FOREST OPERATION PLANNING DECISION SUPPORT SYSTEMS FOR JAPAN

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Abstract

Forest operations managers are required to function in an increasingly complex, ill-structured and unstable planning environment. Various surveys of the Canadian forest industry and the authors' experience revealed that although forest managers were favorably disposed towards the use of appropriate analytical and planning techniques, such tools were not in general use. It is argued that the currently available forest planning models did not adequately describe the managers problem and were not transparent to the users.

Furthermore, the techniques used to describe and model the managers decision-making processes were inappropriate given our present comprehension of those processes. Recent research indicated that the decision support system (DSS) approach to decision analysis and model development may be successful in the current forest operations planning environment. The DSS philosophy and approach to system development which respects the primacy of the manager is then described. A forest operations planning DSS, OP-PLAN, developed and marketed by the authors is then presented as proof of the viability of the DSS approach in the forest operations planning environment.

Introduction

It has not been difficult to find references to the increasing complexity of decision-making environments that confront managers. In many publications concerning planning or management, it is stated that contemporary planners must be able to make better quality plans faster and more often than ever before in unstable situations rife with conflicting goals, greater constraints and more limited resources (for example: Drucker, 1987; Taylor and Hussey, 1982; Radford, 1977; Argenti, 1974). Some management writers even suggest that the rate and magnitude of change is such that past rules and "truths" no longer hold (see especially Drucker, 1987), although hard

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evidence is not usually offered to support these statements. Nevertheless, when it comes to forest operation planning, practising managers have often indicated to us that the climate in which they must plan their operations have become more complex and volatile over time. Even without the benefit of scientific evidence, many researchers worldwide appear to consider that it is an intuitively reasonable assumption that most forest operation managers are (to paraphrase the ancient Chinese curse) "living in (increasingly) interesting times" (Baldwin, 1984; Tomanic, 1986; Ericson, 1986; Shiba, 1989, Dada et al, 1989).

Ironically, there is evidence that many of these same managers have not significantly increased the sophistication of their planning or the amount of data gathering and analysis they do. For instance, despite the development of many tools for forest operation analysis and planning, a study of planning processes in several Canadian forest products companies revealed that few of these models and techniques were commonly used by forest operation managers on a continuing basis (Prasad, 1985). This was supported by other researchers (Goulet et al, 1980) who found that none of the major stochastic or linear programming models of forest harvesting were being used in the industry. My own experience (first as a forest operation manager then as a researcher and consultant) indicates that, although managers seem favorably disposed towards the idea of using appropriate analytical and planning techniques, their actual use is limited and sporadic at best.

The purposes of this paper are to document this apparent underutilization of modern planning technologies by forest operation management practitioners, to offer an explanation for the situation, and to describe a "tool", an approach that shows promise to remedy the problem. The bases for this work include: surveys of Canadian forest operation planning processes, the thesis-related research of a Master's candidate, management decision-making literature, on-going operational planning research at the University of New Brunswick, and the experiences of the authors as developers of information systems for the forest industry.

Evidence

The 1982 Survey

In 1982 a survey of the Canadian forest industry was conducted by Robak (1984) to: (1) determine the status of operational planning and budgeting processes in the industry,

(2) formulate a descriptive model of the current operational planning process, and (3) determine the extent of deviation from those practices that would be acceptable to managers.

Seventy-five questionnaires were sent to autonomous divisions of 34 companies in the forest industry. There were eighteen complete responses to the questionnaires, as well as five additional letters from divisions giving some information (but not a full response). Subsequently, nine companies were visited and detailed interviews conducted with personnel involved in forest operations planning. A more detailed description of this survey is given by Prasad (1985).

None of the divisions surveyed used any sort of analytical or simulation model for forest operations planning. The planning and budgeting procedures described by the managers best fit Alter's (1980) "accounting" model. Since the Woodlands Departments were treated as cost centers, the objective was to fulfill the mill requirements at the least possible cost. The general procedure was to make point estimates of machine productivity and cost for each area and then summarize costs and production in various ways to produce a harvest plan. Road construction and maintenance, transportation, and administrative activities were then planned to support the harvest plan. Attempts at sensitivity analysis were superficial and centered mainly on the harvesting part of the operations. The major criterion for plan acceptance was unit cost change over previous years. The most popular control mechanism was monthly cost and production statements issued by the head office accounting department. Managers compared the actual costs with the budgeted figures and took whatever remedial measures were necessary to stay within budget.

The survey also showed that forest operational planning is a laborious process, usually requiring more than 60 manager-days per operation, and is therefore undertaken completely only once per year (with partial revisions being made at various times through the year). The plans are experienced-based since the data required by the planners are not easily obtained, and the managers usually rely on their experience to substitute for missing data.

The 1984 Survey

In order to ascertain what changes were occurring or planned in the Canadian forest industry, another survey was conducted in 1984 (Prasad, 1985). The objectives of this survey were to define the components and timing of: (1) improvements to the resource, financial, and equipment databases; (2) advances in information processing technology; and (3) enhancements to corporate

decision making procedures that were occurring, that could be expected to develop, or that should be developed in the near future. Twenty-five companies which seemed to be furthest along in their operational planning practices were first contacted by telephone to determine the extent of their interest in the project. Twenty-one questionnaires were sent, but only nine companies responded to the questionnaire. One organization replied that it did not have enough time to answer the questionnaire.

Five companies had their forest inventory information on computer files. Two of these had already installed the sophisticated Geographic Information System (GIS) described by Erdle and Jordan (1984). This system gave these companies enhanced mapping and information storage and retrieval capabilities. Every other company surveyed planned to install the GIS within the next five years, or to have the capability to access the information from such a system. Although all the companies had (some parts of) their financial system computerized, only in two cases were the forest operations managers able to use the computer to access the financial data. Most managers received printed reports of the financial transactions of their departments every month. Only one company had its equipment data stored in computer files: the others produced printed or verbal reports when requested. All the managers expressed the desire for timely, accurate, easily accessible data (forest, financial and equipment) from which they could produce ad hoc reports interactively.

Four of the companies used computers to assist in the operational planning process. Two of these used microcomputer spreadsheets for sensitivity analyses of certain parts of the planning process. None of the companies indicated that they had access to a computer-based system which would help them plan their complete forest operations on an integrated basis.

Five companies said that they had a group of staff whose responsibility it was to oversee the development of management information systems, at least on a part time basis. Those that did not have such groups recognized the need for one somewhere within the company and planned to lobby for its creation.

Explanation

Literature Review of Planning Models

Since our surveys indicated that forest operation managers perceived the lack of good information and information-handling tools to be a problem, a literature review was undertaken in

order to determine what kind of information systems had been developed or proposed to help them. In this review it was found that, although previous attempts had been made to develop computer-based systems to aid forest operation planning, the systems aimed at more than sub-components of the problem have not been well accepted by their intended users.

In 1969, Carlsson published a description of a system for forest district-level planning of annual wood harvesting, storage and transportation activities. The model was designed to yield "acceptable" harvesting costs, and a linear programming routine was used to minimize the sum of storage and transportation costs for a given amount of wood. Unfortunately, the model did not allow testing of more than one harvesting system per area, "optimized" the harvesting separately from the storage and transportation and didn't consider the cost of roads or other support functions.

Goulet et al (1980) evaluated five simulation models which purported to handle all activities from stump to mill. In the review the authors concluded that no consensus existed on what constituted a harvesting model's essential elements. They decided that the models were not user-oriented and were unacceptable for practical operational planning since managers could not work with the models interactively, but had to rely on the expertise of computer specialists.

Linear programming (LP) was used by Hofle (1971) in Germany to optimize the cost of harvesting small-size wood, and by Newnham (1975) in Canada to minimize the cost of annual logging plans. Newnham described his LOGPLAN planning system as one which uses LP to produce a plan which minimizes the direct and indirect cost per cubic meter of a forest operation (not including transportation). Although LOGPLAN was tested in an actual forest operation, it has not been adopted by the industry. Prasad (1985) concluded that an LP approach may provide useful clues to managers about trends and directions in their operations, but LP tends to be too data-demanding and restrictive for "day-to-day" operational planning and control.

Network analysis techniques for operational planning have been proposed by researchers in Czechoslovakia. Novotony (1971) suggested a procedure which required the use of a combination of network diagrams with Gantt progress charts and with linear programming. The technique would help plan individual stands, but would not help in the essential task of choosing the stands to be harvested.

In summary, the literature review corroborated the evidence of our own surveys which had led us to believe that nobody had yet developed computer-based tools that were accepted by forest industry managers as aids in the task of producing integrated plans.

Reasons for Ignoring Existing Models

As modelers and system developers, it is natural that we should question why this appears to be so. Is it because managers feel that the situations they face are so chaotic, complicated and uncertain that detailed analysis and planning is a waste of time? Or, in fact, do they feel that they haven't been offered the right tools to make the time and effort worth while?

Model and system developers may be tempted to blame this situation on the stubborn conservatism of foresters and forest engineers. However, a survey of the literature on the broader issue to decision-making indicates that a forest industry manager's tendency to pay lip service to, but not apply rationally-based models is a common trait of management (Kunreuther and Schoemaker, 1981). Behavioral and organizational decision making research offers considerable evidence that, besides ignoring such "logical" models, managers are often shown to make "irrational" decisions (for reviews see Connolly, 1977 and Simon, 1979). Furthermore, this "irrationality" cannot be attributed solely to the fact that managers are fallible humans who may have come to the limits of their "bounds of rationality", for there is empirical evidence that human decision processes themselves often do not follow rational models (Schweder, 1977). As well, Jacoby and Chestnut (1981) have shown that managers may use only a small portion of the information that is available and that might be assumed to be required for making good decisions.

If it can be assumed that these research results are valid and that they apply equally to forest operation managers as to the research subjects, we could conclude that researchers and practitioners have been wise to concentrate their efforts on developing ever more logical, precise and sophisticated models. After all, if "humans are such poor and unsystematic decision makers" as research appears to indicate (Kunreuther and Shoemaker, 1981), it only stands to reason that managers should be coerced into using prescribed, logical decision models. Since managers are so foolish as to ignore a great portion of the information that they could use to make decisions, modelers are right to argue for increased use of optimizing models that consider "all" the information in deriving the optimum solution.

However, a closer look at these studies and at other research results might lead to the conclusion that the current approach to model and system development is not necessarily appropriate, if by "appropriate" we refer to approaches that result in implemented applications that help to solve real-world problems. For instance, March (1978) notes that optimizing models are based

upon "macroadaptive rationality" which requires that "the world and preferences are stable and the experience prolonged enough" for actual and optimal behaviour to coincide. Connolly (1981) suggests that many managerial decision making tasks exist in complex environments where "microadaptive rationality" may be the most productive approach. The microadaptive process would be one where managers would tackle a small part of the entire problem, evaluate the results of their action, then use this knowledge to work on other parts of the problem. In complex planning environments managers might analyze and plan part of the entire project, evaluate the results with respect to recognized standards (of cost or production, perhaps) and the overall objectives, and then continue the planning process. Sensitivity and marginal analyses could be used to guide the evolving plan toward the final goals. Since many researchers (as reported by March and Shapira, 1981) have found that organizations often have poorly articulated preferences (or goals) and use preference rules which favor acceptable (rather than optimum) performance, then microadaptive strategies may be most appropriate. Furthermore, March and Shapira (1981) believe that managerial decision making often occurs in an environment which is analogous to a strange game where goals, rules, strategies, players (and their attention to the game) are constantly changing. Attempting to win the game by applying optimization models would have limited chance of success.

Huber (1981) points out that the rational model is only one of at least four empirically-based general models of how decisions are made in organizational settings (the others being the political/competitive, the garbage can and the program models), and that each of these may be considered to be valid and acting in real-world decision environments. As well, Mintzberg (1981) makes a good case for a fifth model which could be called intuition. Some research has shown that in complex decision situations managerial decision making based upon limited information, experience and intuition yields as good or better results than purely rational models. It should be recognized that, although some managerial decision processes do not follow the rational model, they should not necessarily be described as "irrational". Rather, they may be processes which act at such deep levels of human consciousness or in such complex ways that they are incapable of being described through logically-based methods of decision analysis. If this is true, then it may well be, as Mintzberg suggests in the above-mentioned paper, that: "It is we theorists who are poor decision makers ... so intent are we on promoting our own perspective that we blind ourselves to reality".

This is not to suggest that modelers and system developers should spurn logic and rationality. Our experience with industrial clients has shown that managers appreciate the information that well-developed analytical and planning models give them and can be quite forgiving of inadequacies in a model if it gives them information or ideas about better ways to develop solutions. However, there is reason to believe that a modeling approach that ignores the complexity of a managerial decision environment (and the methods that good managers have developed to cope with it) has a limited chance of success.

This argument could explain why optimization model applications are rare in the area of forest operation planning. It may be that managers reject optimization models because they are overly simplified representations of a complex problem environment. Managers may view models which provide the solution to the problem as generators of "toy" solutions to "toy" problems ... and ignore them. Adding more variables, constraints and equations (and boasting that "My model is bigger than your model") is certainly no guarantee of success. After all, it is the managers (not the modeler) who must usually justify the solution to higher management and then implement and control the operational details of the derived plan. If the solution-generation process is so complex as to be opaque to managers, they may have no confidence in the solution or in their abilities to justify, implement or control it. In such a situation managers may feel very uncomfortable about the fact that they have no "feel" for when circumstances have changed to such an extent that the model should be re-run with new data or structurally modified. As well, managers are concerned with the efficiency of solution processes (March and Shapira, 1981) and may not be willing to spend the time or money gathering all of the data that may be necessary to run a large model. Finally, the managerial problem universe is often so volatile that, by the time the model is developed, the data is gathered and the solution is generated, the model no longer addresses the concerns of the managers.

Some evidence that forest operation managers actually reject the use of models for these reasons is found in the 1982/84 studies and in research and development work we have been involved in since then. The studies showed that the data managers used for forest operation planning was not abundant or particularly accurate: their decisions relied a great deal more on their own experience or that of other managers then on reliable databases (Prasad, 1985). Since many models require a relatively large amount of input data to be properly run, these managers would be immediately faced with expensive data gathering requirements and limited model utility until several years of data are gathered. In many companies where managers are rewarded

for "getting results fast" such a high cost and long payback period may well be judged as unacceptable.

For example, in our own experiences with clients, we have been confronted with:

a) A senior manager who was unwilling to consider the development of a planning model for his operating managers, in part because he did not completely understand the design concept or the technology. Although the operating managers, accountants and computer support staff who would have been the ones to run and use the system understood the design and felt confident that the project could be successfully completed, the senior manager never allowed the project to go beyond the early stages of analysis.

b) A case where relatively simple operational planning tools were being developed for another forest products company, and we were informed that certain parts of the model would have to be left undeveloped so that the superintendents who were to use them could do these calculations by hand. When we asked why, we were told that it was because the users didn't believe that they could get good feel for the "rightness" of the answers the model supplied if it wasn't done that way.

These experiences illustrate some of the problems in system and model development that traditional approaches do not appear able to solve. Approaches that stress "rational" models prescribed by experts appear to fail too often to be labelled aberrations. The results of decision theory research indicate that, especially where complex problems involving conflicting goals and unstructured decision environments are concerned, these model design and development methods are not compatible with the ways managers actually make decisions (Einhorn and Hogarth, 1981).

Proposed Solution

Forest Operation Planning Requirements

Forest product companies put considerable effort into the preparation of annual operating plans. Forest operations managers often lament that their plans could be better if they had more time to prepare them: they are not usually allowed the time to test all reasonable alternatives to see if a better plan could be achieved. A planning decision which reduces the cost of wood by a few cents per cubic meter results in savings of tens of thousands of dollars for operations which typically produce 300,000 to 500,000 m³ annually. In order to ensure that the plan recognizes

changing constraints and complies with changing organizational strategies, such planning must be undertaken frequently. Forest operations managers could benefit from a well-designed, computerized planning system which allows the manager to efficiently test alternative plans in real time.

Ideally, the planning model should allow the performance of sensitivity analysis by the planner at several levels of plan development, from the individual machine to the entire district. At the machine level, the planner should be able to vary the discretionary parameters and see how these affect his costs. Similarly, at the system level and at the area level the planner should quickly be able to see all the implications of any change he makes. For example, a change from a feller buncher harvesting system to a conventional harvesting system could result in changes to the road layout, the transportation system and to the camp facilities. The planning model should enable the manager to study the financial effects of all these inter-related changes in his own context.

It is generally recognized that for motivational purposes planning must be done by those individuals in organizational units who will ultimately be responsible for implementation (Cleland and King, 1974). This dictates that the planning should be done by the district manager and his staff who face the real problem of implementation and who intimately understand the planning model and are willing to embrace it as their own. Therefore, the planning system must enable the planner to be in control throughout the planning process without necessarily requiring him to have much knowledge of computer programming.

An Alternate Approach

Our surveys and experiences revealed that forest operations managers were not using any of the larger planning models available to them. Our explanation for this is that none of the models adequately described the problem faced by the managers. The model builders did not adequately take into account the managers' point of view and the models did not reflect managers real needs. The management problem faced by forest operational planners can be described as a complex, ill-structured problem (Khaynish and Vlasov, 1983). Attempts to use formal methods and present-day computing technology to improve the solution of such problems have met with considerable difficulty. When the proposed solution for a manager's ill-structured problem is a highly-structured model (as in the optimization approaches described earlier), the actual situation is far

from adequately represented. The optimization philosophy implicitly assumes that the major complexities of a problem can be incorporated into a model. However, managers act as information filters (Mintzberg, 1975), which often prevents staff analysts from building models which adequately represent the management problem. Even when the solution algorithm would be helpful, a manager's inability to understand it may cause him to reject it. This is why simple, transparent models may sometimes succeed while elegant solutions gather dust.

Since the manager acts as the source of crucial information, he must be allowed to contribute to the solution process. If a manager is simply left with the role of executing the solution generated by the model, there is little likelihood that it will be properly implemented. A well-designed interactive system can tap the manager as a source of information and give credibility to the solution at the same time. Khaynish and Vlasov (1983) believed that such a system should be built around a descriptive model representing the behaviour of a skilled and experienced manager. Emshoff (1978) proposed the approach of experience-generalized decisions whereby the structure and key assumptions of the model are formulated by the managers responsible for the decisions. These researchers were in effect espousing the decision support system (DSS) approach to model and system development.

The DSS Concept

As a result of research into decision processes, experience with management information systems and developments in computer technology, various researchers and practitioners began to expound another approach to system design and development in the 1970's. Decision support system (DSS) applications can be said to involve an attempt to blend the conclusions of research and practice in these areas into an effective system whose purpose is to improve the quality of managerial decision making. This approach is meant to help managers understand the decision environment and the information, data and data processing requirements of a particular application. An increased understanding of the models and the modeling process is meant to result in the development of better models which are more acceptable to managers.

The label "decision support system" was first used by Keen and Morton (1978) to describe computerized systems that:

- tend to be aimed at the less structured, underspecified problems that managers typically face;

- attempt to combine the use of models or analytical techniques with traditional data access and retrieval functions;

- attempt to provide support for all phases of decision-making through an interaction with transaction processing and other information systems;

- specifically focus on features which make them easy to use by non-computer experts in an interactive mode;

- emphasize flexibility and adaptability to accommodate changes in the environment and the decision-making approach of the user.

Watson and Hill (1983) describe DSSs as interactive systems that provide the user with easy access to decision models and data in order to support semistructured and unstructured decision-making tasks. Huber (1981) pointed out that every manager has and uses a system to help in the decision-making process: a set of procedures and mechanisms for examining the desirability of possible choices. Such a system might include decision rules, policy manuals, recollections, and advisors that the manager uses when solving problems. A DSS is, therefore, that portion of the decision support environment that contains data and models which are computer-retrievable and manipulable, usually in a highly interactive environment mode.

Keen and Morton (1978) suggest that DSSs would be most effective for tasks in the semi-structured category where managerial judgement alone will not be adequate because of problem size, complexity and/or required precision. As well, the model and data in themselves are inadequate because the solution involves some judgement and subjective analysis. Under these conditions the manager plus the computer system (the DSS) can provide a more effective solution than either alone.

A DSS always respects the primacy of managerial judgement. Its focus is on helping managers, not providing the "optimal" solution, so although a DSS may include an optimization model it still relies on judgement. For example, in a forest operation planning system a linear programming model might be use to find the "optimum" mix of sources and destinations of wood products, but it would still be up to the manager to accept, reject or modify this solution based upon the realities of the situation as he perceives them.

Improving managerial performance (rather than mere information storage, manipulation, or presentation) should be the ultimate objective of information systems. Practically all information systems provide the user with varying quantities of both information management and data quantification capabilities. The purpose of DSS is to couple the speed and accuracy of automation

with the insight of human experience, while adding the proper blend of quantitative support. To be useful, however, the system must provide results that can be directly applied by the user.

According to Sprague and Carlson (1982), a DSS should provide support:

1) primarily for semistructured and unstructured decisions;

2) for users at all organizational levels, assisting in integration between the levels whenever appropriate;

3) for decisions that are interdependent as well as those that are independent;

4) for all phases of the decision-making process. The phases (intelligence, design, choice) are from Simon's (1960) model of decision making;

5) for a variety of decision-making processes but not be dependent on any one. Consequently, it should provide decision makers with a set of capabilities to apply in a sequence and form that fits each person's cognitive style.

6) A DSS should be easy to use since managers will only use it to the extent that it is valuable and convenient.

Keen and Wagner (1979) suggest that another term for DSS might be "executive mind-support system". This requires that a DSS should be able to reflect the way managers think. It must be flexible and adaptive through ease of use and modification, support managers in a process of exploration and learning, and evolve to meet changing needs, knowledge, and situations. The goal is to provide managers with tools they will choose to adopt and that mesh with their own decision-making and judgement processes.

The DSS Approach

These definitions of DSS may be useful in themselves, but it is the actual approach to DSS design and development which modelers should find helpful in producing successful applications and promoting an atmosphere that is conducive to increased managerial acceptance of their models. The following should be regarded as the essential elements of the approach:

a) **Decision Analysis** — This should not be confused with the term as defined by behavioral and organizational decision researchers. DSS developers are primarily interested in what decisions are made, not why. For example, if a DSS for forest operation planning is to be developed, the goals of the planning exercise and the essential planning decisions that a manager must make are identified. Since the objective is to provide tools that help managers plan a forest

operation, the analyst need not dig very deeply to find out why these particular decisions are made, but only needs to verify that those decisions actually are an integral part of the planning process. In fact, the analyst may have considerable difficulty in identifying the essential decisions since managers have considerable difficulty in articulating their decision processes (Rolph 1979).

b) **Information Requirements** — Once the decisions have been identified, it is necessary to determine what information (not data) the manager requires in order to make those decisions. In most cases, since you are working with managers experienced with the decision making process that is being analyzed, this may appear to be a relatively simple exercise. In my example, the analyst might simply ask the manager to describe what information he uses to make the planning decisions identified earlier. In some cases the manager's responses may actually help the analyst identify decisions that were not discovered during the decision analysis process. An example of this would be where a manager describes information that he uses during the planning process which does not appear to be needed for any previously described decisions. However, as with decision identification, managers may occasionally find it difficult to describe what information is actually used to make decisions.

c) **Data and Models** — Once the information requirements have been determined (at least tentatively), the analyst must determine what data is actually available and what models must be used to process data into useful information. A DSS should be understood to work in an overall problem environment that may defy modeling since many of the solution approaches and evaluation criteria are intuitive and changing. Therefore the analyst/developer must concentrate on developing tools that provide managers with most benefit at least cost. Furthermore, if any data is not readily available, if some of the modeling is expected to be expensive or if some of the data processing is likely to reduce the performance of the DSS, it will be necessary for the manager (with the analyst's help) to decide whether that model should be part of the DSS or not. For example, an analyst may determine that one criterion that a manager uses for judging the acceptability of a harvesting system is its wood costs relative to historical wood costs. Although one approach might be to develop a model which processes historical data into comparative information regarding wood costs, the manager may well decide that the added cost (data gathering, model development, reduced DSS performance) would not be worth the small benefit it would provide, especially if much the same results could be achieved by keeping the cost information from previous years on hand.

d) **DSS Structure** — The objective of a DSS is to support a manager's decision process, not to model or duplicate it. Therefore it should be structured in such a way that it makes available the appropriate information (from computer-based models and data) to a manager that can be combined with other sources of information, experience and intuition to facilitate the entire problem solution process. This often requires a degree of flexibility from the system that may not usually be expected from management information systems. For example, this might mean that although a forest operation planning DSS would be designed to estimate machine productivity, it would still allow managers to "over-ride" the system and designate productivities that they feel are more realistic.

e) **Prototyping** — Except in the simplest of cases, an iterative, progressive design and development process is advised. One of the reasons for this, the difficulty managers have in describing their decision processes and information needs, was described earlier. I have found that managers are much better able (and more willing) to criticize a prototype model than to describe what the model should look like in the first place. Although this tendency may be frustrating for the system developer, the development of rough prototypes and even mock-ups (of menus and information screens) often helps managers articulate their decision processes and information needs. A further benefit of this approach is that, in those circumstances where some models within the system can be developed for immediate use, the manager is able to see a quicker pay-off and may be more willing to maintain interest in the project.

f) **User Involvement** — As the reader should now be aware, the eventual user (the manager) is necessarily an integral part of the analysis, design, development and evaluation process. The system's design is based upon the manager's cognitive processes and information requirements. Although an experienced analyst may be able to offer many useful suggestions concerning model design, information presentation and other technical elements, it must always be recognized that it is the manager who should confirm that they are actually appropriate. Finally, it is the manager who must decide whether the system actually accomplishes the project's objectives (rather than simply satisfying the original design specifications).

The rationale for including these elements in the "DSS approach" stems, to a great extent, from the characteristics and objectives of DSSs as defined by such researchers and developers as Keen and Morton (1978), Sprague and Carlson (1982), and Davis (1984). However, this approach

should also result in other benefits which may influence the success of the project and the manager's interest in working with the analyst on other projects. Since the system is based upon the manager's cognitive processes, it should seem like a simple extension of the processes with which he is familiar. The manager's involvement in the design, development and evaluation process should ensure that he understands how the system works, engender a feeling of "ownership" in the system and a commitment to make it succeed. The prototyping approach should greatly reduce implementation and training time. The flexible structure allows managers to explore new ways of formulating and analyzing the problem and designing solutions and may help them to understand and improve their decision processes. Furthermore, since the system must usually evolve with the changing decisional environment, the manager's familiarity with and understanding of the entire approach should make the system maintenance and modification process much easier.

A DSS Project

The First Forest Operation DSS Project

The DSS approach to forest operational planning has been applied to the planning problems of Canadian forest products companies. The DSS package, called OP-PLAN, is based upon a model developed from the 1982 survey. OP-PLAN enables managers to continue using familiar planning procedures, but at the same time allows them to employ the entire operating budget and other measures of overall performance as criteria for sensitivity analysis. The idea is not to replace managers, but to give them tools which will help them to test alternatives quickly and economically. There is no optimizing procedure; the manager has to test several alternatives and then pick the one that best satisfies his particular circumstances.

The first version of OP-PLAN was developed for a major New Brunswick integrated forest products company. This company's annual harvest of 1,700,000 solid cubic meters of sawlogs, studwood, spoolwood, veneer, pulpwood, and other products is produced from six operating districts. Each of these districts is a separate planning unit supplying wood to various manufacturing plants from as many as 100 separate harvesting areas. Since OP-PLAN is primarily intended to support district-level decision-making, it was decided that it should be microcomputer-based.

The preliminary analysis for the project was begun in late 1983 and the first prototype was ready for implementation in 1984. For a full discussion of the design methodology, DSS structure and results of the project, see Robak (1984; 1986) and Prasad (1985). In summary, however, this first version was not fully implemented, primarily for the following reasons:

1) despite the fact that the system did everything that the managers had originally demanded, the client soon realized that it was still inadequate for their needs;

2) the client had decided that it would implement and support the software, but the staff it assigned to this task did not understand forest operation management or decision support system philosophy;

3) the development language (BASIC) was inadequate as a vehicle for managing the databases required and generated, and was incapable of allowing developers to generate new prototypes quickly.

Subsequent Developments

Despite the fact that OP-PLAN had not been fully implemented by the client, we were encouraged by the favourable reaction of the company's managers and of others in the forest industry, who indicated that, although the prototype needed work, the concept and the approach appeared to be right. At that time we decided to form an organization that would be capable of conducting the research and development and providing the ongoing support that this project required.

The first task of this group was to use the experience and analysis results of the first attempt to formulate better design and performance specifications for the DSS. This was quickly accomplished with respect to the design of a new demonstration version, but it was recognized that the actual design of the system is extremely client-specific. Although we hoped that the core of the system was generally applicable, we recognized that each operation had a distinct decision environment which required a distinctive system design.

We then realized that we would have to refine the approach that we would take with respect to future analysis, design and implementation so that we could expect to have a better chance of success. While developing other information systems, we had found that the prototyping method (described earlier in this paper) worked very well, especially where the system was intended to

work in an ill-structured decision environment. We concluded that prototyping was a necessary component of our overall design and development methodology.

The adoption of the prototyping method placed an even greater emphasis on the last major task that our group set for itself: the identification of the hardware and software technologies upon which we could base our newest version of OP-PLAN. Besides being capable of accomplishing all of the data-handling and dialogue tasks that we had identified earlier, we realized that the development language would have to allow us the ability to develop new versions very quickly and "cleanly" (ie. in a structured fashion). Furthermore, we had already identified from our own experience that the resulting system would have to be microcomputer-based but yet capable of providing the information required quickly enough to satisfy the needs of managers.

The Current Project

We are currently in the process of implementing our new version of OP-PLAN (Version 2) for another Canadian forest products company. We have concluded that the system should be MS-DOS based, and that the minimum hardware requirements are an 80286 CPU and a fast hard disk. This project relies heavily upon the prototyping methodology. The development language being used is called "CLIPPER", a product of Nantucket Corporation. CLIPPER is actually a compiler for the database management system and programming language, "dBase III+" (Ashton Tate Ltd.). Although dBase III+ is itself a relatively powerful development language and has had many development tools developed for it, the use of a compiler such as Clipper means that these capabilities can be combined with the advantages of modelling tools developed using the 'C' or assembler languages.

One of the major problems to be overcome in this project was the fact that the installation site is in a relatively isolated area in the province of Quebec, about one thousand kilometers from our offices. Ordinary prototyping, to be done properly, would require that the developers and/or forest operation managers get together frequently to ensure that needs are being met in progressive system designs. In this case this would be expensive and would tend to discourage managers from evaluating prototypes and articulating needs. We have pioneered an innovative technique that will couple the use of very fast (9600 baud) modems with special communication software ("CLOSE-UP", by Norton Lambert Corp.). After installing a demonstration version of OP-

PLAN and teaching managers how to use it, there has been no need for face to face contacts between the users and ourselves. CLOSE-UP allows us to interactively demonstrate ideas, discuss needs and designs and redevelop the system even while we are a thousand kilometres apart. The new generation of 9600 baud modems allows this to happen without long waits or great risk of data corruption.

Other Implementations and Future Proposals

OP-PLAN has been implemented and is being used for teaching and research at the University of New Brunswick and the University de Moncton. Other implementations for educational institutions which are proposed for 1989 and 1990 are in Ireland (University College Dublin), Sweden (Sverige Lantbruksuniversitet, Garpenberg), New Zealand (University of Canterbury), Australia (Australian National University) and Japan (Nagoya University). Furthermore, studies to test the feasibility of using OP-PLAN as a planning and control tool will be conducted by the following public and private agencies: The Irish Forestry Board, The British Forestry Commission, Mellanskog AB and the Japanese Forestry Service.

Conclusion

The evidence of empirical and anecdotal studies of information system development projects suggests that traditional design and development methods are often unsuccessful in the development of decision support systems and complex management information systems. Moreover, more time spent employing orthodox analysis, design and development methodologies does not appear to be a valid solution since their sequential nature does not allow managers' and developers' perceptions of the problems and needs to evolve. In other words, conventional techniques do not allow the participants to learn and to incorporate the results of this new knowledge in the information system design in an efficient manner. Recent literature suggests that decision support approach, with an emphasis on prototyping and coupled with some of the better standard analytical techniques, should be conducive to the efficient development of more functional systems. Personal experience confirms that, although this approach is not a panacea, it may be the best way to ensure that forest operation managers' needs are met when systems are developed for them. In fact, it may be the only way that systems can be developed which enable managers to employ poorly understood but valuable intuitive skills.

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