Participative Modeling To Support Strategic Decision Making in Operations - A Case Study

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ABSTRACT

In this paper a case study is described in which a consultancy method based upon participative modeling was used to support strategic decision making in the field of operations. In this case study the Dutch client company faced serious logistical and financial problems after an attempt to attain competitive advantage through drastic improvement of its delivery speed. The modeling project produced several valuable insights. These insights have resulted in a better logistical performance at lower cost. The participative approach taken in the project has made implementation of the recommendations resulting from the project easier. It has also resulted in a better quality of systems thinking and a better understanding of the operations system throughout the company. In short, in organizational learning. This case study has been conducted within a research project aimed at the development of a modeling oriented consultancy method to support strategic decision making in operations. Several observations made in this case study with respect to the development of this consultancy method are discussed.

INTRODUCTION

In the field op operations management one would expect simulation modeling to be a standard element of any strategic decision making activity. There are a number of reasons to expect this. First of all, excellence in operations and logistics performance has become of such crucial importance for business success that a thorough analysis of any strategic operations issue seems nowadays essential (Andrews and Johnson 1982, Cohen and Zysman 1987, Sharman 1984). Secondly, operations issues tend to be very complex and demanding from a technical point of view (Maruchek et al 1990, Miller and Hayslip 1989, Voss 1990). Indeed complexity is such that formal models are required to analyze effectively the effects of any decision in strategic operations issues (Lyneis 1980). And finally, there is a wide array of mathematical models developed within the field of operations research / management science (OR/MS) precisely for operations issues (Buffa 1980).

However, reality is rather different. Regrettably it is safe to say that for a majority of strategic operations decisions the use of modeling and simulation is absent and for the remainder of cases its use is rather limited (Simulation Study Group 1991). In the face of the business importance of the issues at stake, their analytical complexity and the availability of models for these issues, surely managers, academics and modelers alike must agree that this is really a waste of potential.

But why then isn't modeling and simulation being used more often for this purpose? One reason may be that although the analytical complexity of strategic operations issues is well acknowledged, their organizational complexity isn't. In the process of strategic decision making in operations quite a number of flaws can be detected. Most of these flaws boil down to shortcomings in the organizational structure and shortcomings in the organization of the strategic decision making process (Akkermans and van Aken 1991a). Normally, models are used without taking these organizational complexities properly into account. The results then tend to be disappointing. Perhaps a better approach might be to take into account both analytical and organizational complexities. In the past few years several techniques have emerged that attempt to do just that (cf. Rosenhead 1989). From the field of system dynamics modeling and simulation, "participative modeling" (Vennix 1990, Vennix et al. 1990) cr "modeling as learning" (Lane 1989, EJORS 1992) has evolved as a very succesful member of this family of techniques.

RESEARCH SETTING

The LogSim research project (Akkermans and Vennix 1990) employs participative modeling to deal with both analytical and organizational complexity within the field of operations. It it aimed at the development of a participative modeling oriented consultancy method to support strategic decision making in the field of operations. This research project consists of two parts. In the first part an initial consultancy method has been developed. This initial method was based upon literature reviews of the three intersections of the fields of strategy, simulation modeling and operations, i.e. strategic modeling (Akkermans and Vennix 1990), operations strategy (Akkermans and van Aken 1991a) and operations modeling (Akkermans, Bertrand and Vennix 1991, Akkermans and van Aken 1991b).

In the second part of the research project the consultancy method is tested and refined in a number of case studies. These case studies are conducted as consultancy projects by the author for his consulting company. Of course these case studies are partly meant for testing the method. In addition, they are also meant for its refinement. After each study, the research team engages in so-called "boil down sessions." In these sessions a "post mortem" is made up. Here it is attempted to "boil down" from the experiences of this one case insights that may be of a more general nature. These insights are then incorporated in the consultancy method that is used in the next case study.

THE CLIENT COMPANY

The client company was acquired a few years ago by a major magazine publisher and distributor in Holland. It imports foreign newspapers and distributes these throughout Holland. The client company's business is extremely time-critical. All through the night vans with loads of newspapers from all over Europe arrive at its distribution center. All these newspapers have to distributed over a host of outlets located throughout Holland in a few hours time. Each outlet receives its own special package of different numbers of different newspapers. These packages change over time. Most newspapers show a clear seasonal demand, with peaks during the summer holidays, when many foreign tourists come to Holland.

Last year top management of the parent company, led by its founder-owner, decided that in order to face growing competition in the united European market of 1992, strategic measures had to be taken. These were twofold. First it was decided that all deliveries of newspapers to outlets in the future would have to be made before opening time of the outlet. Until then some deliveries were made as early as that, but most of them were considerably later, especially deliveries to outlets at faraway locations, and deliveries containing newspapers which normally arrived late. This arrival before opening time should enable the client to increase sales of the newspapers it distributes because of better availability at the outlets. Also it might make more foreign publishers interested in using the client company as their distributor. Finally it should discourage any potential competition.

The second strategic decision was to set up a single new internal distribution facility at the main site of the parent company, replacing the two different distribution facilities the company had at that time. This new facility would be operated by a totally new crew. This crew would consist of personnel from other distribution companies of the parent company, as well as of personnel from the original two facilities, as well as of newly hired workers. Using the broad expertise the parent company had accumulated in the distribution of its magazines -a closely related business it was thought - the crew should set up a distribution system that could accomplish the required higher delivery speed.

THE PROBLEM

Unfortunately, the implementation of these measures did not go as smoothly as was expected. For a large part this was due to the tightness of the time schedule and to the inexperiencedness of the crew with the new situation. For in the time schedule that was to be followed the move to the new location was planned just before the yearly seasonal peak. So when the company actually made the transition to the new distribution system the first night, something of a disaster happened, according to several of the people we spoke with in retrospect. Due to the crew's inexperiencedness with the special chacteristics of newspaper distribution, the design of the distribution systems that had been set up initially was such that the company could simply not produce the required delivery speed with such high volumes. After some weeks this situation slowly began to improve, but not without highly increased costs because of higher headcount and higher transportation mileage. At around the starting time of the simulation project people had just about catched their breath again after a very turbulent summer.

The reason for the start of a simulation project was that things were going better, but not at all good enough. The client company was still losing money month by month. The expected increase in sales was nowhere visible, and yet distribution costs had almost doubled. Management remained convinced that there must be "smarter" ways to set up the distribution system, so that faster processing would be possible with fewer people. Unfortunately, how this was to be achieved was an issue about which little agreement existed. Everyone had an opinion, for sure, but these did not add up at the time. One had considered experimenting with different distribution lay-outs and methods in real life, but this was very costly if it was to be done off-line, and this was a definite no-no if it was to be done on-line, after the experiences during the peak season. Rather it was thought that "playing" with a computer model might have some definite advantages over "playing with reality", as it was called.

THE MODELING / CONSULTANCY APPROACH

Project Scope

After an initial quick scan it was decided that the simulation project should focus on the internal distribution part of the process chain of the client company, for a number of reasons. Firstly, this part of the process was scheduled to move to a new nearby building in a few months time. That was an excellent opportunity to change the process layout, if required. Secondly, it was one of the two main sources of costs. Thirdly, in the other main cost source, external transport, quite some improvements had been made in the mean time. And finally, it was this internal distribution process that seemed most complex to understand and to improve.

Project Setup

An informal project team was formed, consisting of the manager of internal operations, his assistant, the account manager for the client company from the parent company's computer services branch and the author, as an external consultant. At least once a week, but usually more often, most of the team members held informal meetings. Approximately every month project progress was reported to senior management of the company. As much as possible the people from the client company were involved in the model building exercise. The external consultant however remained the project leader and modeling expert. At several instances he conferred with his colleagues at his consulting company for third party feedback and technical assistance.

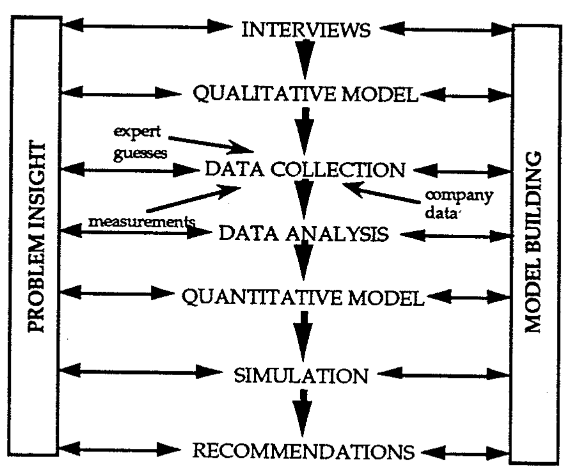

Figure 1: The modeling / consultancy approach employed in the project

Project Phasing

The approach that was taken in this project was fairly straightforward, as becomes apparent from its illustration in Figure 1. First a quick scan was conducted by the external consultant. This quick scan consisted of a number of interviews with the members of the client company's management team, and visits to the nightly operations. These interviews resulted in an initial problem definition or quick scan report, as described above. From this report a more precise description arose of the actual questions that had to be addressed in the modeling project.

A qualitative model was developed in a participative manner. The team members had several rounds of discussions, in which they gradually developed some sense of a qualitative, or conceptual, model of the problem at stake. The external consultant played a facilitating role here, but was at the same time also very much analytically involved. Consultancy techniques such as brainstorming methods, causal diagramming and process structure diagrams helped a great deal in steering and clarifying the discussion. This phase took some five to six weeks.

Data collection came next. Soon it became apparent that more data was needed to quantify the qualitative relationships that had been established at that time. This turned out to be no small matter. It took considerable time before the raw data were available.

Data analysis was also quite extensive. The basic data that were made available had to be modified and analyzed. However, this also turned out to be a very rewarding phase. Several of the questions that had been set up at the outset of the project could be answered here. Data analysis may have taken three weeks.

The formulation of a quantitative model and the subsequent simulation experiments was not so hard after all this. These may have taken three weeks. These activities, as well as the preceding one, were mainly performed by the external consultant, with regular feedback to the other team members. Here clearly a switch from a facilitator role to an expert role took place.

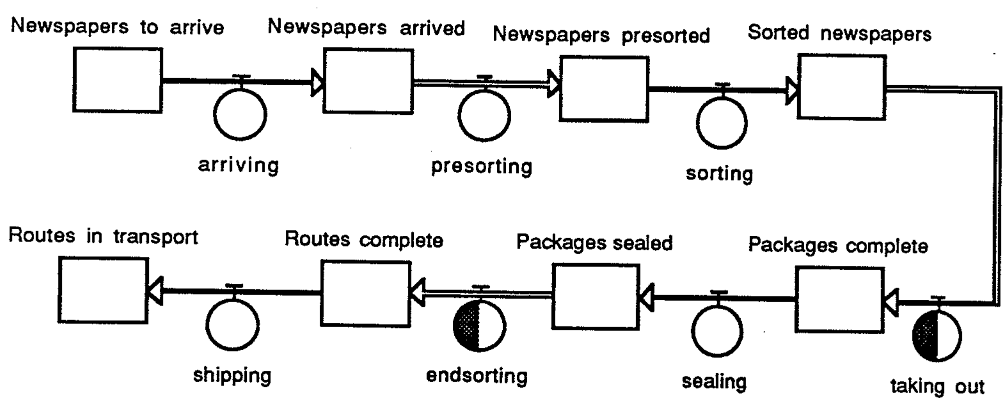

Figure 2: An overview of the model, consisting of the main stages in the internal distribution process

PROJECT FINDINGS

Model Overview

The basic structure of the model that was developed is very simple and straightforward. There is hardly any feedback, there is the odd co-flow, and an arrival pattern to make things happen. Basically the model consists of a sequence of the generic flow process known as "production" or "external resource production"[1]. This sequence corresponds closely to the main production phases in the distribution process. As becomes apparent from Figure 2, every night there is a certain load of newspapers due to arrive. When these arrive on time, they are presorted to a number of parallel sorting stations. There the sorting to specific outlets takes place. Once an outlet has all the newspapers it is supposed to receive, it is "complete". Depending on the take-out criterion, it is either then or later taken out of its sorting station for sealing. These sealed packages are then sorted once more, this time to the specific "route" to which they belong. Each van or truck has its own route, consisting of a number of outlets to be served. Once a route is complete, it can go into external transport.

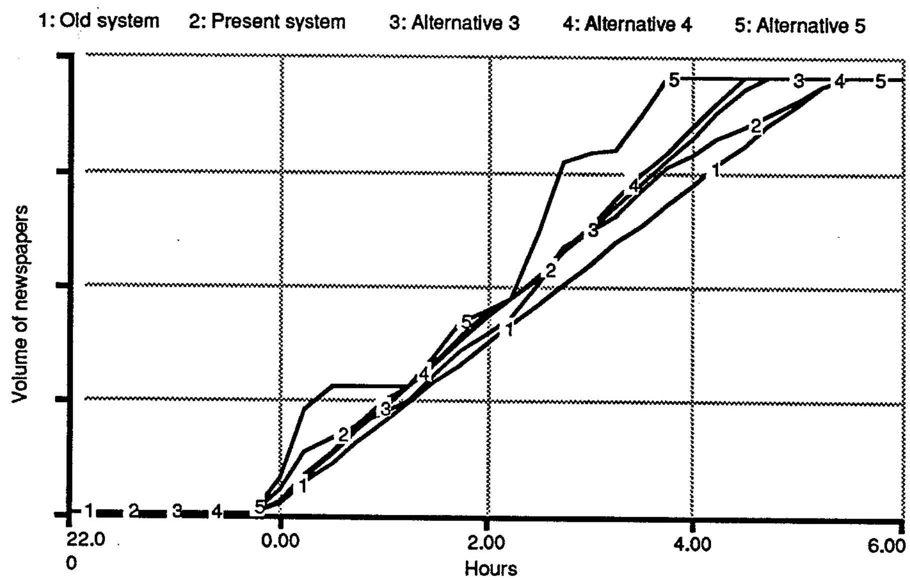

Figure 3: Performance of alternative sorting methods during the peak season

Arrival Patterns

At the beginning of the project there was a great deal of attention for those newspapers that arrived late at night. Understandably so, for until those newspapers weren't sorted, packaging and endsorting could not be finished. And as long as these processes weren't finished, the vans couldn't leave. It had been calculated that in order to achieve the strategic objective of having all outlets served before opening time, the last van should have left internal distribution shortly after four a.m. at the latest. In the early days, vans would leave as late as five or six o'clock in the morning. So getting the goods out by four was all important.

An "early dip" in the arrivals of newspapers however, turned out to be far more important. This fact only became apparent in the simulation runs. Between half past twelve and half past one no newspapers arrive.

[1]This generic flow process follows the equation: Inflow = External resource * productivity, or (u/t) = U * (u/U)/t. An example: production rate = number of workers * production rate per worker. Cf. Richmond (1990), p.62

This means that for a certain period of time there was insufficient workload for the night crew[2]. And that indicates possibilities to reduce the number of working hours, or perhaps the number of workers during the night. Surely, one hour less working hours for a whole shift is a substantial cost reduction indeed.

The occurrence of this "early dip" was known at the work floor, but management attention to this phenomenon was not very high, focused as it was on the last arrivals in the night. Some time before it had been decided that most of the workers needed to start as late as twelve o'clock, despite the fact that the first newspapers arrived shortly after ten o'clock. The simulation experiments showed that this more or less ad hoc decision had been a wise step indeed. It also shifted management attention to getting the gap in arrivals filled, and showed that sound analysis could lead to further reduction in working hours.

Sorting Methods

The most important tasks for the project team, at least at the outset, was to evaluate under which conditions which sorting method was preferable. This issue had been the subject of frequent discussions between the various managers at middle and top level. It would go too far to describe in detail the technicalities involved, but the results of this performance evaluation are shown in Figure 3. This graph shows the performance of five different sorting methods during the peak season. Please remember that performance is to be evaluated in terms of how quickly a horizontal line occurs, for this then means that all newspapers have been sorted.

Each sorting method had arguments in favor of it and against it. Within the client organization, each method had its own advocate(s) and antagonist(s). As it turned out, most arguments were correct in a qualitative manner. However, in the quantitative analysis some factors turned out have a more decisive impact on overall performance than others. So everyone had been right - partly, and had been wrong -mostly.

Although the results surprised many people, there was very little discussion about their validity. For surely, everyone had had a say in which factors were relevant. And the data had to be correct too, for they came directly from the company's information system. And finally the time measurements had been performed by their own people. In short, there was little left to argue about and attention could shifted towards getting alternative 5 implemented, the alternative with the best performance in the model.

The Packaging Bottleneck

The simulation project also found possible solutions to the packaging bottleneck problem at the client company. There were two sequential bottlenecks in the internal distribution process: the sorting process and the packaging process. Each package of newspapers for a certain outlet had to be sealed by a sealing machine or some other packaging device. Of course these sealing machines had limited capacity. Unfortunately, this limited capacity was not used at all during most of the night and was used in full towards the end of the shift. Why was this? Well, the company had what the team called a "touring car problem". Just as a touring car bus cannot leave until the last - and usually delayed passenger - has got on the bus, just so a package could not be sealed until all the newspapers it was supposed to entail had arrived and had been sorted. And since the last newspapers did not arrive until after three o'clock, there was very little time left indeed for this packaging process.

However, the team found out that not every outlet had to wait until the last van loaded with newspapers had arrived. Actually this was to be expected, since the average outlet received only at about a quarter of the total range of different newspaper titles. Data analysis showed that the actual situation was more one in which every X percent of newspapers being sorted lead to a similar percentage of outlets being fully served. This relationship illustrated quite clearly that in theory packages could be sent to the sealing machines all through the shift, and certainly considerably earlier than at 3:30 a.m.. This would annihilate the packaging bottleneck. "In theory", it was said, because in practice this was not an easy matter. For in this proposed system it would have to be possible to determine for every individual outlet whether or not it had received all the newspapers it needed. A the time this was not yet possible, but after the simulation experiments management attention shifted towards making it possible.

Workforce Reductions

In this department the highest cost factor was labour. Sensitivity analysis showed that the proposed sorting method (with sorting being the most labour intensive process step) would still perform better than the

2This lack of work showed up more clearly in the model than in reality, probably because workers tend to slow down when there is fewer material to work with.

present system even after a workforce reduction of as much as 25 %. Understandbly this pleased management greatly.

BUSINESS RESULTS

The modeling project has been a success, it is safe to say. The recommendations have been taken to heart. This has lead to improvements in logistical and financial performance. The project has also induced several, less tangible but no less important, organizational improvements. Therefore a separate discussion of both technical and organizational results.

Technical Results

- *Design of and transfer to new lay-out*: In the spring of 1992 the transfer to the new building has been accomplished. A new lay-out has been designed and built, according to the design principles developed during the project. This new lay-out has become operational without any unexpected problem whatsoever.
- *Implementation of new sorting method*: The sorting method that turned out to have the best performance in the simulation experiments is currently being implemented. Since this method requires a highly automated system, this means a considerable investment. However, there is little doubt about its necessity and its payback.
- *Possible removal of packaging bottleneck*: One characteristic of the new sorting system is that it makes it possible to see right away when a package for an outlet can be sealed. This means that the packaging bottleneck will cease to exist. (Interestingly, the company had just before acquired a new sealing machine to accomodate the perceived lack of capacity, at a cost of some $ 70,000, which now is no longer absolutely necessary).
- *Continuing reduction of working hours*: The company has seen that considerable reductions in working hours are possible. These reductions happen gradually. Every month fewer working hours are needed for the same or higher output. This process will continue for some time. Other personnel management insights are the importance of well-trained employees and the difference in required capacity during and outside of the season.
- *Accomplishment of early departures*: All important was the time the vans loaded with packages for outlets left at night. At the beginning of the project, external transport often had to start late. Shortly after the move to the new location however, the transport department had to ask the internal operations manager if the vans could not depart a little later. For the early departures that had become more and more common caused problems in the rest of the transport chain...

Organizational Results

- *Belief in findings and commitment for implementation:* The findings from the modeling project were believed, surprising as they sometimes were. No more energy was spent in discussing different alternatives. Instead attention switched towards getting the recommendations from the project implemented. Clearly this was due to a large degree of participation in the project, and the model ownership by the client that resulted from it.
- *Appreciation of the problem solving approach:* Much appreciated by management was the problem solving approach that the team had chosen. The focus on both conceptual underpinnings as well as quantification and fact-finding found much appeal. Several people said that this should be the kind of approach by which other problems of the company should be tackled.
- *Higher esteem operations manager:* During the course of the project the status of the operations manager and his crew clearly increased. The fact that advanced tools such as simulation were used within his department, as well as the proposed investment in advanced automation gained the operations manager much respect. Also, as he told himself: "I don't have to explain the problems I have to cope with every day to anyone anymore." More understanding for his problems and, as a consequence, more appreciation for how he dealt with those problems, was also a "soft" result from the project.
- *Higher quality of systems thinking*: The quality of reasoning, of systems thinking if you like, has undeniably increased amongst the team members. This becomes apparent in internal discussions and in discussions with members from other departments. There is more refinement in the causal reasoning chains being set up, there is a broader perspective, taking also processes in other departments in account,

there is a better distinguishing of what is most important and what is less important. It is safe to say that the mental models of the modeling participants have become enriched through the modeling process.

- *Organizational learning*:All these organizational results clearly indicate that organizational learning has occurred. Compared to a conventional "expert" project approach, this participative project approach has made that:
  - The project team members have learned more about their own system.
  - The project team members have learned more about the problem solving approach, i.e. double loop learning has occurred (Argyris and Schön 1978): Next time a problem like this occurs, they are likely to solve it a way different from the ad hoc manner in which problems are usually tackled in this organization
  - The level of systems thinking, the so-called "fifth discipline of organizational learning" (Senge 1990) has clearly increased.

DISCUSSION

The "Boil Down" Sessions

As has been described above, the research approach in the LogSim project is such that after the project so-called "boil down" sessions are held, in which the following three questions are assessed:

- How well did the consultancy / modeling method work in this case?
- What needs to be improved in the method and how?
- What other insights gained may be of interest?

The next paragraphs elaborate on these questions. Since the research project aims to support decision making on (a) strategic operations issues by way of (b) a consultancy method that (c) employs participative modeling, it seemed only natural to divide findings into these three categories.

Operations Strategy Insights

- *Operations are indeed of strategic importance* The client company saw its survival directly linked to an operations "order wining criterion" (Hill 1985): their delivery speed of newspapers to the outlets. One might reply however by saying that such was obvious for this company because distribution was its core business in newspapers: it does not publish these, unlike the magazines it distributes.
- *The operations strategy process : forward in reverse?* The approach towards implementing an operations strategy as it was taken by top management was refreshing. No formal SWOT-analysis, no cost-benefits analysis and gradual introduction of improvements. Instead strategic planning went precisely the other way round, truly "forward in reverse" (Hayes 1985). First a clear and unambiguous goal was being set: "delivery to every outlet before opening time". Next everyone tried to achieve this goal. At first this attempt did result in inadequate performance and large losses. But gradually performance improved and losses diminished, as the company realigned itself more and more towards achievement of the goal. There are no operations strategy frameworks mentioned in the literature that work this way (cf Akkermans and van Aken 1991a, Anderson et al. 1989, Swamidass 1989), but it surely looks like it works...

Consultancy Insights

- *The modeling and the consultancy approach cannot be separatedd*: A modeler might look at the project approach depicted in Figure 1 and see nothing unusual: a straightforward modeling approach. Also an management consultant might look at Figure 1 and see a standard consultancy approach for operations issues. Both are right, for the approach attempts to be both at the same time. Some might like to see the LogSim approach as sound modeling in the system dynamics tradition (Roberts 1977), others might see it as a consultancy approach for operations issues, with some Operations Research add-ons (Platts and Gregory 1990, Verstegen 1989).
- *A model building project is both a threat and an opportunity for a manager*: At the outset of the modeling project, the manager whose problems are going to be modeled, may see this project as a threat. Are his own expertise and capability perhaps being doubted by management? Is the external consultant going to take over? Only after carefully explaining that it is he or she who is being supported, and not senior management at a higher level, the manager's trust can be gained. Saying; "I want outside help for my

problem" is an act which shows vulnerability. However, at the end of the project, this act often turns out to have been an act of strength.

- *Switching between the facilitator and the expert role, is beneficiary, but should not be absolute*: The advantages of the facilitator role over the expert role in modeling have well been documented (e.g. Lane 1989, EJORS 1992, Senge 1990, Vennix 1990). Participative modeling works very well to come up with an conceptual, model of high quality which is "owned" by the client. However, some parts of the modeling process are still best done by someone with technical modeling expertise, in an expert role. In particular this is true for the translation of the conceptual model into a computer model. Also this is true for most of the data analysis, which normally requires quite some technical expertise in both analytical techniques and computer software programs. The final stages of simulation experiments and dissemination of knowledge can should once again be highly participatory.

  The switch to the expert role should not be too absolute, however, One should continue providing regular feedback to the client, even during the "expert mode" phase. Such feedback can be provided by frequently discussing intermediate results presented in graphs and the like, with the client. If this feedback does not take place, the client may not trust the correctness of the translation of the qualitative model he cooperated in building into the computer model.

Modeling Insights

- *Qualitative models may be complex, quantitative models should be as simple as possible*: The causal map of the qualitative model was fairly complex. The implemented computer model wasn't. This was mainly due to the fact that many of the causal relationships that indirectly influenced the main flow rates and levels of the model were "frozen" into specific parameter values. These parameter values were derived by complex calculations using multiple spreadsheets, databases and computer languages. These calculations were not represented in the simulation model, however. That was not built to show how parameter values were derived, but to show how these values and their relationships within the model structure influenced behavior.

  There might be a more general rule in here. It has been said that people who distrust simple models for strategic decision making are mistaken: they think that modeling is simple, so that the model can be complex. In reality, it's the other way round (Bertrand et al. 1990, p.97, p. 114). Modeling a system, i.e. taking from the countless phenomena that one observes in reality, the few that are of crucial importance for the problem at hand and determining the relationships between these few, is very complex indeed. The resulting model will then often be simple.

- *Many insights are gained during the data analysis phase*: Many system dynamics case studies contain one or more references to experiences of "counter-intuitive behavior"(e.g. Senge 1990, Sterman 1989, Vennix et al. 1990). These are experiences of surprise when out of the structure of a model arises a behavior that was not expected by the clients that were involved in its development. Such experiences occurred also in this study, but certainly not only during the actual running of the model. Also well before that phase several surprising insights were obtained.

  In the qualitative modeling phase, the global behavior of the model could already be predicted. It has been observed before that an experienced modeler can often already guess from the qualitative model what will be the behavior of the quantitative model (Morecroft 1985). For an experienced modeler at best the quantitative model helps to clarify more precisely the order of magnitude of model behavior. At worst it reveals the modeler's limitations as an equation writer" (Morecroft 1985, p.2) .

  Also during the data analysis phase many lessons were learned in this project. In retrospect, many of those lessons could be traced back to basic Pareto distributions. For certainly in the field of operations, it is essential to find out what 20 % make up for which 80 % of what, and vice versa. To know typical Pareto distributions for operations systems such as the distributions of processing times, product costs and product range buildup is invaluable for any real understanding of an operations problem. However, since in such distributions there are few dynamics in time involved (at least in the short term), no dynamic simulation model is required for gaining such knowledge.

- *The availability of company data is a crucial factor for project success*: If the project team does not get the required data available in a short period of time, the project is in danger. Surely this is one of the aspects that should be very well researched before project duration and price are determined. "Available" does not just mean that the data is there. It should also be in a computer-readable format, and preferably condensed to a level where it is usable for management support purposes. Regarding data, some special phenomena tend to be the case in operations environments:

- There is an enormous amount of basic, "raw" data being collected on a daily basis. "In the field of operations, people tend to stand knee-deep in their data", in the words of Terry Hill[3].
- This data is normally not in an easily processable or understandable format. It is often not-computer readable, or only readable by the computer the company uses itself. Also it needs to be condensed, aggregated and reformatted in order to be usable for managerial decision making.
- Despite this abundance of data, some of the data one really needs is not available. It will have to be collected specifically for the problem at stake.

• *Perceived model validity depends not only on the opinion of the client, but also on data*: In many system dynamics studies it is stressed that the main validity test for a model is whether the client understands both structure and behavior of the model and can explain the interaction between the two (Barlas and Carpenter 1990). This is not enough in the field of operations, fine as it may be for very hard, ill-defined problems where the main point is to get some kind of consensus. Fact-finding and sound operations analysis is just as important, because the client himself does not really know the precise nature of the relationships in his system. There is a solid, well-developed set of analytical techniques in operations. This set of techniques is used successfully by many consultants in this field, and should also be used in a model-building project for operations issues.

• *The implementation language of the quantitative model (discrete event simulation or system dynamics) is often not very important*: At the outset of this project it seemed that it would be best to develop the model in a discrete event simulation language. Reasons for this choice were the short time span of the model (a few hours, versus several years in most system dynamics models), the different characteristics that different types of newspapers had and the stochastic nature of so many of the processes involved. Also the fancy animation facilities of the discrete event package demonstrated at the outset clearly appealed to the client.
The actual choice for a computer simulation language however was postponed until the qualitative modeling phase was finished. During this qualitative modeling phase, system dynamics techniques and diagrams were used, simply because they wer judged as most appropriate for this type of conceptual model building. During the data analysis phase it became apparent that the problem at hand could be represented very well in system dynamics[4]. The advantage of the chosen system dynamics simulation software package Ithink™ then is that the same diagrams that are used in the qualitative modeling phase reappear on the computer screen.

• *After the modeling project, the computer model soon becomes no longer necessary*: Although the simulation model can be investigated from the operations manager's desk, and although he has become familiar with the software needed for running it and exploring different scenario's, the model is hardly used at all by now. This does not mean that the project was a failure, certainly not. It's just that there is nothing in the computer model anymore that isn't in the manager's mental model by now. The questions that were pressing him at the beginning of the project have been answered, but now his attention has shifted towards getting the project recommendations implemented. His problems of today are different. A different question requires a different model. The model that was developed does not provide answers to everything. It only gives answers to the questions that it was supposed to answer at the time. Also, as time goes by, the "base run" of the model, which was supposed to simulate an ordinary night in the old situation, becomes more and more different from the daily operations of the present date. The model is still used however to explain to other people who were not involved in the project why certain decisions have been made. Clearly the dissemination of knowledge has not yet ended in this organization.

3verbal communication with Professor Terry Hill, London Business School. See also Hill (1985).
4It is very hard to model an operations system in system dynamics if either the interactions between different products are important (e.g. in mix decisions) or if questions regarding the stochastic behaviour of individual products had to be answered (e.g. in determining delivery reliability distributions for different types of products) (Akkermans and van Aken 1991b) Neither of these were the case.

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