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SOFTWARE FOR SIMULATION

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ABSTRACT

This tutorial describes software for conducting computer simulation other software that supports simulation.

1 INTRODUCTION

The next two sections describe general purpose and manufacturing oriented software, respectively. The fourth section describes simulation software for business process reengineering. Next, simulation based scheduling software is introduced. Then, an animator for simulation is discussed. Finally, some simulation support software is described.

2 GENERAL PURPOSE SOFTWARE

Simulation applications are usually accomplished with the use of specially developed software. This tutorial describes the software in two categories. The first of these is software for general purposes. This type of software can solve almost any discrete simulation problem. In this section, seven products, GPSS/H™, GPSS/World™, SIMAN®/Cinema®, SIMSCRIPT II.5®, AweSim®, SIMPLE++™, and Extend™ are discussed.

GPSS/H is a product of Wolverine Software Corporation (Crain and Smith 1995). It is a flexible, yet powerful tool for simulation. It provides improvements over GPSS V released many years earlier by IBM. These enhancements overcome the need to use external routines in FORTRAN to accomplish complex modeling tasks, significantly faster execution, an interactive debugging environment, a floating-point clock, built-in file I/O, use of named entity parameters, extended simulation control statements, built-in math and trig functions, and ampervariables that allow complex arithmetic combinations to be used in the simulation. Version 3.0 adds 23 new random variate distributions, generalized data assignment statements and simplified syntax, enhancements to manipulating entities on user-defined chains, and several new system attributes for extracting data from the simulation. Options available include 32-bit GPSS/H Professional for unlimited model size, Personal GPSS/H for size-limited models, and Student GPSS/H.

GPSS World, from Minuteman Software, is a complete redesign of GPSS/PC™ (Cox 1991). It is designed as a high power environment for simulation professionals. It includes both discrete and continuous simulation. Its features include interactivity, visualizability, and configuration flexibility. It utilizes 32-bit computing, virtual memory, preemptive multitasking, symmetric multiprocessing, and distributed simulation.

Highlights include drag-and-drop model building, 512 megabytes of virtual memory for models, point-and-shoot debugging, an embedded programming language, built-in probability distributions, multiple data types, and many other improvements to GPSS/PC.

There is an enhanced memory version of GPSS/PC that is also available. It allows access of up to 32 mb of memory.

SIMSCRIPT II.5, from CACI Products Company, is a language that allows models to be constructed that are either process oriented or event oriented (Russell 1993). The microcomputer and workstation versions include the SIMGRAPHICS animation and graphics package. SIMSCRIPT can be used to produce both dynamic and static presentation quality graphics such as histograms, pie charts, bar charts, levels of meters and dials and time plots of variables. Animation of the simulation output is also constructed using SIMGRAPHICS. SIMGRAPHICS can be used also to produce interactive graphical front-ends or forms for entering model input data. An input form may include such graphical elements as menu bars with pull-down menus, text or data boxes, and buttons that are clicked on with a mouse to select an alternative. The graphical model front-end allows for a certain set of modifications to the model to be made without programming, facilitating model use by those that are not programmers.

SIMAN/Cinema, from Systems Modeling Corporation, is a general-purpose simulation language and animation system designed to model discrete event, continuous, and combined discrete/ continuous systems (Profozich and Sturrock 1995; Banks, Burnette, Jones, and Kozloski 1995; Pegden, Shannon, and Sadowski 1995).

SIMAN models generally are constructed in a graphical form. In this form, the model is built in the Arena environment and the appropriate data for each SIMAN Block and Element are entered through one or more interactive dialog boxes. Models also can be constructed in a statement form, in which the Block and Element statements are entered into a file using any editor that can create an ASCII file.

Some important aspects of SIMAN V are as follows:

1. Special features useful in modeling manufacturing systems include the ability to describe environments as workcenters (stations) and the ability to define a sequence for moving entities through the system.

2. Constructs that enable the modeling of material handling systems including accumulating and non-accumulating conveyors, transporters, and guided vehicles.

3. An interactive run controller permits breakpoints, watches, and other execution control procedures.

4. The ARENA environment includes menu-driven point-and-click procedures for constructing and animating models.

5. The Input Analyzer assists in fitting distributions to data.

6. The Output Analyzer can be used to obtain confidence intervals, histograms, correlograms, and so on.

7. Models created on any platform are compatible on all other platforms.

AweSim, from Pritsker Corporation, is an integrated simulation system for PC's based on the Microsoft® Windows™ interface. All features are accessible through pull-down menus and dialog boxes, and are selected from the AweSim Executive Window. An AweSim project consists of one or more scenarios, each of which represents an alternative system configuration. A project maintainer examines the components of the current scenario to determine if any of them have been modified, indicates whether tasks such as model translation should be performed, and allows the user to accomplish these tasks before the next function is requested. AweSim allows multiple tasks to be performed in parallel while the simulation is operating in the background.

Some of the features of AweSim are as follows:

1. Models, i.e., networks, are built graphically. Most numeric fields accept expressions. The number of resources to allocate, or the activity number to select, can be determined as an entity flows through the network.

2. Output analysis includes a "report browser" that allows alternative text outputs to be compared side-by-side. Output may be viewed in the form of bar charts, histograms, pie charts, and plots. Output from multiple scenarios can be displayed at the same time in bar chart form. Using the Windows environment, multiple output windows can be opened simultaneously. Built on a relational database, output data can be accessed with commercial database software. Thus, custom reports can be developed.

3. Animations are defined via point and click operations. Animations may be previewed without running the simulation. Multiple animations can provide different concurrent views of the system.

4. AweSim was designed to be used in an integrated manner. For example, historic data may be read to drive the simulation. CAD drawings may be loaded. Output charts and plots created by AweSim may be exported via the clipboard to other applications.

5. Interactive simulation is attained via a control panel that enables stepping through a model, setting breakpoints, examining queues and system variables, and saving model status for a later restart.

SIMPLE++, from AESOP Corporation, is a fully object-oriented simulation system with an integrated graphical user interface (Geuder, 1995). The user creates models by making a library of objects. These library objects represent classes (or parents), whose instances (or children) can be inserted into the models. Simple++ takes advantage of the features of object orientation including modularity, class structure, inheritance, hierarchy, and polymorphism.

Extend, from Imagine That, Inc., is a visual, interactive simulation tool (Krahl, 1995) that contains a built-in development system that allows the user to construct components and build custom user interfaces. Models are constructed graphically by dragging and dropping blocks (high-level model components) from library windows onto the model worksheet. Data can be entered directly into block dialogs, interactively using controls, or read from files as the simulation runs. Output is in the form of plots, histograms, tables, and customizable reports. The block development environment allows simulation modelers to add custom functionality, including hooks to external languages such as C or Fortran. Additional features include multiple scenario analysis, unlimited hierarchical decomposition, animation, client/server interprocess communication, custom icons, work areas for centralized model control and reporting, over 300 built-in functions, 32-bit computing, and compatibility across platforms.

3 MANUFACTURING ORIENTED SOFTWARE

The software discussed in this section is limited to only seven within the category including ProModel®, AutoMod™, Taylor II®, WITNESS®, AIM™, Arena® and Extend+Manufacturing™. For the most part, these software are used for the simulation of manufacturing and material handling systems. References for these software packages include the following: Dewsnup and Bollenbach (1995) for ProModel, Rohrer (1994) for AutoMod, Thompson (1995) for WITNESS, and Nordgren (1995) for Taylor II. For AIM, the reference is Lilegdon, Martin, and Pritsker (1994). For Arena, the reference is Hammann and Markovitch (1995). The reference for Extend+Manufacturing is Krahl (1995).

ProModel, from PROMODEL Corporation, has programming features within the environment, and the capability to add C or Pascal type subroutines to a program. Some of the features of ProModel, Release 3, are as follows:

1. Models are created using a point and click approach. Intuitive interfaces, interactive dialog and online help are provided. An auto-build feature guides the user through the model building process. An online trainer is available.
2. The software operates in the Windows environment, as a 32-bit application, taking advantage of memory management techniques, synchronized windowing and data exchange. Windows fonts, printer drivers, cooperative multitasking, and the Dynamic Link Library are available.
3. Virtually unlimited model size is offered.
4. The simulator offers a 2-D graphics editor with scaling, rotating, and so on. Icons can be defined using either vector based or pixel graphics. These icons are saved as bitmaps at runtime for fast animation during the simulation.
5. CAD drawings as clipart can be imported as well as process information and schedules. Customized output reports and spreadsheet files can be produced. If the data is another Windows application, cutting and pasting can be accomplished.
6. The static and dynamic elements of the animation are developed while defining the model. That is, the simulation model and animation are integrated.
7. Business output graphics are automatically provided and may be printed in color.
8. Only standard hardware is required (IBM or compatible with VGA graphics). No special graphics cards, monitors, or math coprocessor chip is needed.
9. Preprogrammed constructs are provided. This allows for fast modeling of multi-unit and multi-capacity locations, shared and mobile resources, downtime, shifts, and so on.
10. Automatic statistics are available.
11. Submodels allow the creation of a library of templates of work steps, activities, or sub-processes that can be reused. This allows for model construction to be accomplished by a team with later merger of submodels into one model.
12. A free runtime, multiple scenario, capability is provided. Statistics from multiple scenarios can be viewed simultaneously.
13. Multiple views can be saved for easy navigation and graphic layout.
14. Cranes can be added with multiple bridges.
15. Models can be encrypted for protection of data.
16. Interactive subroutine can be added to allow changes to model parameters during model execution.

A model is constructed by defining a route for a part or parts, defining the capacities of each of the locations along the route, defining additional resources such as operators or fixtures, defining the transporters, scheduling the part arrivals, and specifying the simulation parameters. The software then prompts the user to define the layout and the dynamic elements in the simulation.

AutoMod, from AutoSimulations, Incorporated, has general programming features including the specification of processes, resources, loads, queues, and variables. Processes are specified in terms of traffic limits, input and output connections, and itineraries. Resources are specified in terms of their capacity, processing time, MTBF, and MTTR. Loads are defined by their shape and size, their attributes, generation rates, generation limits, and start times, as well as their priority.

The simulator is very powerful in its description of material handling systems. AGVs, conveyors, bridge cranes, AS/RS's, and power and free devices can be defined. The range of definition is extensive. For example, an AGV can be defined in terms of the following: multiple vehicle types, multiple capacity vehicles, path options (unidirectional or bidirectional), variable speed paths, control points, flexible control and scheduling rules, arbitrary blocking geometries, automatic shortest-distance routing, and vehicle procedures.

Numerous control statements are available. For example, process control statements include If-Then-Else, While-Do, Do-Until, Wait-Until, and Wait For. Load control, resource control and other statements are also available. C functions may be defined by the user. Attributes and variables may be specified.

The animation capabilities include true 3-D graphics, rotation, and tilting, to mention a few. A CAD-like drawing utility is used to construct the model. Business graphics can be generated.

In 1993, AutoSimulations added the Simulator to AutoMod. Features of the Simulator include its spreadsheet interface. This eliminates the need for programming in building models.

Another option as a separate utility is AutoStat. It provides simulation warmup capability, scenario management, confidence interval generation, and design of experiments capability.

Taylor II is a product developed by F&H Simulations. It runs under Windows. Working with Taylor II starts with building a model. All model building is menu driven. A model in Taylor II consists of four fundamental entities: elements, jobs, routings, and products. The element types are inout, machine, buffer, conveyor, transport, path, aid, warehouse, and reservoir. One or more operations can take place at an element. The three basic operations are processing, transport, and storage. Defining a layout is the first step when building a model. Layouts consist of element types. By selecting the elements in sequence, the product path or routing is defined. Routing descriptions may be provided from external files.

The next step is detailing the model. In this step the parameters are provided. In addition to a number of default values, Taylor II uses a macro language called TLI for Taylor Language Interface. TLI is a programming language that permits modifications of model behavior in combination with simulation-specific predefined and user-definable variables. TLI can also be used interactively during a simulation run to make queries and updates. Interface to C, Basic, and Pascal is also possible. Local and global attributes are available.

During simulation, zoom, pan, rotate, and pause are options. Modifications can be made on-the-fly. The time representation is fully user-definable (hours, days, seconds, and so on can be mixed). Output analysis possibilities include predefined graphics, user-defined graphics, predefined tabular reports, and user-defined reports. Examples of predefined graphics are queue histograms and utilization pies. User-defined outputs include bar graphs, stacked bars, and other business graphics. Predefined tables include job, element and cost reports.

Animation capabilities include both 2-D and 3-D. The 3-D animation can be shaded. Standard indicators can be shown for elements. Icon libraries for both 2-D and 3-D animation are provided. Each of these libraries contains more than 50 icons.

Additional features include 650 pages of online, context sensitive help with index and page-search capability. Educational support materials are available.

WITNESS, a Windows application from AT&T Istel, contains many elements for discrete-part manufacturing For example, machines can be single, batch, production, assembly, multi-station, or multi-cycle. Conveyors can be accumulating or non-accumulating. Options exist for labor, vehicles, tracks, and shifts. WITNESS also contains elements for continuous processing including processors, tanks, and pipes.

Variables and attributes may be specified. Parts can be smart (having their routing attached) or dumb (elements of the process decide the appropriate routing). Distributions and functions can be used for specifying operation times and for other purposes. Machine downtime can be scheduled on the basis of operations, busy time, or available time. Labor is a resource that can be preempted, use a priority system, and be scheduled based on current model conditions.

Track and vehicle logic allow requests for certain types of jobs, vehicle acceleration and deceleration, park when idle, and change destinations dynamically. Many types of routing logic are possible in addition to the standard push and pull. For example, If-Then-Else conditions may be specified.

Simulation actions, performed at the beginning and end of simulation events, may employ programming constructs such as For-Next, While-End, and GoTo-Label. The user can look at an element at any time and determine the status of a part.

Reporting capabilities include dynamic on-screen information about all modeled elements. Reports may be exported to spreadsheet software.

C-LINKS allows detailed programming and subroutines to be attached to WITNESS.

Data inputs can be numeric, variables, distributions, or a user-defined equation.

Debugging or brainstorming can be accomplished by stopping the model, changing desired parameters, and continuing with the model from the same point in simulation time.

An animation is constructed along with the model definition. This animation and statistical feedback can be turned on or off during any run. Many changes to the model may be made at any time.

Built-in experimentation capabilities are available from the menu bar. The results of the experiments are output to a CSV file by default, or other file types by user choice. The CSV file is in a format that allows the internal statistics package to create confidence intervals.

The capabilities of Witness, version 7.3, include the following:

1. Unlimited number of variables or attributes. Variables can be arrayed.
2. Up to 1000 distinct random number streams.
3. Bitmap import/export with icon sizes increased to 256x256 pixels.
4. 'Module' element for hierarchical modeling. One icon represents the detail existing in another submodel.
5. Double click on an object to open a menu for filling fields with rules, distributions, built-in functions, and so on, for defining elements 'on the fly.'
6. Utilizes WIN32S to run in 32-bit mode.
7. OLE2 compatibility.

AIM (Analyzer for Improving Manufacturing), from

Pritsker Corporation, is one of three applications of **FACTOR**. The other applications are Factor Production Manager and FI-2. Factor Production Manager performs detailed planning/scheduling of operations, order promising, order release, and supply-chain management. FI-2 is an interactive graphical scheduling board. All of these applications use the same data base.

AIM models are OS/2 based and built graphically with icons that represent machines, operators, conveyors, and so on, placed directly on the screen. The animations are created in a virtual window. The current release of AIM is version 6.0. During a simulation, the model can be stopped to check its status or add other components, then continue the simulation. Performance data is dynamically updated and displayed while the simulation is running. A dynamic Gantt chart is provided for tracking machine and operator status. Inventory levels and material handling utilization can also be graphed dynamically. Outputs include bar charts, pie charts, and plots of inventory levels. Alternately, information can be transferred to other software for development of presentation graphics.

Features of AIM include the following:

1. Manufacturing representation. Manufacturing specific modeling components can represent a variety of discrete manufacturing processes. Standard rules provide choices that are interpreted with processes. Custom rules may be written to extend the logic.

2. Integrated with scheduling applications. Models written with AIM can be used with other FACTOR applications providing support for capacity, logistics, production scheduling, supply-chain analysis, and schedule management.

3. Manufacturing data. AIM is built around a relational database that stores the manufacturing operation and simulation output. Part descriptions, process plans, order release schedules, machine locations and schedules, shift schedules, and so on can be transferred from other data sources to the AIM database.

4. Animation support. AIM models are built graphically and are animated automatically during model construction.

5. Interactive model building and simulation. Components are located on a scaled facility background. Intelligent defaults are provided for all components. Components are customized by completing forms. During execution, the modeler can change the status of a component and observe the simulated impact on the manufacturing system.

6. Comparison of alternatives. The AIM project framework organizes all aspects of a manufacturing simulation project. Alternative models of the manufacturing process are stored. Comparison reports show model performance data to identify differences between alternatives.

7. Gantt charts. AIM supports the creation of Gantt charts for the improved verification and validation of models. Model performance can be reviewed in the Gantt chart to follow a single load or the decisions of a resource.

8. Cost modeling methodology. The latest version of the software includes a detailed cost modeling capability. AIM models can be used to represent alternative costing philosophies such as standard cost, ABC, and so on.

ARENA, a product of Systems Modeling Corporation, is an extendible simulation and animation software package. It provides a complete simulation environment that supports all steps in a simulation study. Arena® combines the modeling power and flexibility of the SIMAN simulation language and the Cinema animation system, while offering the ease-of-use of Application Solution Templates.

Arena is a graphical modeling/animation system that is based on hierarchial modeling concepts. It allows users to create new modeling objects called modules, which are the building blocks of model creation. All aspects of a particular process-logic, data, animation, and statistics collection-can be modules to represent the process through which entities flow.

Modules are organized into groups contained in templates. These templates can be used to tailor the software to a specific animation. Application Solution Templates in areas such as business process reengineering, health care, high speed manufacturing, semiconductor wafer fabrication, transportation, and others currently exist or are under development.

The Arena system also includes the Input Analyzer, designed to give users the ability to read raw input data, and the Output Analyzer, for simulation data viewing and analysis.

EXTEND+MANUFACTURING is a product of Imagine That, Inc. It has all of the features of Extend, mentioned previously, plus the following:

1. Blocks that represent machines, stations. Labor buffers, bins, fixtures, and so on.
2. Reneging, preemption, and interruptible processes.
3. Ability to specify sequences for merging and routing streams of entities.
4. Scheduled and unscheduled down times.
5. Material handling constructs.
6. Automatic statistical reporting.

4 BUSINESS PROCESS REENGINEERING

Several vendors have developed software to facilitate the reengineering process. These include BPSimulator™, ProcessModel™, SIMPROCESS®, Time Machine™, and Extend+BPR™.

BPSimulator, a product of Systems Modeling Corporation and Technology Economics International, as an Application Solution Template under Arena. Model building is focused on the activities that comprise a business process. Models are created by placing activity modules in the Arena work space and providing information about each activity. The software can be used for activity based costing by defining busy and idle costs for any resource.

BPSimulator also provides constructs for modeling human and technological resources. Costs, schedules, downtimes, efficiencies, and other resource attributes can be specified.

An interface to Lotus and Excel is provided. The software is capable of reading pertinent process data from existing IDEF0 models.

ProcessModel, a product of PROMODEL Corporation, interfaces with the ABC Graphics Suite™. Flowcharts are developed using ABC FlowCharter®. Modeling capabilities include the following:

1. Staff scheduling and shift planning.
2. Task allocation prioritization and interruption.
3. Use of multiple or alternative resources.
4. Individual or group processing.
5. Matching of orders to correct customers.
6. Document splitting and tracking.
7. Customers dropping out of line.
8. Activity-based costing.
9. Resource scheduling for breaks and downtimes.
10. Ability to change graphics during simulation.

SIMPROCESS, a product of CACI Products Company, integrates icon-based process flowcharting, hierarchical event-driven simulation, activity-based costing, and data analysis capabilities into a tool for business process reengineering. Other features include reusable templates and advanced modeling constructs, such as If-Then-Else logic. SIMPROCESS is based on CACI's MODSIM®, an object-oriented architecture for simulation. It runs under both Windows and UNIX operating systems.

Time Machine is a product of F&H Simulations. It is a Windows based dynamic simulation worksheet used for flowcharting, process modeling, what-if-analysis, concept validation and the dommunication of ideas. It is built on Taylor II, described previously.

Extend+BPR, a product of Imagine That, Inc., is based on the Extend software discussed previously. It has the following features:

1. Blocks that represent operations, transactions, workflow stacks, labor resources, decisions, and so on.
2. Ability to have entities renege.
3. Specification of rules for the flow of work throughout the operation.
4. Activity-based costing and resource planning.
5. Automatic statistical reporting.

5 SIMULATION-BASED SCHEDULING

Several of the many simulation-based scheduling software currently available are Preactor®, AutoSched™, and FACTOR®. These are discussed briefly in the following paragraphs.

PREACTOR, from Systems Modeling Corporation, is a visually interactive finite capacity scheduling system. Preactor features include automatic sequencing using forward, backward, and bi-directional rules, job selection by priority, due date, or first come-first served. A variety of output reports are available. Comprehensive data import and export capabilities for integration with other manufacturing technologies (e.g., MRP, MEP) are included.

AutoSched, from AutoSimulations, Incorporated, is based on AutoMod, a simulation language that was described previously. The following data/information is handled by AutoSched for capacity analysis and scheduling:

1. Production resources consisting of workstations, storage locations, operators and tools.

2. Products consisting of parts to be manufactured along with their routings.

3. Production requirements consisting of orders and lots.

4. Operating rules including how tasks are selected and calendars that specify when workstations are unavailable. Much of the information required by AutoSched may already exist in a database such as an MRP. If it does exist, AutoSched can import it.

AutoSched allows task selection rules for each resource. More than one rule (logic filter) is allowed. Significant scheduling improvements can be achieved through the application of these sophisticated rules.

AutoSched performs a simulation of the shop floor according to the task selection rules provided by the user. Two outputs are provided, graphical and statistical. Business graphs can be created to track any statistic(s). These graphs are updated dynamically. AutoSched also contains an interactive Gantt chart from which an event can be selected for detailing to include the quantity of orders in a workstation's queue when an order was selected, the quantity of orders in the next workstation's queue, etc. Statistical or historical reports are also available. These include the master schedule file, performance report, workstation report, and other user-defined reports.

FACTOR, from Pritsker Corporation, is an integrated software system that provides capacity management applications to help manufacturers meet customer demand (Lilegdon, 1993). FACTOR includes finite capacity scheduling, operations planning and loading, and order promising capabilities. Since its introduction, the software has been enhanced to include relational database capabilities, Client-Server installations, interactive schedule adjustment, and automatic scheduling capability.

To use FACTOR, a model is built by combining components consisting of order characteristics, shop floor status, production calendar, shift schedules, resources, functional resource groupings, preventive maintenance plans, parts definitions with the associated routings, material availability, tooling requirements, and operator capability. Any of these model components may be defined directly or taken from pre-existing manufacturing system files. A simulation of selected alternatives is conducted for various scheduling strategies with results stored in a database for analysis and eventual shop distribution.

In practice, FACTOR is used to schedule operations at regular intervals (e.g., shifts) or upon demand (when a significant event occurs). In either case, up-to-date status information is transferred into the FACTOR database and the FACTOR scheduling engine generates a recommended schedule based on the objective (e.g., maximize throughput, minimize order lateness). The user reviews a summary of the performance anticipated from the schedule and may then accept it, revise the objective and generate another schedule, or interactively make manual adjustments to the schedule.

6 ANIMATORS

Most simulation animators are integrated with the software. However, this is not always the case, and the introduction of general purpose animation packages allows the use of custom made environments.

Proof Animation is a product of Wolverine Software Corporation (Earle and Henriksen 1995). Any software that can write ASCII data to a file can drive Proof Animation™. Thus, BASIC, C, FORTRAN, GPSS/H, GPSS World, SIMAN V, and SIMSCRIPT II.5, among others, can serve as drivers. Animation is accomplished by using a static background, the layout file, and a trace file that contains dynamic events. Some of the features of the software are as follows:

1. Graphics are vector based, similar to CAD programs.
2. AutoCad-compatible layouts can be imported and exported.
3. Zoom in, zoom out and multi-window animations are supported. Maximum resolution is assured at any scale.
4. Drawing takes place on a coordinate grid using mouse-driven primitives.
5. Moving objects are defined internally by their geometry.
6. Statistics, graphs, and plots can be displayed dynamically.
7. Animation occurs in a postprocessing mode.
8. Motion is smooth on VGA PC's.
9. There is a steady ratio of animated (simulation) time to viewing (wall clock) time. This ratio may be varied while the animation is running.
10. Top view can be changed to isometric and back to top view instantly.
11. An option allows the construction of a demo disk.

7 SIMULATION SUPPORT SOFTWARE

Two products, among many that are available, are discussed in this section. The first is ExpertFit™ from Averill M. Law and Associates, for input data modeling (Law and Vincent 1995). The second is SIMSTAT from MC^2 Analysis Systems for input and output data analysis (Blaisdell and Haddock 1993).

ExpertFit is used to model input data distributions. It is the Windows-based successor to UniFit II. It puts a distribution into the proper format for thirty simulation software products. The software augments the built-in distribution capability of most of the software described previously. For example, GPSS/H has four built-in distributions, but ExpertFit increases that number to 40. Selection of the best probability distribution for a data set is accomplished automatically. The software determines whether the selected distribution is good in an absolute sense or whether an empirical distribution should be used. It provides more than thirty 2-D and 3-D graphical plots of the data. Lastly, ExperFit assists in picking a distribution in the absence of data, including models for random machine downtime.

SIMSTAT 2.0 is an interactive graphical software tool that performs statistical analysis on simulation input and output data. The software uses pull down menus and is integrated into the Windows environment. Data is maintained in a spreadsheet format for editing, examination and analysis. SIMSTAT takes advantage of the Windows Clipboard. Some of the many graphical capabilities of SIMSTAT include the fitting of input distributions to data, the determination of initialization bias, and autocorrelation plots.

8 SUMMARY

This tutorial describes software for simulation organized in six categories. The first of these is general purpose software. The second is manufacturing oriented software. Then, business process reengineering software is presented. Next, simulation-based scheduling software is described. Then, an animator is described. Finally, some simulation support software is discussed.

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