Chapter 1

Supporting Business Decision-Making

Good information is essential for fact-based decision-making.

Introduction

Beginning in the late 1970s, many vendors, practitioners and academics promoted computer-based Decision Support Systems (DSS). They created high expectations for DSS and much optimism about the prospects for improving decision-making. Despite the hyperbole, the success rate of DSS applications has been less than anticipated. Although the computing industry has transformed how business transactions and data are processed, managers have often 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 is a positive development, but both managers and MIS practitioners need to discuss and review their expectations about Decision Support Systems before they begin important projects.

Anecdotes and research demonstrate that computer-based Decision Support Systems can provide managers with analytical capabilities and information that improves decision-making. In pursuing this goal, many different types of computerized Decision Support Systems have been built to help decision teams and individual decision makers. Some systems provide structured information directly to managers. Other systems 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.

This book and chapter discuss how computers and information technology can support and improve business and managerial decision-making. The chapter begins with a short history of Decision Support and Management Information Systems; then the focus

turns to examining the Decision Support Systems concept. Based on that examination, a revised framework for categorizing DSS is discussed. Finally, the new framework is linked to the traditional components of a Decision Support System.

A Brief History of Decision Support Systems

Prior to the mid-1960s, it was not cost effective to build large-scale information systems. The first Management Information Systems (MIS) were developed at about that time 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 (1978), claim the concept of decision support evolved from "the theoretical studies of organizational decisionmaking 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." Table 1.1 summarizes major developments in the evolution of Decision Support Systems concepts.

Evolution of DSS Concepts

1960s	1970s	1980s	1990s
MIS and structured reports	BrandAid	Key books	Data Warehouses
interactive systems research	MDS	GDSS	OLAP
theory development	RDBMS	EIS	Data mining
		Expert Systems	

Table 1.1. Evolution of DSS Concepts.

In 1971, Michael S. Scott Morton's book **Management Decision Systems: Computer-Based Support for Decision Making** was published. In 1968-69 Scott Morton studied how computers and analytical models could help managers make a key decision. He conducted an experiment in which managers actually used a Management Decision System (MDS). Marketing and production managers used an 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 Decision Support Systems design issues in his 1971 **Sloan Management Review** article titled "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 clients' 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 **Management Information Systems: Conceptual Foundations, Structure, and Development**. He asserted 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)."

Davis's Chapter 12 titled "Information System Support for Decision Making", and Chapter 13 titled "Information System Support for Planning and Control" created the setting for the development of a broad foundation for Decision Support Systems research and practice. MIS was in many ways beginning to converge with DSS concepts.

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. Little, in his **Management Science** article titled "Models and Managers: The Concept of a Decision Calculus" identified criteria for designing models to support management decision--making. His criteria included: robustness, ease of control, simplicity, and completeness of relevant detail.

Peter G. W. Keen and Michael Scott Morton's DSS textbook titled **Decision Support Systems: An Organizational Perspective** was published in 1978. Their text provided a comprehensive behavioral orientation to DSS analysis, design, implementation, evaluation and development.

In 1980, Steven Alter published his doctoral dissertation results in a book titled **Decision Support Systems: Current Practice and Continuing Challenge**. Alter's research expanded the framework for our thinking about management DSS. His case studies provided a firm descriptive foundation for identifying Decision Support Systems.

Bonczek, Holsapple, and Whinston’s (1981) book, **Foundations of Decision Support Systems**, created a theoretical framework for understanding the issues associated with designing Decision Support Systems. They identified four essential "aspects" or components common to all DSS: 1. A language system (LS) - all messages the DSS can accept; 2. A presentation system (PS) - all messages the DSS can emit; 3. A knowledge system (KS) -- all knowledge the DSS has stored and retained; and 4. A problem-processing system (PPS) -- the "software engine" that tries to recognize and solve problems during use of the DSS.

The book **Building Effective Decision Support Systems** by Ralph Sprague and Eric Carlson (1982) was an important milestone. It provided a practical, understandable overview of how organizations could and should build DSS. Although the book created some unrealistic expectations, the problem was more the limits of the 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 and organizational decision-making (cf., DeSanctis and Gallupe, 1987). For the next 10 years, many research studies examined the impacts and consequences of GDSS.

Executive Information Systems (EIS) evolved from the single user Model-Driven Decision Support systems and improved relational database products. The first EIS used pre-defined information screens and were maintained by analysts for senior executives. Beginning in about 1990, data warehousing and On-Line Analytical Processing (OLAP) began broadening the realm of EIS and defined a broader category of Data-Driven DSS (cf., Dhar and Stein, 1997).

A detailed history on the origins of OLAP products by Nigel Pendse (1999) is available on the Web at URL http://www.olapreport.com/origins.htm. Pendse traces OLAP to APL, Express and Comshare's System W. He claims the first explicit Executive Information System product was Pilot Software's Command Center.

Today, a number of academic disciplines provide the substantive foundations for Decision Support Systems development and research. Database researchers have 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 DSS research. Some other important fields related to DSS include artificial intelligence, human-computer interaction, software engineering, and telecommunications.

A Conceptual Perspective

In the late 1970s, a number of companies developed interactive information systems that used data and models to help managers analyze semi-structured problems. These systems were called Decision Support Systems. DSS can be designed to support decision-makers at any level in an organization. They can support operations, financial management and strategic decision-making. Many of the more interesting DSS are targeted for middle and senior managers. DSS are also often designed for specific types of organizations like hospitals, banks or insurance companies. These systems are sometimes referred to as vertical market or industry-specific DSS.

DSS are both off-the-shelf and custom designed systems. DSS may support a small group of managers using a single personal computer or a large group of managers in a networked client-server 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, in their book **Decision Support Systems: A Knowledge-Based Approach** (1996), identified five 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. The Holsapple and Whinston characteristics are:

1. A DSS includes a body of knowledge that describes some aspects of the decision-maker's world, that specifies how to accomplish various tasks, that indicates what conclusions are valid in various circumstances, and so forth.

2. A DSS has an ability to acquire and maintain descriptive knowledge (i.e., record keeping) and other kinds of knowledge as well (i.e., procedure keeping, rule keeping, etc.).

3. A DSS has an ability to present knowledge on an ad hoc basis in various customized ways as well as in standardized reports.

4. A DSS has an ability to select any desired subset of stored knowledge for either presentation or deriving new knowledge in the course of problem recognition and/or problem solving.

5. A DSS can interact directly with a decision maker or a participant in a decision in such a way that the user has a flexible choice and sequence of knowledge-management activities.

Sprague and Carlson (1982) and others define Decision Support Systems 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 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.

Case studies from the past 25 years have demonstrated that it is possible to support management activities in many ways. Some DSS help managers by expediting access to information that would otherwise be unavailable or difficult to obtain; others contain explicit models that provide structure for particular decisions. Some systems are primarily tools for individuals working more or less alone on decision tasks; others serve primarily to support communication among people whose work must be coordinated.

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 is finding software and systems that meet a manager's decision support needs and provide appropriate management information.

Management Information

Managers and their support staffs need to consider what information and analyses are actually needed to support management and business activities. Some managers need both detailed transaction data and summarized 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 want financial analyses and some managers want primarily "soft", non-financial 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, 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.

Decision Support Systems need to provide current, timely information that is 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 or 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. **Managers want the right information, at the right time, in the right format, and at the right cost.**

DSS versus MIS

How does a Decision Support System differ from a Management Information System? Let's 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 Decision Support Systems 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).

Decision Support Systems should be defined as a broad category of analytical management 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 Decision Support System 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 Decision Support Systems. The term MIS will be used sparingly and usually it will broadly refer to any information system that assists or supports managers in their various tasks.

Decision Support versus 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 Decision Support Systems. 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 Decision Support Systems.

Technology is creating new decision support capabilities, but much learning and discussion needs to occur to successfully exploit the technological possibilities. Decision Support Systems differ in many ways from operational Transaction Processing or Online Transaction Processing Systems. 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, Enterprise Resource Planning is an integrated Transaction Processing System that facilitates the flow of information between all of the functional areas of a business. Recently, DSS have been built to help managers analyze the data from ERP systems.

This section discusses how Decision Support and Transaction Processing Systems differ. Let's begin by briefly reviewing the concept of a system.

What is a system?

The term system is used in many technology-related concepts including Decision Support System and Transaction Processing System -- both are computing or information systems. Managers and MIS specialists use the concept of a system frequently and yet it is hard for most of us to define and understand the concept.

Let's begin exploring this key term by defining a system as an interrelated set of components including people, activities, technology and procedures that are designed or intended to achieve a predefined purpose. A system receives input from its environment and the various subsystems or components of the system interact to produce outputs. Systems are defined in terms of their components. System components are surrounded by an imaginary boundary that separates a specific system from its environment. A system designer identifies both inputs from the environment as well as the outputs from the system. Systems also have feedback mechanisms to provide a means of controlling the operation of the system. Feedback is an output from a system that later reenters the system as an input.

Let's examine a simple conceptual specification of a system. The initial input into the system is a bank customer requesting a loan. The customer makes a request to a bank officer. The bank officer collects information from the customer and enters that information into a computerized form. A loan approval model is built into a computerized decision aid. Some people identify the computerized model as the actual decision support system. The banker uses the result from the computerized loan approval model to finalize the decision to approve or deny the loan. In some cases the loan information will need to be shared with a loan committee possibly using a group support system. The actual decision is then communicated to the customer either face-to-face or by a formal letter that may be generated by a computerized decision aid. Feedback comes from the customer.

This decision process and the overall conceptual system may include various Decision Support Systems. The bank's Transaction Processing System would be updated when the loan was made and the funds distributed. The loan is the primary transaction. Making the loan is the decision process. DSS can support making loans or a DSS can help analyze lending activity at the bank or predict lending activity and interest rates.

In a Decision Support System, the primary focus is often on the computerized components of the system. This is a narrow perspective for defining the components of a system; it is often helpful to define the DSS boundary to include a broader decision process that may involve people performing non-computerized tasks as well as more routine data gathering tasks. The users of the computerized tools are also part of the broader system. Finally, note that the actual communication or transmission of decisions may not occur using computerized systems. This step in a decision process needs to be considered in the design of the DSS and it should be included within the boundary of the system.

We need to define Decision Support Systems on both a conceptual level and a concrete, technical level. Both managers and DSS designers need to understand what they are trying to accomplish. The specific purpose of a proposed Decision Support System and its components need to be defined early in the design and development process.

Major differences

A major difference between Transaction Processing Systems and DSS is the general purpose of each type of system. Transaction Processing Systems are designed to expedite and automate transaction processing, record keeping, and simple business reporting of transactions. Decision Support Systems 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 Decision Support System use, either by using the DSS herself or by asking a staff intermediary to use a DSS. Some managers and especially clerical employees use Transaction Processing Systems to support operations. DSS are designed for use by line managers and support staff. TPS record current information and maintain a database of transaction information. Some DSS use historical internal and external data for analysis. Other DSS focus on modeling current and future scenarios and incorporate historical data, forecasts, and assumptions. TPS emphasize data integrity and consistency; and although these qualities in a system are important, a DSS places it primary emphasis on flexibility and supporting ad hoc queries and analyses.

One can draw many distinctions between Transaction Processing Systems and DSS, but analysts and managers need to stay focused on the phrase "decision support" in the term Decision Support System. Decision Support Systems 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.

Examples of DSS Applications

Hundreds of DSS applications are described in professional journals like **Interfaces** and in Information Systems trade publications like **Information Week** (http://www.informationweek.com). Many DSS case studies are also available on the World-Wide Web. This section discusses various Decision Support Systems examples and a number of taxonomies of DSS.

One of the long-standing conclusions 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 vary in many ways. They 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. 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.

A few examples show the wide variety of DSS applications. Major airlines have DSS used by analysts 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. Investment evaluation and support systems are increasingly common. Frito-Lay has a DSS that aids in pricing, advertising, and promotion. Route salesmen use hand-held 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 materials requirements planning. More recent MRP systems support "what-if" analysis and simulation capabilities. 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 support distributed decision activities using groupware and a corporate intranet.

Alter's Taxonomy

In 1980, Steven Alter (pps. 73-93) 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 Decision Support Systems. 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, providing pre-specified 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 was that a Decision Support System 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 of DSS. His seven types 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, 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 relationships that are causal as well as 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 typology like Steven Alter's helps reduce the confusion for managers who are investigating and discussing Decision Support Systems. The taxonomy also helps users and developers communicate their experiences with DSS.

Other Taxonomies or Frameworks

Holsapple and Whinston (1996) identify 5 specialized types of DSS (see pp. 178-195). First they identify an evolving group of systems they call Text-Oriented DSS. This type of DSS supports a decision-maker by electronically keeping track of textually represented knowledge that could impact 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 institutional or ad hoc DSS. Institutional DSS support decisions that are recurring. An ad hoc DSS supports problems that are not anticipated and that are not expected to reoccur. Hackathorn and Keen (1981) identified DSS in three distinct yet interrelated categories: Personal DSS, Group DSS and Organizational DSS. Many DSS are designed for a particular problem in a particular company, but some DSS are generic or ready-made DSS (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.

An Expanded DSS Framework

The terms frameworks, taxonomies, conceptual models and typologies are often used interchangeably. Taxonomies classify objects and typologies show how mutually exclusive types of things are related. The general desire is to create a set of labels that help people organize and categorize information. In this section we want to categorize the large number of computerized systems that support decision-making. Sprague and Watson (1996) argue typologies, frameworks or conceptual models are "often crucial to

the understanding of a new or complex subject." A good framework shows the parts of a topic and how the parts interrelate.

A new, broader typology or framework than Alter's is needed today because DSS are much more common and more diverse than when he conducted his research and proposed his framework. Alter's typology is still relevant for categorizing some types of DSS, but not for all DSS. To keep the number of categories in a new framework manageable, one can and should simplify Alter's typology into three types of Decision Support Systems: Data-Driven, Model-Driven and Knowledge-Driven DSS. We can also categorize DSS in terms of internal and external users, specificity or function and technology. The following expanded DSS framework is probably not comprehensive and parsimonious, but it helps categorize the most common DSS currently in use. Some DSS are hybrid systems driven by more than one major DSS component. The framework focuses on one major dimension with 5 categories and 3 secondary dimensions.

Data-Driven DSS

Let's call the first category of Decision Support Systems **Data-Driven DSS.** These systems include file drawer and management reporting systems, data warehousing and analysis systems, Executive Information Systems (EIS) and Geographic Information Systems (GIS). Business Intelligence Systems are also examples of Data-Driven DSS. Data-Driven DSS emphasize access to and manipulation of large databases of structured data and especially a time-series of internal company data and some times external data. Simple file systems accessed by query and retrieval tools provide the most elementary level of functionality. 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 Online Analytical Processing (OLAP) 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). Professor Paul Gray argues that in approximately 1993, "the data warehouse and the EIS people found one another, with the data warehouses obtaining their needed application and the EIS people receiving a new breath of life from expanding beyond the pretty screen."

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.

Knowledge-Driven DSS

The terminology for the 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 can suggest or recommend actions to managers. 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. It 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** or Knowledge Management System, is evolving to help managers retrieve and manage unstructured documents and 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-Based 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, pp. 125-136).

Communications-Driven and Group DSS

Group Decision Support Systems (GDSS) came first**,** but now a broader category of **Communications-Driven DSS** or groupware can be identified. This type of DSS includes communication, collaboration and decision support technologies that do not fit within those DSS types identified by Steven Alter. Therefore, Communications-Driven DSS need to be identified as a specific category of DSS. We will call these systems Communications-Driven DSS even though many people are more familiar with the term GDSS. A GDSS is a hybrid DSS that emphasizes both the use of communications and decision models. A Group Decision Support System 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 enhancing activities. We have a number of technologies and capabilities in this category in the framework -- GDSS Decision Rooms, two-way interactive video, White Boards, Bulletin Boards, and Email.

Inter-Organizational or Intra-Organizational DSS

A relatively new category of DSS made possible by new technologies and the rapid growth of the public Internet is **Inter-Organizational DSS.** These DSS serve a company's customers or suppliers. The public Internet is creating communication links for many types of inter-organizational systems, including DSS. An Inter-Organizational 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 **Intra-Organizational 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 and “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 like 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 Suggestion 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 function or a production function). This type of DSS is 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.

Web-Based DSS

Finally, all of the above types of DSS can be implemented using Web technologies and we can call these systems Web-Based DSS. A **Web-Based DSS** is a computerized system that delivers decision support information or decision support tools to a manager or business analyst using a "thin-client" Web browser like Netscape Navigator or Internet Explorer. The computer server that is 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 is supporting a large group of managers using Web browsers in a networked environment. Managers often have Web access to a data warehouse as part of a DSS architecture. Today Web technologies are the primary tools used to create Inter-Organizational DSS that support the decision-making of customers and suppliers.

Web or Internet technologies are the leading edge for building DSS, but some Intra-Organizational DSS will continue to be built using traditional programming languages or fourth generation languages or application development tools using “thick-client” or mainframe enabling technologies.

Column one of Table 1.2 list five broad categories of Decision Support Systems that differ in terms of the DSS technology component, including Communications-Driven DSS, Data-Driven DSS, Document-Driven DSS, Knowledge-Driven DSS and Model-Driven DSS. Subsequent chapters explain these categories in more detail and identify development and implementation issues. The new DSS framework also categorizes Decision Support Systems by user groups – intra-organizational and inter-organizational. The new category called Inter-Organizational DSS helps us 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. A New DSS Framework.

From a different perspective, Decision Support Systems can be categorized by the purpose of the DSS. Many DSS have a narrow, focused, 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. We can use dominant DSS component, user group, purpose and enabling technology to categorize a specific system. For example, we may want to build a Model-Driven, Inter-Organizational, Product Design, Web-Based DSS.

Building Decision Support Systems

Traditionally, academics and practitioners have discussed building Decision Support Systems 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 DSS framework is based on the different emphases placed on DSS components when systems are actually constructed (see Figure 1.1).

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. Experience and some empirical evidence indicate that design and implementation issues vary for Data-Driven, Document-Driven, Model-Driven and Knowledge-Driven DSS. Multi-participant systems like Group and Inter-Organizational 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 DSS 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, the analyst should be

concerned about possible misunderstandings of what the model means and how it can or cannot be used (cf., Alter, 1980, p. 92). Networking issues create challenges for many types of DSS, but especially for Communications-Driven systems with many participants, so-called multi-participant 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 Group DSS are often purchased as off-the-shelf software. Creating Enterprise-Wide DSS environments remains an iterative and evolutionary task. An Enterprise-Wide DSS grows and 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.

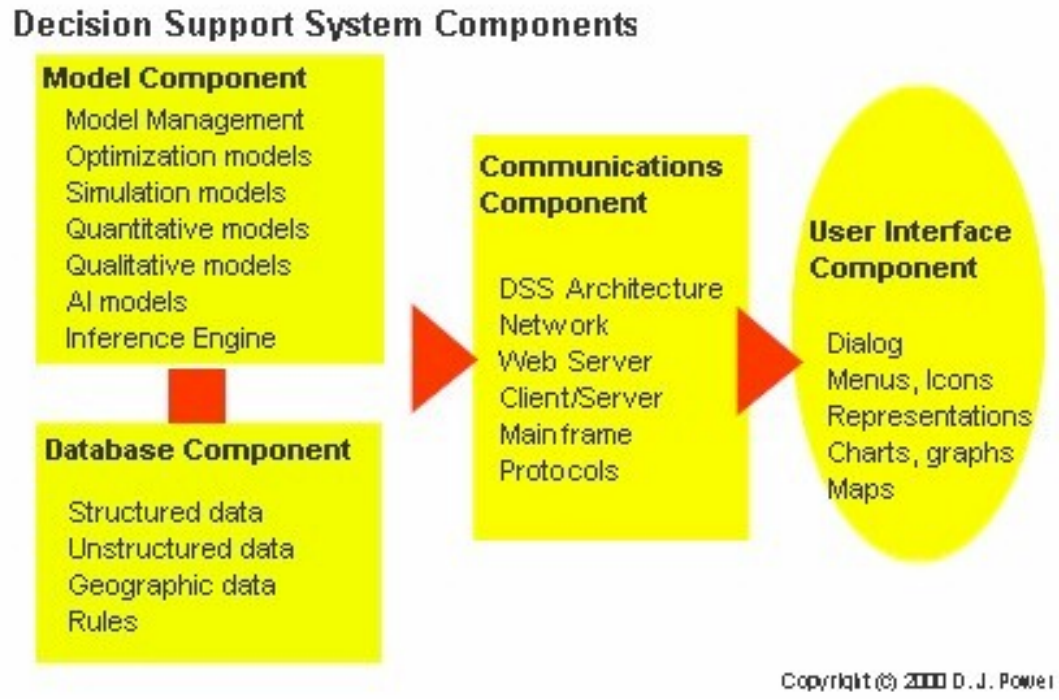

Figure 1.1. Traditional DSS components.

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. We are expanding the data 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. 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, often repeatedly, 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. Suggestion DSS use special models for processing rules or identifying relationships in data.

The DSS architecture and networking design 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. Managers and MIS staff both need to develop an understanding of the technical issues and the security issues related to DSS architectures, networks and the Internet. Networking is the key driver of Communications-Driven DSS.

Managers and DSS analysts both need to emphasize the user interface component. In many ways the user interface is the most important component. The tools for building the user interface are sometimes termed DSS generators, query and reporting tools, and front-end development packages. Much of the design and development effort should focus on building the user interface. We need to remember that the screens and displays in the user interface heavily influence how a manager perceives a DSS. What we see 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 Information Systems professionals to centralize and control information and yet easily distribute it in a timely manner to managers who need it. Also, the internal Internet or Intranet is providing many opportunities for delivering information from data warehouses, models and other tools to the desktop. The Web DSS permit and encourage further analysis and collaboration. The technologies and software associated with Decision Support Systems continues 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 new 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. The DSS design and development environment is changing as rapidly as the software tools and in as positive a direction. The Web technologies will facilitate improved DSS tools at manager's desktops.

General Managers need broad knowledge of the managerial and technical issues associated with the various categories of Decision Support Systems. MIS professionals

need this same general knowledge and they need specific skills in analysis, design and development of DSS.

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 still occur. Failures occur in leading edge application areas and for what turn out to be overly ambitious projects. A shortage of MIS professionals is also slowing development in some areas and increasing failures of innovative systems. All of us need to recognize that resistance to change and insufficient user involvement contributes to DSS project failure in some situations. Managers need to resolve political issues associated with building new Decision Support Systems and 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 email?

Managers and MIS practitioners need to consider at least five major issues associated with building and using Decision Support Systems. First, we must determine what business and decision processes should be computerized? And in some situations we need to ask what part of the process should be supported? In many companies this issue needs to be re-examined for current Decision Support Systems. Chapters 2 and 3 address this issue. Second, we 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, we need 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 Decision Support Systems are creating results that are "decision-impelling"? (based on Davis, 1974, p. 6). Chapters 7 to 11 review the possibilities for building innovative DSS.

Finally, we need 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. Understanding the various categories of Decision Support Systems that can be built begins the task of rationally answering the above questions. Subsequent chapters provide more elaboration and some details.

Decision Support Systems 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 is 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 to support decision-making have increased, but we still have very real technical, social, interpersonal and political problems that must be overcome when we build DSS. Chapter 12 addresses these issues and the evaluation of proposed DSS projects.

Audit Questions

1. Does your firm actively manage decision-relevant information?
2. Has your firm implemented any computerized systems to support decision-making?
3. Are you using any Decision Support Systems? If so, from what category?

Questions for Review

1. What is the MIS concept? How is it related to DSS?
2. What are the major characteristics of a DSS?
3. How does a Transaction Processing System differ from a Decision Support System?
4. What are the categories of DSS included in the proposed DSS framework?
5. What components are common to the design and implementation of computerized Decision Support Systems?
6. What were the two main streams of research that led to the evolution and development of Decision Support Systems?

Questions for Further Thought

1. Do managers need the support provided by DSS?
2. Is it realistic to use technology to support decision-making?
3. Do managers want to use decision support tools?
4. What experiences have you had using Decision Support Systems? What was a good experience? What is an example of a bad experience?

Internet Exercises

1. Find an example of a Decision Support System at a Web site. Use the DSS Framework and classify the DSS.
2. Search for the term DSS using 2 Web search engines.
3. Visit the Web sites of Information Week (www.informationweek.com), Internet Week (www.internetwk.com) and CIO (www.cio.com) and search for articles on key terms from this chapter like DSS, and MIS.

Brief Examples of DSS Implementations

Advanced Scout

IBM has prototyped software to help National Basketball Association (NBA) coaches and league officials organize and interpret the data collected at every game. Using software called Advanced Scout to prepare for a game, a coach can quickly review countless stats: shots attempted, shots blocked, assists made, personal fouls. But Advanced Scout can also detect patterns in these statistics that a coach may not have known about. Advanced Scout software provides an easy and meaningful way to process information. "It helps coaches easily mine through and analyze a lot of data and no computer training or data analysis background is required," says Dr. Inderpal Bhandari, computer scientist at IBM's T.J. Watson Research Center. Patterns found through analysis are linked to the video of the game. Coaches can look at just those clips that make up an interesting pattern (check http://www.research.ibm.com/scout/works.html).

BCA DSS (Base Closure and Analysis DSS)

An application called the Base Closure and Analysis DSS provided the U.S. Air Force with a robust methodology and common framework for analyzing the impact of various base closure scenarios. The software used a multi-layer, hierarchical filtering process to evaluate the relative impact of closing each base. Bases that posed minimum strategic, operational, social, and economic impact were placed at the top of the closure recommendation list. At any step, base closing committee members could review DSS-developed impact analyses to assist in determining which bases should be included in the next level of analysis. Using the DSS, the committee members could perform analyses using eight main criteria and 212 sub-criteria on which all bases were evaluated. These criteria, specified by DOD, focused on elements that impact operational effectiveness, including such items as alternate airfield availability, weather data, and facility infrastructure capacity (from URL http://www.strategy.com/success/msi_saf1.htm).

FedEx Business Intelligence System

Federal Express, based in Memphis, Tenn., rolled out Business Intelligence capabilities to a global base of 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. The solution, from Pinnacle Solutions Inc., was deployed on a group of Dell PowerEdge servers running Windows NT Server 4.0. Data is stored in an Oracle database, and analytical queries are run against a separate server running Hyperion Essbase, an online analytical processing (OLAP) engine. Most access is from browsers over the corporate intranet, along with some standard client/server deployments using Excel spreadsheets.

ShopKo

In 1997, ShopKo developed a "Merchandise Data Warehouse." ShopKo stores carry 200,000 stock units of data. This results in massive amounts of data. Sales statistics on every stock unit in every store is collected daily and stored in a data warehouse. This central data repository is used in analysis, querying, and decision-making. The main strategy in developing the DSS tool was to allow ShopKo associates to query a common business repository for identification and analysis of business opportunities and

exceptions. With this strategy, ShopKo stores are able carry the right merchandise at the right time in the right place while remaining current with changing demands due to seasons, trends, etc. Some of the important goals of this project were: improvement of sales analysis, understanding of inventory levels, determining market trends, and improvement of advertisement effectiveness. ShopKo extended its DSS capabilities to its store units by using a Web-based DSS.

Y2K GroupSystems Online

During the week leading up to and immediately following January 1, 2000, approximately 150 people participated in the crisis management activities 24 hours a day, 7 days a week using GroupSystems OnLine. Representatives from the Office of the Secretary of Defense, C3I, JCS Staff, Federal Emergency Management Agency (FEMA), the State Department and Legislative Affairs among others participated in crisis management sessions over a secure Intranet within the Pentagon known as the SIPRNET. Although major crises did not materialize during the course of the two-week period, some non-crisis events did occur that required internal action and decision making on the part of the Pentagon. GroupSystems OnLine was used to communicate information and it was used to provide input, discuss solutions and create reports of recommended action (cf., http://www.groupsystems.com).

Questions for discussion of the case examples:

1. Use the DSS framework to categorize the examples. What type of DSS was implemented?

2. Does each DSS seem useful? Would you use the system?

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This chapter is a working draft. I would appreciate your comments and feedback. This chapter may be used for non-commercial or academic purposes during Year 2000. Last revised by D. J. Power, Sunday, September 24, 2000, email power@dssresources.com.