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IIASA Working Paper

WP-81-053

April 1981

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ABSTRACT

Decision Support Systems (DSS) are a new kind of information systems as yet not well understood by managers or even by researchers in management science. The purpose of this paper is to present, as simply as possible, the concept underlying DSS, to discuss its applications to management and to examine some of the concerns managers might have regarding DSS. It is important to understand DSS because they offer managers the opportunity to directly improve their managerial effectiveness.

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INTRODUCTION

Information systems have so far had very little impact on the decision-making process at the middle and senior management levels. Their contributions have been felt mostly at the clerical and lower management levels. Decision Support Systems (DSS) are a new kind of information systems whose objective is to improve managerial effectiveness by supporting managers in their decision-making tasks. The purpose of this paper is to introduce and discuss the concepts underlying DSS.

To define DSS is difficult. To illustrate the problem let me preface my definition with the following proposal put forth by a discussion group at a conference at IIASA in 1980 [6]:

> We [the discussion group] believe that managers live in a constant state of transition. Perplexity is always within the manager's mind, and this will not change. The manager will continue to act without full understanding and will not consider this to be a problem; while attempting to increase his understanding, he never expects to arrive at a full understanding.
>
> We do not want DSS to be another "MIS." That was a mechanistic attempt at a "solution," which does not and never did work. We must take another approach.
>
> We recognize that any attempt to give definite form to DSS would be an attempt to deny the necessity of living with perplexity. We prefer to be a *movement* with no attachment to any technique. We choose to act from a sense of this movement, not because of an attachment to a technique. And we choose *not* to act in ways which imply knowledge that does not exist.

The "movement" mentioned in the above proposal was born out of a common dissatisfaction with the application of technology to management or, shall we say, with the practice of throwing technology at managerial problems. One thing is to stress, therefore, that DSS is a concept free from any technological context. In other words, there is no technical conception of DSS for which one cannot readily generate counter examples in other areas of computer application.

But clearly DSS does lie within the area of information systems, that is, systems dedicated to improving the performance of workers in organizations through the application of information technology. It is crucial, however, to differentiate between DSS and Management Information Systems (MIS). In MIS the strong link is between task and system (i.e., a system is designed for a specific task); in DSS the linkage is between user and system.

A DEFINITION

I define DSS very generally to include all systems that support the decision-making process in such a way as to improve managerial effectiveness. By "*system*" I mean a complex whole comprising a professional worker or workers (e.g., managers, researchers, professionals, staff analysts, and clerical workers whose primary responsibility is the handling of information in some form), a set of tools (usually, but not necessarily, computerized), and, when different from the user, a system designer or developer. "*Support*" here means to make possible or to expand human capabilities for such activities as accessing facts, retrieving information, making computations, comparisons, projections, models, simulations, decision trees, etc. "*Decision making*" implies the intellectual activities that might comprise a decision such as intelligence gathering, screening, classification and structuring of data, model construction, simulations, formulation and testing of alternatives, choice of approach and implementation strategies. The distinguishing feature of DSS is its objective to improve managerial effectiveness.

Having now provided a somewhat general definition of DSS, I will, in the next section, elaborate on the kinds of decisions DSS addresses.

KINDS OF DECISIONS ADDRESSED

In order to identify the kinds of decisions or problems addressed by DSS it is useful to merge Anthony's [2] framework of analysis based on the level and purpose of the management activity and Simon's [12] distinction between programmed and non-programmed decisions. Because of the pejorative connotation of programmed and non-programmed, researchers in the field of DSS prefer to talk of structured and unstructured decisions. Incorporated into the matrix are examples of the kinds of decisions identified by the intersection of Anthony and Simon's categorizations of management decisions. The resulting matrix is given in Figure 1.

In figure 1, structured operational control type decisions are exemplified by those involved in payroll accounting and semistructured strategic planning type decisions by those associated with a departmental reorganization. The reader will no doubt have observed the addition of semistructured decisions to the matrix. These are decisions which combine structured and unstructured components. The example given for a semistructured operational control type decision, decisions made by investment officers in a bank, illustrates the point. The decisions involve a set of rules; however, they often also involve judgment. The process cannot be automated, but, it is far from being a discretionary exercise in judgment.

DSS deals mostly with semistructured decisions. DSS systems have dealt with semistructured operational control type decisions. Such a system--and one of the most successful to date--is PMS (Portfolio Management System) [7,9,1], a system used by investment managers in a large

xx	Operational Control	Management Control	Strategic Planning
Structured	Departmental payroll accounting	Variance analysis of service delivery	Branch office location
Semistructured	Professionals dispensing services to clients (e.g. Bank investment (portfolio) officers)	Financial planning and budget preparation	Departmental reorganization
Unstructured	Press releases	Hiring of managers	Elaboration of departmental objectives and policies

Figure 1

bank. DSS systems have also addressed semistructured management control type decisions. BRANDAID [10] is such a system. It supports decisions regarding marketing plans. DSS systems addressing semistructured strategic planning type decisions are rarer and are usually tailored to the particular needs of the organization (e.g. The Gotaas-Larsen Shipping Corporation planning system [1]).

With reference to figure 1, MIS type systems address structured management decisions or tasks and DSS type systems address semistructured ones--and to a certain extent unstructured ones. MIS apply when

the task is structured and the functions specified. DSS on the other hand apply when the functions are unspecified. We shall return to this fundamental difference in the next section.

DESIGN AND DEVELOPMENT

As was pointed out in the introduction, what distinguishes DSS from MIS is that the user-system link is much stronger. Accordingly, DSS design and development strategies tend to focus on the user. Furthermore, DSS deals primarily with semistructured decisions and, potentially, with unstructured decisions. The task comprising such decisions is therefore ill defined. Managers either will not or cannot give functional specifications as they did for MIS systems. The result is that DSS systems are by definition *underspecified*. Their development is evolutionary and continuous. "Sign off" procedures are unknown in DSS systems.

DSS has given rise to a series of innovative implementation strategies called adaptive designs, for example, "the evolutive approach" [5] and middle-out design [11]. Their main characteristic is that they proceed without any functional specifications. Data Processing (DP) systems require extensive planning before programming. Not so with DSS where coding starts as soon as possible. The idea is to identify a relevant problem--which later fades in importance as the whole system evolves--and tackle it right away in order to give the manager something to work with. From this embryonic start managers can further define their task and their own methodology and the system can evolve. The development of DSS is therefore much more than programming. It involves learning on the part of both manager/user and designer. In future, with the advent of artificial intelligence, the machine might also share in this learning process.

AN EXAMPLE

DSS systems dealing with semistructured management control type decisions are perhaps the most appropriate as examples. They deal primarily with a subject matter familiar to most managers, namely, management planning and financial budgeting. The example I have selected is such a system. It is called Budget Information System (BIS). It is an online system for planning, budgeting, and control at the Great Northern Bank (one of the leading banks in a large city). The system is described fully in Alter's book entitled: Decision Support Systems: Current Practises and Continuing Challenges [1]. I give here a summary version of his description. Other available case studies of DSS are listed in the Appendix.

Part of the basic budgeting and planning of the bank takes place at the cost center. The budget and long-range plan figures are entered online by cost center managers and/or the decision comptroller. The "actual" figures in the database are updated by standard monthly update runs. The information is obtained by other accounting systems in the bank. Access to the database is controlled. A cost center manager may access only records affecting that cost center, whereas the division comptroller has access to all records affecting that division. Users access BIS by means of video terminals or printing terminals. Hard copy reports can be produced by means of a command that creates a file for printing on a terminal.

Interactive Exception Reporting

Interactive exception reporting is a performance evaluation whereby a cost center manager or division comptroller prepares a *customized* monthly variance report comparing actual with budgeted performance by cost center or centers. Performance for each data type (direct expenses, indirect expenses, incomes and personnel) may be evaluated. When the performance evaluation function is invoked, the user is able to tailor the report by means of a number of choices that are presented. For instance, the user can title the report, specify the transaction types to be considered, and specify whether the output should be at a terminal or a printer. It is possible to perform computations (additions, percentages, etc.), create forecasts using a linear regression function, retrieve selected data, print comments, and prepare graphs. Most important for exception reporting, the user can state both dollar and percentage criteria for what constitutes an exception. By doing so, the user can eliminate from the report those expense items that are within budget and do not require additional attention.

On or after the eighth business day of each month, the BIS database is updated with direct expenses (by type within cost center) for the previous month. All of this data is obtained from a previously developed transaction-oriented expense accounting system which captures and displays all transactions within each expense class for each cost center. The comptroller specifies dollar and percentage criteria for the BIS exception report. He scans the exceptions on-line, annotating them with any comments deemed appropriate. Next, the report goes (electronically if so desired) to the cost center manager, who attempts to justify any

variances the comptroller did not understand. In explaining these variances, the cost center manager often refers to the detailed batch report generated monthly by the transaction-oriented expense accounting system. Later, the cost center manager returns the annotated report to the comptroller and discusses the significance of any variances that may indicate problems.

Thus BIS is designed as a tool for facilitating communication between comptrollers and cost center managers. Instead of being forced to thumb through the transaction-by-transaction detail of the batch reports, the comptroller can allow BIS to select for his attention only those expense classes in each cost center that merit his attention. The cost center manager, who should have a close fix on the detailed expenses, can then refer to the batch reports to explain what happened wherever it is not apparent.

Although exception reports can be generated in batch mode, the online nature of BIS permits the customizing and annotation of these reports The cost center manager knows that the exception report contains only variances that really require some explanation. In addition, the process of customizing exception reports means that both comptrollers and cost center managers will have given some thought to the exceptions prior to their meeting, thus facilitating communication.

Interactive Planning Tools

Interactive planning tools are a series of programs that are available for developing both the long-range plan and the yearly budget. There are two types of functions. The first is *Planner*, which provides a status report by expense type (with a selective exception reporting feature) for the manager to review before entering the interactive planning mode. This report consists of two sections: a standard format section, which may be produced without interaction, and a customized section, generated in interactive mode for exception testing and analysis by means of standard analysis routines. The second type of function, *Projection*, leads managers through each data item that must be included in their long-range plans or annual budgets It allows them to experiment with various projections for any item and to perform revisions in order to help them arrive at plans that are appropriate. The program relieves managers of clerical work and allows them to spend more time thinking about alternatives. BIS utility programs summarize and print the plans in a standard report format.

In order to understand the ways BIS is used for planning, one must have a familiarity with the bank's planning process. Bank managers attend an annual planned-growth conference. At the conference, they work out the kinds of strategies and programs they want to pursue over the five-year planning horizon. The financial implications of the long-range plan are developed fully after the conference (i.e. two months later). After another two months, the budget for the next year is firmed up. Historically, this process of generating and firming up the budget has required a great deal of clerical work on three levels. First, the cost

center manager has to develop a one-year budget and five-year plan that seems adequate. In the past, cost center managers have found this task highly distasteful, particularly since it involved extensions of payroll taxes and other items that applied differently to employees of different grades, to part-time versus full-time employees, and to overtime versus regular time. Next, the division comptroller must consolidate the cost center tabulations to produce a one-year budget and five-year plan for the division. Whenever the total budget seems too high, iteration and pruning of cost center budgets are required. Each iteration requires more clerical work. Finally, the Corporate Comptroller's Division consolidates all budgets to produce an overall financial plan for the bank. Once again, consultations between the division comptrollers and the Corporate Comptroller's Division result in revisions of the division budgets and yet more paperwork on all three levels. In addition to the work required of clerks and accountants, a painful typing effort was required of secretaries, who were fine at typing letters but not particularly good at typing numbers in columns.

It is generally felt that BIS has played a valuable role in reducing the clerical work at all levels. BIS aids the cost center managers and division comptrollers in preparing a budget by providing listings for each expense class of last year's actuals, this year's budgeted, year-to-year actuals, and projected actuals for the reminder of the year. This helps the cost center manager reconstruct the thinking of last year and helps to produce a new budget, which incorporates both the history and the new considerations that have become relevant. BIS allows the user to generate new plans that differ from previous ones by percentages or fixed

amounts. This streamlines the clerical process of producing a plan and allows the user to consider several alternative plans before deciding which one to submit. Particularly important is the automatic calculation of estimated expenditures for taxes, office space, insurance, and so on. The cost center manager merely states the number of people of each grade and the number of square feet; BIS produces the dollar amounts.

The consolidation of divisional plans is now done automatically. The Comptroller's Division can now look at both individual budgets and the overall bank budget and five-year plan without expending a considerable effort on manual consolidations.

By expediting the production of budgets, and long-range plans, BIS frees time formerly needed for clerical functions and allows the comptrollers on both levels to consider more alternatives and thus do more analysis. The assumption is that these improvements in the planning process will lead to "better" plans. Whether "better" plans are being produced is not known with certainty, but it is clear that tighter and more consistent plans are developed, given the assumptions on which the plans are based. The plans are tighter because the calculations are more accurate and because the growth of the plan can be tracked from year to year. The plans are more consistent because it is possible to make comparisons across divisions or cost centers and thereby to spot discrepancies.

Future Developments of BIS

Whilst consolidating its previous developments vis-a-vis the users and continuing to perfect these applications according to the users' needs, BIS continues to evolve. The latest applications are: a quarterly preparation of P and L statements; free form inquiry, analysis, and report preparation; and sophisticated management aids such as linear programming, model building, and probabilistic analysis. However, the continuing growth of systems like BIS can only be achieved if there is a process of "refreezing", into the work patterns of employees, of the use of the applications developed, and if the development of new applications occurs as a result of a felt need or of a "defreezing" of old work habits.

Conclusion

In many respects BIS is close to an MIS design. What differentiates BIS and makes it what I call a "first generation DSS" is that the focus of the system is on the user (i.e. the cost center managers and comptrollers) rather than on the task (i.e. budgetary control). As DSS systems evolve and become more common, I predict that the shift in emphasis between user and task will become even greater and lead in many instances to the kind of personalized systems which I have described in a previous publication [3].

MANAGERIAL CONCERNS

The difficulties with DSS so far are not so much technical as behavioral in nature. The demands DSS place on the managers' time and energy and the inherent reservations and limitations managers have regarding computerized information systems both contribute to the problem. The need for insight into managerial behavior cannot be underestimated when developing management aids and management systems. To illustrate, consider the example of audio teleconferencing and graphical displays. On the face of it, these two simple management aids should be highly beneficial to managers. Yet, to this day, they remain grossly underutilized.

Audio teleconferencing has been technically feasible since the invention of the telephone in the last century . People on party lines have often used the opportunity to speak to several neighbours at the same time; nevertheless, there has been no demand for such a facility as a management aid for over half a century. Developers did not heed the warning and even today, many years after the development of audio teleconferencing, companies like AT&T are still pondering over the lack of demand for this service. Technical problems alone cannot account for the lack-luster performance of this management aid. Possibly the importance of non-verbal communication or body language, and consequently, the implicit value managers place on face to face contact in meetings, has been seriously underestimated.

Most people would agree that graphical displays are a powerful aid in presenting information succinctly; the scientific community uses them as a matter of course. However, relatively little use of graphics is made by

managers, even today when technology is pushing ahead with color graphics . The following explanation can be suggested: managers distrust graphical displays because, contrary to tables which they associate with accounting, graphs have no agreed upon convention or calibration, no standardized language, no accreditation, no tradition . It appears that managers will be reluctant to use management aids such as graphical displays before they have developed sufficient trust in them.

One can suggest several specific reasons why these management aids failed; however, in general, it seems that too much attention has been paid to the technical considerations and not enough to behavioral ones. Managers tend to be highly critical of the benefits of new management aids and keenly aware of the costs to them which will result from their utilization. In the above examples, the costs are the time and effort required to develop new skills better suited to teleconferencing meetings and to learn how to use graphical displays. Managers are also well aware that any change involves a certain amount of risk. In the case of teleconferencing, the trading of old skills at handling conventional meetings, for new ones, may well favor some people and not others and result in a shift in the relative influence of the members of a committee that has adopted this new meeting format. Similarly, the use of graphical displays may be to the advantage of people with scientific or engineering backgrounds.

Today, with the advent of new computer technology, a great number of management aids has burst onto the scene. Unfortunately, managers have not yet had the time (nor are they likely) to develop the attitude, skills, and trust necessary to accept and use the new aids. It is therefore disturbing to realize that, even now when technology has so clearly over-

taken our ability to use it effectively, we still tend to study the development and implementation of new computer management systems from a technical point of view. It is important, in our attempt to harness new technology, that we not be mesmerized by it.

In my view DSS is still very much a captive of the technology (i.e. mini- and micro-computers, time sharing, and "friendly" interfaces) to which it owes its very existence. I believe DSS research has so far failed to gain sufficient insight into the crucial aspects of managerial behavior to ensure DSS acceptance and utilization by managers. For instance, the following issues have yet to be properly addressed:

- aversion to ***risk*** and lack of ***trust***, already mentioned above and also possible barriers to the development of DSS;
- the ***fear*** of an Orwellian type organization where accountability for decisions taken can be traced by means of computer logs;
- the ***fear*** of having one's decision-making methodology (if it exists) revealed;
- the ***fear*** of exposing personal data (i.e. judgemental data about subordinates, peers, superiors, even the chief executive, about rules, regulations, projects, programmes, departments, policies, about the real mission of the organization, about one's own personal goals and hidden agendas, etc.);
- ***legality***, in some countries (e.g. Canada) any record on individuals, be they customers, clients, employees, etc., must be made available to them for their inspection on demand;

- *learning*, more precisely the fear of not being able to learn because of personal limitations (very little is known about adult learning), incompatibility of cognitive style with that of analysts and the computer systems they design, lack of time;
- *status*, or loss thereof vis-a-vis superiors and peers if the DSS experiment is a failure;
- *loss of face* with subordinates as a result of using a keyboard, performing simple tasks at a terminal or needing the assistance of a tutor or coach;
- *complexity and subjectivity of thinking* [3], or the difficulty for managers to articulate the subjective views they have of their management activity and its environment.

To ignore those managerial concerns is to lose sight of the DSS objective which is to provide ways and means for managers to improve their own decision-making effectiveness. Traditional programmers must broaden their horizons to include the views and needs of managers. In fact, there is talk that a new breed of system designers might be required in the future. But to fully capitalize on the benefits of DSS will require changes in both users and designers.

CONCLUSION

As was pointed out earlier, technology has outstripped our ability to use it effectively. This is nowhere more true than in the area of information systems. The immediate task, therefore, is not so much to develop more technology but rather to learn how to use what we already have at our disposal. The task is to adapt technology to the needs and capabilities of the managers that must use it. In this sense DSS, as a concept at least, is on the right track.

The success of DSS will depend to a large extent on our ability to understand the manager and the managerial environment. To do so DSS will have to draw heavily on a number of contributing disciplines such as organizational science, psychology, sociology, communication theory, etc. DSS researchers will have to be very attentive to the teachings of those other disciplines. What is more, they will have to elicit interest in DSS from those other disciplines. DSS must become truly interdisciplinary if it is to succeed in its objective to improve managerial effectiveness.

APPENDIX: CASE STUDIES OF DSS

AAIMS:	An Analytic Information Management System [4,1]
BIS:	Budget Information System [1]
BRANDAID:	Marketing Brand Management [9]
CAUSE:	Computer Assisted Underwriting System at Equitable [1]
CIS:	Capacity Information System [9]
EIS:	Executive Information System [4]
GADS:	Geodata Analysis Display System [9]
GMIS:	Generalized Management Information System [9]
GPLAN:	Generalized Planning [4]
IMS	Interactive Marketing System [1]

IRIS Industrial Relations Information System [4]

ISSPA: Interactive Support System for Policy Analysts [8]

MAPP: Managerial Analysis for Profit Planning [4]

PDSS: Procurement Decision Support System (International Harvester, private paper)

PMS: Portfolio Management System [9,1]

PROJECTOR: Strategic Financial Planning [9]

REGIS: Relational Generalized Information System [4]

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