STATE OF THE ART OF RESEARCH IN MANAGEMENT SUPPORT SYSTEMS

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STATE OF THE ART OF RESEARCH IN MANAGEMENT SUPPORT SYSTEMS

I. BACKGROUND

This is a time of broad technological change, one result of which is unprecedented 'information power' finding its way into the hands of users. This takes the form of the ubiquitous personal computer as well as more traditional timesharing systems. Organizations are rapidly trying to cope with a proliferation of varied computers by networking them together and linking their system to others outside the organization. As a result of this spread of information power to the end user, the nature of the information systems field is undergoing rapid change. The systems professional, either in the corporation or the university, is now clearly in the minority as an innovator and implementor of information technology. Such professionals are surrounded and outnumbered by a huge number of 'end users', each of whom is increasingly armed with computer capacity and powerful software tools which they can directly apply.

This proliferation of information power in the hands of users , in particular, is transforming the Management Support Systems (MSS) field from an interesting, but somewhat isolated use of information systems by a small core of creative individuals to a central position among management tools. One increasingly finds Management Support Systems woven into the very fabric of management. This transformation has just begun and the enormity of its impact has not yet been felt.

The goal of this paper is to identify some patterns in the ongoing research in the Management Support Systems arena. The

patterns that will be identified have been drawn from a search through some three hundred articles that have been published in the last three years and that have appeared in the journals listed in the bibliography to this paper. These journals are primarily American but an attempt was made to scan the relevant European journals.

II. DEFINITION OF MSS

Management Support Systems is open to a great many interpretations. For the purposes of this conference we define it as "the use of information technologies to support management." Rapid changes in technology make it necessary to define the 'systems' in Management Support Systems to include several forms of information technology that go beyond and are quite different from the computer used in traditional data processing. For example, teleconferencing, electronic data bases, and graphics workstations are all information technologies that are potentially useful for MSS. This is why our definition of management support systems is not restricted by using the term 'computer technologies'.

Many writers in the past two years have begun to redefine our concept of management systems to more clearly delineate the importance of information and related technologies. They make it clear that our entry into the information era must be acknowledged. (See Rockart and Scott Morton's, "Implications of Changes in Information Technology for Corporate Strategy.") Naisbitt, in his book Megatrends is perhaps the most visible author to highlight the shift to an information era. In the first chapter, on our transition from an industrial society to an information society, he provides some provocative and compelling illustrations of how far America has

moved in this direction. The implications for organizations and their managers are further developed in his chapter on networking (Chapter 8). Here, Naisbitt quotes Intel's Vice Chairman, Robert Noyce. "What we've tried to do is to put people together in ways so that they make contributions to a wider range of decisions and do things that would be thwarted by a structured, line organization." Elsewhere, Naisbitt gives examples of information technology providing the tools to do this. The current literature indicates, that if Management Support Systems is to be an effective concept for the decade ahead, it must be defined broadly. Our understanding of management is changing as we enter an information era that will require new and sophisticated forms of management. Our understanding of systems continues to evolve as new information technologies redefine the frontier of possibilities. It is the term 'Support' that provides the foundation for our definition of Management Support Systems. It is 'support' that differentiates MSS from so many other applications of information technology. Thus, we have emphasized support in our review of the literature. There has been no attempt to review research whose primary goal is to replace rather than support managers.

III. TECHNOLOGIES

Technologies related to Management Support Systems (MSS) can be divided into four major categories for purposes of helping to define what is meant by MSS.

1. Hardware: There is no reason to suppose that there is any one particular form of computer hardware and related components that is any more relevant to management than any other. Therefore, MSS hardware includes the full spectrum of computers (micros to mainframes) and the full spectrum of the way they are made available to management (remote access from a central location or fully distributed access in one's local site or office).

2. Software: Software for management support takes many forms ranging from tailor-made special purpose applications, to general purpose modeling packages, to information bases to support management. At the core, of each, is a language that defines the set of capabilities of the software.

3. Communications: Management Support Systems can now use communications that cover both narrow band and broad band paths and that apply both inside and outside the organization. This view allows applications such as video conferencing, an area not traditionally considered part of the computer-based management support systems domain. However, it is part of information support for management.

4. Methodological Tools: The continuing progress in the fields of behavioral science, management science, and the study of management decision making has made it apparent that there exists a class of methodological tools, which should be classified as "technologies." These include many of the techniques in decision

analysis which have been exercised by those in the Operations Research community. Other methodological tools are oriented toward helping the MSS builder. These include techniques for determining information requirements and for planning implementation strategies.

These four general categories of related technologies help define what is meant by Management Support Systems. To simplify and summarize, Management Support Systems (MSS) is the use of computers and related Information Technologies to support managers.

IV. TYPES OF MANAGEMENT SUPPORT SYSTEMS (MSS)

We will discuss the three broad categories of MSS shown below:

Data Support System	Decision Support System	Executive Support System
1	2	3

1. Data Support In thinking about supporting management, it is assumed that the traditional data processing use of technology is largely confined to transaction processing and low level (clerical) operational use. Such traditional uses of data processing are being treated as outside the domain of interest in this paper. However, to the extent that such systems produce information as a by-product then they fall directly in the purview of MSS. Thus traditional DP is not of interest as a form of MSS while the data bases they generate are potentially an element of Management Support. Indeed the whole field of building, maintaining and providing access to information is directly relevant to MSS. There is a series of research in this segment of the MSS field which has resulted in data base management systems which can be, and are being, used as part of Management

Support Systems. Thus, this type of support we will call Data Support. Data Support concentrates on providing information regardless of use or user. Examples of this type of MSS are: the 'Disclosure TM' Service; the 'Source' (belonging to the Readers Digest); the numerous information bases of the New York Times; and the data bases of firms like Data Resource Inc. (DRI). Interestingly, the literature does not contain examples of their use, although faculty in the field are aware of dozens of applications.

2. Decision Support The second class of MSS are Decision Support Systems (DSS). For the purposes of this paper a DSS is a subset of MSS, one that is focused on a specific decision or a specific class of decisions. As has been pointed out by many authors, there has been a general broadening (and consequent debasing) of the term DSS to the point where it no longer has much specific meaning. In particular there has been a lack of differentiation between the system, (of human decision maker and related computer-based support,) and the tools with which the computer piece of the system is created. Thus, for example, IFPS is a language, and by all reports an effective one, but for the purposes of this paper, it is not a DSS. It is a tool for building a DSS.

One of the best broad discussions of the evolution in thinking encompassed by the term DSS is contained in Sprague and Carlson's, Building Effective Decision Support Systems. They build nicely on the early work in the field and capture the essence of what is meant by the concept. Their focus is on what a DSS is and how to build one, not on its organizational impacts and implications. If those who used the term DSS first read this book we could better focus on a common definition. For our purpose here, for a system to be

classified as a DSS there must be a particular class of decision in mind. Looking at examples in the literature it is possible to identify four distinct classes of decisions and to estimate the frequency of their incidence:

	Decision Made by Individual	Decision Made by Group
Ad Hoc Decision	SOME	VERY FEW
Institutionalized system (on going decision)	MANY	VERY FEW

These DSS reported in the literature are not necessarily representative of all that have been built. However, the ones covered in the material represented by the bibliography in this paper fall into the cells as indicated above. It is instructive to compare the excellent papers by Bonczek, Holsapple and Whinston: "Computer Based Support of Organizational Decision Making"; "The Integration of Data Base Management and Problem Resolution"; "The Evolving Roles of Models in Decision Support Systems"; and "Future Directions for

Developing Decision Support Systems" with the book by Sprague and Carlson. These sources taken together highlight the inevitable conflict between our desire for generality and the demands imposed by the specific problem. Bonczek, et. al, are more optimistic about moving toward the general, although many of their ideas await confirmation in practice.

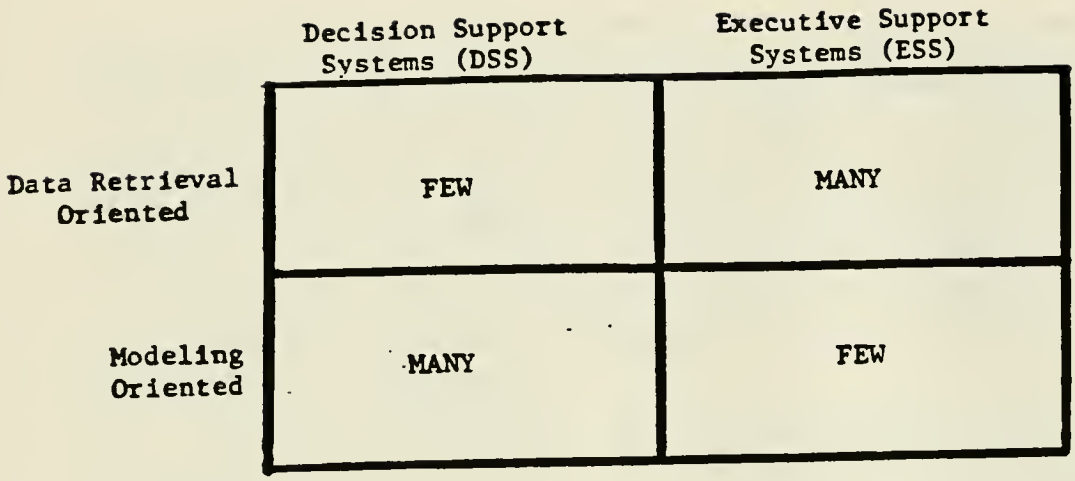
The paper by Bonczek, et al, on future directions and the Luconi/Scott Morton paper define fairly clearly the next generation of DSS, namely Intelligent Support Systems (ISS). An ISS is a form of DSS in which the human decision maker combines heuristics and a knowledge base in order to produce answers for a certain class of unstructured problem. This is not presented, in this paper, as a separate class of support from DSS; it merely uses different tools and therefore can support a different class of problem. It remains, however, focused on a specific problem or class of problems. These (ISS) that are beginning to surface are an outgrowth of the work in Artificial Intelligence (AI) and Expert Systems. It is interesting to note here that much of the work going on in the Expert Systems community does not fall under the heading of a Management Support Systems application type. Rather, it is primarily aimed at replacing the manager, not supporting him. When this is the focus of the work, it has not been included here as a support system.

There were three articles in the general area of Artificial Intelligence as applied to MSS. The most specific was an interesting application by Ben-Bassat ("Research into An Intelligent DSS for Military Situation Assessment") in which he looked at an application in a military context that has some useful implications for business

applications. A more generic discussion is given in Bonczek, et al's, article ("Future Directions for Developing DSS"). They provide some nice succinct descriptions of work in the expert systems field. None of these can really be described as examples of MSS, but they do provide good examples of the current state of the art in AI. The Luconi/Scott Morton piece ("Artificial Intelligence: The Next Challenge for Management) provides a framework that tries to position Intelligent Support Systems (ISS) as a logical outgrowth of DSS. The article, drawing on experience in building a prototype and testing this in use goes on to identify the opportunities and pitfalls that can be expected as these applications evolve. We have classified, as support systems, the one or two applications which have begun to be developed for supporting managers through the use of Expert Systems and related techniques.

3. Executive Support Systems Executive Support Systems (ESS) are focused on a manager's or group of managers' information needs across a range of important and relevant areas of concern. ESS incorporate in a single system the data and analytic tools needed to provide information support for a broad range of managerial processes and decisions. They are not focused only upon a single recurring type of decision. They provide instead a set of capabilities that can be used to meet the various and variable information needs of managers. Thus, Executive Support Systems encompass a broader concept than Decision Support Systems.

Executive Support Systems differ in another important respect from DSS. The majority of ESS are data retrieval oriented whereas most decision support systems are modeling oriented. This is summarized in the following table:



Decision Support Systems, each focused upon a particular type of decision, tend to have as their foundation a model of some aspect of of the decision problem. The model provides a structure for the relationships between relevant data and allows the decision maker to perform complex analysis with relative ease. Executive Support Systems do not focus upon one type of decision. They provide support for many problems and processes. This flexibility cannot usually be accomodated by a model or series of models. Thus, most ESS are data retrieval oriented.

With these definitions in mind the literature was scanned (over 300 items skimmed) and a series of eighty articles selected as being of sufficient quality to be representative of the best of the research work going on in the field. The final group of articles that were selected were those that seemed to focus most on the Management Support Systems dimension and are probably representative of the kind of work going on in the field at this point in time.

V. METHODS AND TOOLS FOR BUILDING MSS

In looking at the literature in the MSS field it did not seem enough just to look at broad application types. It also proved useful to look at the tools and methods that were being applied. The literature shows six categories of tools which we will identify on a continuum that roughly represents their portability, that is the ease with which they can be used by someone other than the original inventor or designer. At one end are the least portable - the methodologies and frameworks and at the other end is hardware - the physical computer, the network, the color graphics terminal, etc.:

Methodologies	Database	Languages	Models	Interface	Hardware
1	2	3	4	5	6

1. Methodologies

The methodologies proposed in the literature are predominantly concerned with proposals as to how one should go about building a DSS. As such, they would perhaps be better described as prescriptive processes, the results of which will yield a "good" system. Alter's June '82, D.S.S Transactions paper is of this type. He sets out to identify the conditions under which a D.S.S can or should be developed and used without professional help. Papers of this form describe methodologies that are difficult for someone else to adopt due to lack of specific implementation directions. This is true even of some of the extensive methodological developments such as the one described by Sprague and Carlson in their book (Chapter 4). If these methodologies were capable of adoption it would then be possible to move to a level of research as yet largely unexplored,

and compare and contrast different methodologies. The lone example of a comparison that surfaced in the literature search was Alavi and Henderson's "An Evolutionary Strategy for Implementing a Decision Support System" in which they make some specific recommendations as a result of comparing two different methodologies.

It is a measure of Herbert Simon's enormous contribution that all the methodologies in the DSS arena, to the extent that they are grounded in theory at all, used his basic view of decision making. None of the material that was found in the course of developing this paper was based upon anything more fundamental or recent than that - an impressive testimony to Simon's insights.

In the emerging area of Executive Support, the most visible methodology is Rockart's Critical Success Factors (CSF) which is based on work by both Robert Anthony and Ron Daniels. The CSF methodology has been used successfully by others and thus can be said to meet the test of portability. However, it seems to be the only one that has been widely used so if we are to take the absence of instances in the literature as any guide, methodologies are not easily transferable.

2. Data Base Technologies

Data Base Technologies are a classic area of computer science that provides some very useful enabling technologies for MSS. However, the absence in the literature of illustrations of application and use of data base technologies used for management support suggests that these technologies are still in the very early phase of their life cycle. In the popular literature there is evidence to suggest that these technologies are being applied to the office. For example, Fortune Magazine has run an extensive series of

advertisements prepared by International Data Corporation (IDC) which focuses on commercial applications. As experience is gained in this office support domain, progress might then be made in turning Data Base Technology in real MSS. An excellent overview of data base technologies is given in Frank Manola's article, "Database Technology in DSS: An Overview." Manola starts with Blanning's (1979) discussion of DSS functions. Based on these he identifies software and data oriented requirements of a DSS and describes how data base technology might contribute to satisfyingthese requirements. In particular, he identifies six areas of data base technologies:

1) Data models and data base system architecture
2) Data transmission and mapping
3) Database access languages
4) Active DBMS's
5) Distributed database systems
6) Database hardware

I do not propose to discuss here what Manola means by the six data base technologies, but the labels he uses provide a flavor of the enormous power available to builders of MSS once tools are available. He provides illustrations of the considerable progress in areas 1 and 2 in which commercial products recently have been released. In area 3 he points out that data base access work has shifted to providing powerful query-based capability for the casual user. This has involved considerable sophistication on the part of the system architects to ensure that the hardware requirements do not become excessive. Progress, as he points out by way of his references, has been considerable. The remaining three areas (4,5,6.) are the foci of intensive research and are beginning to

yield results that are usable as part of MSS's, both for DSS and ESS.

The implication from Manola's article and some of the references he mentions, is that a crucial piece of technology is becoming available to those that wish to build and install MSS. Given the large body of the literature coming from the basic technology work at the research labs of computer vendors and universities, there is every reason to believe that ever more powerful data base tools applicable to MSS will continue to be available.

3. Languages and Packages

MSS's are fundamentally dependent on the power of the tools available for their development. The literature has a number of surveys of such languages; some of the more interesting are given in the bibliography. One of the best is a survey of 237 firms by Brightman, Harris and Thompson. As they point out in their article ("Empirical Study of Computer based Financial Modelling Systems") there are two basic forms of language: the general purpose language (GPL) such as Fortran and APL and the commercial modelling language (CML) such as IFPS, SIMPLAN, CUFFS. There are well over 50 such CML languages available. The study was focused on only one kind of tool, financial modeling languages. Financial modeling languages are particularly useful for model building, one component of certain kinds of MSS. Nevertheless, the results were interesting as they showed that 53% of the firms surveyed had financial modeling systems in use. Of these, 44% were using a general language and 56% had a commercial language. The survey was designed to investigate the impact of CML on the adoption and design of financial modelling systems. The authors established that the CML's do indeed simplify the model building process and make it possible for the decision

maker or related staff to build their own system without the aid of a "data processing" systems person. They went on to document the advantages the users found in a support system of this type. As one would hope in the use of an MSS, advantages included the ability to do more analysis and ask "what if" questions. However, other advantages include perceptible improvements in the decision process as well as the making of better decisions. This article stood out as one of very few that actually took the trouble to sample users and assess the state of current practice and current user reactions. The authors identify a series of further issues on which to follow up, including the question of industry differences in patterns of use.

One very suggestive point that they raise has to do with the barriers-to-use, in an organization, of financial modeling systems and, by analogy, MSS's in general. They found that the lack of a person to champion a model and the cost of the system were the biggest barriers. This suggests that we are still in a stage of evolution of MSS (or at least DSS, which characterized all their examples) which might be described as 'technology first'. A "champion" is necessary for a model primarily if it is the model that is being sold, rather than a solution to a business problem. The literature on 'languages' spends almost no time on a "business need first" perspective. As the tools become more user friendly, then the whole use of DSS becomes a more readily accepted way of doing business. Languages become just one more tool to build a DSS for supporting the solution of a business problem. Fortunately the costs of building a DSS with these languages and using them on the job are going down rapidly so one could expect the two barriers Brightman, et al, identified to come down.

4. Models

Models are one of the tools often used as a basis for a MSS. As represented by Operations Research they are one of the oldest disciplines available to those interested in MSS. Interestingly, much of the literature on models in MSS, certainly in the refereed journals, deals with sophisticated, often optimization, models. There is no recent literature of which I am aware, that suggests when such models are appropriate.

The concept of simple models that provide insight to the manager was not represented in any of the literature that was found for this survey. Nor does there seem to have been any published work on types of models since Alter's 1976 study of 56 case studies of DSS in use in firms (see Alter, "Computer Aided Decision Making in Organizations"). In this study, he identified four categories of models in use as part of a DSS:

1) Accounting relationships - used for estimating the consequences of a decision.
2) Representational models, normally simulation models
3) Optimization models
4) Suggestion models

Judging from the literature the vast preponderance of the use of models is in the financial area and of the accounting relationship form. There are some interesting exploratory efforts (see Bonczek, Holsapple, Whinston, "Generalized DSS using Predicate Calculus") to develop a language, using predicate calculus, for formalizing "stating modeling knowledge." If their project is successful, application specific modeling knowledge would not need

to be embedded in the computer program. However this whole area requires an enormous amount of further research before it can be implemented.

It is interesting to contrast the 'decision sciences' view of models and their development in the context of MSS, with those from a different discipline. An example of the latter is the recent paper by John Morecroft of the Systems Dynamics group at M.I.T. He describes working with a group of senior marketing executives in a major U.S. manufacturing firm. He discusses the concept of 'support,' and then particularizes this to 'strategy support'. He concludes that for highly unstructured strategy questions this means providing insight into the consequences of pursuing strategic initiatives once they have been formulated. Modeling is fit into a framework where mental models and formal computer models (in this case systems dynamics models) result in debate and discussion, followed by reformulation and finally consensus on a strategy. He argues from his experience in this implementation that a formal model in this context must:

1) be a vehicle for extending argument and debate

2) be a generator of opinions not answers

3) deal in concepts with which management is familiar.

He found the key for effective model-based strategic support is to use the model in a dialectical fashion, to challenge prevailing management opinion. The paper stands out as the only one in the current literature that follows a model through its use in practice. Also Morecroft has a very different view of the role of models than do many in the field - a role which uses them as a vehicle for debate rather than a provider of answers.

5. Interface Technologies

One set of technologies that can significantly affect the growth and acceptability of MSS are those that deal with the interface between the human and the system. One aspect of this has to do with new hardware such as joysticks and mice, but part of the interface solution is in the software necessary to provide the color graphics, windows, etc. Closer to the more obvious MSS needs is the whole category of work necessary to translate Bonczek et al's (see "Future Directions for Developing D.S.S") 'Language system' into a general purpose reality. This 'language system' is defined as "the sum total of all linguistic facilities made available to the decision maker by the DSS. The authors point out that the language system is characterized by the syntax it furnishes to the decision maker and by "the statement commands or expressions that it allows the user to make." Thus to them the language system is one of the three components of DSS, the other two being the knowledge system and the problem processing system. This most useful generic description of a DSS allows them to make some interesting points about the role of artificial intelligence in the DSS's of the future. They do not however expand on their view of the likely evolution of the language system. The state of the art appears to regard the interface question for MSS as being not worthy of much research. There were no serious articles that surfaced in the recent journals. There was occasionally a theoretical piece that raised some interesting ideas. One example was Studer's piece on an adaptable user interface for DSS. The heart of his approach is two-fold: first, to provide the system user with an 'application model' via the use of three types of

graph structures:

1) The application structure graph.

2) The operator structure graph.

3) The operator data graph.

The second basic element in his approach is the end user interface. This provides a dialogue which allows the end user to select the components and execute the existing model using facilities that permit him to "navigate" through the graph structures of the model. The description given is extensive but there is no hint of experience, if any, in use in either a laboratory or in an organization.

In short, there is a real dearth of practical experimentation in user interface work and new ideas that are proposed seem to move unusually slowly into practical experimentation. To the extent that the interface technologies are important it appears as though the widespread use of MSS will be slowed down as a result of the dearth of developmental work in this area.

6. Hardware/Network

Much of the impetus in MSS appears to be driven by the relentless drop in cost of hardware and augmented by the changes in communications technology. An excellent article by Bob Benjamin in the MIS Quarterly ("Information Technology in the 1990's: A Long Range Planning Scenario") nicely makes the point that, in the future, we can expect a continued drop in cost and increase in functionality. This is represented by migration of some MSS tools, such as languages, over to micros. Thus we have a number of the language vendors, such as IFPS, making their language, or a subset, available on a personal computer (P.C.). The other trend seems to be

the downloading of central files on the mainframe to the P.C. However, these and other hardware and communication changes are occurring so rapidly that no research on them has yet appeared. One can merely pick up anecdotal illustration from Business Week or Fortune. This suggests that in addition to all the research implicit in the five areas of technology discussed in the preceding pages, much more will be needed just to capture the implications of recent hardware developments.

One of the few articles published in this area is Peter Keen's "A Policy Statement for Managing Microcomputers." In this he develops a persuasive set of arguments for the pros and cons of micro-computer based DSS. The key points of his resulting policy statement are:

1) The role of organization is to encourage use, not control use.
2) Full authority is to be given to end users.
3) A co-ordinator role should exist for the purpose of providing education, user support and recommendations on software, hardware, etc.

What Keen does not go on to develop are the implications of these technological developments on computing in the organization. It seems obvious that the role of MSS in an organization with such a sensible policy such as outlined above will become all pervasive. The hardware changes will begin to blur the lines between what we see as a distinctive category, or existing MSS, and the rest of the things managers do with their time. In short, they will become part of the fabric of the management job.

VI. RESEARCH TYPOLOGY

There are possibly as many ways of laying out a typology of research categories as there are professors active in the field of MSS. Unfortunately each person who develops a typology is correct! The criteria for judging a typology are vague but surely one such criterion is that the typology be found useful. Someone who develops his own is likely to find it useful! With considerable trepidation therefore the following nine categories are submitted as one possible typology:

Build Prototype	Construct a Methodology	Develop Theory	Develop Concept	Empirical Test		Conduct Survey	Describe Case	Declare 'Truth'
				Lab	Real			
1	2	3	4	5	6	7	8	9

Each of these nine categories will be described briefly and one example of MSS research will be given. Of course, many research efforts will fall in more than one category, for example, a prototype DSS which is then tested in a laboratory setting.

1. Building of Prototype

This is basically an engineering concept of research and fortunately has its proponents in the MSS field. An example, which is found in Moskowitz's DSS/F. is a Pascal based DSS for financial applications with a number of innovative uses of virtual memory which permit an unusually interesting collection of features.

2. Construction of a Methodology

This is done whenever a researcher takes the trouble to base

the methodology on theory or on the deductive process gained by trial and error over time in the field. Such an example would be found in Sprague and Carlson's work with ROMC, their methodology for building a DSS.

3. Development of a Theory.

This is possibly the toughest research task of all. It not only requires extraordinary insight, but also extensive work and experience with existing underlying theories. No new theories relevant to the MSS field were found in the recent literature. Of course, Simon's work on decision making remains as powerful as ever, as do many behavior theories i.e, the Lewin-Schein model. (See Schein's Process Consultation: Its Role in Organization Development)

4. Development of a Concept.

The term concept here is meant to suggest an idea or framework that is found to be useful in organizing ideas and suggesting actions. Such concepts can in time lead to work that results in a theory. A recent example of a concept would be Rockart's work on CSF's. This concept has gained in robustness through its testing by many people in actual empirical situations.

5. Empirical Lab Test.

Empirical Lab Testing takes place in an artificial setting using students or managers in an attempt to simulate real world behavior. The literature search for this paper produced only a few experiments, one of the most interesting being Alavi and Henderson's "An Evolutionary Strategy for Implementing a DSS) in which they tested two alternative strategies for implementing a DSS - a traditional and an evolutionary. The process-oriented evolutionary strategy proved most effective. Such controlled lab experiments can

prove to be most useful - a fact which makes their infrequent use hard to understand.

6. Empirical Real World Test

This is the research type which should eventually be used to test the effectiveness of any new concept, methodology or system to test its effectiveness. Too often this does not happen or is not reported. These tests can be of two types - focused or general. Rockart used the focused type (see Rockart's "The CEO Defines His Own Data Needs") in testing his CSF methodology. The general test is exemplified by Fuerst and Cheney's work ("Factors Affecting Perceived Utilization of Computer-Based DSS in the Oil Industry"). Here a test was made of the factors affecting DSS usage of 8 systems and 64 subjects. The hypotheses were derived from prior studies and the outcome verifies the importance of the relevance of the DSS and the quality of the user training. The small number of tests found in the literature indicates they are performed, or at least reported, infrequently.

7. Conduct Survey

This category of research represents those projects that survey a particular population (users, builders, etc.) in organizations to establish the existence or absence of something. This research may be for the purpose of establishing whether a particular class of language is used, or whether a user is satisfied with the quality of service received. This survey work differs from a general empirical test in that it does not attempt to establish causal relationships based on theory or deductive work from prior studies. The work by

Rockart and Treacy (The CEO Goes On-line) represents a fine example of this genre as it found five common characteristics among the 16 users of Executive Support Systems.

8. Describe a Case

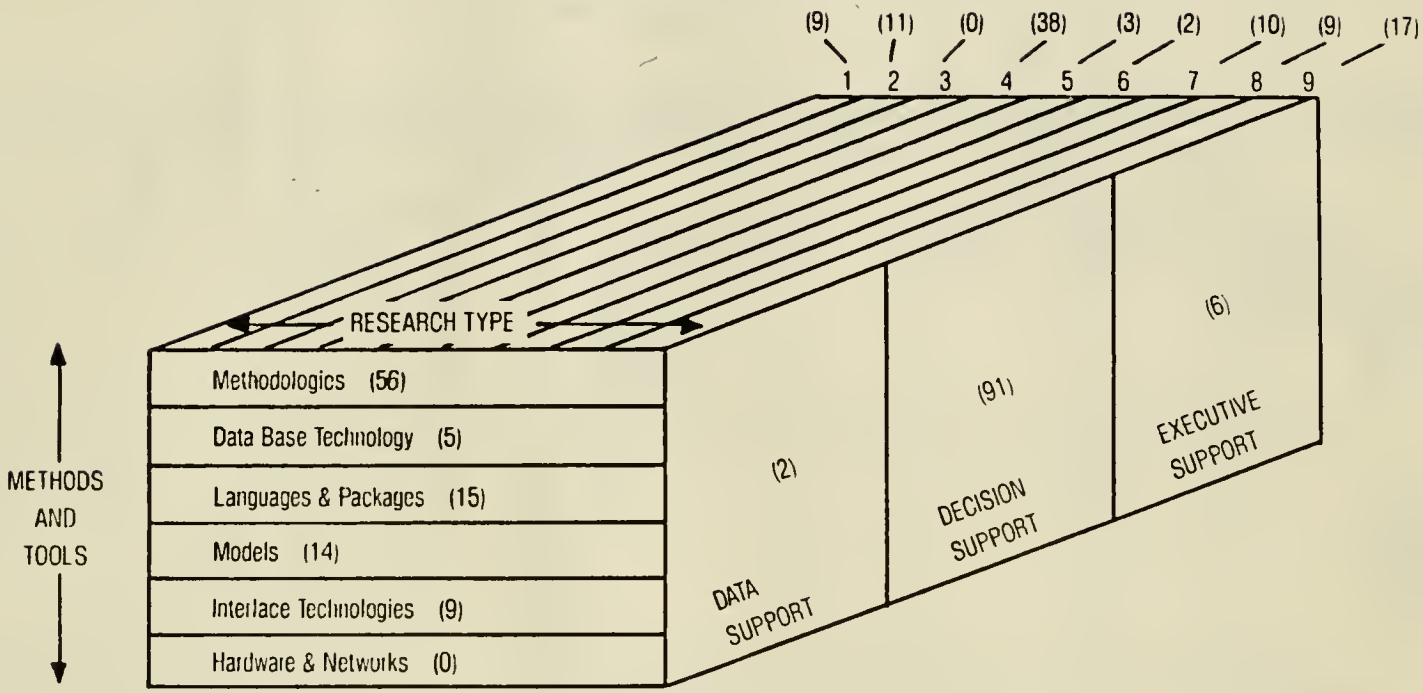
This method is often very helpful in providing a rich sense of the context and nuances of the application in question. This seems to be particularly true in MSS work which has so many dimensions and facets. One example would be Ben-Bassat's fascinating AI based DSS (Research Into an Intelligent DSS for Military Situation Assessment).

9. Declaration of a "Truth"

Periodically workers in the field of MSS are moved to make a declaration. Ideally this declaration is made by a wise person whose experience has led to a genuine insight. When this is the case, as soon as the idea is read, it strikes one as "right", even without the corroboration of theory, implementation, or use. The difficulty is what strikes one reader as insightful may strike another as foolish. Only time, unfortunately, can reveal the truth. Keen's "Policy Statement for Managing Microcomputers" is an example of this category of research style.

VII. SUMMARY OF RESEARCH STATUS

This paper has suggested that we could use a three dimensional figure to look at the state of the art in research in management support systems:



(Numbers in parentheses represent pieces of research, in each category, found in the literature search)

It has been suggested that three types of management support are adequate for our purposes: Data Support, Decision Support and Executive Support. When the work in the articles that have been culled from the literature are placed in this cube it should be no surprise to discover that, by far, the largest number are in the Decision Support category. This testifies to the stage of the life cycle of the concept, if nothing else. However, if we now take each of these three slices in turn to produce the resulting two dimensional grid, the following patterns emerge:

1. DATA SUPPORT SYSTEM

Methods & Tools	Research Typology →								
	1 Build Prototype	2 Build Methodology	3 Develop Theory	4 Develop Concepts	5 Empirical Research Lab	6 Empirical Research Real	7 Conduct Survey	8 Case Study	9 Declare Truth
Methodologies, Frameworks				X					
Data Base Technology									
Languages & Packages									
Models				X					
Interface Technologies									
Hardware & Networks									

2. DECISION SUPPORT SYSTEM

Methods & Tools	1 Build Prototype	2 Build Methodology	3 Develop Theory	4 Develop Concepts	5 Empirical Research Lab	6 Empirical Research Real	7 Conduct Survey	8 Case Study	9 Declare Truth
	← Research Typology →								
Methodologies, Frameworks	XX	XXXX XXXX		XXX XXXX XXXX XXXX XXX	XX X	X	XXXX	XXXX X	XXXX XXXX XXXX
Data Base Technology	X			XX				X	
Languages & Packages	XX			XXXX			XXX		XXXX
Models	XX	XXX		XXX XXXX				X	
Interface Technologies	X			XXXX		X		XX	X
Hardware & Networks									

3. EXECUTIVE SUPPORT SYSTEM

Methods & Tools	Research Typology → 1 Build Prototype	2 Build Methodology	3 Develop Theory	4 Develop Concepts	5 Empirical Research Lab	6 Empirical Research Real	7 Conduct Survey	8 Case Study	9 Declare Truth
Methodologies, Frameworks				X			XX		
Data Base Technology		X							
Languages & Packages	X						X		
Models									
Interface Technologies									
Hardware & Networks									

4. MANAGEMENT SUPPORT SYSTEMS

Methods & Tools	1 Build Prototype	2 Build Methodology	3 Develop Theory	4 Develop Concepts	5 Empirical Research Lab	6 Empirical Research Real	7 Conduct Survey	8 Case Study	9 Declare Truth	
	← Research Typology →									
Methodologies, Frameworks	XX	XXXX XXX		XXXX XXXX XXXX XXXX XXXX	XX X	X	XXXX XX	XXXX X	XXXX XXXX XXXX	56
Data Base Technology	X	X		XX				X		5
Languages & Packages	XXX			XXXX			XXXX		XXXX	15
Models	XX	XXX		XXXX XXXX				X		14
Interface Technologies	X					X		XX	X	5
Hardware & Networks										0
	9	11	0	34	3	2	10	9	17	

VIII CONCLUSIONS

The patterns of work, or lack of it, revealed in the matrices in Section VII bring us to three specific conclusions and an overall observation.:

1. We still appear to be in the very early phases of the emerging area of M.S.S. So far almost all the work has been with DSS and only during the last eighteen months or so have we begun to see published results from the Data Support and ESS worlds. As these 'product' types develop, it will be interesting to see if they are accompanied by the development of an appropriate body of literature dealing with empirical testing and observation.

2. There appears to be a disproportionally large amount of work in the methodologies and frameworks area. this is not in itself bad, but it seems unfortunate that almost none of the work falls into the area of empirical testing of the methodology or framework. The insights gained from testing, or at least reporting on use, could be a powerful means of improving the quality of the methodology. A similar comment can be made with respect to the research work on languages. The lack of testing, or surveying experience in the field must surely remove one major souce of insights. These insights can lead to important changes in a new generation of languages and to changes in the practice of management.

3. The surprising lack of published research in the hardware and communications domain may well be a reslut of a faulty search process. It does not seem reasonable that hardware, at least, is not a primary research focus as an aspect of MSS at this point in time.

However, the search process, which included the ACM publication "Computing Reviews'" did not produce any articles. One other possible reason may simply be that it is the business schools in universities that have, thus far, done most of the research and publishing in the MSS field. This may not be a community drawn to do work that has hardware as its major focus. With an increasing availability of low cost MSS hardware tools we may begin to see this lack of research start to change.

4. There is another surprising vacuum - the lack of work on the "impacts of MSS." There is much work on the impacts of traditional MIS but virtually nothing on the impacts of MSS. If this lack is real, and not simply an error of our literature search, it is a sad commentary on the state of the field. A careful examination of the impacts of MSS is needed if we are to have the evidence necessary to improve the effectiveness with which MSS are used. This literature survey indicates those in the field make declarative statements and build interesting new tools which are never tested by practical use, comparative evaluation, or user opinion.

As an overall observation one has to conclude that there are an unfortunately large number of unexplored areas. One further dimension of this was revealed by a bibliography count taken from the bibliographies cited in the ninety items referenced here. A count was made of all the different articles referenced in the collected bibliographies and of how many times each of these was cited. The overwhelming conclusion that emerges is that in the vast majority of cases an article is cited by only one author. In short, those in the field do not build on the collective experience of each other. Research efforts appear to be individualistic and fragmented.

BIBLIOGRAPHY COUNT

Number of Articles	Number of Times Cited
259	1
40	2
27	3
10	4
1	5
3	6
0	7
1	8
2	9
2	10+

The heavily cited articles were:

	Number of Times Cited
Gorry and Scott Morton - Framework for MIS	8
Bonczek, et al - Evolving Role of Models	9
Alter - D.S.S. - Current Practice	9
Sprague - A Framework for Research	10
Keen and Scott Morton - D.S.S.: An Org. Perspective	20

Our four conclusions on the state of research in Management Support Systems are reflected in the many issues raised at the 1981 Conference on Decision Support Systems. The group discussions at this conference are summarized in "Issues for the Future in DSS." A major concern was the lack of research on the support needs of groups and committees. They felt such organizational MSS may represent many unique problems not found in single user or single decision types of MSS. Research into these issues may address our concern for a lack of research on executive support and data support systems.

Other issues were raised regarding the tools of MSS: software languages and design, implementation, and evaluation methodologies. Particular concern was expressed about the latter area, the lack of substantive results addressing the evaluation and justification of MSS. The discussants' concerns mirror our concern for more research on the impact of support systems on the organization. The value of a Management Support System is found in its impacts. If we can study these in greater depth, understand and catalogue them, then we move a step closer toward understanding where best to apply MSS to improve the effectiveness with which organizations operate.

If the research that has been done is a measure of the maturity of the field, then it has much more growing to do. Hopefully, future research will begin to fill in the very large number of blank areas in the grids in Section VII.

One prospective area of study that may begin to fill in some of these gaps is Artificial Intelligence (AI). Artificial Intelligence has been worked on by some of the best brains in the country for over twenty years. Its recent leap into the limelight (See Fortune's "Thinking Machines" series and Business Week's "Artificial Intelligence article of March 8, 1982) is due partly to the availability of inexpensive and powerful programming tools designed for 'heuristic' work. This availability is important due to the insatiable hardware appetite of any realistic AI application. There are years of work ahead (see Bonczek, et al Future Directions for developing DSS). Research is needed in all of the following areas: natural language; knowledge engineering (the ability to extract and encode the knowledge in a human's mind); development of tools and techniques to build domain-specific knowledge; and the tools,

techniques and models necessary to construct the general purpose 'inference engines' that will work on the domain specific knowledge.

In the meantime, for those interested in Management Support Systems there is the attraction of being able to provide help that addresses a whole new class of management problems (see Luconi/Scott Morton). This support will be particularly useful where precise rules cannot be made explicit in a form that is computable but where heuristics can genuinely be helpful. Intelligent Support Systems may be one of the most fruitful areas of MSS research in the decade ahead.

This look at the future from a detailed level can be instructive. However, it is also useful to look at the driving forces in the field from a macro perspective. This can be done from the perspectives of both supply push and demand pull.

On the supply side we have, as always, the hardware vendors. However, with software becoming a major part of their sales they will likely keep flooding the market with tools that can be built into an MSS. The resources of the hardware vendors are being mightily leveraged by the host of software firms and users who launch new products once they have developed something that sells.

The other supply push is the information coming from the twenty years of building internal transaction processing and other data processing systems. In many firms they are supplying the information. When you add to this the the information coming from external data base purveyors it is clear that there is an abundance of information which causes an inevitable supply-side push in the field of MSS.

The same pattern can be seen on the demand pull side where a long litany of forces pulls at management. In responding to this, an MSS of the general type we have defined in this paper can be of real use. The widespread needs caused by the global economy, the need to increase productivity, and so forth all suggest that management at all levels must think 'smarter.' This has always been true, but will be more so in the decades of the 80's and 90's. The ability to harness the burgeoning supply of new technology to meet business demands will prove invaluable. If MSS can reach their potential to help achieve this, they will become an integral part of business. Like the telephone, we will take them for granted.

The literature survey suggests that we ar far from being at such a point, but that the trend is in the right direction. Certainly the new technologies are driving us ever forward.

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