A Contingency Model For User Involvement In DSS Development

By: Robert I. Mann
Hugh J. Watson
Department of Management
The University of Georgia
Athens, Georgia 30602

Abstract
Many authors have stressed that DSS development requires a high level of user involvement. Three DSS case studies are presented which illustrate that the level of user involvement can vary considerably. Based upon the existing literature, a tentative model of the dimensions affecting user involvement in the creation of a DSS is hypothesized. This model is then refined in light of the three case studies presented.

Keywords: Decision support systems (DSS), systems development

Decision support systems (DSS) are one of the most recent and interesting developments on the computer-based information systems scene. They are used by marketing managers to support brand decision making [14], by bank officers for financial planning and controlling purposes [20], by physicians for diagnosis and therapy [6], by academic administrators for academic planning [8], and for a growing number of other applications. While there is no universally accepted definition for DSS, the following one is used here:

A decision support system is an interactive system that provides the user with easy access to decision models and data in order to support semistructured and unstructured decision-making tasks.

This definition is compatible with those suggested by others [14, 22].

While definitions are useful, they often fail to "tell the whole story." Such is the case with DSS and explains why some scholars prefer to discuss DSS characteristics rather than definitions. For example, Sprague has suggested that a DSS [21]:

- tends to be aimed at the less well structured, underspecified problems that upper managers typically face;
- attempts to combine the use of models or analytic techniques with traditional data access and retrieval functions;
- focuses on features which make them easy to use by noncomputer people in an interactive mode; and
- emphasizes flexibility and adaptability to accommodate changes in the environment and the decision making approach of the user.

These characteristics enhance understanding of the DSS term as it is used in this article.

A number of practitioners and scholars have stressed that a DSS requires a somewhat unique development approach. Names such as heuristic
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[4], iterative [21], adaptive [11], and L’Approche Evolutive (evolutionary) [5] have been suggested. Advocates of these development approaches point out the difficulty, if not impossibility, of establishing DSS specifications without a trial-and-error process. Unlike transaction-oriented applications which are relatively well defined and not subject to rapid environmental changes, decision support systems often serve users who are, at least initially, unsure of their specific information needs. Furthermore, these needs may change over time as the environment changes. Consequently, the user tends to be more involved throughout the DSS development process than with most other systems.

Adding to the attention given to these new development approaches has been the emergence of DSS generators such as IFPS, EIS, XSIM and EMPIRE. These software packages have aided the development of decision support systems in many organizations. In some cases they have made it feasible for the user to develop his or her own DSS with little or no outside assistance.

It has been pointed out that as a given field in management matures, universal principles develop into contingency approaches. Schonberger has suggested that this is true of MIS design [18]. Based on our observations of systems which satisfy the DSS definition and characteristics given earlier, the same applies to DSS design. Our purpose is to provide a broader perspective of the role of the user in DSS development by providing a contingency model which describes the variations in the systems which we have observed.

The contingency model will be developed in the following way. First, the organizational personnel who may become involved in the creation of a DSS and their potential roles will be reviewed. Then, three DSS case studies which illustrate the range of potential user involvement in the development of a DSS will be presented. Next, a tentative contingency model suggested by the MIS and DSS literature will be given. Finally, a refined contingency model which accurately describes the role of the user in the three DSS case studies will be presented and discussed.

Organizational Personnel and Roles

A variety of organizational personnel can become involved in the development of a DSS. Sprague has described them as the user, intermediary, DSS builder, technical supporter and toolsmith [21]. For our purposes, it is more efficient to describe the organizational personnel as user, intermediary and technician. Each category is differentiated by characteristics such as who they are, their potential DSS role, their knowledge and skills, and their location in the organization’s structure.

Users

A user can be either a manager or a staff specialist (e.g., corporate planner, marketing researcher, or production planner). This is the person who benefits from the output provided by the DSS. Users can vary from managers with little knowledge and/or interest in computer technology to staff specialists with extensive computer training. Consequently, some users build and operate their own DSS while others have no hands-on contact with the DSS. A common denominator is that users are organizationally located where the decisions are made.

Intermediaries

Many organizations employ personnel with data processing, management science, and functional area skills to serve as information analysts. Often such personnel are MBA graduates with a Management Information System (MIS) specialization. They frequently serve as a liaison between the data processing group and a functional area or as an in-house consultant to a functional area. Their role in a DSS may be to build and/or to operate it for a user. Most commonly, an intermediary is organizationally located in a functional area, but some organizations are creating separate DSS groups and an intermediary may be housed there [22]. Sometimes a DSS is created by a consultant who may also be categorized as an intermediary.
Technicians

Data processing (e.g., programmers, systems analysts, and database administrators) and MS/OR personnel may become involved in the creation of a DSS. At one extreme they may assume the primary responsibility for building the DSS. At the other extreme, they may play only a minimal role (e.g., placing a DSS generator on a computer system). Technicians tend to have highly specialized skills in areas such as computer science, statistics, and mathematics. They are organizationally housed in units such as data processing and management science.

Three DSS Case Studies

The roles of users, intermediaries and technicians in developing a DSS can vary considerably. This can be seen in the three following case studies of decision support systems developed at Southern Railway, LTV, and General Dynamics.

Computer-assisted dispatching at Southern Railway

In 1976 Southern Railway began development of a computer-assisted dispatching system which became operational in 1980. The system contains two subsystems which are oriented toward slightly different functions. The dispatch management system handles the traditional dispatching activities of the rail system. It shows the current status of trains on a CRT, performs record keeping on train activity, and accepts “switch” and “signal” setting decisions from the train dispatcher. The meet-pass system provides the decision support capabilities of the system. Using data from the dispatch management system and a sophisticated branch and bound model, the system suggests dispatching plans designed to minimize train delay time. The dispatcher can either accept the suggested plan or explore other alternatives through the system’s “what if” capabilities.

The computer-assisted dispatching system was developed by the management science group at Southern Railway. Specifications for the system changed relatively little during its development. At points in the development process, future users of the system were brought in to test a prototype of the system and to make suggestions for change. The length of the development process was substantial, requiring 10 man-years and encompassing a time span of 4 years. The system was configured using DSS tools rather than with a DSS generator. Existing DSS generators were not considered appropriate for this application.

The computer-assisted dispatching system is used by several organizational levels of the operations group at Southern Railway. Train dispatchers use the system continuously as part of their job of determining the dispatching plan for trains in the system. The chief dispatcher monitors the system continuously to insure that trains are dispatched effectively. The superintendent of operations employs the system for status reporting and reviews of previous operations. The system also generates summary reports on train and dispatching operations for middle management.

The Like Center model at LTV

In 1981 the LTV Corporation was trying to decide whether or not to sell the Like Center, which is one of the largest downtown office buildings in Dallas, Texas. Because of the large number of variables, interactions among variables, possible conditions, and limited time in which to perform an analysis and arrive at a decision, management decided to construct a model to assess the building’s future value and to support the decision making process.

The model was developed by the upper-level manager responsible for exploring the sale decision and by a financial analyst. The manager worked closely with the analyst in defining the model and the analyst created the model using Interactive Financial Planning System (IFPS), a DSS generator. Three weeks were required to develop the final model. The model allowed the manager to explore “what if” questions about the future value of the building and to “goal seek” conditions which would be necessary in order for a specified objective to be realized.

The model was used by the analyst under the direction of the manager or by the manager directly from 5 to 20 times per week while the...
sale decision was being considered. Based on the analysis performed by the model, a recommendation to sell the building was made, and was accepted by upper management.

**Price analysis at General Dynamics**

In 1979 the corporate pricing department at General Dynamics developed a price analysis system. A major use of the system is to support the evaluation and approval of all proposals relating to pricing. This occurs in both the evaluation of prices to be paid for individual and component parts by General Dynamics, and for the sale of finished products by General Dynamics. The price analysis system provides answers to “what if” questions about the impact of price changes and decisions, uses linear programming to suggest optimal pricing decisions, and has a goal-seeking capability which identifies the price required to realize a prescribed goal.

The price analysis system was developed in the corporate pricing department with no external assistance. Development of the system required only one week, but occasional modifications continue to be made. The system was developed using Executive Information Services (EIS), a DSS generator, which is available on the Boeing Computer Services (BCS) timesharing network. Leading the development effort was the head manager of pricing who was the driving force in terms of both concept and hands-on development.

The price analysis system is used by all managers and staff analysts in the corporate pricing department. When information is needed quickly, a manager can operate the system personally, or can delegate the task to a staff analyst. The system is used on a daily basis.

**Comments**

These case studies illustrate the dramatically different degrees of user involvement in the development of a DSS. In the case of the computer-assisted dispatching system at Southern Railway, technicians were almost wholly responsible for its development. Users only made suggestions for change based upon experiences with a prototype. In the Like Center model at LTV, an intermediary with guidance from the user built the DSS. Finally, the price analysis model at General Dynamics was developed by users without outside assistance. These three cases actually illustrate three points along a continuum. All points along the continuum require some degree of user involvement, but this can vary from low to moderate to high.

It should be noted that we are primarily concerned with the user involvement dimension. A more detailed study might investigate various points in a three dimensional space with user involvement as one axis, intermediary involvement the second axis, the technician involvement the third axis. With this schema one could investigate the situation where the development of the DSS is largely the responsibility of technicians and intermediaries with little to moderate involvement by the users. This might be the case where an organization’s database management system (requiring the technician’s skills) and a DSS generator (requiring the intermediary’s skills) are needed or used in the creation of a DSS. Such a situation would correspond to point A in Figure 1. Another situation, corresponding to point B in Figure 1, is where the user and intermediary work as a team creating the DSS with no technician involvement.

Utilizing the three dimensional schema, points 1, 2, and 3 in Figure 1 represent the projection to the user axis of the points representing Southern Railway, LTV, and General Dynamics, respectively.

**A Tentative Contingency Model**

For each of the cases discussed earlier the users considered their DSS to be successful. No attempt was made to empirically measure success. For that reason we consider this proposed model to be descriptive in nature, rather than normative. Nevertheless, the development of a descriptive model may be considered a first step toward the ultimate development of a prescriptive model.

Consider the model

\[ U = f(T_1, T_2, T_3, T_4, S_1, D_1) \]  

(1)
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Figure 1. Personnel Involvement Space for DSS Development

where U is the extent of user involvement in the development of a specific DSS and

- $T_1$ is the nominal level of management activity;
- $T_2$ is the nominal level of task structuredness;
- $T_3$ is the nominal level of task interdependence;
- $T_4$ is the nominal level of task repetitiveness;
- $S_1$ is the nominal level of user cognitive style;
- $D_1$ is the nominal level of available DSS technology.

Note that $T_i$ represents task technology factors, $S_i$ represents social factors, and $D_i$ represents DSS technology factors.

Task technology factors

Schonberger [18] has recommended a contingency approach to MIS design in which the desired level of user involvement depends on Anthony's [1] levels of management activities and Simon's [19] classification of decision structure. The Schonberger contingency model is an extension of the Gorry and Scott Morton [9] framework which hypothesizes that the attributes of the information needed by the decision maker depend upon the level of management activity and the degree of structure inherent in the decision process.

This hypothesis is partially supported by the findings of Macintosh and Daft [17] in which evidence is submitted showing that task understanding and task variety are related to information attributes. Since task understanding and task variety are directly related to the degree of task repetitiveness, this model is extended to
include task repetitiveness in order to differentiate between the ad hoc and institutional decision support systems described by Donovan and Madnick [7].

Finally, we include Thompson's [23] classifications of task interdependence as suggested by Hackathorn and Keen's [10] and Sprague's [21] extensions of the Gorry and Scott Morton model. Table 1 illustrates the dimensions of task technology.

With the exception of Schonberger, each of the cited authors has focused on the impact of task technology variables on the information requirements. Our contingency model, and, implicitly, Schonberger's model, requires an additional link; one between a system's information requirements and the involvement of users in the development of that system.

To the best of our knowledge, no empirical work has been done to establish this link. However, its presence was certainly recognized by Gorry and Scott Morton when they stated that "these (decision support) systems may best be built by people other than those currently involved in the operational control systems area. The requisite skills are those of model building based on close interaction with management, structuring and formalizing the procedures employed by managers, and segregating those aspects of the decision process which can be automated" [9, p. 65].

The linkage is illustrated in Figure 2. With respect to equation (1), we would specify the following relationships.

\[ U = g(R), \]

\[ R = h(C), \]

\[ \text{(2)} \]

Table 1. Dimensions of Task Technology

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Activities</td>
<td>Operational Control</td>
</tr>
<tr>
<td></td>
<td>Management Control</td>
</tr>
<tr>
<td></td>
<td>Strategic Planning</td>
</tr>
<tr>
<td>Task Structuredness</td>
<td>Unstructured</td>
</tr>
<tr>
<td></td>
<td>Semistructured</td>
</tr>
<tr>
<td></td>
<td>Structured</td>
</tr>
<tr>
<td>Task Repetitiveness</td>
<td>ad hoc</td>
</tr>
<tr>
<td></td>
<td>Institutional</td>
</tr>
<tr>
<td>Task Interdependence</td>
<td>Independent</td>
</tr>
<tr>
<td></td>
<td>Pooled Interdependent</td>
</tr>
<tr>
<td></td>
<td>Sequential Interdependent</td>
</tr>
</tbody>
</table>
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DSS technology factors

Finally, it seems reasonable to suggest that a direct relationship exists between the level of available DSS technology and the extent of user involvement in the development of the system. Here we refer to the taxonomy suggested by Sprague [21] as DSS tools, DSS generators, and specific DSS’s. The specific DSS is the end product of the design process. We are more concerned with the nature of the software available to create this end product.

DSS generators are user-friendly software packages that combine a set of capabilities which facilitate the development of a specific DSS. Since these generators require minimal user training, we would expect to see greater user involvement in the system development process when one or more DSS generators are available.

DSS tools, on the other hand, are the basic software elements typically used by trained systems personnel to develop traditional management information systems, DSS generators, and specific decision support systems. These tools include programming languages, statistical analysis packages, mathematical programming packages, and database management systems. Their use requires extensive specialized training, and thus we would expect to see a relatively smaller ratio of user involvement in the design process where only the basic tools are available.

A Revised Contingency Model

The contingency model can be revised using observations from the three case studies. Table 2 gives a summary of the DSS case studies in terms of these development factors.

The Southern Railway system was developed by an operations research group using DSS tools, and with a minimum of end user involvement. The system is used on an ongoing basis for operational control by line operations personnel and by low and middle level managers. Each end user generally utilizes the system independently of other users and is held responsible for the outcome of decisions which are made. Only occa-
Table 2: Summary of DSS Case Studies

<table>
<thead>
<tr>
<th>Development Factor</th>
<th>Southern Railway: Computer-Assisted Dispatching</th>
<th>LTV Corporation: Like Center Model</th>
<th>General Dynamics: Price Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>management activity</td>
<td>operational control</td>
<td>strategic planning</td>
<td>management control</td>
</tr>
<tr>
<td>task structuredness</td>
<td>semistructured</td>
<td>semistructured</td>
<td>semistructured</td>
</tr>
<tr>
<td>task interdependence</td>
<td>independent</td>
<td>independent</td>
<td>pooled interdependent</td>
</tr>
<tr>
<td>task repetitiveness</td>
<td>institutional</td>
<td>ad hoc</td>
<td>institutional</td>
</tr>
<tr>
<td>user cognitive style</td>
<td>unspecified</td>
<td>unspecified</td>
<td>unspecified</td>
</tr>
<tr>
<td>DSS technology</td>
<td>tools</td>
<td>generator</td>
<td>generator</td>
</tr>
<tr>
<td>user involvement</td>
<td>low</td>
<td>moderate</td>
<td>high</td>
</tr>
</tbody>
</table>

tionally are pooled interdependent decisions made by a dispatcher working with a superior.

The LTV application was developed by an intermediary with the active involvement of the upper level manager responsible for making a single, strategic disposition decision. The intermediary used a DSS generator to build the system, and the manager used the system and reached a decision independent of other management.

The General Dynamics system was developed entirely by end-users utilizing a DSS generator. The system is used on an ongoing basis for management control by staff specialists and by middle and upper level managers. Decisions are frequently made on a group basis after evaluating the output of the system.

The three cases discussed illustrate the range of user involvement in DSS design approaches. While the sample is limited, some tentative observations may be made concerning the predictive ability of the contingency variables on the degree of user involvement in the creation of a DSS.

Schonberger [18] claims that the level of user involvement increases directly with the level of management activity. Although the involvement of upper level management in the creation of the LTV Corporation DSS was considerable, it was less than the involvement experienced with the General Dynamics DSS. The summary data presented in Table 2 suggest that task interdependence and task repetitiveness have entered the picture. One might also suspect that upper levels of management would have less time to devote to system development than would middle level management. It would make more sense for intermediaries to play a larger role. It would also appear that higher levels of task interdependence encourage higher levels of user involvement. Tasks that are highly interrelated have less well defined information needs initially, and tend to evolve over time.

Our example of a system developed with a relatively low level of user involvement was also the sole example of a system developed using DSS tools. Since the skills required to build a specific DSS without the use of a DSS generator are primarily possessed by technicians and intermediaries, user involvement relative to the other two categories of personnel can be expected to be less. This should not be construed to mean that significant user involvement is not or should not be present.

Finally, we observe that three of the contingency variables originally considered appear to lack significance in our limited sample. Task structuredness, in each case, lies between the extremes of structured and unstructured. Since most DSS's fall within these extremes, it may be that this important MIS contingency variable has little explanatory power for DSS.

Task repetitiveness appears to have no consistent relationship to user involvement, with institutional systems occurring at both ends of the involvement spectrum. The cognitive style of the
user was not explicitly measured. Since DSS's emphasize flexibility and adaptability to the decision making approach of the user, and since researchers have yet to conclusively establish a relationship between cognitive style and information attributes, we will disregard this variable in the revised model.

The proposed model of user involvement in the development of a specific DSS is presented in Figure 3 and in the following equation:

\[ U = f(T_1, T_3, D_1) \]  

(3)

where \( U, T_1, T_3, \) and \( D_1 \) are defined as in equation (1).

We suggest that this parsimonious model helps to describe user involvement in the decision support systems described earlier and may indeed be an adequate paradigm for DSS in general.

**Conclusion**

Decision support systems are currently being used in a wide variety of organizations for a diverse set of applications. The number of decision support systems will undoubtedly grow as decision makers seek support for the difficult decisions they face. This growth will be stimulated as the computer industry provides concepts (e.g., the information center) and products (e.g., DSS tools and generators, personal computers) that facilitate the development of decision support systems. These trends increase the importance of understanding the factors which affect the level of user involvement in the creation of a DSS.

Practitioners and scholars have suggested that decision support systems require a unique development approach. High levels of user involvement are commonly mentioned as being important to this approach. However, as the cases described in this article indicate, the level of user involvement can vary widely. A review of the literature and these cases suggest that the DSS technology (DSS tools and generators), the management activity (operational control, management control and strategic planning), and the nature of task interdependence (independent, pool interdependent and sequential interdependent) all interact to affect the level of user involvement.

The literature suggests that a user's cognitive style might be an important consideration when designing a DSS. If this is true, it might also be a factor which influences the level of user involvement in the creation of a DSS. None of the case studies presented in this article shed any light on this possibility. However, it is the authors' experiences that in most instances the user's cognitive style is not an item which is given much consideration when a DSS is designed. This is especially true when a DSS generator is used. DSS generators tend to accommodate the cognitive style of the users through the software system employed. Furthermore, this accommodation is growing as new and enhanced versions of DSS generators are released.

Our contingency model describes user involvement only as it relates to building a DSS. While this is an important focus, it should be recognized that there are other types of user involvement. In the case of a DSS which already exists, a user can become involved either through formal training or self-training. These types of involvement become increasingly important as an organization's decision support systems age and succeeding generations of users seek decision support.

A number of issues are left for future investigations. This study raised issues concerning the nature of the factors that may be important to the different types of user involvement. Earlier we discussed a three-dimensional model that included intermediary involvement and technician involvement as well as user involvement. What factors influence the involvement of intermediaries and technicians? Finally, and most importantly, we identified the descriptive nature of our model. How then, is involvement related to DSS success? Such questions suggest profitable directions for future research.

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Figure 3. Contingency Model for DSS Development
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References


About the Authors

Robert I. Mann is Assistant Professor of Management at the University of Georgia. He received his doctoral degree in Quantitative Business Analysis from Arizona State University in 1981. His research interests include systems development, contingency theories, IS impact on managerial and professional productivity, and business and...
economic forecasting models. He is currently working on a technique for the evaluation of decision support system effectiveness. Dr. Mann is an active member of SIM, TIMS, AIDS, ACM, and the Academy of Management.

Hugh J. Watson is Professor of Management and Director of MIS Programs at the University of Georgia. He is the author or co-author of nine books, including most recently, Computer-Based Information Systems. His articles have appeared in MIS Quarterly, Management Science, Communications of the ACM, Academy of Management Journal, California Management Review, Interfaces, and other journals. He has been involved in DSS research since the early 1970’s.