

MAKING BETTER MANUFACTURING DECISIONS WITH AIM

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ABSTRACT

FACTOR/AIM (AIM) is a simulation system designed specifically for use in manufacturing decision support. AIM has been successfully applied to engineering design, scheduling, and planning problems within numerous manufacturing organizations.

AIM operates on the Windows 95® platform and all model data is stored in a Microsoft Access® database. This open database structure provides many new opportunities. Models can be built faster by importing data from existing sources into AIM. Custom reports are easily created with Access® report wizards. In addition, simulation based decision support applications complete with menus and dialog boxes can be developed with Access® application wizards.

Unlike language-based simulation products which require modelers to learn specific syntax and then abstract your system to fit this syntax, AIM uses the language of manufacturing. Example AIM components include machines, operators, materials, parts, jobsteps, process plans (routings), and conveyors. In addition, a comprehensive set of pre-defined manufacturing rules is available to you. Using AIM you can quickly and accurately build a model of any manufacturing process on your PC. Spending less time on modeling means more time to use the model to help you make decisions to improve your manufacturing operations.

This paper provides an introduction to AIM including AIM modeling constructs, the use of AIM for capacity engineering, planning and scheduling, and costing with AIM.

1 USING AIM TO MAKE MANUFACTURING DECISIONS

AIM is designed to help you make decisions regarding your manufacturing organization's productive capacity. When you build an AIM model, you develop a more thorough understanding of how your system operates and

its capacity. You can use the model to investigate a variety of issues, for example to determine the impact of a proposed change, without affecting production. This enhances your ability to manage the system, control its capacity, and make better decisions regarding its operation. Which in turn improves profitably and your ability to predictably deliver quality product to your customers. These issues of predictability, profitability, and quality face every manufacturing organization today. Figure 1 shows the functional breakdown of the capacity management decision areas.

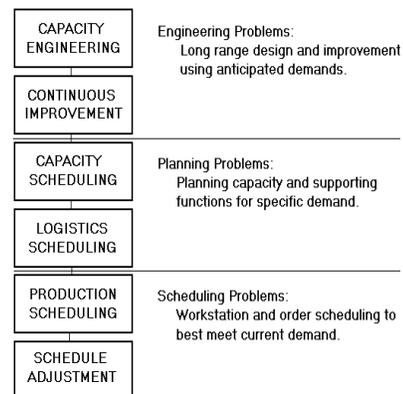


Figure 1. Capacity Management Decision Areas

Engineering problems focus on long-term questions regarding system design and continuous improvement. Planning problems address capacity issues including evaluating the impact of changing product mix or demand. Scheduling problems seek solutions to daily issues including on-time order completion, priority changes, and unplanned changes in resource availability.

Most products focus on one capacity management decision area. With AIM you build a single model and use it to support engineering, planning and scheduling decisions. For a product to support manufacturing design, planning, and scheduling, it must:

- make it easy to develop an accurate model of the manufacturing process,
- support loading complete data on the manufacturing system including the current system status and new orders to be processed,
- produce accurate, detailed equipment, material, and personnel schedules, as well as statistical performance information, and
- provide complete results in a timely manner -- when they are needed to make a decision.

AIM addresses all of these requirements. In addition, AIM results are presented in a manner which is easily understood by shop floor personnel – who most likely will not be familiar with traditional simulation analysis terminology.

1.1 Capacity Engineering Decisions

One key use of AIM for capacity engineering is in designing a new manufacturing facility. Most manufacturers would never consider building a new product without first designing a prototype, and then testing and refining that prototype before production begins. The same is true for a new manufacturing facility. Building the facility on the computer using AIM, before you buy equipment and begin construction, can save millions of dollars. By buying only the equipment you need, and ensuring that your facility design can produce at the anticipated demand rate, you minimize risk and capital expenditures.

Once a facility is in operation, AIM can be used to evaluate system improvements. You can analyze the impact of facility changes like: adding a new piece of equipment, changing the material handling system layout, reducing work-in-process buffer, etc. You can identify potential problems and correct them using your AIM model, instead of perturbing the real system with sub-optimal approaches. This translates into real monetary savings, improved employee relations, and increased customer satisfaction.

1.2 Planning Decisions

You can use an AIM model to address planning issues. Suppose you get a call from a new customer who wants you to make a new – though similar product. Wouldn't it be great to know the effect of this request before agreeing to do the job and setting a delivery date? AIM can help you determine the effect of adding a new product or increasing volume of existing product.

Your AIM model can also help you in logistics planning. In order to maintain a manageable schedule for the manufacturing floor, materials need to be ordered and procured at the proper time. You can use your AIM

model to test material procurement policies such as reorder points, delivery procedures, etc., in order to manage your inventory better.

1.3 Scheduling Decisions

AIM is used to schedule operations for smaller scale production facilities, for individual departments within a larger facility, or for facilities requiring a PC based scheduling solution. Pritsker's FACTOR/PM and OrderLinX products were designed to fill the niche for large scale scheduling applications.

1.3.1 Data Integration for Scheduling

A key factor in the success of any scheduling system is the ability to integrate the scheduling software with existing production data systems. An accurate schedule depends upon precise production system status at the beginning of the schedule window, and complete data on new orders. Although it is possible to enter this required data manually, it is usually not practical to do so. Using AIM information can be imported from other sources with speed and ease.

The AIM model is stored in an open, relational database. In-process status and new order data are loaded into the AIM database using custom data transfer procedures. The data connections usually associated with an AIM scheduling application are shown below in Figure 2.

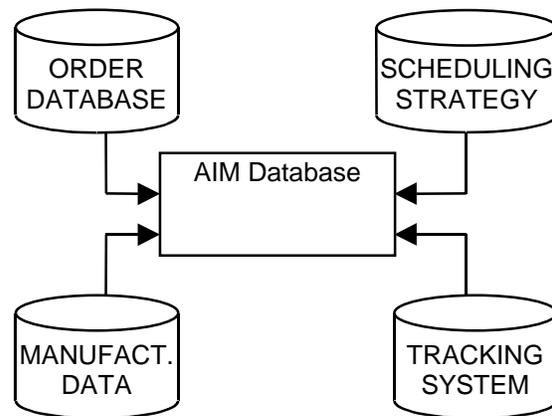


Figure 2. AIM Data Connections

1.3.2 The AIM Scheduling Process

The first step in the AIM scheduling process is to transfer information on system status into the AIM database. Then an order book containing all new orders to be processed during the scheduling interval, (e.g., shift, day, week), is imported to drive the production schedule. The scheduler executes the simulation and reviews a summary of the order, resource, and schedule performance. These reports allow the scheduler to detect potential scheduling problems and adjust the parameters of the AIM model. The new alternative is then executed and performance of the two alternatives is compared. This process is repeated until a feasible, desired schedule is achieved. Detailed schedules are generated for the components of interest (e.g., equipment, personnel, materials), and distributed to the proper personnel such as operators or automated cell controllers.

Schedules can also be viewed in an interactive graphical GANTT chart form (see Figure 3), using the AIM GANTTs Module.

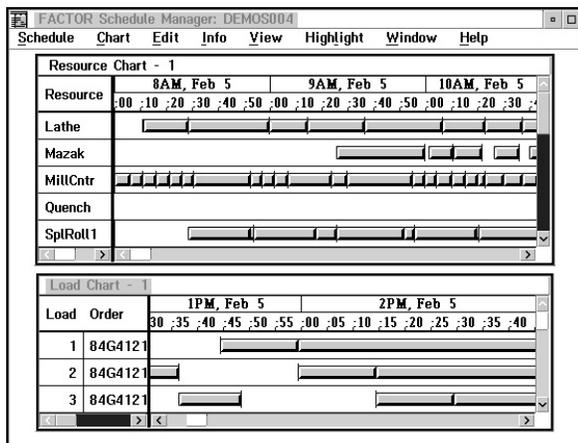


Figure 3. AIM GANTTs User Interface

The GANTTs Module is a graphical schedule display tool which provides a convenient mechanism to review an AIM schedule. A separate GANTT chart display for orders, jobs, and resources allows the scheduler to quickly review critical information. In addition, an extensive network of detailed information on the schedule and the AIM model is provided.

2 AIM ORGANIZATION

AIM is organized into five modules as shown in Figure 4 below. The AIM Executive controls data collection for a simulation and provides database and alternative management capabilities. It also invokes all the other AIM modules.

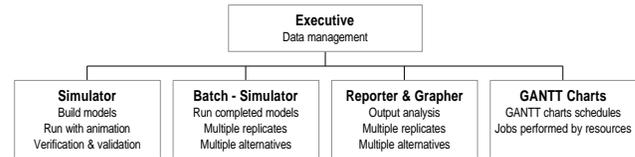


Figure 4. AIM Organization

The Simulator module is where you build your AIM model and run it with animation. The Batch Simulator supports alternative evaluation through multiple replicates and multiple alternative runs. The Reporter displays textual reports on model performance. The Grapher displays plots, pie charts, bar charts, and histograms, summarizing model performance. Both the Reporter and Grapher support alternative and replicate comparison. The GANTTs module displays detailed schedule information showing the specific operations performed during the simulation.

3 BUILDING AND RUNNING AN AIM MODEL

You create a model by pointing and clicking to locate graphical components (e.g. machines, conveyors) on the AIM facility window. Figure 5 shows an example model in the AIM facility window. This model contains machines, operators, and work-in-process buffers.

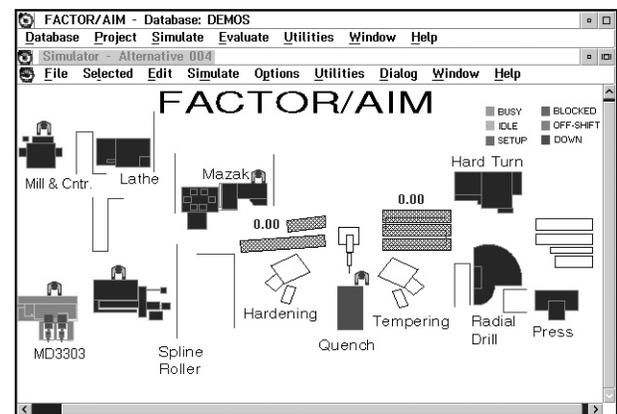


Figure 5. Sample FACTOR/AIM Facility Window

Once the graphical layout is complete, you add your parts and define their process routings. You can further refine the model as needed, using the information dialog boxes provided for each AIM component. For example, you can enable overtime for your operators by simply clicking a check box in a resource dialog box.

Another way to create a model in AIM is to load part or all of your model directly into the AIM database tables. Loading is done using Access® data import wizards. If you have existing information in electronic form, this can be a time-saving option.

Animation of your AIM model is automatic. As you create the layout of your system on the facility window, you are providing the location information needed to animate the model. If you load your resource and material handling information directly into AIM, you will need to provide location information for your layout.

Building and running a model in the AIM Simulator module is a very interactive process. You can build part of the model, run it, make changes, and run again. In addition, the Simulator has extensive support for model verification and validation including:

- automatic animation which allows you to watch your model as it simulates
- dynamic graphs of system conditions (e.g. resource queue length) which you can view while the simulation is running,
- reports and graphs summarizing system performance which you can view any time you pause the simulation,
- a network of status information boxes providing detained information on the state of each model component, and
- an events viewer which allows you to view all scheduled events and step through them while your model is running.

You can also run your model in batch mode, without animation, using the Batch Simulator module. You can request runs of multiple replicates and multiple alternatives for analysis purposes.

You have complete control over the type of data collected during an AIM simulation run. Summary and raw data outputs exist for every AIM component. All simulation output is stored in the AIM database. An extensive set of standard output reports and graphs are provided to analyze the system's performance. Figure 6 shows an example graph.

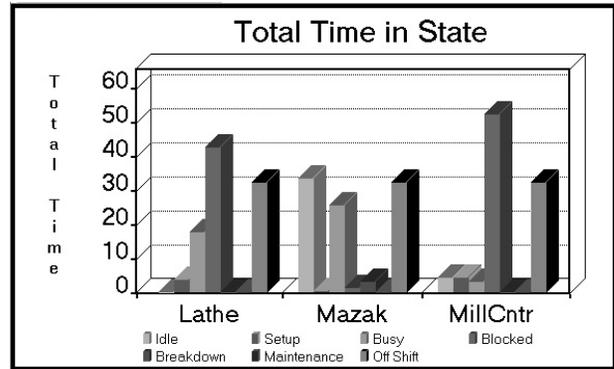


Figure 6. FACTOR/AIM Output Graphics

AIM reports and graphs make it easy to compare different potential configurations of your system – that is different AIM alternatives. Stochastic models can be built in AIM representing the random nature of the manufacturing process. AIM output reports and graphs are designed to reflect the stochastic nature of the analysis. AIM can also create schedule reports and communicate schedules graphically using a GANTT chart, as shown previously in Figure 3. In addition, you can create your own custom reports and graphs using Access® report wizards. Output data can also be saved directly to an Excel® spreadsheet for further analysis, formatting, or graphing.

4 AIM MODELING COMPONENTS

AIM components correspond closely with the actual components of your manufacturing system. This reduces the amount of abstraction that is required to build models, and the amount of time it takes to build a model. Sample AIM modeling components include:

- | | |
|-----------|-----------------------------|
| Machines | Parts |
| WIPs | Orders |
| Operators | Process Plans |
| Fixtures | Material Handling Equipment |

The following sections provide more information on AIM components, and give a brief overview of the AIM modeling approach.

4.1 Types of AIM Components

You build an AIM model by defining the capacity constraining resources and the parts that flow through these resources. The resources are most commonly machines, operators, work-in-process areas, and the material handling equipment. Each resource component is represented directly in AIM, and has its own graphical

location and appearance. Animation of resources is automatic.

You can control the availability of resources by assigning them to shift, breakdown, and maintenance schedules. The sample editor shown in the Figure 7 is used to define and access shifts, breakdowns, and maintenances for the machine.

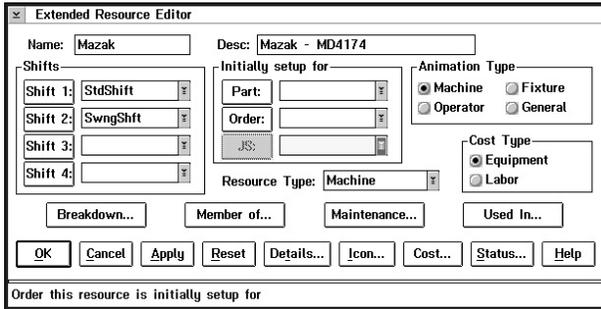


Figure 7. Sample Machine Resource Editor

The AIM process plan component captures the logic of your manufacturing system. You can think of a process plan as a flowchart describing the movement of parts or part families through their manufacturing process. You can easily translate your existing part routing sheets into AIM process plans.

An AIM process plan is actually a collection of jobsteps describing the sequence of operations performed on a part. These parts flow through the manufacturing facility as loads. At each jobstep, the load seizes the resources which are required to perform the operation. For example, a lathe machine and an operator are required for the job of setting up the lathe. Other resources which are no longer needed by the load are released. A sample of the types of jobsteps available in AIM include:

- | | |
|--------------|------------------------|
| Setup | Remove from a Material |
| Operations | Assign a Variable |
| Kanban | Accumulate/Split |
| Assemble | Inspection |
| Move Between | User Defined |

Loads in AIM are created by several different means, including:

- Loading an existing order log or book directly into the AIM database. With this approach, you can compare the performance of your manufacturing operations under different configurations using actual production loading. You can also import system status information along with your order book in order to make planning and scheduling decisions.

- Modeling pull oriented manufacturing systems. You describe when new parts or sub-assemblies are needed by the system, for example when an inventory depletes to a threshold level. Pull orders generate new loads that represent the required parts or sub-assemblies.

Several other methods of load creation exist in AIM. An AIM model can contain any combination of these load creation methods.

4.2 Adding Manufacturing Details

You control the behavior of each AIM component using a robust library of pre-defined actions and rules. For example, you can control how a specific machine chooses the next job to start when it completes a job using AIM's extensive library of resource sequencing and selection rules. Examples of these rules follow.

- | | |
|-------------------------|--------------------------|
| Adjusted Dynamic Slack | Least No. of Jobsteps |
| Earliest Due Date | Least Processing Time |
| Earliest Release Date | Least Static Slack |
| FIFO | Longest Any Jobstep |
| High Attribute Value | Longest Current Jobstep |
| High Priority | Low Attribute Value |
| Large Load | Low Priority |
| LIFO | Shortest Current Jobstep |
| Least Av. Dynamic Slack | Smallest Load |
| Per Remaining Jobsteps | Min Setup Time over |
| Least Dynamic Slack | First N Loads |
| User Defined | etc... |

AIM contains over 160 locations where you can choose from alternative actions or rules in order to refine component behavior and capture the details of your manufacturing operation. In most cases this information appears on the component's detail page. The resource detail page is shown in Figure 8 below.

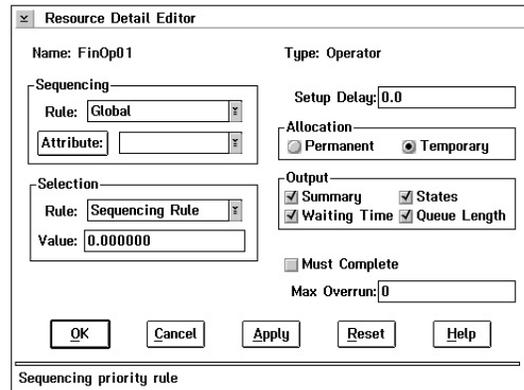


Figure 8. Sample Resource Details

If the built-in rules do not represent the logic of your system, you can create your own custom rule. You write custom rules in the C language and compile and link them without leaving AIM. AIM makes it easy for rules to be created by an expert user, and then used by less experienced modelers.

4.3 AIM Modeling Summary

AIM modelers describe their production process using manufacturing terms. Figure 9 shows a summary of the major AIM modeling components and their relationships.

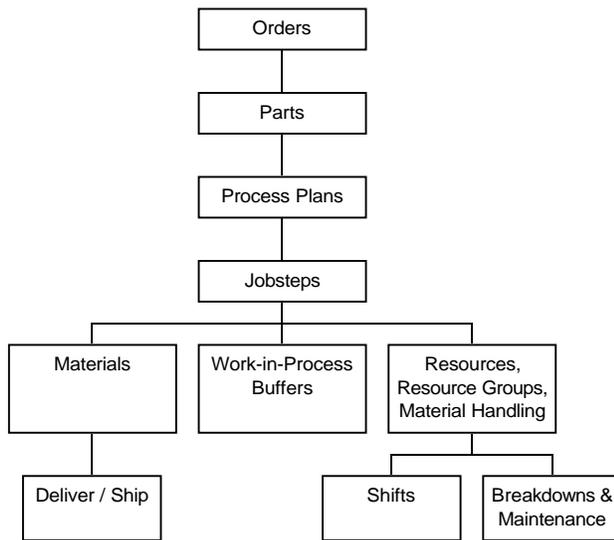


Figure 9. FACTOR Modeling Components

5 AIM COST MODELING

To this point we have demonstrated how to build an AIM model which captures the details of a manufacturing process. We have also shown how the AIM model can be used in the broad areas of capacity engineering, planning and scheduling. Now we will present AIM's financial modeling capabilities.

AIM extends its manufacturing simulation capabilities to include the modeling of manufacturing costs. This makes great sense. An AIM model already captures the details of how parts are processed. It is a logical extension to also capture the costs of these operations.

AIM modelers can define product costs with simple fill-in-the-blank forms. These costs fall into four general classifications; operating costs, overhead costs, inventory

costs, and lateness costs. Operating and overhead costs are defined for the resources in your facility – machines, labor, material handling devices. Inventory costs are associated with raw material, work-in-process buffers, and finished goods storage. Lateness costs are penalties associated with not completing orders on time.

Separate output reports and graphs are available to communicate the outcome of the cost simulation. The average operating expense per part, the value of inventory, and total expense incurred are just a sample of the reports and graphs available. Utilizing the custom reporting of FACTOR/AIM it is possible to generate cash flow reports and pro forma income statements from the model.

5.1 Operating Costs

Operating costs are costs directly tied to the production of parts. Examples of operating costs include cost of labor to setup and operate a lathe; cost of fuel and lubrication to run a gantry crane; and cost of supplies used at a washing station. AIM tracks the operating costs consumed by a part as it flows through the shop. It also tracks the operating costs incurred by each machine, operator, fixture, and other resources. These costs can be reported for the system as a whole, by part type, or for each resource individually.

5.2 Overhead Costs

Overhead costs are costs that cannot be directly related to the processing of individual parts. Examples of overhead cost include: management costs, engineering costs, rent, capital equipment expenditures, and depreciation. Overhead costs can be defined for the same resources as operating costs, and they are evaluated and assigned to parts and resources at the end of the simulation.

5.3 Inventory Costs

Inventory costs reflect the value of parts in work-in-process storage, as well as the value of raw and finish goods inventory. Inventory carrying costs and turnover rates are also tracked and reported by AIM.

5.4 Lateness Costs

Lateness costs are incurred when product cannot be delivered on time. They can be used to quantify the negative effects of lateness including expedited shipping costs, contract penalties, and the cost of customer dissatisfaction.

6 THE AIM TUTORIAL

The tutorial at the Winter Simulation Conference will provide details about building an AIM model and scheduling with AIM. The presentation will include details about modeling components, example output reports and a demonstration of AIM. The modeling process will be discussed in detail, as will the use of the AIM model for making better manufacturing decisions in the areas of capacity engineering, planning and scheduling. In addition, upcoming product enhancements will be demonstrated.

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AUTHOR BIOGRAPHIES

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