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THE FUTURE OF SIMULATION SOFTWARE: A PANEL DISCUSSION

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ABSTRACT

Panelists represent vendors of simulation software. Six of the panelists present their position on the question, “Where do you see simulation software headed?” The panelists are given seven areas as suggestions for their response.

1 INTRODUCTION

In November of 1996, the same panel was convened at AUTOFACT to discuss the future of simulation software. The topic was of great interest to the panelists, all representatives of simulation software vendors, as well as the audience. The panelists agreed to restate their positions after more than a year had passed. One year is quite some time in the software business, so the topic is certainly not redundant. The panelists were asked the question: Where do you see simulation software headed in the following areas?

Rapid model building via templates
Object-oriented simulation
Virtual reality
Interface to other software tools
Output analysis
Optimization
Internet applications

The response of six of the panelists is given in the following sections

2 MATT ROHRER, AutoSimulation, Inc.

2.1 Rapid Model Building via Template Models

As the simulation market matures, we move into the market segment called the “Early Majority” (Moore 1991). This is a large group of potential buyers of simulation products, but they need application of specific models in order to justify the cost of performing a simulation. Simulation software needs to be open enough so that experts can build template models for casual users. The interface must be easily customized, allowing for spreadsheet data input and mouse-based interaction with the model. Simulation products must also provide for customization through a structured language.

The number of those using models built by others will continue to climb. Also, we will see more expert users creating templates as a business venture. These trends will drive the simulation vendors to create more open products and tools to assist the model builders in creating templates.

2.2 Object-oriented Simulation

Object orientation (OO) includes many important concepts which apply to all software including simulation. However useful OO is, the majority of simulation users should not be expected to learn the technology. Simulation tools and their interfaces will provide OO features without requiring the users to understand the underlying concepts. An example is a feature found in AutoMod’s conveyor template. The user can create types of conveyor sections, each having its own attributes like speed and spacing. Each type can inherit from another type, but with changes in one or more of the section’s attributes. Thus, a hierarchy of conveyor section types is created in which the OO concept of inheritance is provided directly to the simulation user.

2.3 Virtual Reality

As mentioned earlier, the simulation market is moving to the early majority which makes it harder to justify the hardware required to perform virtual reality (VR). VR solutions currently require expensive workstation hardware costing ten times as much as a standard desktop personal computer.

The real need is to get decision makers “inside” their facilities and data through visualization. Not everyone needs to get inside their model and manipulate it using VR. Simulation products today run the gamut from 2D schematic pictures to realistic 3D animation. The market is pushing to have photorealisitic animation at the level seen in movies such as “Toy Story” and “Jurassic Park.” As 3D Application Programming Interfaces (API) are used to build the next generation of simulation tools, all simulation products will have better graphics. Ten years ago simulation vendors might have said that realistic graphics were not important. Now, realistic graphics are required. In the future, graphics will continue to improve allowing more people to visualize systems before they are built.

2.4 Interface to Other Software Tools

As CAD systems advance, more intelligence will be embedded within drawing objects, and simulation tools will adapt to import drawing intelligence directly. An example could be an intelligent machine in the CAD database. The CAD operator will be able to select a specific machine from a library of machines from different vendors. The library element will not only contain accurate dimensional information about the device, but also the downtime and preventive maintenance schedules. This information will be passed to the simulation directly from the CAD system.

Many simulation software products use spreadsheets for their user interface. Some use a proprietary spreadsheet solution, while others link to products like MS Excel. As mainstream spreadsheet products continue to improve, spreadsheet user interfaces will be more prevalent. Most computer users are familiar with spreadsheet use, so spreadsheets can become the common input data environment for user friendly template models.

2.5 Output Analysis

Output analysis tools for simulation need to include more guidance for users to prevent erroneous inferences. The software needs to protect the non-expert user from making mistakes when interpreting the results. Additionally, the expert user needs better tools for constructing customized reports and capturing simulation information for later analysis.

2.6 Optimization

Many of our customers and prospects want simulation to go farther in providing a good solution to a given problem. They want the computer to perform the tedious job of iterating to that solution. The decision maker using a simulation model and optimization needs to be careful and understand the results supplied by the model. Blindly following the recommendation of a software package could lead to costly mistakes.

Several simulation products today include optimization technology. Heuristic algorithms usually require many runs of the simulation. New algorithms will be developed to reduce the number of simulation runs required. Simulation tools should be able to adapt quickly in applying the new algorithms. Additionally, simulation software that allows for parallel and distributed computing can take advantage of networks of computers where many runs or long run lengths are required.

2.7 Internet Applications

Simulation tools will provide better ways of disseminating information using the Internet. The web is a perfect medium for information transfer in many forms. Animation video, still pictures, reports, and graphs will come together on the web to help others see the results of simulation models.

User friendly interfaces will be developed in Java to provide a way of inputting data and experimenting with models. Thus, simulation will become a client/server application in many organizations, and the Internet will be the conduit.

3 JIM RIVERA, Imagine That, Inc.

The current focus of the simulation industry is to increase the usability of simulation software while maintaining or increasing flexibility and accuracy. Borrowing successful features from other desktop applications, simulation software is developing into a more user-friendly tool. Advances such as graphical user-interfaces, object-oriented programming, template models, and interfaces with other tools will continue to make it easier to build and maintain useful simulation models. This will make the power of simulation accessible to more people than ever.

3.1 Object-oriented Simulation

Object-oriented program development allows users to take advantage of flexible pre-built constructs. Combined with a graphical user interface, this has greatly altered how people are creating models. Today, it is not uncommon for entire models to be created using “point and click” methods and by completing simple dialog boxes. In addition, by allowing the user to hide and show model details as appropriate for the target audience, hierarchy has changed how models are presented. As these interfaces become more sophisticated, building and presenting models will become more intuitive.

3. 2 Template Models

Template models will also reduce model building effort. While no two companies conduct business in exactly the same way, it is very common for companies within the same industry to perform the same tasks. A flexible template model can provide a framework to which detail can be added to accurately depict specific processes. Template models, developed by industry experts, can not only help reduce model development time, but can provide valuable insight into the appropriate inputs to be considered when analyzing a given process.

3.3 User Interface

For most complex problems, simulation is only one part of the total solution. A variety of applications can help the users define their processes, acquire the necessary empirical data, model and simulate the process, analyze and optimize the process, and present the results. Improvements in the interface between different software applications will help to provide a seamless integration of tools therefore reducing unnecessary rework and user errors.

Advances in simulation software will never eliminate the need for users to have a good understanding of their processes. However, reducing the amount of effort required to build and maintain a simulation model will help users to spend less time on the details and overhead of modeling and more time solving the problem at hand.

4 DONALD A. HICKS, PROMODEL Corp.

Predicting the future is a tricky game. The saying goes that the person who speaks from the crystal ball should learn to live with the taste of broken glass. Yet, there is much to be gained from taking a step back from the urgent affairs of the day to examine the implications of the enormous waves of change threatening to wash through the shores of the tiny technological island called “simulation.” While one does not wish to spend time picking glass shards from the teeth, many of the ramifications of the current waves are so evident as to merit a few precarious prognostications.

To get a feel for where simulation software and the industry that produces it is headed, we must first understand the major waves of change in two areas: software in general, and simulation techniques in particular.

4.1 The Software Industry

The global software industry, as it is indeed a world-wide market, has two major technological forces that will directly change the shape of simulation in the future. The all powerful and much ballyhooed Internet is often mistakenly confused with the related concept of distributed computing. The Internet puts everyone on the same network, allowing people to share and collaborate on computing tasks. Distributed computing means that software components on any single machine can offer their services to other machines on the network. Conversely, multiple programs can collaborate with each other, turning a bunch of little computers into a giant, immensely powerful computing organism. The effect for all software programs is that computing power is becoming scalable.

While the speed of individual computing nodes will continue to improve (doubling approximately every 18 months), distributed computing will present opportunities to increase computational power by several orders of magnitude very quickly. Think of it this way: A single simulation running on a single machine can be sped up mainly by getting faster hardware. What if, however, you could run each of your 50 replications on a different machine on the network simultaneously? How about 1000 simulation experiments? If you could get simulation output 1000 times faster, how would you change your approach to experimental design?

4.2 Simulation Software

Object technology goes hand in hand with distributed computing. For distributed computing to be viable, software must be designed and implemented as components whose services can be accessed from any other component that needs it. Simulation software, like most programs, is really a bundle of interacting functional components (random number generator, event calendar, statistical output processor, and user interface, just to name a few). To improve performance, or because the software was designed using older design paradigms, or sometimes out of bad habit, developers of simulation software have tended to tightly bundle all of the components together as a single program, without adhering to a disciplined object-oriented component-design approach.

The result is that simulation programs have tended to be difficult to integrate with other applications. Oh sure, ActiveX/OLE automation wrappers and custom APIs have made it possible for programs to talk to each other, but future applications, including simulation software programs, must allow users access to all of their components, to utilize any of the services they need. Don’t like the user interface that comes with the basic modeling environment? Create your own. Need to stream output statistics directly to a remote user's screen, a data warehouse, or an external optimization program? Have your MIS department (or your summer intern) implement a bridge.

4.3 Predictions

Obviously not every user of today's simulation software will be writing custom simulation applications. However, some will. And what is more likely, simulation capabilities will be a set of services that systems designers and IT producers will include based on users' business needs. This should greatly increase the number of simulation users—but not necessarily the number of model builders. In fact, many models will be built directly from data sources already present in the enterprise computing system of large businesses.

So, distributed computing and object technology will make the next generation of simulation software able to tackle much more complex problems, while increasing the availability of its power to many users who are new to simulation technology. While these waves in themselves are enough to redefine simulation as an industry, there is an extremely important shift in how simulation itself is used and in what capacity.

Simulation, as a tool, is used in projects for one or more of the following three reasons; calculation, visualization, and communication. Improvement in simulation's usefulness as a visualization tool will continue to improve, as will its importance as a means of communication. However, the most exciting and dramatic changes will occur in simulation's ability to calculate information.

With the integration of optimization approaches and machine learning techniques, simulation becomes the engine of a much more complete, and useful, computational approach to problem solving. A major part of the simulation's future lies in this area: simulation calculates the performance measures, or outputs, of a model, while intelligent experimental procedures use goal seeking methods to find solutions.

This approach is extremely powerful and unique. Problems that cannot be modeled using mathematical equations can be tackled by bringing computational power to bear on them. Here's an example: Assume that we are attempting to schedule 10 jobs through two production lines (three machines in each line). There are different changeovers involved between any two of the 10 jobs, and each job has a different cycle time on each machine. Today, we model this problem and optimize the sequence and assignment of the jobs using a mathematical model.

What if we have only one operator, who must be present for some portions of the operations? What if we have other complex constraints that are time related and dependent on the situation? These issues typically befuddle the mathematical programming approach, because they become impossible to model using equations. In simulation, however, we have a means to model the system very accurately. Combined with an intelligent goal seeking algorithm, the simulation simply becomes the function mapping inputs (the assigned line and sequence number of each job) with outputs (time to compete all jobs, total setup time, etc.).

One further point regarding optimization: Do we really want the "absolutely optimal" sequencing and line assignments for our 10 jobs? What if our optimal schedule happens to be completely derailed by any deviation from the plan? Put another way, if random variance occurs in any of the aspects of the predicted system performance, does it change our notion of "best?"

In the real world, variance happens. A major advantage of simulation is that, in addition to dealing with complex problems, it can handle variance in inputs and outputs. As simulation grows into a problem solving technique, we will need to help users clarify exactly what they really want out of a "good" solution. Our definition of "problem solving" must, in the light of computational based approaches, evolve to mean something akin to "problem negotiating," i.e., finding answers that matter because they are relevant to improving real-world situations, not identifying abstract mathematical extreme points. Indeed, the very concept of an "optimal" solution is overly simplistic. As a production manager, would you rather run a schedule that is the mathematically optimal solution, but will perform abysmally 65% of the time, or the 6^{th} best mathematical solution that will perform well 95% of the time?

Companies that successfully adopt this kind of approach to decision making will, over time, perform better financially than those that don't. Simulation based computational problem solving approaches are the tools that will support those successful companies. The next 10 years should prove to be an amazing time for those of us in the simulation world. We are the ones who are responsible for putting simulation's power in the hands of people who can use it to make better decisions. Our success will depend almost entirely on our attitude: We make simulation technology serve our customers and not vice versa.

5 MARTIN R. BARNES Deneb Robotics, Inc.

This position statement provides a view of the future of simulation from two vantage points: The current trends, and some opportunities for changing direction.

5.1 Current Trends

The discrete event simulation marketplace is comprised of a small core of experts and a large shell of consumers. Fortunately for the larger group, the experts have managed to impose a degree of rigor on simulation vendors. This has tended to filter out products that are smoke and mirrors or that would produce invalid results even when used properly. Thus the trend towards easy modeling has been tempered by the inclusion of powerful features which can complement the easy modeling by providing additional flexibility. Future evolutionary development will continue this trend largely because in this field acknowledged experts do have significant influence on product acceptance. Similarly, the community of users formed by SCS, IIE etc., provides communication about products that would quickly shoot down a new product that was deficient.

5.1.1 Ease of Use – Ease of Understanding

A feature common to all markets is the desire for a tool that solves a problem exactly the way an individual user wants and with no effort or understanding involved. We just want the simulation to do what we want it to do without the bother of telling it what we want it to do. Well, unrealistic as this is, it does point vendors in the direction of products that assist the modeling and analysis processes. In general, the more focused a product is, the easier it can be made to use. Simulation vendors should be trying not only to make their products easy to use, but also to make them such that the model behavior is easy to understand. Simply building a model without understanding how it operates, and then accepting the numeric results, is a recipe for disaster.

5.1.2 Domain-specific Products

In general, the move towards the end user requires problem domain terminology and interfaces with two main areas of promise. Firstly, templates which typically provide generic modeling capability within a vertical industry. Secondly, the provision of equipment-based modeling objects, such as specific robots with known performance capabilities. The latter approach requires more cooperation with equipment vendors, but offers the end user a richer approach to easier modeling.

5.1.3 Object-oriented Modeling

The direction of object-oriented modeling fits well with the discrete-event simulation paradigm. The capability to create classes of elements, with a combination of shared and unique behavioral characteristics fits particularly well with the equipment-based modeling objects described above.

5.1.4 Graphics and Virtual Reality

Virtual reality is simply the next stage in the user interface. The communication aspects of realistic, three-dimensional graphical representations of the simulation model are what we would have liked to have at the beginning if we only had the combination of hardware power and graphics tools. However, the use of immersion and interaction with the simulation world is still in its infancy. In the future, expect to see a design team, immersed entirely in the virtual world, building and testing its manufacturing processes. In this world, problems and improvement possibilities will be identified by a mixture of observation, analysis and human communication. Solutions will be tried interactively, using a mixture of tools including behavioral logic that will be constructed with voice input.

5.1.5 Interface to other Software Tools

The simple interfaces to/from CAD, spreadsheets, databases etc. are now established as part of most simulation products. The links to more specialized software tools such as process planners are already available, typically using techniques such as ASCII files or DLLs. The links will become easier and more generally available. The advantage to this kind of integration is often perceived as the reduction of reentering data. However, (see below) more often the real value is in bringing together a team of people, each member of which has responsibility for part of the data and educating the team members as to the impact of their area of responsibility on the overall manufacturing process.

5.1.6 Output Analysis

The use of designed experiments and optimization techniques can be expected to grow. The inclusion of goal-seeking in spreadsheets has clearly shown the desire for tools to help sift through a range of possibilities in a more effective manner. Once again, the mathematical complexity of the solution needs to be masked by an interface applicable to both the power user and the average user. As for the running model, it is important that the user has the tools to assist with an understanding of what is happening.

5.1.7 Internet Applications

There are already simulations keyed off browsers, executed remotely and passing back data. VRML 2 can be used to pass around recordings of running 3D simulations. These recordings allow the viewer to 'walk' or 'fly' around the virtual world as the simulation runs. More sophisticated tools allow a running model to be viewed simultaneously at several sites, with run control being passed from site to site as required.

5.1.8 Expanded Use

A trend in the use of simulation that has really been tackled quite effectively is to get it more widely used. Education has contributed to this and the simulation vendors have often been at the forefront. Also, the advances in ease and speed of use have allowed the tool to be more accepted, and more easily used by both experts and non-experts and often on projects where time scales are short so that in earlier days it would not have been possible.

5.2 Possibilities

The advances made in computer-based discrete event simulation so far tend to mask the poor progress that has been made in ongoing use of simulation. Most models are thrown away. Once the apparent urgency of a situation has passed, the effort in maintaining a model, in case it might be needed quickly some day, is not very attractive. To some extent this is because in many situations there is a continual 'creeping' change rather than a single major change. Human nature is to believe that the results of small changes can be foreseen without a detailed analysis. Another reason for this is that potential ongoing applications of simulation have not yet been adequately explored, developed or marketed. Can we find cost/benefits that encourage the ongoing use of simulation models? Some areas of promise are scheduling, process monitoring and process control.

Another area of promise is for companies to use simulation as a thread of communication between their various organizational elements. To be able to link simple conceptual modeling, through focused highly detailed modeling to the final big picture modeling is a major attraction for senior management. The removal of different modeling methods/repeated work to reduce training time/duplication of effort is attractive but far more is the attraction of a consistent and effective communication process for the various elements of the organization. This requires more highly integrated simulation tools as well as the ability to integrate with other software.

6 WILLIAM R. LILEGDON, PRITSKER Corporation

For many years, simulation has been used by manufacturers to predict the impact of change on their manufacturing processes. The success of these projects has been well documented and the return on investment significant. However, discrete-event simulation remains more of an art form than an everyday tool due to the complicated nature of building and maintaining models. Two key technical developments may now change this environment: integration with other applications, and interoperability between simulation products.

6.1 Integration

Building and analyzing models of manufacturing processes requires a thorough understanding of both the process and the data associated with the process. Now that more manufacturers are implementing systems such as enterprise resources planning (ERP), computer-aided design (CAD) for facility layout, and computer aided process planning for product development, all of which store data in an accessible format, simulation software can more easily access this data. Initial applications are using this data to begin to define process flow and operation times in models. While this data will not fully represent the process, it does help reduce the model building time and increase its accuracy by eliminating misinformation and errors. Integration between a manufacturing planning system or software such as CAD also means that the model can be updated with actual data from manufacturing systems.

Integration with these other systems will force simulation software providers and users to rethink applications. Models that use data from the shop floor directly and automatically, are being used today, and increasing so. As this trend continues, simulation applications will become less expensive and more commonplace.

6.2 lnteroperability

Exchanging data between different simulation tools is an emerging technological improvement that brings significant contributions to the bottom line. Selected simulation tools can predict tool path or robotic performance, while others predict overall system throughput or specific work center loading or job sequence. Understanding these performance issues before implementation can contribute to better product and process design. However, creating a model, representing the same scenario, with different simulation tools, can be tremendously expensive. Several research programs and initiatives are underway that address this interoperability issue. These efforts focus on creating environments where simulation tools with different areas of application can use a common data definition for product and process information. From this common database, the tools can provide their independent predictions of performance, all using the same definition of the process. This interoperability will lead to dramatic shortening of the product and process design cycle and savings for the organizations that implement these technologies.

The U.S. Air Force-sponsored Simulation Assessment Validation Environment (SAVE) has demonstrated the possibilities of an integrated product and process design approach. The program was aimed at integrating and implementing modeling and simulation tools into a virtual manufacturing environment to reduce life cycle costs in the development of fighter aircraft. The first phase of this project demonstrated an integrated simulation environment using CAD, project risk, robotic performance, process performance, and schedule simulations. The program demonstrated total life cycle cost savings of $3 billion. The impact of one recommendation arrived at through the program-the modification of a horizontal stabilizer assembly for F-16 fighter planes represents a net savings of $885,465.

Simulation software can follow the path of other design and analysis software that allow the sharing of data between applications. Users get faster, more accurate models of the systems they manage and can rapidly improve these systems.

7 DENNIS PEGDEN, Systems Modeling Corp.

Over the past 35 years, simulation technology has moved from the domain of a small group of highly technical and skilled technology enthusiasts to a broad base of users in both manufacturing and non-manufacturing applications. Simulation technology has advanced to the point where it has become a mainstream critical technology that helps large and small enterprises around the world reduce risks and make better decisions.

7.1 Improving Tools

Simulation tools are becoming dramatically easier to learn and use, and as a result, the barrier to new users has been reduced significantly. Along with the widespread availability of personal computers, this ease-of-use component has been the primary factor creating the rapid expansion of technology in enterprises throughout the world.

In addition to providing a dramatically simplified modeling environment, these tools also provide a total project orientation that supports the simulation process from initial data collection and analysis through model building, verification and validation, design of experiments, and analysis of results. The environments also provide computer-directed tutorials, online documentation, context-sensitive help, and highly focused examples. The role of graphics in simulation has continued to expand and improve.

One of the important areas of focus for simulation tools is data and program integration. The data for models typically reside in spreadsheets, corporate databases, and other sources. The ability to access this data directly from within a model is a very important capability. In addition, there is frequently a need to interface simulation models to other programs such as flowcharting systems, spreadsheets, data analysis programs, etc. In the Microsoft® Windows® operating system environment, the Object Linking and Embedding and ODBC integration technologies are providing the foundation for dramatic improvements in the integration features in simulation tools.

Over the next five years, we will see continued advancements in simulation tools move this technology from a niche market to a mainstream market. We will see simulation begin to reach its potential in the design and analysis of a broad range of systems.

7.2 Template Modeling

In the past, many of the applications of simulation have been for manufacturing. The use for simulation in manufacturing was driven by the high cost of modern manufacturing systems combined with rapid changes in manufacturing system design.

The dramatic success of simulation in manufacturing systems has helped to expand simulation to other application areas. In recent years, there has been dramatic growth in the application of simulation in non-manufacturing areas such as health care delivery systems, transportation systems, communication systems, packaging systems, and business processes. Although in the past these applications have been modeled using general-purpose tools created for the manufacturing market, the trend is toward having dedicated template-based simulation tools for each of the primary vertical application areas.

Over the next five years, template-based simulation tools will continue to drive new simulation products for a wide variety of vertical applications. This important trend will expand this technology to a wide a range of users.

7.3 Simulation-based Scheduling

Simulation technology has traditionally been applied to the design and analysis of complex systems. Within this context, simulation is used to analyze proposed design concepts. Simulation is used in this way both to evaluate improvements to existing systems as well as to evaluate the performance of entirely new systems.

More recently, simulation applications have been expanded to include real-time factory scheduling. Within this context, simulation is a competitor for existing finite-capacity scheduling systems. However, simulation offers a number of compelling advantages over these traditional finite-capacity scheduling systems.

Over the next five years, we will see a dramatic increase in the application of simulation technology to scheduling as the benefits of this technology become more widely understood and accepted. Simulation-based scheduling tools will be deployed in both stand-alone mode and as part of a broader Enterprise Resource Planning environment.

7.4 Real-time Control

A new and evolving area for simulation technology is real-time applications. In this context, the simulation model is used to control a real system. In this case, the simulation model is purposely slowed down to run in real time and to execute in parallel to the real system. During execution, the model exchanges messages with the controller (either a computer or a person). These messages allow the model and real system to remain synchronized. These messages are also used by the model to issue commands to the real system to initiate specific tasks.

A simulation-based control system has a number of important advantages over traditional control systems. One very important advantage is that a simulation-based control system can, at any point in time, use its system model to examine the system status at some time in the future.

Although simulation-based real-time control systems are in their infancy, they show great promise for the future. Over the next decade, simulation-based real-time control systems will move from "cutting-edge," to a proven and widely deployed technology.

8 CONCLUSION

Simulation software is dynamic. Changes are occurring rapidly. In virtually all of the areas suggested to the panelists, large strides are forecasted. If this panel is reconvened in one year, the responses will evolve greatly since the hardware is increasing in its capability allowing for increases in the capability of software, and since software capability is increasing as more developers are advancing the state of the art.

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AUTHOR BIOGRAPHY

JERRY BANKS was General Chair of WSC’83 and was a member of the Board of WSC for eight years, including two years as Board Chair.