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INFORMATION STRUCTURE TO SUPPORT DISCRETE EVENT SIMULATION IN MANUFACTURING SYSTEMS

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ABSTRACT

Discrete Event Simulation (DES) is ranked among the top three tools for management support. However, it lags in becoming the successful tool in the industry that many experts have predicted. In this paper, sixteen projects accomplished in the area of DES have been analyzed in order to find the reasons for this delay. Most important is the lack of reliable manufacturing data in companies. This is due to inadequate practices within the organization, thus forcing users to build simulation models with estimated data. The paper also answers other questions as to why DES is an underutilized decision tool. DES is an information-intensive tool for decision-making, but has weak support concerning working procedures within organizations. Continuous generation of manufacturing data at all levels has to be supported by the working procedure in order to increase the use of DES as an everyday tool. How to improve this situation also is discussed.

1 INTRODUCTION

Due to the global market, there has been much focusing on shortening the time-to-market, including the development times for products and processes (Mansurov and Probert 2001, Terwiesch and Bohr 2001, Driva et al 2000). In parallel with the shorter lifecycles of products (Driva et al 2000), the need for faster decisions is more urgent than ever. Here, DES has been called upon as a potential savior (Banks et al 2001, Klingstam 2001, Law and Kelton 2000), and has been rated among the top three as a tool in management support (Ericsson 2003). Although DES is a very potent tool for capturing the dynamic complexity that many companies today are living in, the innovation of DES is diffusing only slowly into many industries (Ericsson 2003). For many years, experts have classified Sweden as a country with well-developed use of IT (The 2002 Information Society Index). The first DES systems were developed in the sixties. Although simulation has matured into a widespread engineering tool among industries, successful simulations are applied within as few as half of them (Ericsson 2003). Accordingly, many leading industries consider DES to be time-consuming and expensive (Banks et al. 2001). What are the reasons for this dearth of success among simulation projects? This is the main question to analyze in this paper.

2 FRAME OF REFERENCE

Earlier, production engineers have worked with static information and methods to improve shop-floor efficiency beginning with the first production design. Due to the shortening of product lifecycles it is even more important to do right the first time, since there will be less time for work with continuous improvements. This can be done only by structuring and handling information for making the right decisions in early phases. Nowadays DES is a tool that many companies classify among the most important ones for achieving a production with the needed capacity and flexibility. The “gap” between product design and production, Figure 1, for many years has been neglected. There is a need for supporting the information not only for the product (CAD and PDM) and for the planning (ERP and MRP), but also for data consisting of process-flows, disturbances, and logical couplings (Klingstam 2001).

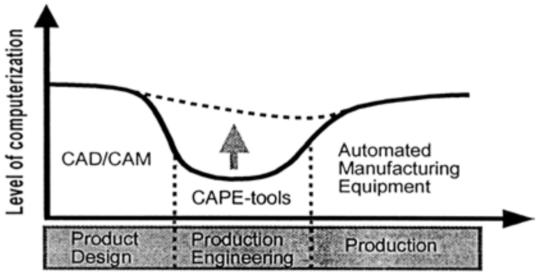

Figure 1: CAPE Tools Bridge the Gap Between Product Design and Production (Klingstam 2001)

An organization's competitiveness depends upon the effectiveness of information flow, which includes having access to ”the right kind of information at the right time” (Mandal and Gunasekaran 2002). As a PD manager states in a similar vein: “It is not a matter of having access to information, it is a matter of getting the right information” (Svensén et al 2000). There is no time for mistakes due to lack of information (Svensén et al 2000). All these statements can be summarized as: When trying to shorten the timescale there will be difficulties finding proper data for good decision-making. Impact of early decisions and the amount of accessible information during the project have been outlined by Christensen and Kreiner (1991), see Figure 2.

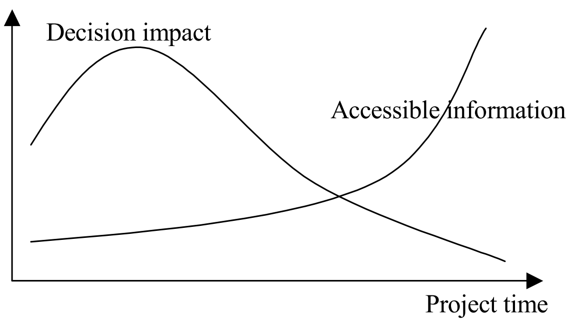

Figure 2: The Impact of the Decision in Comparison With Accessible Information During the Project Time (Christensen and Kreiner 1991)

From these statements arises the question: Is there a lack of structured production data in the industry? This has been highlighted when many projects in the area of DES at Chalmers University of Technology met difficulties in the data-collecting phase of the model-building.

3 SURVEY

The DES projects that were studied show that companies characteristically underestimate the importance of information-handling. Although it is understood that DES is a powerful tool in decision-making, companies have little support for the model-building phase. Since there is a lack of support, a deeper investigation of the factory is needed before simulation models can be built, in order to answer the questions that the user has raised.

Projects at Chalmers University of Technology show that little information is connected to facility equipment. It is understandable that the engineers are focused on the core process, but the lack of information in this area can be devastating for the model output and, in the end, the success of the project. In some projects, there was also lack of information connected to the process, which is ominous.

The reports show a dearth of data in the following areas:

- Equipment
- Processes
- Logistics.

This survey comprised analysis of 16 DES projects undertaken from 1995 to 2001 in Sweden, England, and Singapore. The aim was to analyze to what degree information was structured to support the DES projects with data. The input data for the projects were to be collected automatically through a database or, if the input data collection had to be measured / approximated, during the project. Table 1 shows the results from the survey.

Table 1: Summary of the Survey, Describing the Percentage Available Data in Each Category of the 16 Projects

DOMAIN	SECTOR	DATA TYPES	Projects
Production data available	Logistics	Logistics service provider, supplier data, part data	31%
	Plans	Product production plans, production schedules, flexibility needs/capabilities	88%
	Equipment	Machines, tools, jigs, fixtures, infrastructure, buildings, material transport, storage equipment	56%
	Processes	Process plans, instruction sheet, numeric control programs	44%
	Organization	Shop-floor status, inspection data, tractability data	75%
All production data available		Summarizing the above five categories	6%
Project Performance	Project satisfaction	Fulfillment of the project goal	81%
	Assumptions made	Forced to use assumptions in project caused by lack of documented data	100%
	Model sensibility	Model sensibility analysis performed	75%
	Model reliability	Warm-up period used, Multiple runs used	75%
	Validation problems	Validation problems of the model because of inaccurate data use	44%

The study also indicated that there has been an understanding in many projects that DES is unnecessary in many cases, and the goal has been met only by making a deeper static analysis of the real problem, which correlates with Johansson's study (Johansson and Grünberg 2001).

Table 1 clearly shows a distinction that, in most cases (94%), there is data missing for the DES project, and all projects have used some assumptions. The reasons for the assumptions were: The data is not accurate, good enough, reliable enough, or simply cannot be found anywhere. Only one of the DES projects had all the necessary data available in a database, but not even then could assumptions be avoided (Jörgensen 2000). The survey also shows that even if there is a lack of input data to the DES projects, the results are not that bad; 6% had all production data available, and as many as 81% reached the goal of the project. This does not mean that the project was successful (Ericsson 2003). Remarkable in this survey is the observation that few of the projects have led to a continuous DES activity within the companies, i.e. most were one-of-a-kind projects.

4 IMPLEMENTATION OF DISCRETE EVENT SIMULATION

There are a handful of companies in Sweden working with the task of structuring their DES projects within the organization. They are currently working in all the three categories shown in Figure 1. Among these companies are Volvo Cars, SKF AB, and Kockums AB. In a research project at a large Swedish company, Klingstam (2001) summarizes the problems they have in four categories. The survey in this paper correlates with Klingstam's study:

1. DES is used for solving one-of-a-kind problems rather than for the same task in every new development project (Williams 1996).
2. DES is a stand-alone-technique rather than an integrated part of the development process.
3. DES is mainly used to verify already developed solutions rather than as a design and decision-making support technique.
4. DES is mainly used in late project phases, rather than continuously throughout a development project.

Results are presented in Klingstam (2001), and Klingstam and Johansson (2000) from the research for implementation of an organizational structure and working procedures to make DES an accepted and more understood tool. Klingstam states that there is 100 times as much work with the organization to make it stay focused on DES, compared to the DES methodology (Figure 3) and ten times as much with the implementation of the everyday working procedures for DES, compared to the DES methodology (Figure 3).

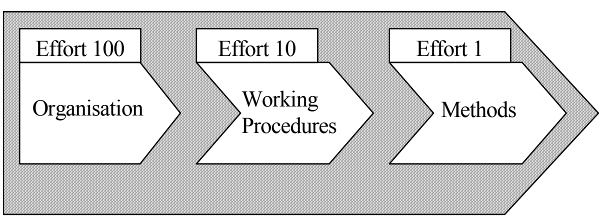

Figure 3: Effort to Implement DES at Different Levels of a Company (Östman 1998)

5 CHANGES IN ORGANIZATIONAL STRUCTURE

During the last decades, the organization within many companies has gone through considerable changes. From being hierarchically ruled, where information was well structured by decision makers, to become more decentral Ized where decisions are made by operators working with the product. This new organization has been successful in terms of shorter lead-times, quality improvements, and more substantial work tasks. What we see right now is that what companies gained in the short term, they lost in the long run. The knowledge to make right decisions, improve productivity, and respond to market needs has been neglected. It is important to understand that the bricks in a company's structure are dependent on each other. This means that you cannot change one without affecting the other. What we have seen lately in Swedish industry is that the empowerment issue has given the operator more responsibility to take over some of the work that earlier was done by production engineers. The problem is that they merely took over the methods of solving the problem and not the working procedures, such as how to save the data in a structured manner. The operators also do not have the holistic view of the decisions impact, and in many cases, there are chances of redundancy.

The operations shown in Figure 3 are different work areas for developing and improving a certain technique, for example DES. The Methods part of these work areas is well covered in the DES field. There are numerous interpretations of the methodologies used for a DES project (Banks et al. 2001, Law and Kelton 2000, Johansson and Grünberg 2001). However, the other two parts in Figure 3 (Organization and Working Procedures) are ill-structured and weakly organized in companies today in the DES field.

Drucker (1988) calls the new organization an information-based organization and claims that a hierarchic structure is not needed since information-flow does not need any "relay station". The information-based organization is built on responsibility and will work only if all departments accept the responsibility for their goals, priorities, relations, and communications. This also means that all communication towards structured data has to be integrated, which is very hard to manage. Access has to be granted for the responsible areas, and the updating of the process and flow-data has to be organized in a way that correlates with the PDM systems for products today.

6 DES INFORMATION HANDLING

The phases (Banks et al. 2001, Law and Kelton 2000, Johansson and Grünberg 2001) of a DES project can be divided into those represented in Figure 4, which also shows an example of the percentage of time spent in each phase. This differs from project to project. The bars in Figure 4, suggested

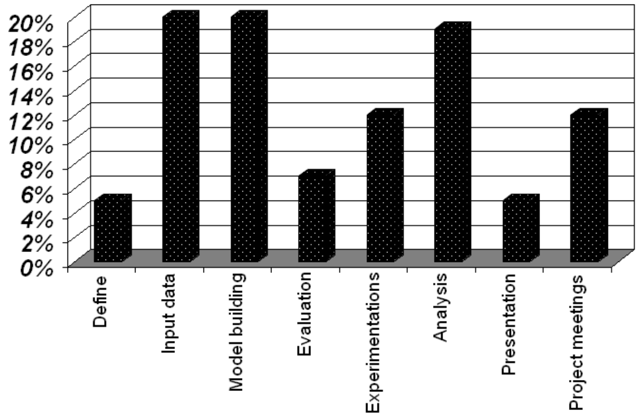

Figure 4: Example of a Time-Distribution Within a DES Project

by a consultant company in Sweden working with DES, point out that collecting input data for the model is the most time-consuming activity along with the model-building. The consultant company makes the data collection phase the responsibility of the customer. This means that at least 20% of a DES project consists of data collection, which in turn means that the time for data collection in most projects is the most time-consuming event. To reduce such time-loss and make the project less expensive and more efficient this issue needs to be investigated more deeply.

Every department within a company makes decisions based on the information that they are provided with. If there is a lack of handling information within the company there can be great problems if departments strive in different directions. The right information at the right place and time is needed to make the whole company strive in the same direction.

The classic answer to why companies do not use DES in their daily work has been that it is considered an expert tool that is time-consuming and expensive (Banks et al. 2001). The simulation expert has to work closely with engineers and technicians to bridge system know-how and simulation know-how, see Figure 5.

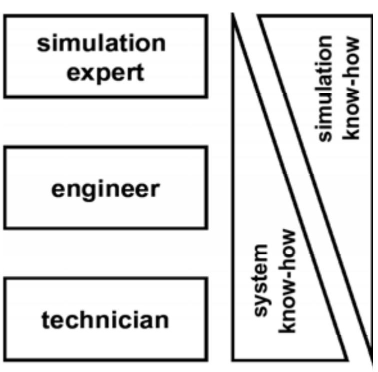

Figure 5: Specific Capabilities (Bley et al 2000)

7 CONCLUSIONS

The survey clearly shows that information is not well structured in today's companies to support DES in the daily work. Only 6% of the investigated DES projects had the obtainable, it has to be modified to fit into the dynamic world of simulation. DES is an information-intensive tool for supporting the decision-making in companies. Many other tools within the company do not need the dynamic information that a simulation model needs. This has made the organization lose focus on understanding the value of effort invested in collecting and updating this information. When there is no support within the organization for this investment of effort, simulation has no chance to become the daily tool for production engineers that many experts predict.

DES has been given no priority to be integrated into the daily work, and engineers have no time to work with data, which forces them to make assumptions. Information handling consists of collecting, validating, and systematizing data. Today most DES activities are situated at the Physical and Application Integration in Figure 6.

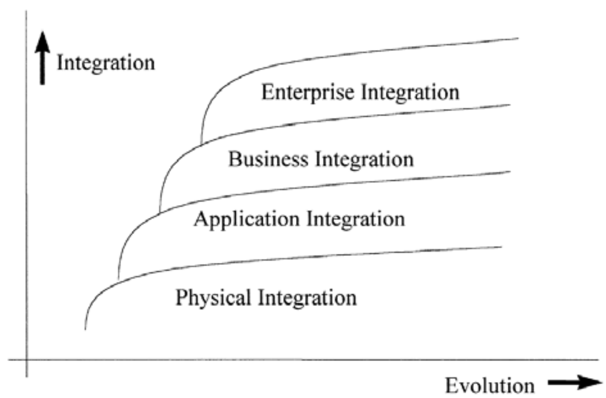

Figure 6: Enterprise Integration Evolution (Ortiz et al. 1999)

To move DES to higher levels in Figure 6, i.e. Business and Enterprise Integration, is a very hard task. It will demand an enormous effort and take a very long time to conduct. There are some demands that has to be fulfilled in order to achieve a higher level of integration in a successful manner:

- To be able to utilize DES at its full capacity there is a great need for data-handling systems that automatically generate and present the appropriate data from real-world raw data.
- This system has to follow an accepted standard such as GERAM and CIMOSA (Vernadat 1996) to diffuse into the daily work in industry, and to be compatible between suppliers and customers.
- The organization and the working procedures have to correlate with the DES project-methodologies.

The conclusion of the above three points is that DES projects surely will not become a tool for everyday work and continuous improvements for the industry in general for many years to come; the diffusion of this innovation will need more time to evolve. There are some larger companies, however, that will be able to use DES more frequently within the near future. This is possible because of the effort put into the problem at an early stage in the diffusion of the innovation DES. The new system must be able to handle all kinds of production data from many existing systems to become a system that can handle all kinds of data concerning production. This system also has to be updated frequently, and the access has to be distributed to the responsible parts of the organization. On top of this, the DES software has to be adapted to the database and vice versa. Some research on standards for DES models, such as McLean and Leong (2002) is needed in order to achieve an overall acceptance and frequent use of DES.

However, one must remember that there is a frequent use of DES as a sustainable tool for solving one-of-a-kind problems. These projects are time-consuming in the sense that collecting data is taking much time. Even in these cases, one must not forget that DES is a useful, often very potent and helpful tool, if it is used to find decision-help with a distinct focus, such as the one described in Johansson and Kaiser (2002).

8 FUTURE RESEARCH

The research on Discrete Event Simulation at Chalmers University of Technology will focus on handling data and information concerning *production systems* in a life cycle perspective. Many production systems nowadays are one-of-a-kind solutions and are not reconfigurable to last for many product life-cycles. If data, information, and the production systems were modularized, they could last for many product life-cycles and become flexible and reconfigurable. This technique would benefit from using DES as the production planning and control tool when reconfiguring the system for future products and product variants. This approach will also support the trend on shorter product life cycles and the striving for shorter time to market for the products, higher flexibility and reconfigure ability of the production systems in an cost-effective way. The research will also address the continuously growth of outsourcing, wherein large industries move their production sites to "low-cost" countries with labor flexibility as the major factor for production planning and control, instead of using the advanced technical advantage to keep the production and profitability in the native country.

The DES related research at Chalmers University of Technology will also address the collaboration in strategic alliances which has become more important lately. The main question to investigate in this area are how tools like DES can be adopted effectively to suit within these forms of collaboration groups, such as virtual enterprises, local SME groups etc...

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