Chapter 1

Supporting Business Decision Making

INTRODUCTION

Beginning in the late 1970s, many vendors, practitioners, and academics promoted the development of computer-based Decision Support Systems (DSS). Their actions created high expectations for DSS and generated much optimism about the prospects for improving decision making. Despite the buildup and excitement, the success rate of decision support applications has been unsatisfactory. Although the computing industry has transformed how business transactions and data are processed, managers have frequently been disappointed by attempts to use computers and information technology to support decision making (cf., Drucker, 1998). Recently, because of technological developments, managers have become more enthusiastic about implementing innovative decision support projects. This attitude change is a positive development, but both managers and Management Information Systems (MIS) practitioners need to discuss and review their expectations about Decision Support Systems before beginning new projects.

According to Sprague and Carlson (1982), "DSS comprise a class of information system that draws on transaction processing systems and interacts with the other parts of the overall information system to support the decision-making activities of managers and other knowledge workers in organizations" (p. 9). Decision Support Systems are defined broadly in this book as interactive computer-based systems that help people use computer communications, data, documents, knowledge, and models to solve problems and make decisions. DSS are ancillary or auxiliary systems; they are not intended to replace skilled decision makers.

Decision Support Systems should be considered when two assumptions seem reasonable: first, good information is likely to improve decision making;

and second, managers need and want computerized decision support. Anecdotes and research show that some computer-based DSS can provide managers with analytical capabilities and information that improves decision making.

In pursuing the goal of improving decision making, many different types of computerized DSS have been built to help decision teams and individual decision makers. Some systems provide structured information directly to managers. Other systems can help managers and staff specialists analyze situations using various types of models. Some DSS store knowledge and make it available to managers. Some systems support decision making by small and large groups. Companies even develop DSS to support the decision making of their customers and suppliers.

Today, e-business technologies are transforming business transactions, and similar technologies can transform and improve decision activities. This book discusses how computing, the World-Wide Web, and information technologies can support and improve business and managerial decision making. This chapter begins with a short history of Decision Support and Management Information Systems; and then examines the DSS concept. Based on that analysis, a revised framework for categorizing DSS is proposed and discussed. Finally, the revised DSS framework is linked to the traditional components of a Decision Support System. The last section previews the topics in subsequent chapters.

A BRIEF HISTORY OF DECISION SUPPORT SYSTEMS

Prior to 1965, it was very expensive to build large-scale information systems. At about this time, the development of the IBM System 360 and other more powerful mainframe systems made it more practical and cost-effective to develop Management Information Systems (MIS) in large companies. MIS focused on providing managers with structured, periodic reports. Much of the information was from accounting and transaction systems.

In the late 1960s, a new type of information system became practical— model-oriented DSS or management decision systems. Two DSS pioneers, Peter Keen and Charles Stabell, claim the concept of decision support evolved from "the theoretical studies of organizational decision making done at the Carnegie Institute of Technology during the late 1950s and early '60s and the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s" (Keen and Scott Morton, 1978, preface).

In 1971, Michael S. Scott Morton's book, *Management Decision Systems: Computer-Based Support for Decision Making,* was published. In 1968–1969 Scott Morton studied how computers and analytical models could help managers make a key decision. He conducted an experiment in which marketing and production managers actually used a Management Decision System (MDS) to coordinate production planning for laundry equipment. Scott Morton's research was a pioneering implementation, definition, and research test of a model-based decision support system.

T.P. Gerrity, Jr. focused on DSS design issues in his 1971 *Sloan Management Review* article, "The Design of Man-Machine Decision Systems: An Application to Portfolio Management." His system was designed to support

investment managers in their daily administration of a client's stock portfolio. DSS for portfolio management have become very sophisticated since Gerrity began his research.

In 1974, Gordon Davis, a professor at the University of Minnesota, published his influential text on MIS. He asserted that the MIS concept was "a substantial extension of the concepts of managerial accounting taking into consideration the ideas and techniques of management science and the behavioral theories of management and decision making" (p. 8).

Davis defined a Management Information System as "an integrated, man/machine system for providing information to support the operations, management, and decision-making functions in an organization. The systems utilize computer hardware and software, manual procedures, management and decision models, and a database" (p. 5). His book helped create a broad foundation for DSS research and practice. Management information systems were providing fact-based decision support reports.

By 1975, J. D. C. Little was expanding the frontiers of computer-supported modeling. Little's DSS, called Brandaid, was designed to support product, promotion, pricing, and advertising decisions. Also, Little (1970) in an earlier article identified criteria for designing models and systems to support management decision making. His four criteria included robustness, ease of control, simplicity, and completeness of relevant detail. All four criteria remain relevant in evaluating modern DSS.

Peter G. W. Keen and Michael Scott Morton's DSS textbook (1978) provided a comprehensive behavioral orientation to DSS analysis, design, implementation, evaluation, and development. In 1980, Steven Alter published his MIT doctoral dissertation results in an influential book titled *Decision Support Systems: Current Practice and Continuing Challenge*. Alter's research expanded the framework for our thinking about management DSS. Also, his case studies provided a firm descriptive foundation for identifying DSS.

Bonczek, Holsapple, and Whinston (1981) created a theoretical framework for understanding the issues associated with designing knowledge-oriented DSS. Their book showed how Artificial Intelligence and Expert Systems technologies were relevant to developing DSS. Also, they identified four essential "aspects" or components that seemed common to all DSS:

1. A language system (LS) that specifies all messages a specific DSS can accept;
2. A presentation system (PS) for all messages a DSS can emit;
3. A knowledge system (KS) for all knowledge a DSS has; and
4. A problem-processing system (PPS) that is the "software engine" that tries to recognize and solve problems during the use of a specific DSS.

Ralph Sprague and Eric Carlson's (1982) book *Building Effective Decision Support Systems* was an important milestone. It provided a practical, understandable overview of how organizations could and should build DSS. Although the book probably created some unrealistic expectations, the problems stemmed more from the limits of existing technologies for building DSS than the limits of the concepts Sprague and Carlson presented.

In the mid-1980s, academic researchers developed software to support group decision making (cf., DeSanctis and Gallupe, 1987; Huber, 1984). Since that time, many research studies have examined the impacts and consequences of Group Decision Support Systems (GDSS). Also, a number of companies have commercialized GDSS and groupware.

Executive Information Systems (EIS) evolved from the single-user model-driven decision support systems and improved relational database products. The first EIS used predefined information screens and were maintained by analysts for senior executives. Beginning in about 1990, business intelligence, data warehousing and On-Line Analytical Processing (OLAP) software began broadening the capabilities of DSS (cf., Dhar and Stein, 1997).

In the early 1990s, a shift occurred from mainframe-based data-driven DSS to client/server DSS. Some desktop OLAP tools were introduced at this time. In 1992–1993, some vendors recommended object-oriented technology for building "re-usable" decision support capabilities. Also, some of the first data warehouses were completed. In 1994, many companies started to upgrade their network infrastructures. Database Management System (DBMS) vendors changed their focus from On-Line Transaction Processing (OLTP) and "recognized that decision support was different from OLTP and started implementing real OLAP capabilities into their databases" (Powell, 2001).

In 1995, data warehousing and the World Wide Web began to impact practitioners and academics interested in decision support technologies. Many companies purchased enterprise resource planning (ERP) applications. Independent data marts were popular alternatives to data warehouses.

Corporate intranets were initially developed in the mid-1990s to support information exchange and knowledge management. The primary decision support tools in use in 1996 included ad hoc query and reporting tools and quantitative models.

By 1997, according to Powell, "The data warehouse became the cornerstone of an integrated knowledge environment that provided a higher level of information sharing across an organization, enabling faster and better decision making." In approximately 1998, enterprise performance management and balanced scorecard systems were introduced to update the executive information systems of the 1970s and 1980s.

As the millennium approached, the rush was on by the laggards to introduce new Web-based analytical applications. Also, many vendors upgraded their Web-based analytical applications and business intelligence solutions.

In 2000 and 2001, application service providers (ASPs) began hosting some application software and some of the technical infrastructure for decision support capabilities. Decision support has gone full-circle and returned at least partially to the time-sharing DSS of the late 1970s. More sophisticated decision portals have also been introduced that combine information portals, knowledge management, business intelligence, and communications-driven DSS in an integrated Web environment.

A more detailed history on the origins of OLAP products, written by Nigel Pendse (1999), is available on the Web at URL http://www.olapreport.com/. Pendse traces multidimensional analysis and OLAP to the APL programming

language, Express, and Comshare's System W. He claims the first Executive Information System product was Pilot Software's Command Center. Table 1.1 summarizes some major developments in the history of Decision Support Systems.

Evolution of DSS Concepts			
1960s	**1970s**	**1980s**	**1990s**
MIS and Structured Reports	BrandAid	Key Books	Business Intelligence Data Warehouses
Interactive Systems Research	MDS	GDSS EIS Expert Systems	Data mining OLAP
Theory Development			Portals

Table 1.1. Evolution of DSS Concepts.

Today, a number of academic disciplines provide the substantive foundations for DSS development and research. Database research has contributed tools and research on managing data and documents. Management Science and Operations Research have developed mathematical models for use in model-driven DSS and provided evidence on the advantages of modeling in problem solving. Cognitive Science, especially Behavioral Decision Making research, has provided descriptive and empirical information that has assisted in DSS design and has generated hypotheses for decision support research. Some other important fields related to DSS include artificial intelligence, human-computer interaction, software engineering, and telecommunications. The history of DSS is relatively brief, but the concepts and technologies are still evolving. In fact, the Internet and Web have sped up developments in decision support and have made it hard to keep up with the rapid changes in DSS capabilities.

A CONCEPTUAL PERSPECTIVE

By the late 1970s, a number of companies had developed interactive information systems that used data and models to help managers analyze semistructured problems. These diverse systems were all called DSS. From those early days, it was recognized that DSS could be designed to support decision makers at any level in an organization. DSS could support operations, financial management, and strategic decision making. Over the years, many of the more interesting DSS have been targeted for middle and senior managers. DSS are also often designed for specific types of organizations like hospitals, banks, or insurance companies. These specialized systems are sometimes referred to as vertical market or industry-specific DSS.

DSS are both off-the-shelf, packaged applications and custom designed systems. DSS may support a manager using a single personal computer or a

large group of managers in a networked client-server or Web environment. These latter systems are often called enterprise-wide DSS.

Characteristics of DSS

Although the term "Decision Support System" has many connotations, based on Steven Alter's (1980) pioneering research, we can identify the following three major characteristics:

1. DSS are designed specifically to facilitate decision processes,
2. DSS should support rather than automate decision making, and
3. DSS should be able to respond quickly to the changing needs of decision makers.

Clyde Holsapple and Andrew Whinston (1996) identified characteristics one should expect to observe in a DSS (see pages 144–145). Their list is very general and somewhat abstract, but it provides an even broader perspective on the DSS concept. Holsapple and Whinston specify that a DSS must have a body of knowledge, a record-keeping capability that can present knowledge on an ad hoc basis in various customized ways as well as in standardized reports, a capability for selecting a desired subset of stored knowledge for either presentation or for deriving new knowledge, and must be designed to interact directly with a decision maker in such a way that the user has a flexible choice and sequence of knowledge-management activities.

Sprague and Carlson (1982) and others define DSS broadly as interactive computer-based systems that help decision makers use data and models to solve ill-structured, unstructured or semi-structured problems. Bonczek, Holsapple and Whinston (1981) argued that the "system must possess an interactive query facility, with a query language that ... is ... easy to learn and use" (p. 19). Various types of DSS help decision makers use and manipulate very large databases; some help managers apply checklists and rules; others make extensive use of mathematical models.

Many terms are used for specific types of DSS, including "business intelligence," "collaborative systems," "data mining," "data warehousing," "knowledge management," and "on-line analytical processing." Software vendors use these more specialized terms for both descriptive and marketing purposes. What term we use for a system or software package is a secondary concern. Our primary concern should be finding software and systems that meet a manager's decision support needs and provide appropriate management information.

Management Information Needs

Managers and their support staffs need to consider what information and analyses are actually needed to support their management and business activities. Some managers need both detailed transaction data and summarized transaction data. Most managers only want summaries of transactions.

Managers usually want lots of charts and graphs; a few only want tables of numbers. Many managers want information provided routinely or periodically and some want information available on-line and on demand. Managers usually want financial analyses, and some managers want primarily "soft," nonfinancial or qualitative information.

In general, an Information System can provide business transaction information, and it can help managers understand many business operations and performance issues. For example, a computerized system can help managers understand the status of operations, monitor business results, review customer preference data, and investigate competitor actions. In all of these situations, management information and analyses should have a number of characteristics. Information must be both timely and current. These characteristics mean the information is up-to-date and available when managers want it. Also, management information must be accurate, relevant, and complete. Finally, managers want information presented in a format that assists them in making decisions. In general, management information should be summarized and concise, and any support system should have an option for managers to obtain more detailed information.

In summary, DSS must provide current, timely information and analyses that are accurate, relevant, and complete. A specific DSS must present information in an appropriate format that is easy to understand and manipulate. The information presented by a DSS may result from analysis of transaction data, it may be the result of a decision model, or it may have been gathered from external sources. DSS can present internal and external facts, informed opinions, and forecasts to managers. As many others have noted, *managers want the right information, at the right time, in the right format, and at the right cost.* These system requirements seem simple and straightforward, but meeting them remains a challenge.

DSS versus MIS

Is a DSS an MIS? How does a Decision Support System differ from a Management Information System? One can begin drawing distinctions between these two terms by first examining the concepts Management Information System (MIS) and Information System (IS). Many authors have used the term "MIS" to describe a broad, general category of information systems. Also, MIS and IS are used interchangeably to describe a functional department in companies and organizations responsible for managing information systems and technology. A number of computing jobs are grouped together under the heading of MIS or IS professionals. Finally, the term "Management Information Systems" or "MIS" is used to identify an academic major and an area of scholarly inquiry in universities.

In the 1970s, an MIS generated periodic management reports. Today, managers use data-driven DSS to meet their management reporting needs. When the term "Management Information System" is defined narrowly, it refers to a management reporting system that provides periodic, structured, paper-based reports. In contrast, data-driven DSS are intended to be interactive, real-time

systems that are responsive to unplanned, as well as planned, information requests and reporting needs. Model-driven DSS are usually focused on modeling a specific decision or a set of related decisions (cf., Power, 1997).

DSS include a wide variety of analytical information systems. DSS provide managers more control of their data, access to analytical tools, and capabilities for consulting and interacting with a distributed group of staff. An enterprise-wide DSS is linked to a large data warehouse and serves many managers within one company. Also, a DSS is defined as an interactive system in a networked environment that helps a targeted group of managers make decisions. The primary focus in the following discussion is on various types of DSS. The term MIS will be used sparingly and will usually refer broadly to an information system that provides managers with on-line access to information.

DECISION SUPPORT VS. TRANSACTION PROCESSING SYSTEMS

Development of Decision Support Systems is one of the rapidly changing frontiers in the application of computers in organizations. One reason we study DSS is to understand how they differ from other systems. We have successfully implemented computer-based Transaction Processing Systems (TPS), but knowledge of building these operational systems is not adequate to create effective DSS. So if DSS are to be successfully designed, developed, and implemented, then both managers and many MIS professionals need a more sophisticated technical and philosophical understanding of DSS.

Technology is creating new decision support capabilities, but much learning and discussion needs to occur to successfully exploit the technological possibilities. DSS differ in many ways from operating systems that process business transactions. For example, a popular system that has been widely implemented is called Enterprise Resource Planning (ERP). ERP is *not* a Decision Support System even though the term suggests that decision making and planning will be improved. In general, ERP is an integrated TPS that facilitates the flow of information between the functional areas of a business. Recently, DSS have been built that help managers analyze data from ERP systems. The implementation of ERP systems has made it much easier to create a enterprise-wide data-driven DSS.

A major difference between TPS and DSS is the general purpose of each type of system. TPS are designed to expedite and automate transaction processing, record keeping, and simple business reporting of transactions. DSS are intended to assist in decision making and decision implementation. Transaction processing is, however, related to the design of DSS because transaction databases often provide data for decision-oriented reporting systems and data warehouses.

Transaction Processing Systems usually provide standard reports on a periodic basis and support the operations of a company. DSS are used on demand when they are needed to support decision making. A manager typically initiates each instance of DSS use, either by using the DSS herself or by asking a staff intermediary to use a DSS. Clerical employees, and some managers, use TPS to support operations. Line managers and support staff are the primary

users of DSS. TPS record current information and maintain a database of transaction information. DSS generally use historical internal and external data for analysis. DSS may focus on quantitative analysis and modeling current and future scenarios. TPS emphasize data integrity and consistency; and although both of these qualities are important in every system, the primary emphasis for a DSS is on flexibility and on conducting analyses and retrieving decision-relevant information and knowledge.

One can draw many distinctions between TPS and DSS, but analysts and managers need to stay focused on the phrase "decision support" in the term "Decision Support System." DSS are intended to improve and speed up the processes by which people make and communicate decisions. Thus, the emphasis in building a DSS is on increasing individual and organizational decision-making effectiveness rather than on increasing efficiency in processing operating data.

CATEGORIZING DSS APPLICATIONS AND PRODUCTS

Hundreds of DSS applications are described in professional journals like *Interfaces* (cf., Eom, Lee, Somarajan, and Kim, 1997) and in IS trade publications like *Information Week* (http://www.informationweek.com). Many DSS case studies are also available on the World Wide Web at vendor Web sites and at DSSResources.COM. This section lists some DSS examples and summarizes some relevant frameworks and taxonomies for categorizing DSS.

One of the long-standing conclusions that comes from reading DSS case studies is that what managers, vendors, and consultants call DSS can "take on many different forms and can be used in many different ways" (Alter, 1980, p. 71). DSS certainly vary in many ways. Some DSS focus on data, some on models, and some on communications. DSS also differ in scope: some DSS are intended for one "primary" user and used "stand-alone" for analysis, and others are intended for many users in an organization. Also, DSS differ in terms of who uses a specific system; that is, some DSS are used by actual decision makers, and some are used by intermediaries like marketing analysts or financial analysts. If a computerized system is not a TPS, and if a manager uses it, many observers will be tempted to call the system a DSS.

Some examples show the wide variety of DSS applications. Major airlines use DSS for many tasks including pricing and route selection. Many companies have DSS that aid in corporate planning and forecasting. Specialists often use these DSS that focus on financial and simulation models. DSS can help monitor costs and revenues and track department budgets. Also, investment evaluation and support systems are increasingly common. Frito-Lay has a DSS that aids in pricing, advertising, and promotion. Route salesmen use handheld computers to support decision-making activities.

Many manufacturing companies use Manufacturing Resources Planning (MRP) software. This specific, operational-level DSS supports master production scheduling, purchasing, and material requirements planning. More recent MRP systems support "what-if" analysis and simulation capabilities. DSS support quality improvement and control decisions. Monsanto, FedEx, and most

transportation companies use DSS for scheduling trucks, airplanes, and ships. The Coast Guard uses a DSS for procurement decisions. Companies like Wal-Mart have large data warehouses and use data mining software. Business Intelligence and Knowledge Management Systems are increasingly common. On the World Wide Web one can find DSS that help track and manage stock portfolios, choose stocks, plan trips, and suggest gifts. DSS can support distributed-decision activities, using groupware and a corporate intranet. The following paragraphs provide more details on four decision support applications:

Federal Express has business intelligence capabilities for 700 end-users. FedEx created a central, integrated data warehouse hub, which provides Web-based, real-time access to financial and logistical information necessary for planning and decision making. Most access is from browsers over the corporate intranet, along with some standard client/server deployments using Excel spreadsheets.

In 1997, ShopKo developed a "Merchandise Data Warehouse." The main strategy in developing a decision support tool was to allow ShopKo associates to make ad hoc queries and prepare reports. ShopKo extended its DSS capabilities to its store units by using a Web-based DSS.

According to a MicroStrategy case example, the U.S. Air Force developed a decision support application called the Base Closure and Analysis DSS. It provided a common framework for analyzing the impact of various base closure scenarios. The software used a model to evaluate the relative impact of closing each base. Using the DSS, committee members could perform analyses using eight main criteria and 212 subcriteria on which all bases were evaluated. These criteria, specified by the U.S. Department of Defense (DOD), focused on elements that affected operational effectiveness, including such items as alternate airfield availability, weather data, and facility infrastructure capacity.

Also at DOD, during the weeks leading up to and immediately following January 1, 2000, approximately 150 people participated in crisis management activities, 24 hours a day, 7 days a week. An "off-the-shelf" decision support product, GroupSystemsOnLine, was used to communicate information and provide input, discuss solutions, and create reports of recommended action (cf., http://www.groupsystems.com).

Alter's Taxonomy

In 1977, Steven Alter proposed a taxonomy of DSS. The next few paragraphs summarize his taxonomy and discuss some of the key issues for each type of DSS. Alter's taxonomy is based on the degree to which DSS output can directly determine the decision. The taxonomy is related to a spectrum of generic operations that can be performed by DSS. These generic operations extend along a single dimension, ranging from extremely data-oriented to extremely model-oriented. DSS may involve retrieving a single item of information, providing a mechanism for ad hoc data analysis, or providing prespecified aggregations of data in the form of reports or "screens." DSS may also include estimating the consequences of proposed decisions and proposing decisions.

Alter's idea (cf., 1977, 1980) was that a DSS could be categorized in terms of the generic operations it performs, independent of type of problem, functional area, or decision perspective. Alter conducted a field study of 56 DSS that he categorized into seven distinct types. These include:

- **File drawer systems** that provide access to data items. Examples include real-time equipment monitoring, inventory reorder, and monitoring systems. Simple query and reporting tools that access OLTP fall into this category.

- **Data analysis systems** that support the manipulation of data by computerized tools tailored to a specific task and setting or by more general tools and operators. Examples include budget analysis and variance monitoring, and analysis of investment opportunities. Most data warehouse applications would be categorized as data analysis systems.

- **Analysis information systems** that provide access to a series of decision-oriented databases and small models. Examples include sales forecasting based on a marketing database, competitor analyses, and product planning and analysis. OLAP systems fall into this category.

- **Accounting and financial models** that calculate the consequences of possible actions. Examples include estimating profitability of a new product; analysis of operational plans using a goal-seeking capability, break-even analysis, and generating estimates of income statements and balance sheets. These types of models should be used with "What if?" or sensitivity analysis.

- **Representational models** that estimate the consequences of actions on the basis of simulation models that include causal relationships and accounting definitions. Examples include a market response model, risk analysis models, and equipment and production simulations.

- **Optimization models** that provide guidelines for action by generating an optimal solution consistent with a series of constraints. Examples include scheduling systems, resource allocation, and material usage optimization.

- **Suggestion models** that perform the logical processing leading to a specific suggested decision for a fairly structured or well-understood task. Examples include insurance renewal rate calculation, an optimal bond-bidding model, a log-cutting DSS, and credit scoring.

An understandable taxonomy like Steven Alter's helps reduce the confusion for managers who are investigating and discussing DSS. The taxonomy also helps users and developers communicate their experiences with DSS.

Other Taxonomies or Frameworks

Holsapple and Whinston (1996) identified five specialized types of DSS (see pp. 178-195). First, they identified an evolving group of systems they called text-oriented DSS. This type of DSS supports a decision maker by electronically keeping track of textually represented knowledge that could affect decisions. This type of system supports document creation, revision, viewing, searching, and hypertext links. Holsapple and Whinston also discuss database-oriented DSS, spreadsheet-oriented DSS, solver-oriented DSS, and rule-oriented DSS. A solver is a general algorithm that can be customized to solve a specific

instance of a more general class of problems. These last four types of DSS match up well with Alter's categories.

Donovan and Madnick (1977) classified DSS as either institutional or ad hoc DSS. Institutional DSS support decisions that are recurring. Institutional DSS are often integrated in business decision processes. An ad hoc DSS supports problems that are not anticipated and that are not necessarily expected to reoccur. Ad hoc DSS are often used for special analytical studies in companies. Hackathorn and Keen (1981) identified DSS in three distinct yet interrelated categories: Personal DSS, Group DSS and Organizational DSS. These three categories identify differences in who the intended users are for a particular DSS. Many DSS are designed for a particular problem in a particular company, but some DSS are generic DSS generators or "ready-made" DSS for particular applications like budgeting (cf., Turban and Aronson, 1998). Golden, Hevner, and Power (1986) identified decision insight systems as a particular category of model-oriented DSS that uses decision analysis tools to help decision makers structure decision situations and gain insight about possible solutions. All of the above categories provide adjectives to help describe a specific DSS or decision support product.

AN EXPANDED DECISION SUPPORT SYSTEM FRAMEWORK

The terms "frameworks," "taxonomies," "conceptual models," and "typologies" are often used interchangeably. Each can be used to help classify objects and to show how mutually exclusive types of things are related. The idea is to create a set of labels that help people organize and categorize information. Sprague and Watson (1996) argue typologies, frameworks, or conceptual models are "often crucial to the understanding of a new or complex subject." A good set of categories should show the parts of a topic and explain how the parts interrelate. "Framework" seems like the broadest and most general term to use for a classification system. This section provides a framework or scheme for categorizing the large number of computerized systems that support decision making.

A broader framework than Alter's is needed today because DSS are much more diverse than when he conducted his research and proposed his taxonomy. His seven categories are still relevant for identifying some, but not all, types of DSS. To keep the number of categories in a new framework manageable, one should simplify Alter's 1980 taxonomy (p. 73) into three types of DSS: data-driven, model-driven, and knowledge-driven DSS. One can and should continue to categorize DSS in terms of intended users, purpose, and enabling technology. The following expanded DSS framework helps categorize the most common DSS currently in use (cf., Power, 2001). Some DSS are hybrid systems driven by more than one major DSS component or subsystem. The framework focuses on one major dimension with five categories and three secondary dimensions. The term "driven" is used as a common or shared descriptive adjective in the expanded framework. "Driven" refers to the tool or component that is providing the dominant functionality in the Decision Support System.

Data-Driven DSS

The first category of DSS, data-driven DSS, emphasizes analysis of large amounts of structured data. These systems include file drawer and management reporting systems, data warehousing and analytical systems, Executive Information Systems, and Spatial DSS (SDSS). EIS are targeted to senior managers, and SDSS display spatial data for decision support. Business Intelligence (BI) systems are also examples of data-driven DSS. A data-driven DSS provides access to and manipulation of large databases of structured data and, especially, a time-series of internal company and external data. Simple file systems accessed by query and retrieval tools provide the most elementary level of functionality, including aggregation and simple calculations. Data warehouse systems that allow the manipulation of data by computerized tools tailored to a specific task and setting or by more general tools and operators provide additional functionality. Data-driven DSS with On-Line Analytical Processing provide the highest level of functionality and decision support that is linked to analysis of large collections of historical data (cf., Dhar and Stein, 1997).

Model-Driven DSS

A second category, model-driven DSS, includes systems that use accounting and financial models, representational models, and optimization models. Model-driven DSS emphasize access to and manipulation of a model. Simple statistical and analytical tools provide the most elementary level of functionality. Some OLAP systems that allow complex analysis of data may be classified as hybrid DSS systems providing modeling, data retrieval, and data summarization functionality. Model-driven DSS use data and parameters provided by decision makers to aid them in analyzing a situation, but they are not usually data intensive. Very large databases are usually not needed for model-driven DSS, but data for a specific analysis may need to be extracted from a large database.

Knowledge-Driven DSS

The terminology for this category of DSS is still evolving. Currently, the best term seems to be "knowledge-driven" DSS. Sometimes it seems equally appropriate to use Alter's term "Suggestion DSS" or the narrower term "Management Expert System." Knowledge-driven DSS suggest or recommend actions to managers. They use business rules and knowledge bases. These DSS are person-computer systems with specialized problem-solving expertise. The "expertise" consists of knowledge about a particular domain, understanding of problems within that domain, and "skill" at solving some of these problems. A related concept is "data mining." This term refers to a class of analytical applications that search for hidden patterns in a database. Data mining is the process of sifting through large amounts of data to produce data content relationships. Tools used for building these systems are also called Intelligent Decision Support methods (cf., Dhar and Stein, 1997). Data mining tools can be used to create hybrid data-driven and knowledge-driven DSS.

Document-Driven DSS

A new type of DSS, a document-driven DSS, is evolving to help managers gather, retrieve, classify and manage unstructured documents, including Web pages. A document-driven DSS integrates a variety of storage and processing technologies to provide complete document retrieval and analysis. The Web provides access to large document databases including databases of hypertext documents, images, sounds, and video. Examples of documents that would be accessed by a document-driven DSS are policies and procedures, product specifications, catalogs, and corporate historical documents, including minutes of meetings, corporate records, and important correspondence. A search engine is a powerful decision-aiding tool associated with a document-driven DSS (cf., Fedorowicz, 1993). Some authors call this type of system a Knowledge Management System.

Communications-Driven and Group DSS

Group Decision Support Systems (GDSS) and groupware came first, but now a broader category of communications-driven DSS can be identified. This type of DSS includes communication, collaboration, and decision support technologies that do not fit within those DSS types identified by Alter. Therefore, communications-driven DSS need to be identified as a specific category of DSS. It seems appropriate to call these systems communications-driven DSS even though many people are more familiar with the term GDSS. A GDSS is best viewed as a hybrid DSS that emphasizes both the use of communications technologies and decision process models. A GDSS is an interactive computer-based system intended to facilitate the solution of problems by decision makers working together as a group. Groupware supports electronic communication, scheduling, document sharing, and other group productivity and decision support activities. A number of technologies and capabilities are included in this category in the framework – GDSS, decision rooms, two-way interactive video, white boards, bulletin boards, chat and e-mail systems.

Interorganizational or Intraorganizational DSS

A relatively new category of DSS made possible by new technologies and the rapid growth of the public Internet is interorganizational DSS. These DSS serve a company's customers or suppliers. The public Internet is creating communication links for many types of interorganizational systems, including DSS. An interorganizational DSS provides stakeholders with access to a company's intranet and authority or privileges to use specific DSS capabilities. Companies can make a data-driven DSS available to suppliers or a model-driven DSS available to customers to design a product or choose a product. Most DSS are intraorganizational DSS that are designed for use by individuals in a company as "stand-alone DSS" or for use by a group of managers in a company as a group or enterprise-wide DSS. The prefix "intra" means the DSS is used within a specific organization; "inter" means the DSS is used more widely.

Function-Specific or General Purpose DSS

Many DSS are designed to support specific business functions or types of businesses and industries. We can call such DSS function-specific or industry-specific DSS. A function-specific DSS, like a budgeting system, may be purchased from a vendor or customized in-house using a more general-purpose development package. Vendor developed or "off-the-shelf" DSS support functional areas of a business like marketing or finance; some DSS products are designed to support decision tasks in a specific industry, such as a crew-scheduling DSS for an airline. A task-specific DSS has an important purpose in solving a routine or recurring decision task. Function or task-specific DSS can be further classified and understood in terms of the dominant DSS component, that is, as a model-driven, data-driven or knowledge-driven DSS. A function or task-specific DSS holds and derives knowledge relevant for a decision about some function that an organization performs (e.g., a marketing or a production function). DSS can be categorized by purpose: function-specific DSS help a person or group accomplish a specific decision task; general-purpose DSS software helps support broad tasks like project management, decision analysis, or business planning. Some general-purpose DSS actually help create task-specific DSS. Such systems have been called DSS generators.

Web-Based DSS

All of the above types of DSS can be implemented using Web technologies. When the enabling technology used to build a DSS is the Internet and Web, it seems appropriate to call the system a Web-based DSS. A Web-based DSS is a computerized system that delivers decision support information or decision support tools to a manager or decision support analyst using a "thin-client" Web browser like Netscape Navigator or Internet Explorer (Power, 2000). The computer server hosting the DSS application is linked to the user's computer by a network with the TCP/IP protocol. In many companies, a Web-based DSS is synonymous with an intranet or enterprise-wide DSS. A company intranet supports a large group of managers using Web browsers in a networked environment. Managers often have Web access to a data warehouse as part of an Information System architecture. Today, Web technologies are powerful tools for creating DSS and especially interorganizational DSS that support the decision making of customers and suppliers. Web or Internet technologies are the leading edge for building DSS, but some DSS will continue to be built using mainframe and client/server-enabling technologies.

Column one of Table 1.2 lists five broad categories of Decision Support Systems that differ in terms of the dominant decision support component, including communications-driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS and model-driven DSS. Subsequent chapters explain these DSS categories in more detail and identify development and implementation issues. The expanded DSS framework also categorizes DSS by user groups—intraorganizational and interorganizational. The new category

called interorganizational DSS helps one focus on the broadening of the DSS user group to include external stakeholders.

Dominant DSS Component	User Groups: Internal, External	Purpose: General, Specific	Enabling Technology
Communications **Communications-driven DSS**	Internal teams, now expanding	Conduct a meeting Bulletin board Help users collaborate	Web or Client/Server
Database **Data-driven DSS**	Managers, staff, now suppliers	Query a Data Warehouse	Main Frame, Client/Server, Web
Document base **Document-driven DSS**	Specialists and user group is expanding	Search Web pages Find documents	Web
Knowledge base **Knowledge-driven DSS**	Internal users, now customers	Management advice Choose products	Client/Server, Web
Models **Model-driven DSS**	Managers and staff, now customers	Crew scheduling Decision analysis	Stand-alone PC

Table 1.2. An Expanded DSS Framework.

From a different perspective, DSS can be categorized by the purpose of the DSS. Many DSS have a narrow, focused, and specific purpose rather than a general purpose. Finally, DSS can be categorized by the basic enabling technology. The Web is an important new development arena for DSS, so it is crucial to examine and understand Web-based DSS. One can use the dominant DSS component, user group, purpose, and enabling technology to categorize a specific system. For example, a manager may want to build a model-driven, interorganizational, product design, Web-based DSS to support a business decision process. Another manager may want to build a data-driven, Web-based DSS to support senior executives in business operations monitoring and control.

BUILDING DECISION SUPPORT SYSTEMS

Traditionally, IS academics and practitioners have discussed building DSS in terms of four major components: 1) the user interface, 2) the database, 3) the models and analytical tools, and 4) the DSS architecture and network (cf., Sprague and Carlson, 1982). This traditional list of components remains useful because it identifies similarities and differences between categories or types of DSS, and it can help managers and analysts build new DSS. The expanded DSS

framework is based on the different emphases placed on DSS components when a specific system is actually constructed (see Figure 1.1).
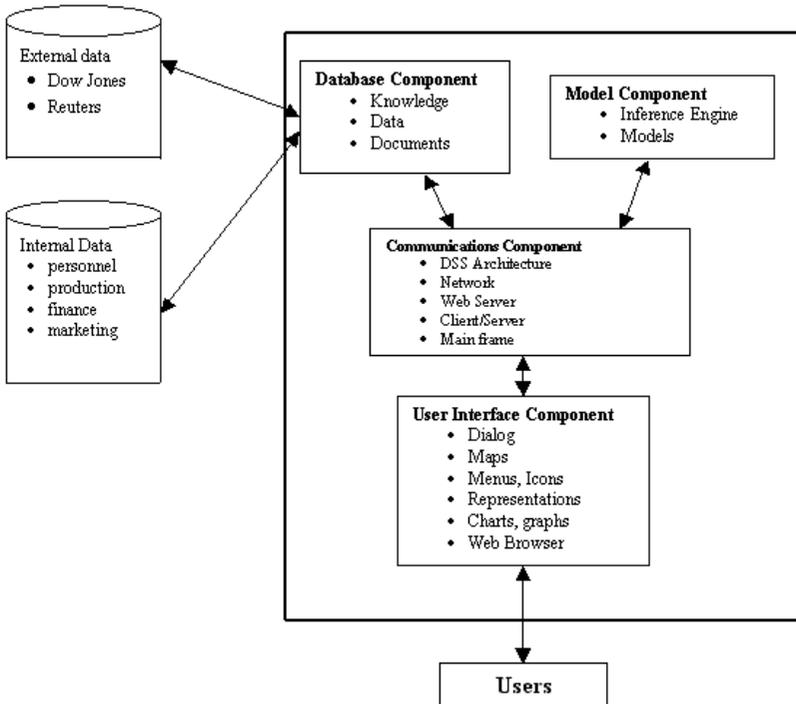

Figure 1.1. Traditional DSS Components.

Data-driven, document-driven and knowledge-driven DSS need specialized database components. A model-driven DSS may use a simple flat-file database with fewer than 1,000 records, but the model component is very important and it provides the functionality. Experience, and some empirical evidence, indicates that design and implementation issues vary for data-driven, document-driven, model-driven and knowledge-driven DSS. Multiparticipant systems like group and interorganizational DSS also create complex implementation issues. For instance, when implementing a data-driven DSS, a designer should be especially concerned about the user's interest in applying the DSS in unanticipated or novel situations.

In creating an accounting or financial simulation model, a developer should attempt to verify that the initial input estimates for the model are thoughtful and reasonable. In developing a representational or optimization model, an analyst should be concerned about possible misunderstandings of what the model means and how it can or cannot be used (cf., Alter, 1980). Networking issues create challenges for many types of DSS, but especially for communications-driven systems with many participants, so-called multiparticipant systems. Today, architecture and networking issues are increasingly important in building DSS.

DSS should be built or implemented using an appropriate process. Many small, specialized model-driven DSS are built quickly. Large, enterprise-wide DSS are built using sophisticated tools and systematic and structured systems analysis and development approaches. Communications-driven and GDSS are usually purchased as "off-the-shelf" software and then implemented in a company. Creating enterprise-wide DSS environments remains an iterative and evolutionary task. As an enterprise-wide DSS grows, it inevitably becomes a major part of the overall information systems infrastructure of an organization. Despite the significant differences created by the specific task and scope of a DSS, all DSS have similar technical components and share a common purpose—supporting decision making.

A data-driven DSS database is often a collection of current and historical structured data from a number of sources that have been organized for easy access and analysis. The above framework expands the database component to include unstructured documents in document-driven DSS and "knowledge" in the form of rules in knowledge-driven DSS. Large databases of structured data in enterprise-wide DSS are often called data warehouses or data marts. Data-driven DSS usually use data that has been extracted from all relevant internal and external databases. Managing information often means managing a database. Supporting management decision making means that computerized tools are used to make sense of the structured data or documents in a database.

Mathematical and analytical models are the major component of a model-driven DSS. DSS models should be used and manipulated directly by managers and staff specialists. Each model-driven DSS has a specific set of purposes, and hence, different models are needed and used. Choosing appropriate models is a key design issue. Also, the software used for creating specific models needs to manage needed data and the user interface. In model-driven DSS the values of key variables or parameters are changed to reflect potential changes in supply, production, the economy, sales, the marketplace, costs, and/or other environmental and internal factors. Information from the models is then analyzed and evaluated by the decision-maker. Knowledge-driven DSS use special models, an inference engine, for processing rules or identifying relationships in data.

The communications component refers to how hardware is organized, how software and data are distributed in the system, and how components of the system are integrated and connected. A major issue today is whether DSS should be available, using a Web browser, on a company intranet and also available on the global Internet. Both managers and MIS staff need to develop an understanding of the technical issues and the security issues related to DSS architectures, networks, and the Internet. Networking and communications technology is the key driver of communications-driven DSS.

Managers and DSS analysts also need to emphasize the user interface component. In many ways it is the most important component of any DSS. The tools for building the user interface are sometimes termed DSS generators, query and reporting tools, and front-end development packages. Much of the DSS design and development effort should focus on building the user interface. It is important to remember that the screens and displays in the user interface heavily

influence how a manager perceives a DSS and whether it is used. What one sees is the DSS.

CONCLUSIONS AND COMMENTARY

The rapid growth of the World Wide Web has created enormous opportunities for making more organizational information available to decision makers. Web architectures permit IS professionals to centralize and control information and yet easily distribute it in a timely manner to managers who need it. Also, the internal intranet is providing many opportunities for delivering information from data warehouses, models, and other tools to the desktop. Web-based DSS permit and encourage further analysis and collaboration. The technologies and software associated with DSS continue to change rapidly, and development tools are overlapping for some applications. In general, managers and IS staff need to recognize that the overall technological and social context of DSS and business management is changing.

The managers who are, and will be, using company intranets and the Internet are more technologically sophisticated than the managers of the past. They will have high expectations for DSS, but in many ways they will be much better customers of computerized decision support. Managers need broad knowledge of the managerial and technical issues associated with the various categories of DSS. MIS professionals need this same general knowledge, and they need specific skills in analysis, design and development of DSS.

The DSS design and development environment is changing as rapidly as the software tools and in as positive a direction. Web technologies will facilitate improved DSS tools at managers' desktops. The Web does, however, solve all problems. In 1974, Gordon Davis wrote, "The application of computer technology and MIS concepts has produced some spectacular successes and also some rather expensive failures." Both successes and failures will continue to occur. Failures occur in leading edge application areas and for what turn out to be overly ambitious projects. A shortage of DSS professionals is also slowing development in some areas and increasing failures of innovative systems. Managers need to recognize that resistance to change and insufficient user involvement contributes to DSS project failure in some situations. Also, managers need to resolve political issues associated with building novel DSS and with providing greater access to management information. For example, senior managers need to address questions like: How should data be shared and how much data should be shared? Should all managers be required to use a DSS and support systems like e-mail?

Managers and MIS practitioners need to consider at least six major issues associated with building, implementing and using DSS. First, managers and MIS practitioners must determine what business and decision processes should be computerized. And in some situations one needs to ask what part of a process should be supported. It is also necessary to evaluate what ad hoc or on-demand information retrieval and analysis is needed. In many companies this broad purpose issue needs to be reexamined. Chapters 2 and 3 address this major issue. Second, one must ask what data should be captured in processes and how should

it be stored and integrated? Continuing to rely on existing decision processes may limit the information that can be provided to decision makers. Chapter 4 discusses DSS design and development issues.

Third, one needs to ask how data should be processed and presented to support decision making. Chapter 5 emphasizes user interface design issues. Fourth, and perhaps the major issue, is whether current DSS are creating results that are "decision-impelling"? (based on Davis, 1974, p. 6). Chapters 7 to 11 review the possibilities for building innovative "decision-impelling" DSS.

Fifth, one needs to ask what information technology should be used for building DSS. Chapter 6 reviews DSS architecture and networking issues. Managers need some technical familiarity and sophistication to evaluate the wide-ranging set of technologies that are available for DSS applications. Sixth and finally, one must always ask why a project sponsor wants a proposed DSS. Understanding the various categories of DSS that can be built begins the task of rationally answering some of the above questions. Subsequent chapters provide more elaboration and some details of the expanded framework and on decision support technologies.

DSS are not a panacea for improving business decisions. Most people acknowledge that managers need "good" information to manage effectively, but a DSS is not always the solution for providing "good" information. A DSS can provide a competitive advantage and a company may need computerized decision support to remain competitive, but decision support capabilities are limited by the data that can be obtained, the cost of obtaining, processing, and storing the information, the cost of retrieval and distribution, the value of the information to the user, and the capability of managers to accept and act on the information. Our capabilities for supporting decision making have increased, but we still have very real technical, social, interpersonal, and political problems that must be overcome when we build a specific DSS (cf., Davis, 1974). Chapter 12 specifically discusses the evaluation of proposed DSS projects.