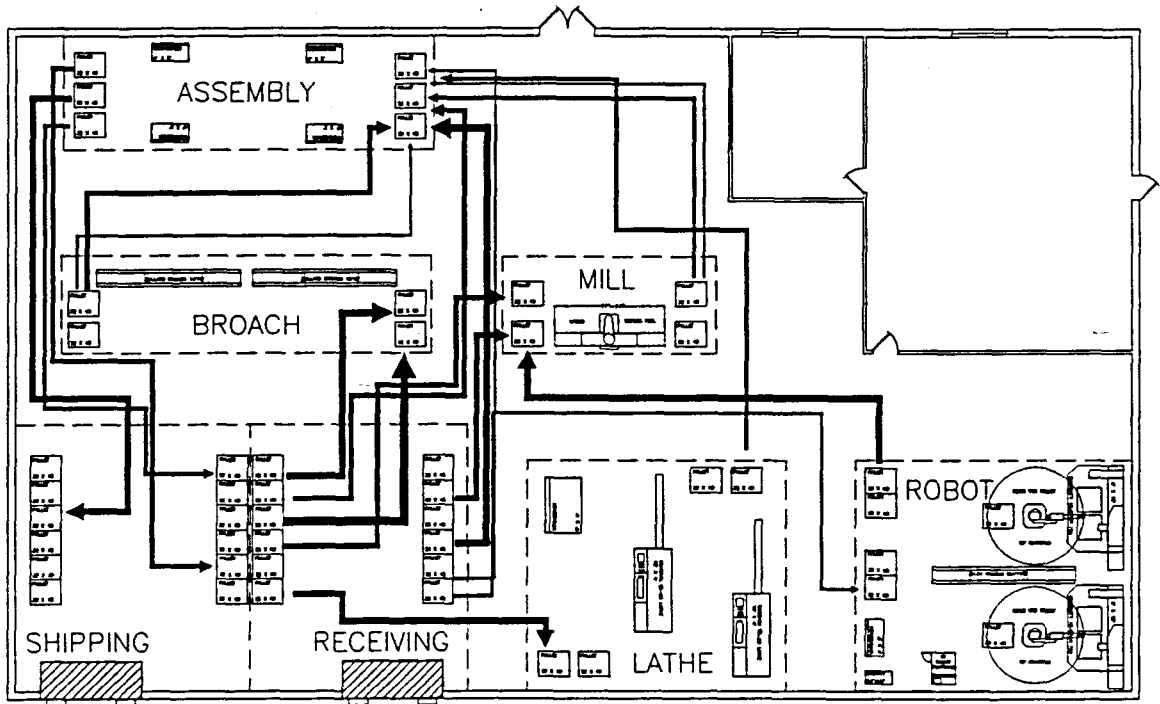


Figure 1. Product Flow Diagram

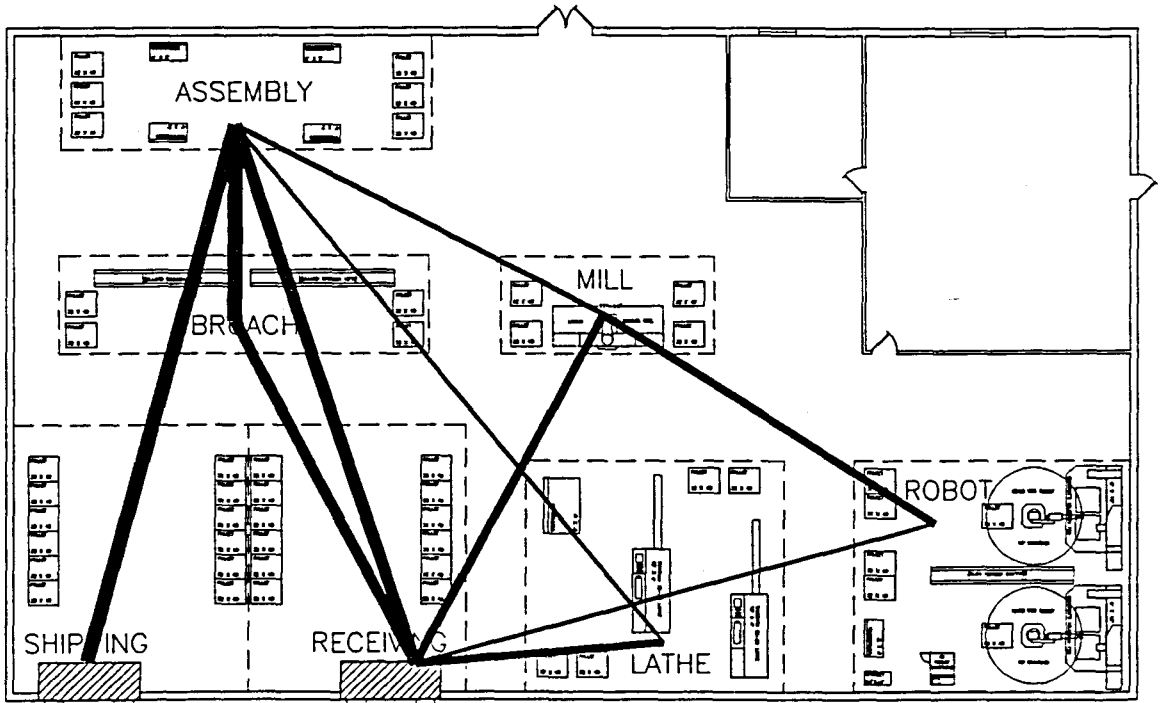


Figure 2. Composite Flow Diagram

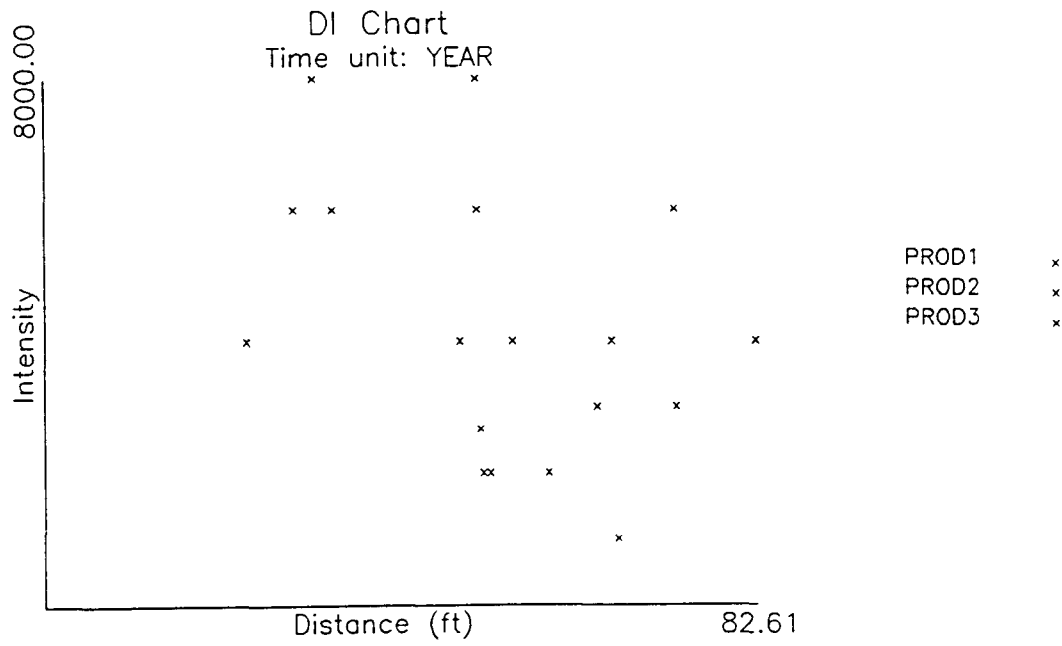


Figure 3. Distance-Intensity Chart

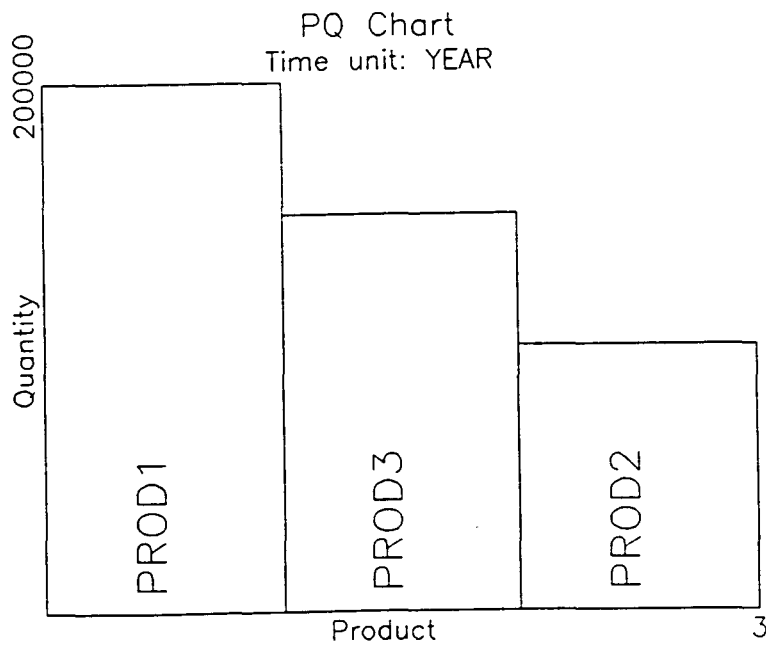


Figure 4. Product-Quantity Chart

COMPANY NAME: ABC CORPORATION
 PROJECT NAME: FACTORYFLOW ANALYSIS
 DATE: 11/21/1989
 TIME: 10:04

MATERIAL HANDLING REPORT

PRODUCT	PART	FROM	TO	MATERIAL HANDLING	TOTAL COST (\$/YEAR)
PROD1	PART1	ASSEMBLY	SHIPPING	MH1	1,465.09
PROD1	PART13	RECEIVING	ASSEMBLY	MH1	2,876.26
PROD2	PART2	ASSEMBLY	SHIPPING	MH1	2,993.09
PROD2	PART22	RECEIVING	ASSEMBLY	MH1	742.22
PROD2	PART211	RECEIVING	MILL	MH1	1,898.69
PROD3	PART3	ASSEMBLY	SHIPPING	MH1	2,275.93
PROD3	PART33	RECEIVING	ASSEMBLY	MH1	2,213.29
Subtotal of MH1					14,464.57
PROD1	PART11	MILL	ASSEMBLY	MH2	1,170.07
PROD1	PART12	BROACH	ASSEMBLY	MH2	602.59
PROD1	PART111	ROBOT	MILL	MH2	2,379.84
PROD1	PART112	RECEIVING	MILL	MH2	928.71
PROD1	PART121	RECEIVING	BROACH	MH2	2,008.33
PROD1	PART1111	RECEIVING	ROBOT	MH2	1,497.66
PROD2	PART21	MILL	ASSEMBLY	MH2	597.16
PROD3	PART31	LATHE	ASSEMBLY	MH2	2,116.98
PROD3	PART32	BROACH	ASSEMBLY	MH2	1,787.12
PROD3	PART311	RECEIVING	LATHE	MH2	1,538.33
PROD3	PART321	RECEIVING	BROACH	MH2	1,472.90
Subtotal of MH2					16,099.69
Grand total					30,564.26

Figure 5. Material Handling Cost Report

COMPANY NAME: ABC CORPORATION
PROJECT NAME: FACTORYFLOW ANALYSIS
DATE: 11/21/1989
TIME: 10:07

MATERIAL HANDLING UTILIZATIONS

Material handling system name: MH1
Available minutes / equipment / YEAR: 105000.00
Busy minutes / system / YEAR: 32875.02
Quantity: 0.50
Utilization (%): 62.62

Material handling system name: MH2
Available minutes / equipment / YEAR: 95000.00
Busy minutes / system / YEAR: 68569.99
Quantity: 1.00
Utilization (%): 72.18

Figure 6. Material Handling Utilizations Report

COMPANY NAME: ABC CORPORATION
PROJECT NAME: FACTORYFLOW ANALYSIS
DATE: 10/21/89
TIME: 10:08

WORKCENTERS UTILIZATIONS

Workcenter name: ASSEMBLY
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 346631
Number of servers: 4.00
Utilization (%): 75.22

Workcenter name: MILL
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 97258
Number of servers: 1.00
Utilization (%): 84.43

Workcenter name: BROACH
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 169104
Number of servers: 2.00
Utilization (%): 73.40

Workcenter name: ROBOT
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 169697
Number of servers: 2.00
Utilization (%): 73.65

Workcenter name: LATHE
Available minutes / server / YEAR : 115200
Busy minutes / workcenter / YEAR : 197917
Number of servers: 2.00
Utilization (%): 85.90

Figure 7. Workcenters Utilizations

Glossary

Actual path A material handling path that follows the actual transport route. See also Euclidian path and Rectilinear path.

Busy minutes The number of minutes the workcenter or material handling system is used.

Cell An area of the manufacturing facility where specific operations are performed. This also includes receiving, shipping, and storage. *Same as Workcenter.*

Composite Flow Diagram A diagram showing the total material handling costs between each pair of workcenters for a user selected group of products.

Cycle time The time to handle, machine, and inspect a part in an operation.

Data files The term "data files" as used in the FactoryFLOW manual normally refers to the Products, Parts, and Material Handling Equipment files.

Distance The length of the travel path over which material is moved between a pair of workcenters. *Same as Move distance.*

Distance-Intensity Chart A graph of each move intensity versus distance often used to identify classes of material handling equipment, or to evaluate selections of equipment classes already made.

Euclidian path A direct (straight line) path between two workcenter points. See also Actual path and Rectilinear path.

Fixed move cost The portion of the material handling investment cost allocated to the move.

Frequency The number of moves performed in a time unit over a single path. *Same as intensity.*

From workcenter The workcenter from which a move starts.

Group code An user-assigned alphanumeric code used to classify or group material handling moves.

Intensity The number of moves performed in a time unit over a single path. *Same as Frequency.*

Load and unload time The time it takes to load plus the time it takes to unload a unit load from a material handling device.

Lot size The number of parts produced per operation set-up or routine shutdown.

Material handling effectiveness The distance a material handling device travels with a load divided by the total distance travelled. Expressed as a percentage.

Material handling system A set of identical material handling equipment.

Move A transport operation from one workcenter to another.

Move distance The length of the travel path over which material is moved between a pair of workcenters. *Same as Distance.*

Number of servers The number of identical machines or operators in a workcenter.

Path thickness scale A real number used by CALC: to scale the thickness of Actual paths in the Product Flow Diagram. Paths are scaled to show the material handling move cost per foot along a path: the scale is given in dollars (of move cost)/foot (travelled along a path)/inch (of thickness of product flow line).

Product Flow Diagram A diagram using lines of varying thicknesses and colors to represent the material flow of the different products in a factory.

Product-Quantity Chart A graph of product quantities in order of magnitude.

Rectilinear path A path represented by the sum of the vertical and horizontal distances between two workcenter points. See also Euclidian path and Actual path.

Scrap rate The percent of defective items produced in an operation.

Set-up time The time it takes to set-up a workcenter for specific operations.

Time unit (for analysis) The period of time over which results (total distance, cost, etc.) will be calculated and reported. The possible time units are YEAR, MONTH, WEEK, DAY, and SHIFT.

Time unit (for input data) The period of time over which input data (production volume, material handling investment cost, available minutes) is expressed. The possible time units are YEAR, MONTH, WEEK, DAY, and SHIFT.

To workcenter The workcenter at which a move ends.

Total move cost The cost to perform a move including fixed and variable costs.

Total move distance The distance travelled to accomplish one move including empty travel. The material handling effectiveness is factored in this.

Total move time The time to perform one move including load and unload times.

Unit load The quantity of products, parts, or containers the material handling equipment transports in one move.

Variable move cost The cost to perform a move due to the hourly fuel, power, maintenance, and labor costs of the material handling system.

Workcenter A area of the manufacturing facility where specific operations are performed. This also includes receiving, shipping, and storage. *Same as cell.*

Workcenter point A point indicating location of a workcenter, used in generating the Euclidian/Rectilinear paths and Composite Flow Diagram.

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