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MAP/1™ TUTORIAL

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ABSTRACT

MAP/1 is a simulation-based Modeling and Analysis Program developed by Pritsker & Associates for use in designing and evaluating discrete part manufacturing systems. MAP/1 is a generalized model of a discrete part manufacturing system, which is parameterized to represent a specific manufacturing facility. Parameters which describe the manufacturing facility configuration and associated operating rules are input to the MAP/1 analysis program, which produces a set of predefined output reports and provides measures of facility performance. Using MAP/1, in-depth simulation analyses may be performed to investigate alternative system configurations and operating procedures.

INTRODUCTION

A discrete part manufacturing system is a complex integration of machines, material handling equipment, and operators which produces a variety of types of parts. There are many types of discrete part manufacturing systems, including job shops, flow shops, assembly lines, group technology cells, and flexible manufacturing systems.

Computer simulation is an excellent tool for analyzing discrete part manufacturing systems. It has been used frequently and with much success to help find solutions to many types of system problems. In the past, simulation of discrete part manufacturing systems has been accomplished most often by building a model using a general purpose simulation language. MAP/1 allows models of such systems to be built more quickly and with less effort than similar models built with a general purpose simulation language. Modeling constructs for the basic components of discrete part manufacturing systems and typical component interactions are defined in MAP/1. Building a MAP/1 model involves describing the specific facility to be modeled by parameterizing these constructs.

The components of discrete part manufacturing systems represented in MAP/1 are parts, stations, transporters, conveyors, operators, fixtures, and shifts. Outputs from the MAP/1 program include the performance measures necessary to analyze discrete part manufacturing systems, such as part throughput, station inventory levels, operator and equipment utilizations, and measures of part status over time.

MAP/1 was designed to be used by people responsible for designing, operating, or managing discrete part manufacturing systems. Typically these will be individuals with industrial or manufacturing engineering training or experience. A wide variety of types of problems can be addressed with MAP/1 including bottleneck identification, capacity evaluation, inventory sizing, supply scheduling, and reliability problems.

MAP/1 INPUT

The MAP/1 modeling and analysis program is a computer program written in ANSI standard 66 FORTRAN. It accepts input statements that describe the structure and operation of a batch manufacturing system. It then simulates the operation of this model over time, and produces reports of the measures of the system's performance.

The MAP/1 input statements can be divided into two categories: those which describe the manufacturing system and those which describe parameters which control the simulation run. The input statements which describe the discrete part manufacturing system define parts, work stations, material handling equipment, personnel, fixtures, and shifts. Additional input statements are used to specify simulation run parameters, such as simulation run time, number of runs, initial conditions, selection of output reports, and initial seed values for random number streams. Figure 1 provides a list of MAP/1 system description input statements and associated parameters. Figure 2 provides a list of MAP/1 control input statements and associated parameters.

As an alternative to input statements, a MAP/1 Interactive Input System has been developed, to ease the task of developing and inputting MAP/1 models. This input system has been implemented as a series of forms, which the user fills in to describe the part, work station, transporter, conveyor, personnel, and fixture components of his system. All entries are immediately checked for errors, and on-line help facilities are available to answer any questions which arise. The interactive input system relieves the user of the burden of statement syntax, thus decreasing the time required to format information and correct syntax errors.

Parts. Parts are the items which are processed in a manufacturing system. They are represented explicitly in a MAP/1 model. Parts may arrive to a MAP/1 model from an outside source, such as parts representing raw materials. Alternatively, parts may be created internally to a MAP/1 model such as parts representing assemblies of other parts. Parts are processed at stations in a MAP/1 model. They move from station to station according to a predefined route. Processing at a station is defined in terms of machine setup and operation time, as well as type of operation performed. Parts may return to a station several times for subsequent processing steps.

PART ,	PART TYPE NAME ,	INTERARRIVAL TIME ,	PRIORITY ,	FIRST ARRIVAL TIME ,	ARRIVING LOT SIZE ,	EXPECTED FLOW TIME ;
SCHEDULE ,	PART TYPE NAME ,	EARLIEST START TIME ,	NUMBER OF PARTS ;			
ROUTE ,	STATION NAME/ OPERATION # ,	SETUP TIME ,	OPERATION TIME ,	UNLOAD FIXTURE FLAG ,	LOAD FIXTURE INFORMATION ,	NEXT STATION IDENTIFICATION ;
STATION ,	STATION NAME ,	SIZE ,	PREPROCESS INVENTORY STORAGE ,	POSTPROCESS INVENTORY STORAGE ,	MATERIAL HANDLING EQUIPMENT ,	LOT SIZE ,
	EXCESS RULE ,	SHIFT ID ,	OPERATION MODE ,	OPERATION MODE PARAMETERS ;		
RANKING ,	STATION NAME ,	RANKING RULE ,	MINIMIZE SETUP FLAG ;			
TRANSPORTER ,	TRANSPORTER NAME ,	NUMBER OF TRANSPORTERS ,	MOVE TIME ,	RESPONSE TIME ,	SHIFT ID ,	VELOCITY ;
CONVEYOR ,	CONVEYOR NAME ,	VELOCITY ,	EXCESS RULE ,	CONVEYOR TYPE ,	SHIFT ID ,	PATH LIST ;
MERGE ,	JUNCTURE NAME ,	OUTGOING CONVEYOR NAME ;				
DIVERGE ,	JUNCTURE NAME ,	# OF OUTGOING CONVEYORS ,	CONVEYOR (STATION LIST) ;			
DISTANCE ,	"FROM" STATION NAME ,	"TO STATION" NAME ,	DISTANCE ,	"TO STATION" NAME ,	DISTANCE ,	... ;
PERSONNEL ,	PERSONNEL CLASS NAME ,	NUMBER OF PEOPLE ,	SHIFT ID ,	SELECTION PRIORITY LIST ;		
OPERATOR ,	EQUIPMENT TYPE ,	EQUIPMENT NAME ,	CHOICE RULE ,	PERSONNEL CLASS LIST ;		
FIXTURE ,	FIXTURE NAME ,	NUMBER OF FIXTURES ,	SHIFT ID ,	ALLOCATION RULE ,	LOAD STATION LIST ;	
BREAKDOWN ,	EQUIPMENT TYPE ,	EQUIPMENT SPECIFICATION ,	TIME BETWEEN BREAKDOWNS ,	REPAIR TIME ;		
FAILURE ,	STATION ,	STATION NAME ,	TIME BETWEEN FAILURES ,	REPAIR TIME ,	PROBABILITY OF SCRAPPING PART ;	
MAINTENANCE ,	STATION ,	STATION NAME ,	TIME BETWEEN PREVENTATIVE MAINTENANCE ,	PREVENTATIVE MAINTENANCE TIME ;		
CHANGETOOL ,	STATION NAME ,	NUMBER OF CYCLES BETWEEN TOOL CHANGES ,	TOOL CHANGE TIME ;			
SHIFT ,	SHIFT ID ,	WORKING SCHEDULE ;				

Figure 1: MAP/1 System Description Input Statement Summary

BEGIN ,	MODELER'S NAME ,	MODEL NAME ,	DATE ,	NUMBER OF EXECUTIONS ,	SIMULATION START TIME ,
	SIMULATION FINISH TIME ,	INPUT LISTING REPORT FLAG ,	INPUT ECHO REPORT FLAG ,	MODEL STORAGE REPORT FLAG ,	MODEL EXECUTION FLAG ;
CLEAR ,	FIRST TIME TO CLEAR ,	TIME BETWEEN CLEARINGS ;			
ISTATION ,	PART TYPE NAME ,	STATION NAME/ OPERATION # ,	NUMBER OF PARTS IN PREPROCESS ,	NUMBER OR PARTS IN POSTPROCESS ;	
ITRANSPORTER ,	PART TYPE NAME ,	TO STATION NAME/ OPERATION # ,	FROM STATION NAME/ OPERATION # ;		
SEED ,	NEW SEED VALUE (SEED NUMBER) ;				
REPORT ,	REPORT TYPE ,	... ,	REPORT TYPE ,	FIRST PRINT TIME ,	TIME BETWEEN PRINTINGS ;
OUTPUT ,	REPORT TYPE ,	... ,	REPORT TYPE ;		
DEFINE ,	REPORT GROUP NAME ,	REPORT TYPE (REPORT HEADER) ,	... ,	REPORT TYPE (REPORT HEADER) /	INCLUDE OR EXCLUDE ,
	COMPONENT TYPE/ COMPONENT NAME ,	... ,	COMPONENT TYPE/ COMPONENT NAME ;		
SIMULATE ;					
END ;					

Figure 2: MAP/1 Control Input Statement Summary

A MAP/1 model is driven by part arrivals which can be initiated in two ways. Parts may arrive to the system according to a production schedule, where demand for the end product has been translated into introduction times for batches of specific part types with predetermined lead times and associated due dates. A MAP/1 SCHEDULE input statement allows the specification of a production schedule. Alternatively, part arrival patterns may be prescribed in MAP/1 by a statistical distribution.

Regardless of the method used to introduce parts into a MAP/1 model, a PART input statement is used to define each type of part which flows through the model. This statement contains information concerning part priority, flow time, and arrival pattern. Parts can be assigned a priority, which can be used for ordering parts to be processed at a work station. A flow time can also be assigned, which is used to calculate a due date for each part as it enters the system. This due date can be used for ordering parts awaiting processing at work stations. If a due date is specified, information is automatically generated in the output summary reports on the degree to which parts meet their assigned due dates. If parts arrive according to a statistical distribution, the time of first arrival, interarrival time, and arrival lot size fields of the PART input statement are used, to describe the arrival pattern.

Once the part type itself is defined, its processing sequence is specified using ROUTE input statements. A separate ROUTE statement is included for each operation in the part's routing. To describe an operation one defines the station where the operation is performed, the setup and processing times, and the next station or operation to which the part should be routed.

MAP/1 allows one to specify the next stations or operation in one of several ways. If current operation is the last one to be performed, the next station field is defaulted. If a part of a given type always follows the exact same sequence of processing steps which are always performed at specific stations, then deterministic routing can be employed by listing the next station or operation to which the part should be routed. If the current operation is an inspection or qualifying process, probabilistic routing can be employed by listing the next station or operation for accepted parts and the probability of acceptance, followed by the next station or operation for rejected parts and the probability of rejection.

The MAP/1 conditional part routing capability allows detailed modeling of the control component of the manufacturing system. Conditional part routing allows the next station for a part to be selected based upon part attributes, system status, and/or statistical measures of system performance. For example, an individual part's due date, the number in preprocess storage at a station, or the average utilization to-date of a specific operator are MAP/1 variables which can be used in "conditions" to select a next station. A MAP/1 condition takes the form

MAP/1 variable or constant . relational operator . MAP/1 variable or constant

where the relational operators are EQ (equal to), NE (not equal to), GT (greater than), GE (greater than or equal to), LT (less than), and LE (less than or equal to). Conditions may be strung together using the logical operators AND or OR. In addition, arithmetic expressions containing MAP/1 variables and constants and the arithmetic operators + (plus), - (minus), * (multiply) and / (divide), may be used on the left or right side of a condition to specify complex routing logic.

To invoke conditional part routing, pairs of next station names and associated conditions for choosing each station are specified in the next station identification field of the ROUTE input statement. The MAP/1 program will select the first station for which the associated condition is true. If none of the conditions are true, no next station can be selected. When system status changes such that one or more of the routing conditions becomes true, MAP/1 will reevaluate the situation and properly select the correct next station. This "lookback" feature is an important part of the conditional routing function, allowing the sophisticated control logic of manufacturing systems to be accurately depicted in the model.

Work Stations. Parts are processed at work stations in a MAP/1 model. A work station can be a single machine, a group of like machines, a work space where a manual operation is performed, or an area for loading or unloading fixtures. Stations work in one of three operation modes: they process individual parts, produce multiple parts from a single part or assemble one part from several.

Stations frequently have storage space available for parts awaiting processing (preprocess storage) as well as storage space for parts which have completed processing and are awaiting transport (postprocess storage). When these storage areas become full they affect system operation, by causing stations further up the line to shut down until the backlog is cleared up.

In MAP/1, a work station is defined with a STATION input statement. This statement contains fields for specifying such information as the number of machines at the station and the size of the preprocess and postprocess storage areas. One may also specify the operation rule to follow when a station preprocess storage area becomes full. In addition, the type of material handling device which removes parts from their station and the transportation lot size are also specified on the STATION input statement.

RANKING input statements are used to specify how a machine chooses the next part to be processed. Several selection rules are available in MAP/1, including FIFO, LIFO, shortest processing time, earliest due date, and part priority.

Material Handling Devices. Material handling devices are required to move parts between work stations in a manufacturing system. There are two distinct types of material handling devices which can be modeled with MAP/1. The first type is called a regular transporter, and includes such equipment as cranes, forklift trucks, carts, and robots. The second type of material handling device which may be modeled is conveyor systems.

Regular transporters are individual units which operate independently. A regular transporter may service several stations and carry parts in lot sizes of one or more. A regular transporter is considered to be busy when it is traveling empty to pick up a lot or when it is traveling loaded to deliver a lot.

Response and transportation times can be specified as samples from statistical distributions. If a more detailed representation of response and travel times is critical, the exact distances between stations can be used to calculate exact travel times. Distances between stations are defined with a DISTANCE input statement.

Conveyors are frequently used in more automated manufacturing systems as the material handling device which transports parts between work stations. In cases where parts recirculate until room is available at their next station, conveyors are also used as temporary storage media.

Conveyors have special characteristics which differentiate them from regular material handling devices. Their continuous mode of operation and their restriction to movement over a fixed path are two such characteristics. The MAP/1 conveyor capability allows detailed modeling of conveyor characteristics. It provides for specification of closed-loop systems where parts bypass full stations and recirculate on the conveyor, and for open systems where parts do not recirculate. One may also define networks of conveyors in which a single conveyor may diverge into several conveyor paths or several conveyors may merge into one conveyor path.

A CONVEYOR input statement is used to define a conveyor in a MAP/1 model. Parameters defined on the CONVEYOR input statement include the conveyor path, the conveyor length, its velocity, whether it is an open or closed loop conveyor, and whether parts will bypass a full station or accumulate in front of it. A MERGE input statement is used to define a point where two or more conveyors join and a DIVERGE input statement defines a point where a conveyor splits into two or more conveyors.

Personnel. In many manufacturing systems, people are required to operate machines or material handling equipment, or to perform manual operations such as inspection or deburring. In some systems, operators are very critical resources and their availability can greatly affect the overall performance of the system.

Typically, the people who work in a manufacturing system are divided into personnel classes with specific job functions. One personnel class could be forklift truck drivers, who are restricted solely to operation of the forklift trucks. Another personnel class might be master machinists, who are able to operate any machine in a department as needed. When an operator is required for a job, a specific person is selected from one of the qualified personnel classes.

The PERSONNEL and OPERATOR input statements are used to define the possible assignments of personnel in a MAP/1 model. Each class of equivalent personnel are defined with a PERSONNEL input statement which specifies the number of people in the class and the jobs they are qualified to perform. For each piece of equipment requiring an operator, an OPERATOR input statement is developed which identifies the equipment requiring an operator as well as the number of each type of operator required. The information provided on PERSONNEL input statements is used in conjunction with the information provided on the OPERATOR input statement to assign individual operators to individual pieces of equipment.

Fixtures. A fixture is a device which holds a part or group of parts during machining or transport. A pallet can be thought of as a fixture. Usually a fixture is used by a part for several consecutive machining operations and subsequent transports. After finishing one set of operations, a part may be turned over or rotated in the fixture before proceeding to its next set of operations. A part may require the use of several different fixtures to complete its processing. Conversely, one type of fixture may be required by several different parts.

Due to their high cost, fixtures often serve as a limiting resource in manufacturing systems. The number of each type of fixture available usually determines the maximum number of parts which may exist in the system simultaneously as well as the current mix of part types. The rules used to allocate fixtures to the various part types at load stations can have a major impact on system operation.

The MAP/1 fixture capability was designed with all these fixture characteristics in mind. A FIXTURE input statement is used to define each type of fixture used in a MAP/1 model, including the number of fixtures available and the rule for allocating these fixtures to the various load stations where they may be required. Stations at which fixtures are loaded or unloaded are identified in the routing of the part which uses the fixture. Parts are loaded into fixtures based on fixture availability and the ordering of parts waiting at fixture loading stations. A part may return to the same station several times to be loaded into and unloaded from fixtures.

Common Operational Characteristics. There are several operational aspects which workstations, material handling devices, personnel, and fixtures have in common, including their operation according to scheduled shifts and their tendency to breakdown. STATION, TRANSPORTER, CONVEYOR, PERSONNEL, and FIXTURE input statements provide a field for specifying a shift schedule identifier. This shift schedule identifier points to a SHIFT input statement where the sequence of "ON" shift and "OFF" shift time periods is defined. Equipment which is ON shift will continue to process parts until its status is changed to OFF shift. Rules can be specified to control the transition from ON shift to OFF shift processing, including the capability to allow overtime to complete a part in process at the end of an ON shift period, or to refrain from starting a process which cannot be finished before the ON shift period expires.

Equipment is typically not operational 100% of the time that it is scheduled to be ON shift. It may fail occasionally and need to be repaired. In addition, routine maintenance is often scheduled in an attempt to prevent equipment failures at inconvenient times. Tools at stations are worn down by part processing and need to be replaced periodically. Downtime periods such as these may be defined for workstations and material handling devices in MAP/1. Transporter and conveyor downtime is modeled using BREAKDOWN input statements. Workstation downtime can be modeled in greater detail with FAILURE, MAINTENANCE, and CHANGETOOL statements.

General Simulation Information. General simulation information identifies the model by name, indicates the length of the simulation run and the number of simulation runs to be made. This information is specified using the BEGIN input statement. The BEGIN input statement is followed by the system description and simulation control statements for the first run. A SIMULATE input statement is used to separate the simulation control statements for each subsequent run. The end of all input is specified by the END input statements.

Selection of Output Reports. The MAP/1 program provides three types of output reports: (1) pre-execution reports; (2) intermediate reports; and (3) post-execution reports. Pre-execution reports, including the Input Listing Report, Input Echo Report, and Model Storage Report, are printed during and immediately following the input phase, before model execution begins. Printing of these reports is controlled using fields on the BEGIN input statement. Intermediate reports are printed during model execution. These reports are requested for a particular simulation run by using REPORT input statements. Post-execution reports are printed at the end of each simulation run. A standard set of post-execution reports is printed by default. OUTPUT input statements can be used to override the default by specifying which reports should be printed at the end of each run. MAP/1 reports which may be requested for either intermediate printing or post-execution printing include the Production Summary Report, the Current Status Report, the Throughput Report, the Utilization Report, the Overtime Report, the Downtime Report, the Inventory Report and the Time Measurement Report. In addition, a Trace Report may be requested for intermediate printing. Each of these reports is described in the MAP/1 Execution and the MAP/1 Output Sections.

In addition to selecting which reports should be printed, the user may also redefine the format of the standard MAP/1 reports using DEFINE input statements. These statements allow him to specify report headers and the list of components (i.e., part type names, station names, transporter type names, conveyor names, personnel class names, and fixture type names) to be included in each report. More sophisticated users who are proficient in FORTRAN coding can bypass the MAP/1 output features and write their own output subroutines. Support routines are available to provide the MAP/1 simulation data for those who choose this option.

Model Initialization. As mentioned previously, a MAP/1 model is driven by part arrivals. If the model starts empty and idle, it takes a certain amount of time for the flow of parts to extend throughout the model. If the steady state operational performance of the model is of concern, the initial condition bias of starting empty and idle should be eliminated from the data collection process. In MAP/1, this can be accomplished in one of two ways. The CLEAR input statement allows clearing of statistics after a specified startup period. Alternatively, the use of ISTATION and ITRANSPORTER input statements allows the model to start execution in a non-empty state. ISTATION input statements allow parts to be placed at stations in preprocess and postprocess storage areas at the beginning of the simulation. ITRANSPORTER input statements allow transports to be ongoing at the beginning of the simulation.

MAP/1 Execution. A MAP/1 model is simulated by executing it with the MAP/1 simulation analysis program. This program reads in and decodes the input statements. Each input statement is echoed exactly as input in the Input Listing Report. If any errors are detected in the statement, an error message appears immediately following the statement, indicating the exact field where the error was found. If any input errors are found, simulation execution will not be attempted.

If no input errors are found, the MAP/1 simulation program prints an Input Echo Report. This report provides a tabular summary of the system description with appropriate column headings. It should be checked to further verify model input.

If requested, a Model Storage Report will be printed next. This report provides information on the amount of program storage space available for storing characteristics of individual parts as they flow through the system, and reports the maximum number of parts allowed in the system concurrently. It can be used to determine, before model execution begins, whether enough storage space is available for the maximum number of parts which will be in the system concurrently. It can also be used, if necessary, to predict how much extra space is needed, so that program size limits can be adjusted accordingly.

Following the printing of these reports, model execution begins. Run-time errors may be encountered, arising from cross-reference errors not detected during input. If so, simulation execution is terminated and a specific error message is output. If no execution errors are detected, the simulation will continue until the simulation finish time specified by the user is reached. If intermediate reports were requested, they are printed during the simulation execution. If a Trace Report is requested, a detailed message will be printed each time the status of the system changes. This report is useful as a model verification and model debugging tool. When the simulation finish time is reached, appropriate output reports are printed containing system performance measures for the run just completed.

MAP/1 Output. During execution and at the end of each simulation run, any of the standard MAP/1 output reports may be printed. These reports contain the system performance measures of throughput, equipment and personnel utilization, overtime, downtime, inventory levels, and part flow times. A Production Summary Report summarizes the number of parts produced and the production rate over a specific time period. A Current Status Report describes the status of system equipment, personnel, and storage areas at the time the report is printed. A Throughput Report provides statistics on system throughput by part type, workstation, transporter type, personnel class, and fixture type.

A Utilization Report provides statistics on the status of work stations, transporters, conveyors, personnel, and fixtures over time. The utilization of a work station includes information about the fraction of time the station was being setup, or was busy, idle, down or blocked. Conveyor and transporters may be busy, idle, down, and blocked. Personnel and fixtures may only be busy and idle. For each ON shift state, MAP/1 provides statistics on the average number of machines, transporters, conveyor cells, fixtures, or personnel in that state, as well as the standard deviation, maximum and minimum numbers. In addition, statistics are also provided for stations and personnel who work during OFF shift time periods in an Overtime Report. A

Downtime Report provides information on the number of downtime periods experienced by a workstation and their duration.

The Station Inventory Report provides statistics on the number of parts in inventory storage at each station, as well as waiting times for processing and transport. The Time Measurement Report, provides information on how parts spent their time in the system. For each part type, MAP/1 collects statistics on total time in system, dividing this time into four categories: processing time, traveling time, station waiting time, and transporter waiting time. Time between completions and early/late time statistics are also reported.

In addition to tabular output reports, graphical displays of MAP/1 simulation data are available through integration with the TESS™ software. SAVE statements are provided for specifying which MAP/1 data should be stored in the TESS database during the simulation run. This data can be used to create plots, pie charts, bar charts, histograms, or range charts in addition to specialized user-formatted reports. For example, a plot of the number in preprocess at a workstation, a pie chart of workstation utilization showing percent of time setup, busy, idle, down, and blocked, or a range chart showing time-in-system statistics for various system scenarios are all possible.

SUMMARY

This paper has described MAP/1, the modeling and analysis tool for discrete parts manufacturing systems. MAP/1's extensive modeling capabilities provide a user with the ability to represent a wide variety of batch manufacturing systems.

One need not program the operational logic of manufacturing operations to use MAP/1. One simply parameterizes the key components of batch manufacturing systems. This results in a simulation tool which can be used by non-programmers or simulation analysts desiring a less time consuming modeling tool.

REFERENCE

1. Miner, Robin J. and Laurie J. Rolston, MAP/1 User's Manual, Pritsker & Associates, Inc., West Lafayette, IN, April 1983.

LAURIE J. ROLSTON is a Systems Consultant at Pritsker & Associates, Inc. She holds a Bachelor of Science in Industrial Engineering from Purdue University. Since joining P&A in 1980, she has had experience applying SLAM to industrial problems and in the development and support of P&A's commercial software. Ms. Rolston was involved in the development of MAP/1 and is currently responsible for user support, maintenance and software enhancements. She is a member of Alpha Pi Mu, Tau Beta Pi, and AIIE.

ROBIN J. MINER is a Director at Pritsker & Associates, Inc. She holds a Bachelor of Science in Statistics and Computer Science from the University of Delaware and a Master of Science in Industrial Engineering from Purdue University. Ms. Miner has specialized experience in simulation language development and in the application of simulation techniques in system modeling and problem solving. Specifically she has been involved in the design, development and documentation of the Safeguards Network Analysis Procedure (SNAP), a special purpose network simulation language tailored for the analysis of nuclear facilities as well as the design and development of the ICAM Definition Language for Dynamics Modeling, IDEF2, a special purpose modeling capability for describing and analyzing the time-varying behavior of aerospace manufacturing systems. Currently, Ms. Miner is responsible for all software development and user support activities at P&A. She is a member of ORSA, AIIE, Alpha Pi Mu and Phi Kappa Phi.

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