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J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick, eds.

SIMULATION IN THE FUTURE

Jerry Banks, Panel Chair

Brooks Automation, AutoSimulations Division
1355 Terrell Mill Road, SE
Building 1470, Suite 200
Marietta, GA 30067, U.S.A.

ABSTRACT

Seven panelists, all simulation consultants, give their view of the future of simulation. There is some consistency in the views with four areas being mentioned by three of the panelists, and four areas being mentioned by two of the panelists. However, depending on how the counting is performed, there are approximately a dozen other areas with just one mention.

1 INTRODUCTION

This is the fourth year that a panel on the same topic has been convened. For the first two years, the panelists were all simulation software vendors. They discussed their forecasts for the technology in prescribed areas. In the third year, the panel was a mixture from academia, software vendors, consultants, and corporate simulationists. They discussed the needs of simulation in the future. This year, the panelists are all simulation consultants. They use simulation every day. They certainly have some definite ideas about what developments are necessary for the future.

2 DANIEL T. BRUNNER, Systemflow Simulations, Inc.

Simulation is a proven technique in search of even more widespread acceptance than it currently has. Below are five possible future directions for simulation that may be stepping stones to this acceptance.

But first, in order to chart a course for the future of simulation, we need to understand the past. We can skip the early days and assume the existence of various simulation languages with these common built-in elements such as clock management, list management, random variate generation, and statistical reporting.

As of 1980, discrete-event simulation languages were reasonably popular in manufacturing, computer and communications modeling, and in military and government applications. A common thread was the (large) size of the organization typically using this technique. A large number of universities were teaching simulation – meaning simulation using simulation languages – in engineering, business, and computer science programs.

The following subsequent developments got us to where we are today:

- Development of a special purpose language for material handling applications (e.g. AutoMod)
- The introduction of simulation software running on PCs (e.g. SIMAN)
- The introduction of animation (coinciding with the availability of graphics on workstations and PCs) (e.g. SEE-WHY)
- Development and deployment of simulation-based scheduling technology (e.g. FACTOR)
- Development of tools designed from the start for graphically assisted model building (e.g. WITNESS and ProModel)
- Rapid improvements in the graphics and processing power of PCs
- Complete penetration of the technique of simulation analysis of capital projects into one major industry (automotive)
- Development of tools geared toward extensibility (e.g. Extend, Arena, and SLX)
- Rapid penetration of the technique of simulation-based scheduling of day-to-day operations into another major industry (semiconductor manufacturing)

Amazingly, almost all of the above “since 1980” developments were complete or at least well underway by 1990. In other words, not much happened in the 1990s. Simulation did not exactly stand still, but at the same time, we have reached 2000 without the type of widespread permeation through all industries and organizational sizes that many in the community might have hoped would come to pass.

So what does the future hold? Here are some ideas of possible future developments that might help propel simulation into the 21st century.

2.1 Improved Model Delivery Capabilities

From a perspective, it is often important to be able to deliver a model to a customer for experimentation, demonstration, and sometimes ongoing use. What tools are needed to make this process painless and efficient? *Improved data interfaces* would help. Spreadsheets are not always the right choice – alternatives include database interfaces and ad hoc user-controlled inputs within the model execution environment. The ability to deliver a model would also be helped by better *documentation* of the execution environment and smooth, professional-grade end-user *installation processes* for completed models. This has to come from the simulation software vendors – it is not going to come from consultants. Licensing is another issue. The current situation is a bit chaotic, but it appears there is a trend toward freely distributable run-time versions of development models and animations. Finally, attention needs to be paid to emerging possibilities for model dissemination including downloading or running a developed model from a central source (client-hosted or server-hosted execution).

2.2 The Next Great Application Area(s)

As mentioned above, simulation has deeply penetrated automotive manufacturing (for capital project analysis) and semiconductor manufacturing (for analysis and operations management). Another major area is automated material handling and in particular warehousing and distribution applications (often for analyzing and demonstrating new systems). Parcel and letter handling is an important component of this. What are some other opportunities? Discrete-event simulation has penetrated health care but not permeated it. The same goes for business process analysis (although there has been a recent major push into simulation of this area by large management consulting firms). Service industries (particularly high-volume applications such as call centers, fast-food retail, and entertainment facilities) have some use. Transportation systems (streets and highways, pedestrian movement, freight and passenger rail, airport and airspace simulation, water transportation, and port facilities) would seem to be prime candidates, but there is no clear pattern of simulation being widely accepted throughout transportation applications. There are other relatively untapped areas such as pharmaceutical and chemical manufacturing, mining and mineral processing, printing and publishing, and modeling of mid-sized manufacturing operations. What will trigger one, or more, or all of these to take off?

2.3 Embedded Applications

One prediction is an increase in simulation becoming embedded in other tools. There exist many software packages with large markets in the vertical areas mentioned above – much larger than the sales volume of any current discrete-event simulation package. If some of those applications could contain an embedded form of simulation and/or simulation-based scheduling, then some (not all) of the benefits of the technique of discrete-event simulation would reach a much wider audience.

2.4 Emulation

This is another up-and-comer. How often do simulationists end up reprogramming someone else's control logic? Or, in the absence of existing logic (i.e. for a new system), how often do simulationists actually develop system or subsystem control logic, only to have it thrown away and/or reprogrammed at system implementation time? Today it is possible for a simulation model to talk to that "other" control logic, or if the tables are turned to *be* the control logic, as needs may dictate. There are disadvantages to connecting simulations to actual systems instead of describing and implementing specific logic, but it would seem that this is another area whose time has come.

2.5 Training

There is a problem with the way that simulation is taught and to whom. In the past, "basically trained" simulation practitioners came in droves out of Industrial Engineering and Business schools. But it seems that many of today's young engineers and managers aren't interested or capable at the level they once were. Perceiving that simulation is a software tool (in the manner of, say, a spreadsheet), practitioners and their managers sometimes insist on quick, "easy" answers to complex, high-dollar problems. But simulation is *not* a software tool. It is a multidisciplinary technique that requires a fair amount of training, skills, and experience to perform effectively. Furthermore, complex systems sometimes require complex solutions. How can colleges and universities more effectively turn out people who will understand (in their future managerial roles) what simulation can and cannot do, and people who can apply the technique themselves? This is a challenge to all people active in academia in engineering, business, and related fields.

3 KEN BUXTON, Rockwell Software

A number of opportunities for improvement are open to simulation over the next five years. Mainly, reducing the time it takes to build a model, generate a valid solution, and provide the client with a model that is accessible and usable by any person within the company. Some of these opportunities for improvement are discussed in the following paragraphs.

3.1 Data Manipulation

A simulation model is only as good as the data that drive it. Since the client supplies data, it is imperative that the consultant has a quick, easy way to access client data to use in the simulation model. The problem is in the amount of time that it takes to complete this very important step. Existing methods work well, but take an incredible amount of non-value added time.

Project time could be significantly reduced if simulation packages had the ability to pull data directly from any standard MRP/ERP system or any database or spreadsheet product (e.g., Access, Excel, Lotus, etc.). It would require the simulation software to provide drop-down menus for a consultant to input the name and location of the file(s) containing the desired data, the file structure, and the file type. The simulation package would open the client file(s), extract the needed data, and either close the file or keep it open for further access during the run. This would eliminate a lot of project time used for data collection and allow the consultant to focus more time on model logic and validation (value-added activities). In addition, this would allow the model to be easily updated by the client in the future if the data file name or its structure changed.

3.2 Optimization

Clients want the best solution, not a range of solutions, which will enable them to achieve their objective(s). Optimization routines allow clients to find the best solution based on the system modeled and the variables altered. However, because consultants build models that can be quite large and the data to drive the model enormous, the use of an optimization routine is not always an option. The problem arises when the data supplied by the client are enormous and must be electronically read into the model during the simulation run, which cannot be handled by optimization routines.

Simulation companies must find a way to integrate optimization routines into their software so that consultants can build models that allow data to be imported and exported without interfering with the optimization routine. This would eliminate the need for a consultant to create a custom interface for clients to see simulation results in a specific format (e.g., Excel, Access, Lotus, etc.). Optimization routines may also encourage simulation to be used more often within a company if it can provide the information needed by the client in a fast, efficient manner in the format desired.

3.3 Financial Analysis

Clients are interested in “bottom line” results – cost, revenue, profit, ROI, etc. Most clients focus on saving money or cutting the cost of doing business. However, cost is only one side of the profit coin. The generation of revenue is just as important to the ability of a company to become more profitable. Most simulation packages, however, do not handle revenue calculations as easily as they handle cost calculations. Also, cost calculations are usually only broken down by resource cost and inventory carrying (holding) cost. Therefore, the consultant must take more time when building the simulation model to include more detailed cost and revenue calculations so that a better picture of profit will come into focus and the client can make a more informed decision.

It would be beneficial if the Balance Sheet and Net Income Statement line items were integrated into the simulation package. When both revenue and expenses are included in model results, the client can make the most profitable decision and the consultant’s work is much easier.

3.4 Web-Based Simulation

The client is not only interested in the solution, but also in propagating simulation technology to other parts of its business for repetitive use. Web-based simulation is not a new topic, but it is becoming increasingly popular with so many people having access to the Internet. However, most simulation models do not run well over the Internet. This is partially due to the speed of the connection at both ends as well as the amount of traffic on the web. However, much of the blame is due to the “overhead” used by simulation packages to calculate entity movement and update animation. The result is usually a “jerky” simulation that tends to cause more headaches and loss of interest than convey the information intended by the host client or consultant.

Consultants and clients would both benefit from web-based simulation capability. Models could be reviewed with clients via the internet during model development. A consultant could make changes to a model via the internet without traveling to a client site. Data files could reside in one central place for access by the model from any location in the client network. Models used for teaching purposes (e.g., system dynamics) could be shown to a large audience via the internet during a single session.

3.5 Communication

With today’s simulation packages, consultants are able to model the most complex systems. However, it is not the complexity of the system but rather the level of detail that inhibits clients from benefitting more from simulation. It has been said that the success of a client is much more determined by the consultant than by the software. More often than not, the best solutions are generated by the questions a consultant asks, not in what a client is told to do. Simulation is a great tool for generating the questions that challenge a client's thinking and way of doing business. The challenge lies in the consultant's ability to successfully apply simulation to a problem to generate a solution that will maximize a client's profit.

A consulting project and the simulation results can get "muddy" when the client is interested only in the problem at hand (local optimization) instead of the system as a whole. Decisions can be made using simulation that are based on the wrong measurements or can be made without considering the impact they will have on other links in the business and how these decisions will affect the bottom line. Many clients want to model their operations at a *micro*-level while ignoring the advantage that simulation brings when a *macro*-level model is built that shows the impact of decisions made at different links of an organization (manufacturing, distribution, suppliers, transportation, customers, etc.). It is the consultant's job to clearly *communicate* the advantage of using simulation at a macro level to help client's maximize profit.

3.6 Conclusion

All simulation packages have strengths and weaknesses. Some are extremely good at describing specific industries or systems. It is not difficult for a consultant to find a good simulation package on the market today that provides the ability to model just about any system encountered. It is important, though, for consultants to clearly *communicate* to clients that simulation is a tool, not a solution in and of itself.

It is not the software or technology that makes the biggest impact, but rather the client's understanding of the uses of simulation. Clients must understand the importance of a *macro* approach to modeling versus a *micro* approach so that they can see the impact of changes across all links in their business.

Improvements in simulation *software* can help consultants build models faster and more efficiently to shorten project schedules and enable more timely solutions for clients. Improvements in simulation *technology* can allow both clients and consultants to work with models more efficiently and effectively over the web without having to be physically in the same location.

4 JOHN CARSON, AUTOSIMULATIONS, a Brooks Automation company

The future is not just unknown; it is unknowable. With that said, here's what's going to happen. Simulation will be customer-driven and market-based. Anything outside this will go nowhere as far as commercial applications and use by practitioners are concerned.

The market is demanding easier development and usage of models at the same time as it demands more functionality and greater accuracy. Faster and easier to develop, faster and easier to modify, and customized to the customer's industry, even to the customer's applications. The solution is more products with a narrow domain of application–simulation for the niche. The foundation is better tools for simulation consultants to develop, not models, but specialized, customized model templates so that the end user can easily and quickly put together a model using highly specific components that reflect their industry, their company, their production line, their niche.

4.1 The Future

So my focus on doing the impossible (predicting future trends) is on the tools that will make the template models easier for model developers to develop and deploy. The future :

1. Better and tighter integration of simulation software with other industrial software for the purpose of easy exchange of data. CAD, ERP/MES, WMS, and MCS come to mind.
2. Tighter integration of simulation software with control systems and controls emulators, to test controls at the MES/WMS and MCS/PLC levels before they are implemented. These can drastically reduce testing and debugging in the field.
3. The development of simulation-oriented interchange standards. Possibilities include SDX and XML for simulation objects. DXF is already there for CAD import, but others will emerge.
4. Windows user interface development has long been component based. Simulation needs something similar. This is not the same as object-oriented a la C++.
5. Virtual reality will become more prevalent. The market wants some fun, and it's valuable also.

The future is easy to predict because it's just an extension of current trends as my top five so clearly demonstrates. The actual future will have a surprise or two.

4.2 Going Nowhere

Here are some trends that will go nowhere in the near future, if ever, in the general commercial simulation software marketplace:

1. The web has revolutionized communication between customer and consultant. This has

already happened. It will continue to improve. However, an always-up-to-date model that is maintained and runs from a server on the web is a pipedream. The web isn't the problem; it's the always-up-to-date part. Now, coming up with an easy way to maintain an up-to-date model *anywhere* would be a miracle. I predict this will not happen. Whether the model runs on the web is an afterthought. However, using the web to present models to customers in far-flung locations will happen, or already has.

2. HLA, or High Level Architecture, is a DoD initiative. It is just one way to implement distributed simulation. It will go nowhere in industrial use until it can be greatly simplified and re-jigged so that models can be developed transparently.
3. PADS (parallel and distributed simulation) refers to simulating different parts of one model on different computers. According to Jack Kleijnen (private communication to Jerry Banks dated June 16, 2000), PADS "must study the simulation model, and then take it apart so that each CPU can run a part (module) of the total model. So PADS has not a single, standard solution. Popular simulation software does not want to bother, finding a tailor-made solution" for each individual model.

   For discrete-event simulation, it is currently possible to distribute multiple runs over multiple computers on a network, and then to consolidate the results onto the user's computer as if all runs had been made there. This uses those idle CPU cycles. If enough computers are on the net we have a virtual super-computer.
4. Object-oriented simulation packages a la C++ is too hard for most simulation practitioners. Simulation has been object-based from the beginning. The main goal of object-orientation that would be of benefit in simulation is re-usability. Component-based simulation (with some object characteristics in some unknown configuration) is the solution for practitioners; simulation software developers are already using C++ and other object-oriented tools.

The nature of the market is that lots of people will experiment and try lots of ideas, including the ones panned here, and even more importantly, ones that I will never imagine. That's reproduction and mutation. It creates lots of frogs and a few princesses. At the same time, the market will pick and choose the winners and losers, usually with reasons and according to rules that we will not be able to fathom in the short run. As beauty is in the eye of the simulationist, the princess that's chosen may be the frog that I see. That's market selection. That's the way it will happen. If I'm right, well it's like putting 1,000,000 monkeys in a room all flipping coins. Some monkey will get 100 heads in a row.

5 RANDALL GIBSON, Automation Associates, Inc.

In the coming decade we will see a change in the marketing and development of simulation software products away from the recent emphasis on "ease of use," toward more powerful development capabilities that meet the needs of expert users. Simulation models will find more applications, especially as "embedded" modules within larger application software. Simulation models will be used as forecasting "engines" for real-time scheduling and control functions. The developers of these models will require more capable tools – especially those that integrate well with programming and database environments. Standards for development tools, code portability, and integration with major desktop application environments will become the most important concerns to these simulation developers.

5.1 Premise

As simulation modeling becomes more accepted and a preferred solution, more is expected of the models. Most real world projects where simulation modeling is now employed require high fidelity detailed models, which require customized model development tools. So-called "templates" or re-usable models have proven to be of limited use, and too restrictive for the developer to customize to the extent needed to reflect the actual system being simulated. The simplified model "drag and drop" user interfaces which have dominated the simulation market during the last decade will fade as users become more capable and frustrated with the limited capabilities offered in such products. Simulation modeling will become recognized (once again) as an engineering discipline, requiring training and experience to perform properly. The primary paradigm for simulation modeling will become a software development project, as opposed to the way it is often thought of today – as a standard desktop application.

5.2 Discussion

Simulation modeling project requirements are becoming more demanding. The tools that model developers will require and depend upon must change. Simulation software providers will need to enhance the development environment, to tailor it more to the expert user. Too much emphasis has been placed on the "ease of use" drag-and-drop features for the beginning user – at the expense of capabilities that more advanced users need. This will change in response to the requirements of more expert users, who will become the dominant users in the next decade.

A primary requirement will be the ability to more closely integrate programming and database constructs and tools with the simulation software. For example, the ability for a simulation construct to directly reference external (complex) data structures will be increasingly useful.

Simulation products will need to become more "mainstream" for software development environments. Standardization of the development tools and environment to the primary or dominant development and programming environments (e.g., Microsoft) will be required. Programming constructs that allow simulation model programs to integrate with the operating system and special external I/O constructs will be required.

Finally, simulation software providers will need to provide more timely support for current PC hardware, especially graphics standards and hardware accelerators.

6 KHALED M. MABROUK, The Model Builders

As a simulation engineer for the last 13 years, I have had the honor of working with many companies across a variety of industries. Some of these companies were significantly advanced in their use of simulation, and others were novices. In most, if not all, situations, a big frustration for the individuals I have worked with, is that simulation technology has not allowed them to easily enable other individuals, within their organization, to utilize simulation.

As a result of some initial success with simulation that these individuals encounter, they have a strong desire to enable more individuals in their organization to utilize simulation as a decision support tool. The challenges that these individuals have encountered as they try to make simulation more main stream is that simulation modeling requires a high level of craftsmanship to be effective. This high level of craftsmanship is due to the skill level required to build accurate simulation models and to experiment with them.

6.1 Bridging the Simulation Gap

An effective solution for bridging this gap between "wide acceptance" and "wide use" of simulation is the development of library driven simulation tools. This is different from object-oriented simulation tools that present their own set of challenges (not to be discussed here).

For the purpose of this discussion, I am defining library driven simulation tools as the ability to use a library of pre-built icons during the model building process. These pre-built icons would be composed of underlying product specific simulation code, while at the same time accurately reflecting "real life" components of the system to which the simulation user is accustomed. These icons should be very intuitive for simulationists, thus allowing them to build simulation models in minutes or hours instead of weeks or months. A number of products currently exist that allow the building of such libraries through the use of object orientation or template building.

6.2 Creating Raving Fans

Most of the products currently available for developing libraries that would facilitate model building fail on two fronts. The first front on which these products fail is the effort required to develop a library for a specific organization. Currently, for most situations, these libraries take six months to a year to develop. This is due to the difficulty (even for simulation gurus) in using these tools to develop libraries. As a result of this long cycle for library development, it is not conducive for most organizations to have a library developed.

The second front on which these products fail is the cost per seat. If an organization has a library developed for their internal use, they are required to purchase a copy of the underlying software for each computer on which they would like to use the library. This goes against the grain of the concept of "allowing wider use of simulation." Even if the library was developed at a reasonable cost and is technically effective, it makes little sense to spend more than a few hundred dollars per seat to utilize these libraries. But the reality is that today $4,000 to $40,000 per seat must be expended to use these libraries. This pricing structure makes the use of "library" driven simulation cost prohibitive. By resolving these two challenges, I believe that we'll be able to convert many engineers and analysts into raving fans of simulation.

6.3 "Library" Driven Simulation

As a simulation engineer, I forward a request to all simulation software vendors to allow my clients to bridge the gap between simulation capability and simulation usability so that my clients can join the attendees of this conference in becoming raving fans of simulation.

There are two ways that the vendors can help us to achieve this goal: first, make it significantly easier to develop simulation libraries for our clients, and second, make the price of the software needed to utilize these libraries inexpensive.

7 CINDY SCHIESS, Design Systems, Inc.

As consultants using simulation on a daily basis, the easier the software is to use, the more productive we are, and the lower the cost to our customers. In addition to traditional uses of simulation, we use it in non traditional ways such as in the emulation of conveyor controls, ergonomic analyses connected to dynamic simulation, and dynamic evaluations of previously static analyses.

Software and hardware advances over the last few years have allowed us, as consultants, to get involved in the design of systems at a more detailed level without greatly impacting the cost or schedule of a project. Greater simulation involvement in projects has actually allowed installations and startups to occur in a quicker and more controlled manner.

There are definitely more advances to be made in the world of discrete-event simulation. Some desired developments are as follows:

1. Modules that more accurately imitate various material handling constructs without work 'arounds' and with less coding while maintaining the capability to customize the logic to model the devices in detail.
2. Faster runtime capability.
3. Ability to easily exchange CAD files and simulation path constructs.
4. Better graphics with less effort and little to no impact on model performance.
5. Ability to use the simulation model to size the proper conveyor components (apply dynamic loading).
6. Have simulation be more of a seamless transition to the engineering toolbox versus a duplicate effort at times.

More and more simulation packages are emerging due to greater emphasis being placed on simulation and lowering installation/startup/running costs. Having more simulation packages on the market has advanced the quality and capability of the software. As long as each vendor is trying to stay ahead of the competition, we will continue to see useful advancements.

We, as users, need to voice our desires and dissatisfactions to the software vendors in order to have them improve their products. If we jointly ask more of their simulation products, features will continue to emerge allowing us to do our work more effectively and at a lower cost.

8 ONUR ÜLGEN, Production Modeling Corp.

There are five trends in simulation software and technology that can aid its broader use. These trends are explained in the following paragraphs.

8.1 Simulation as Part of a Broader Tool Suite

Simulation software tools will continue their integration with other tools to form tool suites. These other tools may be spreadsheets, statistical analysis software, mathematical optimizers, pattern recognition and artificial intelligence tools, programmable logic designers, ergonomic analysis software, robotic software, or process flow layout and analysis tools. Increasing understanding and prevalence of object-oriented software design and programming methods significantly assists the integration of traditionally free-standing simulation tools with these correlative analytical tools (Ülgen and Williams, 2000). Among these analytical tools, pattern recognition and artificial intelligence tools that identify system bottlenecks and suggest methods to improve them can save significant time for simulation users.

8.2 On-Line Simulators for Quick Decision-Making

Most of the simulation studies in the past have been conducted to aid decision-making for long-term horizons of one year or more. One desirable future trend in simulation applications is building of simulation models for short-term decision making for the next shift, day, week, or month. These simulators should be used in a manner very similar to the scheduling packages currently available in the market place. They should have easy access to the databases that provide real data for current conditions, interfaces that make them easy to use, built-in war-gaming capabilities for quick scenario analysis, and optimizers for optimal parameter settings for selected variables.

8.3 Web-Based Simulation for Broader Use

Web-enabled simulation can expand the use of simulation by providing global support for the users, interactive and collaborative model building, validation, and analysis, more realistic war-gaming simulations for systems with distributed decision-making, etc. Web-enabled simulation will also reduce the cost of software maintenance while increasing the use of the simulation software.

8.4 More Domain-Specific Simulators

Domain-specific simulators had been in existence for more than ten years. Examples include packaging-line simulators, emergency-room simulators, medical system simulators, call-center-simulators, and service system simulators. During the last few years, we have seen tools being developed in additional application areas such as process or BPR simulators, product-development simulators, and supply-chain simulators. It has been observed that each domain specific simulator brings in a new set of users to the simulation world.

8.5 Object-Oriented Simulators that Require no Hard Coding

Commercial object-oriented simulators that were previously available were very difficult to use because they generally required learning a new programming language (e.g., Simple++, Modsim). The new breed of commercial object-oriented simulation software should require no hard coding in an object-oriented language and should be completely menu-driven with all the characteristics of true object orientation such as inheritance. This will speed up model building and increase the reuse of previously verified and validated model components that are placed in company specific object libraries.

9 SUMMARY

There were four areas that were mentioned by three of the panelists. These were the emulation of control systems, tighter integration with other software particularly for the exchange of data, web-based simulation, and the development of data exchange standards. Four areas were mentioned by two of the panelists including new application areas for simulation, embedded simulation, virtuality or better graphics, and real time applications.

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AUTHOR BIOGRAPHIES

JERRY BANKS is Senior Simulation Technology Advisor, AutoSimulations, a Brooks Automation company company in their Marietta, Georgia office. He was formerly Professor of Industrial and Systems Engineering at Georgia Tech. He was the 1999 recipient of the Distinguished Service Award from INFORMS/CS. His e-mail address is `<jerry_banks@autosim.com>`.

DANIEL T. BRUNNER is President of Systemflow Simulations, Inc., a services firm active in manufacturing, material handling, distribution, transportation, health care, computer systems, and mining. He received a B.S.E.E. from Purdue University and an MBA from The University of Michigan. He has served as the Winter Simulation Conference Publicity Chair (1988), Business Chair (1992), General Chair (1996), and Transportation Applications Track Coordinator (1998). He is a member of IIE, INFORMS, and SCS. His e-mail address is `<brunner@systemflow.com>`.

KEN BUXTON is a consultant with Rockwell Software (RS) specializing in teaching and implementing manufacturing and distribution strategies. He is a frequent speaker at conferences, universities, seminars, workshops, and business associations. He is also a developer and instructor of numerous courses, workshops, seminars, and assessment tools that are taught through Georgia Tech, the Institute of Industrial Engineers (IIE), and private industry. He came to RS from Georgia Tech's Economic Development Institute (EDI) where he consulted with Georgia business and industry as a Research Engineer for four years, as well as led EDI's simulation team. Prior to EDI, he worked three years as a consultant with the Georgia Productivity and Quality Center and three years in Productivity Engineering at Delta Air Lines, Inc. He holds a BS degree in Industrial Engineering from the Georgia Institute of Technology and an MBA in Operations Management from Georgia State University. He is a senior member of IIE. His e-mail address is `<kvbuxton@software.rockwell.com>`.

JOHN CARSON is regional consulting manager for AutoSimulations, a Brooks Automation company in their Marietta, Georgia office. He was general chair of WSC'98. He is a co-author of the text *Discrete-Event System Simulation.* He was on the faculties of the University of Florida then Georgia Institute of Technology. He was a principal in the consulting firm Carson/Banks & Associates from 1986 to 1994 at which time the firm was purchased by AutoSimulations. His e-mail address is `<john_carson@autosim.com>`.

RANDALL GIBSON is president of Automation Associates Inc., an independent engineering firm based in Solana Beach, California. The firm specializes in systems design, analysis, and simulation modeling. He has over 12 years of experience in simulation modeling and consulting, and 10 years experience in real-time computer control applications for industrial processes. He received a M.S. in Electrical Engineering and Computer Science from the University of California, Berkeley, and B.S. degrees in Applied Physics and in Psychology from the University of California, San Diego. He has written numerous articles on simulation modeling and industrial applications, and is a senior member of the IIE. His e-mail address is `<rgibson@aaisim.com>`.

KHALED M. MABROUK is a Simulation Strategist for The Model Builders. He has spent over ten years assisting many companies in the U.S. and Canada in successfully implementing simulation as a productivity improvement tool. He received a BS in Industrial Engineering from Purdue University after which he worked with Anderson Consulting for two years. From there he spent over four years with Systems Modeling Corporation in the areas of technical support, consulting, training, and sales and marketing. Khaled has authored eighteen articles on the subject of simulation, is a co-founder of the Michigan Simulation User Group, and speaks frequently both at major conferences and at regional chapters of various organizations. His interests include developing mechanisms both for making simulation as easy to use as spreadsheets and for creating the perfect simulation engineering experience. His email address is `<KhaledMB@cs.com>`.

CINDY SCHIESS is the Simulation Assistant Group Manager at Design Systems, Inc., a Manufacturing Engineering Company based in Farmington Hills, Michigan. She has been involved in the field of simulation for 16 years and has been with Design Systems for 12 of those years. She has a BS in Industrial Engineering from the University of Wisconsin - Platteville. She is involved in the Michigan Simulation Users Group (MSUG) and has been on the Steering Committee for the last 5 years. Current simulation activities at Design Systems include traditional material handling simulations as well as Emulation (AutoMod & PLC/PC Controller) and Ergonomic (AutoMod & EAI Jack) simulation. Her e-mail address is <cschiess@DSI-Solutions.com>.

ONUR ÜLGEN is the President of Production Modeling Corporation (PMC), a Detroit, Michigan, USA-based productivity improvement services company, as well as a Professor of Industrial and Manufacturing Systems Engineering at the University of Michigan-Dearborn. He received his Ph.D. degree in Industrial Engineering from Texas Tech University in 1979. His present consulting and research interests include simulator applications, scheduling, layout optimization, project management, and modeling of integrated information systems. Dr. Ülgen is a member of IIE, INFORMS, SCS, PMI, and APICS. He has been a consultant to major international companies including General Motors Corporation, Ford Motor Company, Daimler-Chrysler Corporation, Aeroquip, National Steel, and Whirlpool. His e-mail address is <ulgen@pmcorp.com>.