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Simulation at digital equiptment corporation: The process expert as simulation expert

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ABSTRACT

Manufacturing process simulation has long been the domain of mathematicians, operations researchers, and consultants; a relatively small, exclusive group of expert practitioners. Consensus has held that only these individuals can successfully practice the craft of simulation. This thinking persists, even today. There are still many manufacturers who believe they can not apply simulation techniques to their operations without prohibitive investments in time, personnel, and money. To most manufacturers, a simulation project requires hiring a simulation expert as a consultant.

Certainly, there are occasional situations in which the easiest, most cost effective solution is to employ an external consultant to perform the required analysis. Perhaps time constraints do not allow for the evaluation, justification, and training required to bring a tool in–house. However, as global competition increases and manufacturing moves toward the twenty first century, the practice of hiring consultants must become the exception rather than the rule. The use of simulation and other analytical tools must become standard operating procedure if a manufacturer is to survive. This requires fundamental changes in the way we do business.

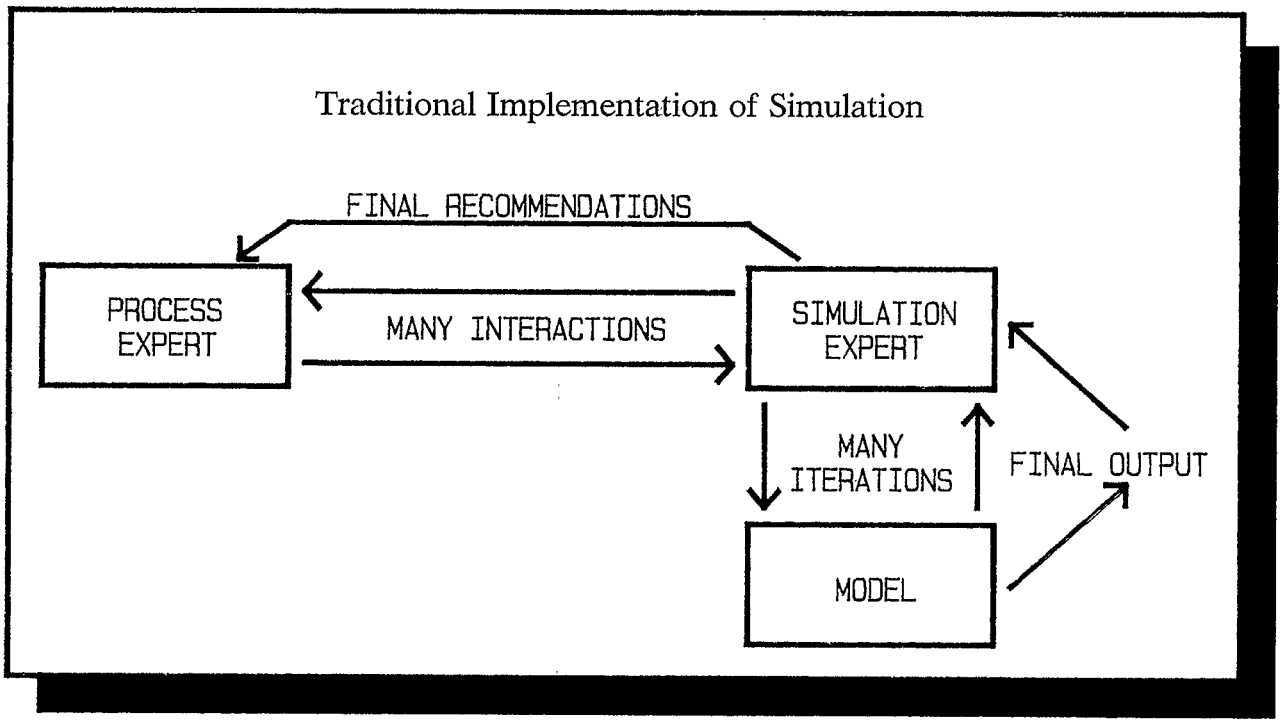
There are several risks inherent in the practice of hiring consultants to perform analyses: the process is enormously time consuming because the consultant must set out to gather critical data with the possibility of having no understanding of the process(es) in question. This drives up project cycle times and, therefore, costs. And, because the consultant may have an inadequate understanding of the system, the study can easily fail to generate viable, dependable results. Simply stated, a simulation study is only as good as the data upon which it is based. Finally, the consultant walks out the door, taking with him all of the hands–on understanding of the project. It is at this point that the cycle perpetuates itself. The technology has not been transferred into the firm in this example, it has merely been visited upon it.

In this paper, the authors will discuss the program that is being used at Digital Equipment Corporation (Maynard, MA) to facilitate the transfer of simulation and other like technologies into the hands of the people who can make the best use of them – our manufacturing personnel. Further, we will discuss how the relationship between manufacturing industries and the aforementioned traditional practitioners of simulation can and must evolve. This evolution is critical to United States' industry remaining competitive in the exploding global marketplace.

BACKGROUND

As long as six years ago, it had become obvious to us that something had to be done to drive the acceptance of simulation and, in turn, its application to our manufacturing processes at Digital Equipment Corporation. The overwhelming body of thinking among decision makers at that time held that process engineers could not succeed at simulating. When simulation was performed, it was performed by consultants hired from outside the Corporation.

That simulation was being used at all showed foresight, but we were failing to realize the full benefits of the technology. The consulting simulationist had to spend a great deal of time gathering information about the workings of a system before model development could begin. Because of human nature, there were flaws in the information, which led to errant assumptions and models that failed to generate real world answers. At this point, the simulationist had to either scrap the model and begin again, or the project



Elements of Failure: In the scenario involving an external simulation expert, use of simulation was sporadic, there was a low rate of acceptance of results, cycle times were long, and the cost was prohibitive.

was scrapped entirely. In the latter scenario, obviously, an enormous investment was lost. But even in the case of the former scenario, assuming eventual success, we were still losing the war in spite of winning the occasional battle.

To rectify this situation, we formulated a program to facilitate the transfer of simulation into Digital's manufacturing community on a first-hand basis. Our belief at the time – a belief that has been reinforced many times over the years – was that it was critical to get the tools into the hands of Digital's manufacturing process experts; it is in the hands of the process experts that the tools can be used to their maximum utility.

The program consists of two parts. First, we work within Digital to foster a corporate wide understanding and acceptance of simulation. In addition, we work to develop a broad base of simulation users from Digital's manufacturing facilities around the world. And, second, we work closely with a number of third-party software vendors/developers to bring users the state-of-the-art in simulation and other design and analysis tools.

WORKING WITHIN THE CORPORATION

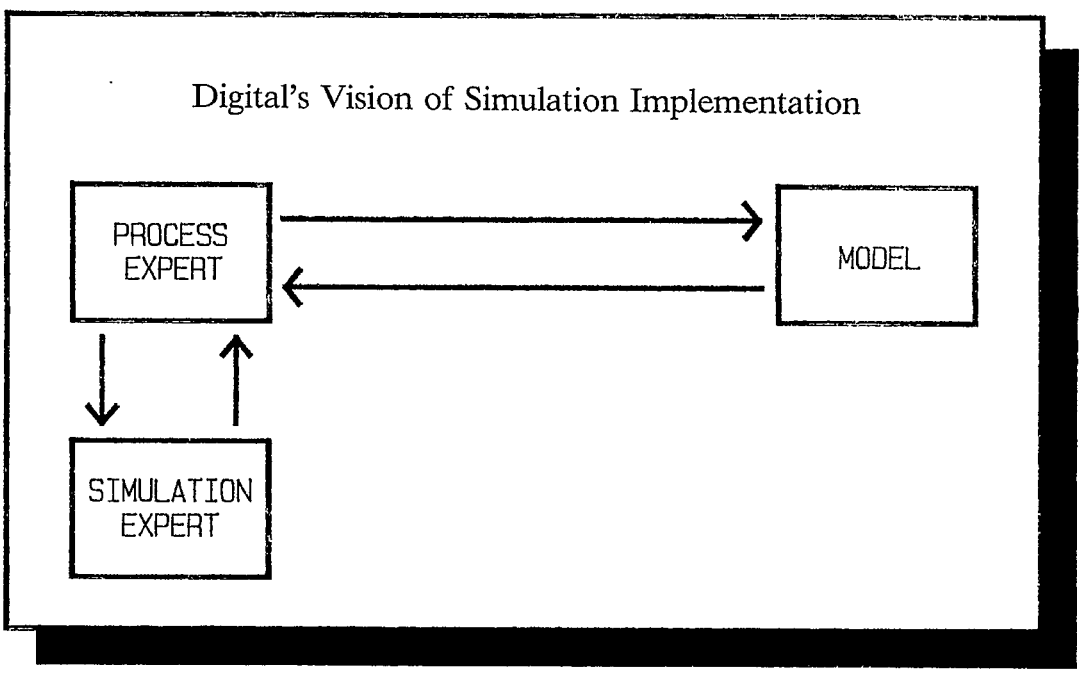
The initial, and most obvious, hindrance to the introduction of simulation into a corporation is its cost. Software can cost tens of thousands of dollars and CPU requirements are such that hardware platforms can cost several times that. In order for a company to undergo such a change, there must be champions to drive the change. We took it upon ourselves to champion the cause of simulation at Digital. In the beginning, we made presentations and demonstrations to anyone who would have us, from upper level management to shop floor personnel. For simulation to happen, it was necessary to gain acceptance at all levels of the organizational hierarchy.

The advent of relatively easy-to-use tools like TESS and MAP/1 (Pritsker & Associates, West Lafayette, Indiana) and MANUPLAN (Network Dynamics, Inc., Cambridge, Massachusetts) paved the way for simulation and analytical tools to reach the

hands of an entirely new group of users – the manufacturing engineers. In the case of TESS, a sophisticated database manager and a graphical model building interface make the tool ideally suited to our needs. Now, instead of having simulation experts spend time learning our systems, we are able to teach the process engineers to apply the current generation of tools to their own problems. MANUPLAN, which provides a short learning curve and rapid model development, allows the user to obtain rough information quickly. This information can be used to narrow the alternatives prior to detailed simulation.

Because different applications and levels of expertise require different tools, we maintain a suite of simulation and analytical tools in our Simulation Lab. These include tools like TESS, SLAM II, MAP/1, MANUPLAN, SIMAN and CINEMA (Systems Modeling Corp., Sewickley, Pennsylvania), and COINS for IDEF0 (Eclectic Solutions, La Jolla, California). We maintain these tools on our system and in our Lab and provide access to everyone in the Corporation, free of charge, over Digital's vast Engineering Network. This allows potential users to gain experience with the tool and complete projects successfully without making any initial monetary investment in the tools. It has been our experience that after early successes, management buy–in is assured and the use of these technologies will become standard operating procedure in an organization.

Members of our staff work closely with users to train them in the use of the tools and to insure that the tools are not misused. Initially, we help the users define the scope of their project and the questions they seek to answer. This accomplished, we help the users to select the tool which is best suited to the application. Once the parameters of the project have been defined, and a tool selected, the user is given comprehensive, one–on–one training in the use of the tool by a member of our staff. It has been our experience that there is no substitute for the one–on–one training environment because of the personalized attention it gives the trainee. Training takes place in our Lab, in the context of solving a real problem, and at the end of the period the trainee has a first cut at the problem



Elements of Success: As a result of our program for simulation implementation at Digital Equipment Corporation, we enjoy a high level of use, there is a high level of acceptance of results, project cycle times have decreased, and highly innovative solutions are being discovered, all at a drastically reduced cost.

completed and has obtained knowledge of the tool and how to best apply it to solve the problem. In some cases, the first cut solves the problem and the project is complete. More often, the first cut leads to more questions and illustrates the need to move on to deeper levels of detail and further analysis. From this point, we continue to provide support both in the Lab and via telephone for the duration of the project. By maintaining close contact with the users we are able to insure that the tools are not misused and that the users are successful.

THE ROLE OF THE EXPERT

The simulation expert is still involved in the process of performing simulation in the role of consultant. First, by providing an introduction to the tools, including an overview of the methods involved. Direction and support for the users as they learn and develop models that represent the system under study are also essential, along with the transfer of an understanding of how to apply the tool in different situations to obtain useful information.

Simulation is a technology that can and must be transferred into the hands of those individuals who can reap the most benefit from its use. The current generation of tools is making that possible by providing a system that makes developing and maintaining a model easier. One of the key advantages offered by TESS is a graphical network builder. Because of the graphical approach, much more information can successfully be managed. The graphical flow is equivalent to the logical flow of the process, which makes logical debug much simpler. It can even permit those not familiar with the details of the language to gain an understanding of the model and serve as a focal point for the information that is exchanged during the project.

BENEFITS TO THE USER

There are several reasons why the process experts are the ones best prepared to build the model. First, there is no one more familiar with a process than someone who is directly involved in its day to day operation. Someone from the outside looking in can not, within a reasonable time frame, develop an equivalent insight into a process. The process expert's intimate, even unconscious, understanding of the system can lead to key assumptions and directions that can be critical in driving a modeling endeavor. Second, no simulation is frozen in time or space. When someone from the outside sets out to model a system, he does so to seek information from which an informed decision can be made. When someone familiar with a system does the modeling, the results may reveal other problems or options that only someone familiar with the system can see. And, finally, the most important advantage of having the manufacturing people simulating is that the expertise remains on the premises and becomes an asset to the Corporation instead of an expense.

Although one could argue that this is not the case for some manufacturing scenarios, there is still an advantage to be gained. In some of our applications, the manufacturing process does not resemble a "traditional" process. Rather, there are modifications and changes, that will have a definite impact on the line, demanded by the technology. Having a person who understands the implications of those decisions outside the traditional manufacturing area using the tools will eliminate the potential errors that may arise.

The model building process requires that the modeler look at a system in a logical manner and view it as a whole instead of independent pieces. The very process of building a model serves to provide information, whether that model is simulated or not. Again, how much is learned in this process depends on the intrinsic knowledge that is available to the modeler/decision maker. The person familiar with the process and the tool is the person best qualified to verify whether or not the model behaves like the real system.

Digital's broader user base gives the corporation greater experience in the use and application of these tools. This, in turn, provides a base community which provides inputs into future developments, linkages, and the like for the user base as a whole, and for the larger simulation base in industry. More importantly, it increases the number of resources available to be applied to investigating and solving problems using the methodology and the tools. It is because of this approach that we are able to use the methodology in a

	ADVANTAGES	DISADVANTAGES
TRADITIONAL APPROACH	- PROPER USE OF TOOLS IS ASSURED	- POSSIBLE MISCOMMUNICATION - POOR ASSUMPTIONS - COSTLY - QUESTIONABLE RESULTS - KNOWLEDGE OF METHODOLOGY REMAINS EXTERNAL
DIGITAL'S APPROACH	- RENEWABLE INTERNAL RESOURCE - BETTER MODEL DEVELOPMENT - FOSTERS LINKAGES TO OTHER ANALYSIS TOOLS - KNOWLEDGEABLE USER BASE - BETTER UNDERSTANDING OF OUR MFG. SYSTEMS	- POTENTIAL FOR MISUSE OF TOOLS EXISTS

This table illustrates the relative advantages and disadvantages inherant in the two implementation scenarios discussed in the paper.

larger number of projects, and in many different disciplines. Had we maintained the typical view of simulation, the number of projects would be limited to three or four a year, primarily in the manufacturing area. Due to this limitation, other projects, if they were even considered, would be undertaken using less sophisticated methods, with less meaningful results, severely limiting our ability to make meaningful improvements with lower risk.

In the manufacture of computer hardware, software, and their supporting documentation, there are many processes where these tools have a direct benefit and have been proven to save money. All industries are bound by cost. It is important to invest money wisely and to obtain the maximum benefit from that investment. By having Digital's people gain knowledge and experience in the use of simulation tools, the expertise developed remains internal and can be utilized again for other projects. By having a community of experts who understand the use of simulation tools, along with the manufacturing technology used to build our products, the time required to develop a model that is close to the real world is drastically reduced. There is less time involved in translating information and less likelihood of misunderstanding. The results that are achieved are better understood because the model, and what it does and does not represent, is better understood.

RISKS OF OUR APPROACH

We have advocated this approach for several years, and for the same period of time there have been individuals, both internally and externally, who have said or implied that the tools are not yet at a state that allows for the non-simulationist to use them. While they provide a benefit to simulationists by cutting the development time, there are many other aspects of the simulation methodology that are not encompassed by the tools.

One of these is related to the information used in the model; an input parameter. Does the value assigned or the distribution used represent the real world situation? Is there sufficient confidence in that value? To determine this with confidence requires further investigation of the data from which it was de-

rived. It may be necessary to view the problem from a different perspective in order to understand the behavior of the system.

The same is true of the information that is gathered from a simulation model. Was the model simulated enough times to have the statistical confidence in the results to use that information in the decision making process? What does the information represent and how should it be interpreted? What additional work must be done?

How these questions are answered is left to those who are performing the analysis. Ideally, they would do all of the things that a simulation expert would do.

There is a risk in having a non–simulation expert use the tools, but there are ways to reduce that risk. The first is to make the process expert an expert at simulation. This is part of what we are doing when we introduce a non–expert to the tools and methodology; we are beginning to develop that expertise. In addition, we assist users in understanding the implications of their decisions when building a model. Given the time constraints that surround most simulation projects, engineering decisions must be made as the model is built and analyzed. These decisions maximize the benefits that are derived from the model.

The second approach is to develop a suite of tools that makes these high–risk, time consuming areas automatic, or transparent to the user. For example, as part of the standard output, the confidence levels for the statistics should be provided

DRIVING DEVELOPMENT OF NEW TOOLS

As time progresses, simulation is going to become a tool that is used on a daily basis to answer questions, particularly in the manufacturing space. It will be part of a tool suite that is used to analyze information to create knowledge which can then be used in the decision making process. For this to happen, the tools must become extremely easy to use so that a non–expert can use them and derive the same results as an expert. It is necessary for the development of the tools to continue to make the analysis of manufacturing more beneficial to the users. What are needed are tools that help automate many of the steps: collecting information, curve fitting that information when required, and generating a post–process analysis of the results obtained from simulation runs.

The simulation packages must also be linked to other tools to provide a robust analysis that encompasses much more, such as financial considerations and quality concerns. There exists a need for robotic simulation that truly represents the actual mechanical device's ability and the relationships between speed and accuracy. There is much work to be done in this area. Ideally, one should be able to analyze every aspect of the manufacturing process. We are working to accomplish these objectives with our vendors. We are constantly aware of the market so that we are able to capture the benefits of new methodologies and tools as they become available.

WORKING WITH THE SOFTWARE VENDORS

The second part of our program involves working closely with the commercial software vendors who create and support the tools we employ. It is an attempt to bring the users and the vendors closer together. To this end, we are working to close the gap between the skill level a user brings to a project and the skill level future generations of simulation tools will demand of users.

We are always seeking opportunities to be a beta site for new software packages. In this situation, we are able to play an active role in the vendor's research and development. In order to provide product direction, we keep detailed logs of problems we experience, along with enhancements we feel are necessary, and this information is relayed back to the vendor. By taking an active role in the research and development of new tools we can, to an extent, tailor the tools to suit the needs of the user community.

We prepare detailed specifications for modifications we deem necessary to insure the usefulness of the tools. Occasionally, we will actually modify the software ourselves. We do not, however, use the modified versions immediately. Modifications are returned to the vendor for test and evaluation, and then included in the next version of the tool if the vendor feels they are of value. It would be unrealistic to use the software we modified ourselves and expect vendor support.

MEASURES OF OUR SUCCESS

Our success is easily documented. When we put the plan in place six years ago, we had only three trained users in the entire Corporation. Today, we have over 300 users worldwide, and the number continues to grow. In fact, simulation has been used at every Digital manufacturing facility in the world.

However, our work is far from finished. At this point, simulation is being done by process engineers. Lead times are still measured in months; this must change. We must continue to work with our users to improve the users' expertise with the technology. And, we must continue to work with our vendors to insure that future generations of tools meet our needs.

REFERENCES

Benassi, F., "Software Tools for Cost Justification," Managing Automation, March, 1988.

Driskell, M., O'Loughlin, M.J., Tubin, G. "Justification and Integration of Automation and Vision in Manufacturing Systems," Proc. of Robots12 and Vision '88 Conference, Vol. 1, June 1988, p. 3-11.

Harper, R.J., O'loughlin, M.J., "Manufacturing Process Analysis - Tools and Applications," Proc. of the Winter Simulation Conference, December 1987, p. 731-737.

Nagler, B. "Making Decisions Through the Art of Simulation," Managing Automation, May 1987.

Pritsker, A.A.B., (1986), Introduction to Simulation and SLAM II, John Wiley & Sons, New York, N.Y.

Suri, R., Dean, R., (1985-1986), MANUPLAN Users' Manual, Network Dynamics, Inc., 1218 Massachusetts Avenue, Cambridge, MA, 39 pages.

Suri, R., Diehl, G.W., "MANUPLAN: A Precursor to Simulation for Complex Manufacturing Systems," Proc. of the Winter Simulation Conference, December 1985, page 411.

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