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MODERN INFORMATION SYSTEMS FOR AGRICULTURE:
THEORETICAL CONCEPTS AND PRACTICAL APPLICATIONS

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MODERN INFORMATION SYSTEMS FOR AGRICULTURE: THEORETICAL CONCEPTS AND PRACTICAL APPLICATIONS*

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The need for more and better information on which to base decisions is not a new problem. In recent years this problem has become even more paramount for agricultural managers particularly in industrialized countries. Today's farm managers are confronted with numerous government regulations, changing tax laws, new emerging technologies, and changing institutions. All these factors make managing a farm a more demanding task. Furthermore, with the agricultural markets becoming more competitive from an international viewpoint, the managers must identify areas where they have a comparative advantage. A wrong decision may have a major long-term impact on the farming operation. Therefore, new and more effective farm level information systems are needed.

This paper has two main sections. First, a review of decision support systems concepts and second, a discussion of our efforts at Michigan State University to build a decision support system for U.S. commercial farming operations.

Decision Support System Concepts

The process leading to the development of decision support systems has been more evolutionary than revolutionary. During this evolutionary process, some concepts have emerged as being more important than others. A concept that has withstood the test of time is one proposed by Davis (1974) and others in which they make a distinction between data and information. This distinction is important because it emphasizes the problem associated with developing and utilizing modern information systems to support decision making. Davis defined data as "a group of non-random symbols which represents quantities, actions, things and so forth. Information is data that has been processed in a form that is meaningful to the recipient or is of real or perceived value in current or prospective decisions." Therefore, for data to be useful for decision making purposes, it must be processed into useful information. Hence, information is data that has been evaluated in the context of a specific problem. (See Figure 1)

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+-------------+        +-------------+        +-------------+
:             :        :             :        :             :
:    DATA     :------> : PROCESSING  :------> :INFORMATION  :
:             :        :             :        :             :
+-------------+        +-------------+        +-------------+
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Figure 1. Transformation of Data Into Information

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Researchers, farm managers and others operate under the mistaken impression that more data results in better decisions. This is only true if it can be processed into information. For example, commodity prices are only useful to the farm manager if he or she is able to convert that data into information on which he or she can base marketing decisions. Likewise, micro-climate data is only useful if it can influence decisions such as helping the farm manager determine the optimal time to spray for pests or to harvest a crop.

In agriculture, as well as in other areas, a significant amount of effort has been directed at increasing the amount of data available, improving upon the processing procedures used to transform data into information, and working with decision-makers to improve their analytical skills to better utilize information for decision making.

This whole process of building better information systems has been greatly accelerated with the advent of computer technology. As computer technology has become more sophisticated, easier to access and more cost effective, information systems have also become more effective and easier to use. In the early 1960s, there was great enthusiasium related to the use of electronic data processing (EDP) in agriculture. A number of conferences were held to discuss possible application areas. From some of these conferences, proceedings were published (IBM, 1965). The proceedings indicate a high level of optimism regarding the potential of EDP to improve management decisions of agriculture operations. The main areas identified as appropriate for EDP were financial and production record systems and the use of optimization techniques, particularly linear programming. As computer technology was applied in these areas, it soon became apparent that there were limitations as to the ability of computerized record systems to improve the decision-making process. Likewise, the use of optimization techniques was constrained by the large amount of time needed to collect the necessary data, transform it into the form required by the standard algorithm available on mainframe computers, generate the results and explain them to the decision-maker. Thus, some of the optimism associated with the advances in computer technology was certainly tempered and new directions were sought.

Improvement in computer technology continued at a rapid pace in the 1960's. Among the improvements emerging in the late 1960's were time-share computer systems, communication networks and more powerful and cost-effective mainframe computers. These advances, coupled with a better understanding of the shortcomings experienced with EDP systems, resulted in the development of management information systems (MIS). These systems contained more problem-solving capabilities and generated standard reports that were more useful to decision-makers. Several MIS projects originated in agriculture. Most were narrowly focused and relied heavily on computerized decision aids as the main building blocks of the system. As a rule, these models were rather fixed in structure and there was little opportunity to share or transfer data from one model or sub-system to another (Harsh, 1979 and Blackie and Dent, 1979). For example, it was not possible to directly use data from the accounting sub-system to drive a cashflow projection model and subsequently pass the cashflow projections back to the accounting sub-system to be used as control parameters.

Although the MIS concepts are more progressive than the EDP approach, there are acknowledged deficiencies. These deficiencies, coupled with further advances in computer technology such as the availability of low-cost microcomputers, development of non-procedural languages, improvements in user interfaces, refinements in database management systems and development of expert system shells, resulted in a strong interest in developing decision support systems for agriculture. These systems are argued to be more flexible and powerful than the earlier developed information systems and thus are in a better position to support managers in their decision-making process. For some, the distinction between the various systems may not be that obvious. Anderson and colleagues (1982), drawing upon the concepts presented by Moore, Chang and others, categorize the systems as follows:

1. Transaction Processing System (TPS)--data processing programs for gathering, updating and posting information according to pre-defined procedures. Examples include a basic payroll system or an order processing system.

2. Management Information System (MIS)--a system with pre-defined aggregation and reporting capabilities often built upon a TPS. Examples include a payroll system with managerial reports such as a labor distribution summary.

3. Decision Support System (DSS)--an extensive system with capabilities to support ad hoc data analysis and reduction as well as decision modeling activities. Examples include a general ledger-based planning system with both pre-formatted and user defined reports loosely interpreted as models.

There are other authors that choose to view DSS in a somewhat different vein. For example, Mills and colleagues (1986), considered the above three classes of systems as part of computer (based) information systems (CIS). The procedures and principles used in developing any of the systems is the same. The main difference relates to the level of management the system is designed to support.

What are Decision Support Systems?

Currently, it seems to be in vogue to indicate you are developing or using a decision support system. Exactly what does it mean when one uses the term "decision support system?" Ginzberg and Stohr (Ginzberg, 1981), in their review of the development of decision support systems observed that in the early 1970's, that a decision support system would generally be defined as "systems to support managerial decision-makers in an unstructured or semi-structured decision situations." The key concepts in this definition are support and unstructured.

These systems do not attempt to replace managers by making decisions for them, but rather supply the manager with the analytical tools and data for them to use in arriving at a decision. They also address primarily unstructured decisions rather than structured ones. Structural decisions are those in which the proceedures for arriving at an appropriate decision are well established and accepted. For example, the feeds to include in an animal ration can be determined with a linear programming model that has been developed for ration balancing. Arriving at structured decisions generally does not require significant management resources because the proceedures are well defined.

Alternatively, with unstructured (semi-structured) decisions, the proceedures to arrive at a decision are less defined and usually more complex. For example, a major expansion of the business would involve evaluating the effectiveness of subcomponents of the business (e.g., machinery systems, cropping systems, livestock housing facilities), the financial impact of the change, and so forth. With these decisions, greater management input and analyses is needed.

Definitions as suggested by Ginzberg and Stohr, captured the main concepts of decision support systems through the 1970's. However, by the end of the decade, new definitions began to emerge. Alter (1980), defined decision support systems by contrasting them with a more simplistic EDP system (See Table 1).

Table 1. Difference Between Information Systems

Dimension	Decision Support Systems	Electronic Data Processing
Use	Active	Passive
User	Line staff, Management	Clerk
Goal	Overall Effectiveness	Mechanical efficiency
Time Horizon	Present and Future	Past
Objective	Flexibility	Consistency

Source: S.L. Alter, Decision Support Systems: Current Practices and Continuing Challenges, 1980.

The framework suggested by Keen and Morton (1978), can also be useful in contrasting decision support systems with the other systems for operational control, management control and strategic planning. (See Table 2) Operational control is concerned with performing predefined activities, whereas management control involves management acquiring resources and insuring they are effective and efficient to achieve the firms objectives. Strategic planning involves setting or changing the firm's objective. It is interesting to note that many of the decisions for which we have developed agricultural computer models would likely be classified as structured. They also stress that a goal of DSS is to improve the effectiveness of decision making rather than its efficiency. They define effectiveness as being able to make timely and correct decisions, whereas, efficiency relates to the amount of managerial resources needed to reach a decision.

Sprague and Carlson (1982), presented a somewhat similar and expanded definition of decision support systems. They define decision support systems as "computer based systems that help decision-makers confront ill-structured problems through direct interaction with data and analysis models." Some of the key words in this definition are computer-based, help decision maker, ill structure, direct interaction data and analysis models.

Table 2. A Framework for Information Systems

	Management Activity			
Type of Decision	Operational Control	Management Control	Strategic Planning	Support Needed
Structured	Inventory control rations	Least cost mix models	Choosing enterprise Man. sci.	Clerical or
Semi-structured	Restructuring the farms debt	Set production goals for the business	Expanding the support business	Decision systems
Unstructured	Hiring farm employees	Delegation of business responsi-abilities	Major re-structuring of the business	Human intuition

SOURCE: Adapted from Keen and Morton (1978) to reflect agricultural examples.

Current Conceptualization of Decision Support Systems

Today, many authors are arguing that Decision Support Systems are composed of models, databases, a user interface and a decision-maker. The above definition by Sprague and Carlson certainly contained these basic components. The conceptual design of decision support systems as proposed by Watson and Sprague (House, 1983), also reflected the basic components of a modern decision support system (See Figure 2). The model base, database and user interface are linked by an integrated database and model base management system. Although a DSS must contain all the basic components, each one will be examined independently.

Database and Database System

A database system is used to store classes of data which have been collected for various purposes such as financial data, production data, marketing data, and so forth. This data can be generated by the firm itself or it can come from external sources. The various databases need to be consistent within the overall structure and need to be shared across functional needs. This means that the accounting data is not stored using a different system than the production or marketing data. Likewise, when the data is entered into the system for one purpose, such as sales data in the financial records sub-system, if it has important data elements which are needed by other record sub-systems (e.g. production records), the data elements need to be appropriately cross linked. Data dictionaries are often employed to help manage the

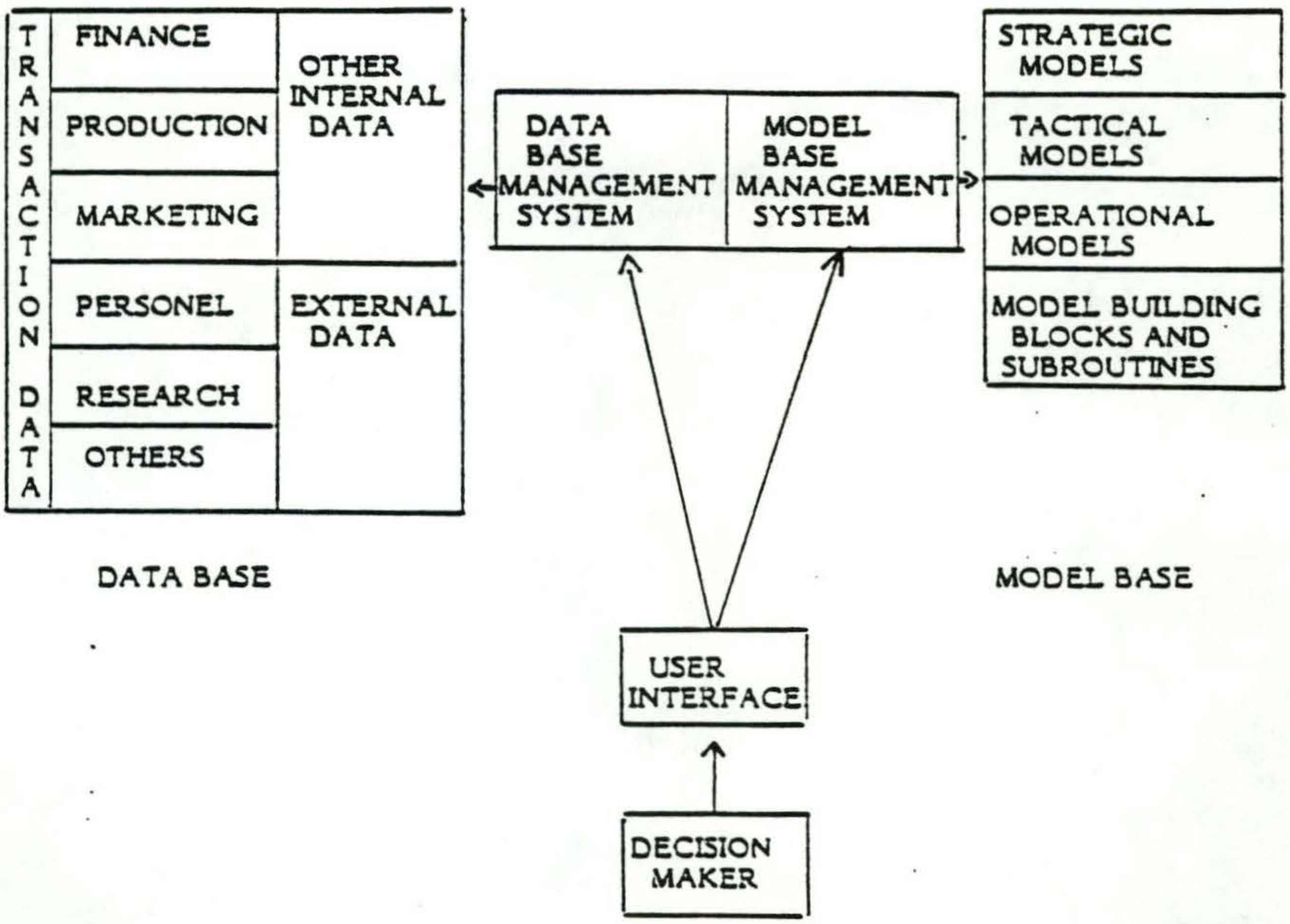

Figure 2. COMPONENTS OF A MODERN DECISION SUPPORT SYSTEM

various sub-databases and data elements. Also, the database management system has the ability to automatically extract data needed by the model based component of the system and likewise take results generated by the model base component and store it in the appropriate sub-system of the database. Obviously, this is a very advanced and integrated database system.

Model Base and Model Base System

Related to the database is the model base. There are several types of models contained in the model base. Some are used for doing strategic planning, and others are used for tactical and operational decisions. The model base is constructed in a modular fashion. This allows for the linking of models together to solve larger or more complex problems.

The model base management system performs the same basic role as the database management system. It is charged with retrieving the appropriate model (or models) needed for the analysis and then requesting the necessary data for the database system and/or the user. If necessary, it can link models together to address large problems and pass results from the models to the database for storage and later use.

Alter (House, 1983) developed a classification system to describe various modeling approaches, that can be used in developing DSS. In his classification system (see Figure 3), he stressed that systems are either data-oriented or model-oriented. There are three data-oriented systems: a) file drawer systems concept, b) data analysis systems and c) analysis information systems. The file drawer system basically reflects a computerization of information that was previously kept in files or notebooks. The computerization simply increases the speed and flexibility of access to the information.

Data analysis systems allow for the manipulation of data by means of a set of general purpose commands. A good illustration is the use of a general purpose database system to tabulate information on which further analysis might be desirable.

The analysis information systems provide access to a series of databases and a small set of models from which analyses can be made. These systems are more powerful than the proceeding systems but the analytical models are still somewhat simplistic in design. The transactional processing or EDP systems (e.g., accounting and payroll systems) are examples of data systems.

File Drawer Systems	Data Retrieval	Data Oriented
Data Analysis Systems	Data Analysis	
Analysis Information Systems		
Accounting Models	Simulation	Model-Oriented
Represented Models		
Optimization Models	Suggestion	
Suggestion Models		

Figure 3. Data-Oriented vs. Model-Oriented Decision Support System Types

As a general rule, the systems that are data oriented tend to be most useful for supplying descriptive and to a lesser extent, diagnostic information to the decision-maker. However, they have limited capabilities of providing predictive or prescriptive information. This is not to belittle the importance of these systems, it simply points out the need for model-oriented systems.

There are four types of model-oriented systems: a) accounting models, b) representational models, c) optimization models and d) suggestion models. Accounting models calculate the consequences of planned actions using an accounting structure. Programs for forward financial planning are examples of such systems. The input/output coefficient of these models are, for the most part, fixed in nature. Even considering some of the shortcomings of accounting models, they remain rather popular techniques for planning purposes.

Representational models attempt to predict the consequences of the actions based on predefined relationships of the system. These models have become fairly sophisticated in their modeling approach and their main objective is often to identify the various interactions of the overall system.

Accounting and Representational models are basically simulation models. They do not give normative answers. Indeed, the decision-maker is charged with using heuristics skills with these models to improve upon previous solutions.

Optimization and Suggestion models constitute the suggestion group. Optimization models are normative in nature because they suggest to the manager exactly what should be done. They supply prescriptive information, and are based on an algorithm that finds an optimal solution within the constraints placed on the problem. Some examples of optimization model uses are linear programming techniques, and to a lesser extent, adaptive control theory.

The last grouping, Suggestion models, perform mechanical work leading to specific suggestions for a fairly structured question. These models have a specific task, performing a set of calculations to achieve a specific recommendation. There are two new activities in the suggestion models area that are particularly interesting and exciting. One activity is the application of expert systems. There are numerous expert systems that have been developed or are being developed for micro-level decisions. Expert systems can be designed to perform several different functions, such as document knowledge or to verify one's own knowledge. However, the primary uses of these systems is to serve as an expert when an expert is unavailable. In this context, they are being used for diagnostic purposes and as a prescriptive tool. The second activity relates to the use of probabilistic models that address decision making under a risk and uncertainty environment.

User Interface

The user interface is one of the more important components. It is interactive in nature and helps the user translate his/her desire for information into a series of commands to give the DSS in order to obtain the desired information. To accomplish this objective, the user interface must be easy to use and provide the user with suggestions on how to proceed. It must also present the information in an understandable form (e.g., use of graphics).

For some problems, this process is fairly straight forward; in other cases it can be quite complex. Benezek and colleagues (1981), argued that the user interface can be the most critical and most difficult component of a DSS. Therefore, its design should not be taken lightly. Bennett and others (1983), state that expert systems can play a role in directing the user on how to proceed with the analysis of the problem situation. Indeed, one of my colleagues, T.J. Manetsch at Michigan State University, in the Systems Science Department, is using an expert system to help instruct the user how to use the appropriate model (e.g., simulation vs optimization) for the problem situation confronted and for the specific goals of the decision-maker.

The Decision-Maker

If information systems are to be successfully utilized, the decision-maker's analytical and conceptual skills need to be improved. Several universities, agribusinesses and other organizations have already conducted workshops that train end users on the fundamentals of computers. These training workshops explain the various hardware components and expose them to the standard set of general purpose software packages such as electronic spreadsheets, database management systems, general financial packages and some office support software (e.g., word processing packages). However, to effectively use either the general purpose software or special purpose agricultural software contained within a DSS, the users must have adequate conceptual skills to apply the appropriate software to their unique problems. For example, for an economics problem, the user needs to know whether capital budgeting, cash flow planning, linear programming, or some other analysis technique is appropriate for the problem at hand. A major educational effort will be required before a large proportion of the agricultural managers have these skills. To help in this educational effort, some of the newer software being developed has the capacity to educate the end user, many of the expert systems will explain the logic rules used to arrive at a conclusion, and some of the newer decision aids have educational features built into them.

Integrated Decision Support System Project at Michigan State University

Background

A common means to describe the design and functioning of a decision support system is to illustrate with examples. The following is a description of our efforts at Michigan State University to build a DSS for a dairy/cash crop farm.

Michigan State University has a long history of applying computer technology to microlevel decision making. The TELFARM system, a computerized accounting system, was started in the mid 1960's. This system continues in operation with approximately 1400 farms half of which are dairy farms. More recently, a microcomputer version of this system has been developed for field use. Michigan was one of the leaders in getting the DHIA system established and in using computers to process the information. The TELPLAN system, a system of nearly 60 decision aids which runs on time sharing computers, was made available to extension agents, farmers and others since 1969. The PMEX system, an integrated pest management system, broke new ground in biological monitoring and pest modeling. There are many models in this system that address microlevel decision making as it relates to pest management.

More recently, Michigan State University established the COMNET system, a computerized communications network that has the capability of delivering timely information to farmers and others. This system has been used to download pest alerts, market information, weather forecast, and give current production recommendations and other information to extension agents, farmers, and agri-businesses. The FAHRMX system, a computerized system for monitoring and tracking the animal health situation for individual dairy farms, was also built and implemented at Michigan State University. Currently, an ongoing project is in the area of computer aided design of agricultural facilities.

Even though a large amount of computer software has been developed for these various systems, the software as a general rule, was lacking in integration ability. The results of one system could not easily be fed into another. As a result, it was decided that it would be desirable to integrate these numerous system into a more comprehensive package, an integrated decision support system for Michigan farms. Reaching this decision was encouraged by the availability of a new research and educational dairy center and farm at the Kellogg Biological Station.

The dairy center and farm at the Kellogg Biological Station (KBS) has activities in the areas of teaching, research and extension. The farm is used for internships to teach students the principles involved in managing and operating a dairy. Research activities are concentrated in the study of dairy and crop production practices. The extension program disseminates to various clientele the latest economically viable research findings and productive practices. The dairy center and farm at KBS are a cooperative effort in agricultural education and research between Michigan State

University and W.K. Kellogg, and more recently the W.K. Kellogg Foundation. The idea of the current KBS dairy center and farm came into being in 1978, and was established through the time and effort of a great many individuals affiliated with MSU. The W.K. Kellogg Foundation provided the grant dollars necessary to make the KBS dairy center and farm a reality.

The farm has 855 tillable acres. A major proportion of this is currently planted to corn and alfalfa. Of this 855 acres, approximately 300 acres are irrigated with two automated systems. The farm has a capacity for 150 milking cows. The dairy herd is currently made up of registered Holstein cows. The milking parlor is a double-six herringbone. It has been designed to permit milking research, so it contains detachers, in-line meters, back flushing and flush tanks for cleaning. It has also been designed to allow for easy electronic data collection of information in the parlor. The dairy barn is a free-stall dairy barn with natural ventilation and it uses a flush system for cleaning. Cows can be easily grouped for research and production testing, and the feeding system is in line feeders.

The manure system is a liquid-solid system. Manure solids can be separated and used for bedding. The liquids can be re-circulated for flushing or irrigation purposes. Heifers can be grouped by age in free-stalls. The young stock are managed in hutches. Both bunker and upright silos are used for feed storage. There is a hay barn for dry hay feeding. The farm also has a modern machine storage/shop building. The on-farm microcomputers are IBM-AT and IBM-XT compatible.

In addition to the dairy center and farm at the Kellogg Biological Station, there is a VAX11/780 minicomputer that can be used for research. Also located at the conference center at KBS is a microcomputer laboratory that can be used for educational workshops. It is anticipated that this laboratory will also be used to train farmers on how to apply the concepts of an integrated decision support system to their own operation.

Because of the wide diversity of software that has already been developed and is available at Michigan State University, a computerized communications network, and the unique opportunities made possible by the Kellogg Biological Station dairy center/farm, it was felt by many that unique opportunity existed for the development of an Integrated Decision Support System (IDSS).

Project Objective

The objective of the project is to improve the efficiency, profitability and long term viability of Michigan farms by improving the decision making process through the development of an on-farm integrated decision support system. The IDSS is intended to provide Michigan farm managers with a set of tools that will aid them in making more timely and correct decisions through both electronic collection of necessary data and processing that data into management information using decision aids and simulation models.

Project Team and Administration

The IDSS project is multi-disciplinary with a project team composed of scientists from four lead departments: Crop and Soil Sciences, Animal Science, Agricultural Engineering and Agricultural Economics. Other departments are involved as well. The team makes major decisions regarding the project as a unit rather than each department working independently under the overall structure.

The IDSS is jointly funded by the Agricultural Experiment Station and Cooperative Extension Service. It is also administrated at the level of the Director's office rather than at the departmental level. This level of administration helps resolve many problems and conflicts.

Development Strategy

The development strategy is illustrated in Figure 4. The IDSS will be built on a commercially available relational database system. We are currently working with a package that uses the Standard Query Language (SQL) structure. The database will allow data from several sources to be cross referenced for daily, weekly, monthly or annual reports, as well as supplying input data for farm planning. It also more easily allows for ad hoc data analysis which is an important function of a decision support system. The use of commercial software wherever possible is important in order to reduce the resources needed for software maintenance and development.

The modeling strategy used is an "open architecture" approach. This approach allows for the models to be used either within the structure of the IDSS or as "stand-alone" models. When a model operates as part of the IDSS system, data needed by the model is automatically extracted from the IDSS database by the database system and selected results from the model are subsequently stored in the database. Whereas, if the model is run in a "stand-alone" mode, the user is prompted for all the needed data. This "open architecture" approach is important if the software is also to be used in Extension.

Transactional Processing

One of the key aspects of the IDSS project will be building an information network as illustrated in Figure 5. The information network will implement electronic data gathering in order to reduce the burden placed upon the manager for entering data (automation of some of the TPS aspects of the system). It is our hypothesis that systems that make excessive data entry demands upon the manager will generally have a low level of success.

The TPS components that will likely be included in the IDSS project include:

1. Animal (weight, milk production, and feed consumptions
2. Feed Parameters (quantity, quality)
3. Field Parameters (treatments, production)
4. Weather (temperature, humidity, precipitation)
5. Plant Growth (lysimeter, observation)
6. Machinery (fuel consumption, maintenance records)
7. Financial Transactions
8. Personnel Records
9. Evaporation Data
10. Soil Moisture
11. Pest Scouting
12. Market Prices

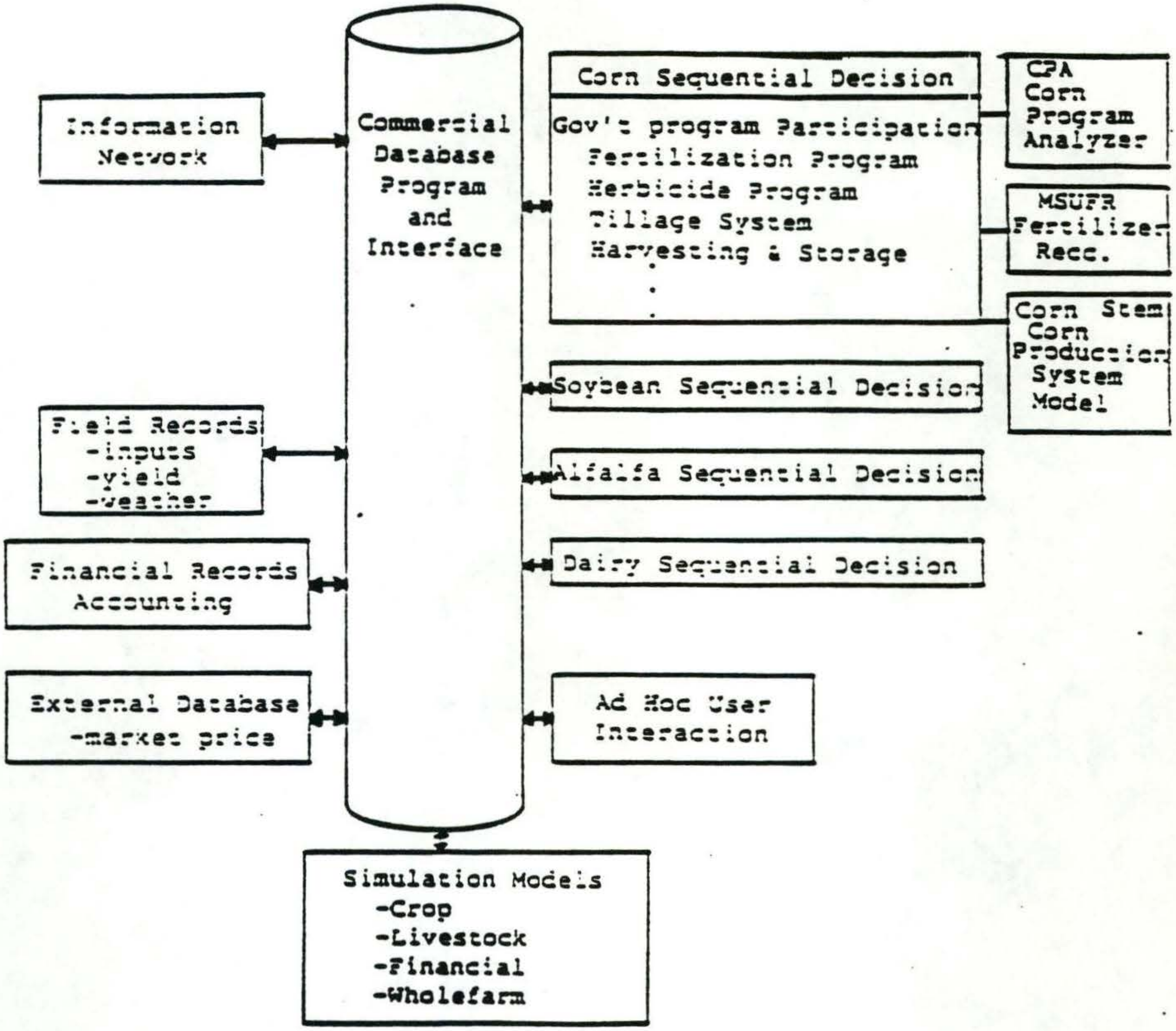

FIGURE 4. IDSS System Design

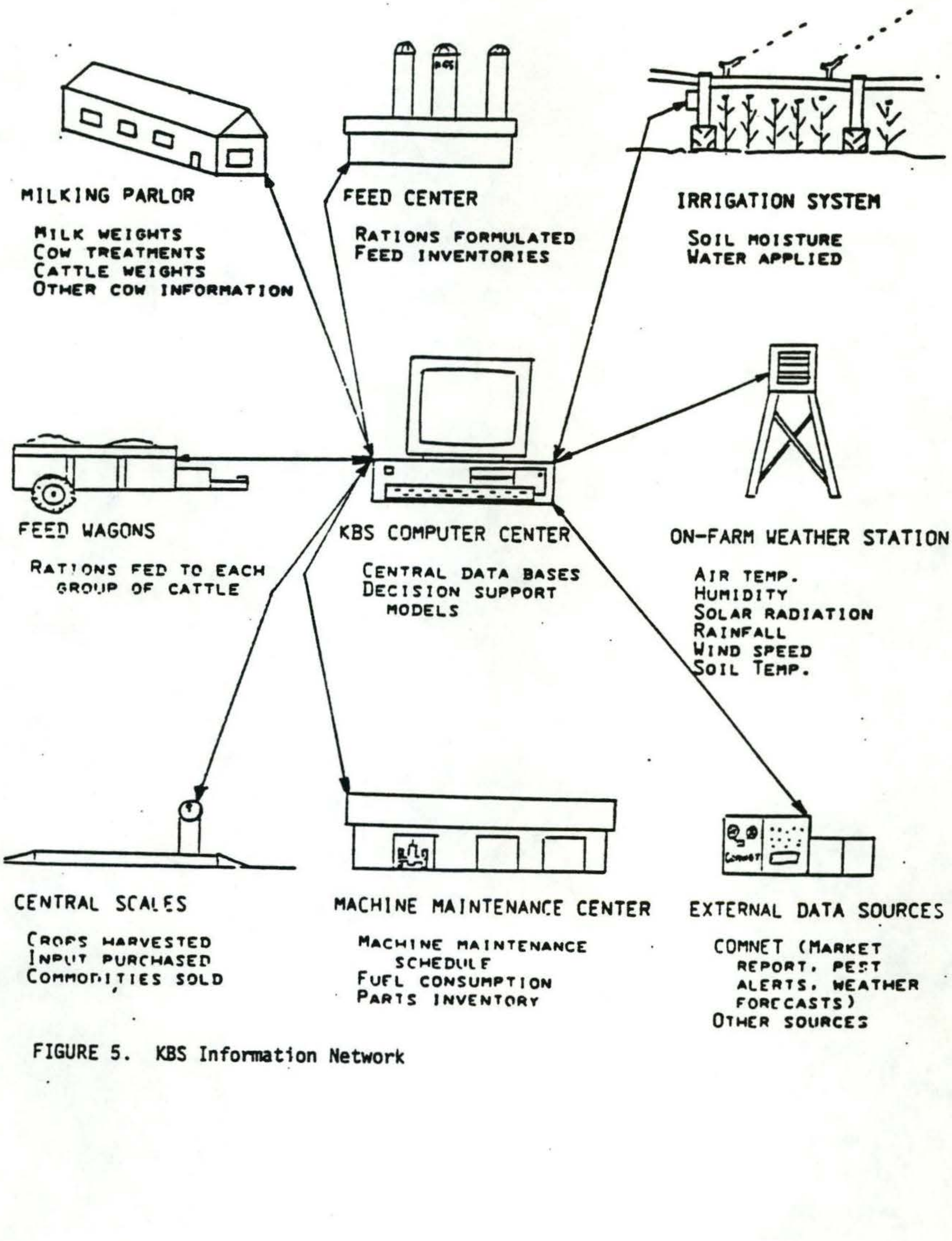

FIGURE 5. KBS Information Network

Management Information

Management information needs include both near term and long range decisions. These decisions may also be classed as tactical and strategic decisions. Tactical decisions include those decisions that occur routinely, (e.g. daily, weekly or annually). Examples include the choice of the best ration to feed dairy cows, the optimum level of fertilizer to use on corn or alfalfa and which pest strategy to use There are many tactical decisions that face a farmer during the course of the year. Some are more important from a management projective than others. The decisions that the IDSS project team have identified as being the most important are listed in Table 3. The priority ranking reflects the needs for the future and acknowledges that some IDSS components have already been developed.

Strategic decisions address long range planning decisions that are often less structured than tactical decisions. The strategic decisions can be addressed through interactive use of the decision modules, as well as through ad-hoc analysis of the data in the database. An important and unique component of the IDSS project is the inclusion of simulation models that can draw data from the database to provide predictive type data that is useful for both strategic and tactical decisions. These simulation models will include dairy-forage models (DAFOSYM), crop growth models (CERES:MAIZE, CERES:WHEAT,...) and animal growth and production models.

Prototype Development

A working prototype of the concepts involved will be developed and implemented at the KBS dairy facility. Its purpose is three-fold. First, it serves as a test site for the decision concepts perceived to be important for agricultural production management. Second, it is an evolving guide for the conduct of component research that is needed to help understand various parts of the production system that have not been adequately quantified in the past. Third, it will serve as a model of principles and procedures for commercial concerns in the development of new products for the farm equipment industry.

Interactive computer graphics technology (ICG) will provide a more understandable communications interface between the user and the computer. The use of ICG has increased greatly, particularly in industrial areas. The information/knowledge output (and sometimes the data input) appear in a graphical form and are more readily accepted and understood than numbers and letters. The user, whether a farmer or an engineer, can concentrate on the problem to be solved rather than on the aspects of computer operation.

A widespread use of expert systems is expected. Our initial experience in using expert systems for analysis of financial records (Philip and Harsh, 1987), and pest management problems are most encouraging. A particularly value feature of expert systems is their ability to explain the logic used to arrive at a conclusion. This capability needs to further be exploited, particularly in those situations that the managers analytical skills may be somewhat limited. Also, they will likely be used to help the user determine which algorithms are appropriate to address different problem situations.

This project also places a high priority on the application of adaptive control systems. Control strategies and algorithms will be developed and implemented for multi-variable control. Most available controllers utilize a single analog sensor in a

Table 3. Sequential Decisions and Ranking of Importance

Decision	Action*
DAIRY RELATED	
Feeding	7
Breeding	
Culling	
CROP RELATED	
Pest Control	1
1. corn herbicide	
2. alfalfa herbicide	
3. corn rootworm	
4. alfalfa insects	
5. European corn borer	
Fertilizer and Manure	2
Forage Harvest and Storage	4
Field Operation Scheduling	5
Tillage Systems	8
Grain Harvest and Storage	9
Alfalfa Establishment	
Irrigation	
Land Allocation	
Marketing	
Seeding Rate	
Variety Selection	
GENERAL Farm Decisions	
Enterprise Combinations	3
Cash Flow Management	6
1. taxes and tax planning	
2. credit planning	
3. cash flow management	
Government Programs	
Labor Management	
Machine Maintenance	
Marketing	

* The action index was developed by project team members. The lower numbered decisions are considered most important for inclusion in the IDSS project. Within the limitations of the interest and capabilities of the personnel involved, these lower numbered decisions will be incorporated first. Others will be incorporated as time and interest permit.

control loop. Multi-variable control would base the control of the process not on just one process parameter, but on several related parameters. While these parameters could be monitored in several separate loops, they are likely to be highly interdependent. Varying one parameter affects the others, and may require associated changes in an upstream or downstream process. Controllers utilizing microcomputers will be able to handle these complexities, but they will still allow flexibility and ease of operation.

Such a prototype must be viewed as evolutionary in nature. Electronics and computer technical areas are rapidly changing, and we must have the flexibility to change with, and incorporate new technology as it becomes available. New developments in sensor technology will expand the number of parameters that can be monitored. Many of the new sensors will be solid-state sensors, that will help minimize mechanical problems.

Commercial (or near commercial), hardware for capturing data and software for decision aids will be incorporated as appropriate. Needed components that are not currently available in the desired form will be developed, tested and incorporated.

The models contained in the system will be developed using the interactive design approach. This approach involves combining the analysis, design, construction and implementation stages of model development into a single but highly interactive stage. Over the long run the system will be adaptive. As the environment in which the farm business functions changes, the system must also adapt to reflect these changes or it will cease to be useful to support managers in their decision making.

Summary

The need for better and more timely information on which to base decisions, has encouraged managers to embrace decision support system concepts. These concepts have taken some years to evolve. This evolvement progress has been accelerated by the rapid advances in computer technology. The evolution has also been encouraged by some of the shortcomings related to earlier developed information systems.

Today's decision support systems are computer based, help managers address unstructured problems, are interactive, and utilize highly integrated databases and model base management systems to manipulate and control database and models. The capability of DSS to allow managers to do ad hoc data analysis and thus support them in addressing unstructured problems, is argued to be the main virtues of these systems over earlier developed information systems.

Although the application of decision support systems concept to non-agricultural areas is still relatively new, the use of these concepts to develop agricultural related DSS is rather limited. Because of this situation, at Michigan State University we have established a multi-disciplinary team to develop a prototype DSS for use on commercial dairy/cash crop operations. This prototype is being built at a new research and educational farm at the Kellogg Biological Station. Although this project has only been functioning for a couple of years, the results are very encouraging as it relates to developing a farm-level information system using decision support system concepts.

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