ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ84-205

INFORMATION SYSTEMS IN ADOT: ANALYSIS OF; INTRA-FUNCTION FLOW, DECISION SUPPORT NEEDS, EXISTING SYSTEMS UTILITY AND USER ATTITUDES.

Final Report
Volume I

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March 1985

Prepared for:
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206 South 17th Avenue
Phoenix, Arizona 85007
in cooperation with
U.S. Department of Transportation
Federal Highway Administration

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Technical Report Documentation Page

1. Report No. FHWA/AZ-85/205/I	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle: Information Systems in ADOT: An Analysis of Intra-Function Flow, Decision Support Needs, Existing Systems Utility and User Attitudes

5. Report Date: MARCH, 1985

6. Performing Organization Code:

7. Author(s): W. C. Moor, J.E. Bailey, P.A. Evans, and A. Roberts

8. Performing Organization Report No.:

9. Performing Organization Name and Address:
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10. Work Unit No. (TRAIS):

11. Contract or Grant No.: HPR-PL-1(27)ITEM 205

12. Sponsoring Agency Name and Address:
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007

13. Type of Report and Period Covered: FINAL MARCH, 1985

14. Sponsoring Agency Code:

15. Supplementary Notes: In cooperation with the U. S. Department of Transportation Federal Highway Administration

16. Abstract

A report is offered on a study of the information activities within the Right-of-Way section of ADOT. The objectives of the study were to adapt and apply techniques to measure user-perceived needs, satisfaction and utility of services provided Right-of-Way by the Information Systems Group (ISG).

A background of the four tested techniques is given along with a review of related literature. The techniques were:

(1) a functional analysis using the IDEF methodology (LeClair, 1982)
(2) a user needs analysis using the Bailey and Federle methodology (Bailey and Federle, 1983)
(3) a systems utility analysis using the Krobock methodology (Krobock, 1981)
(4) a user satisfaction analysis using the Pearson methodology (Bailey and Pearson, 1983)

The procedure used to collect and analyze the data collected in Right-of-Way is briefly discussed. A manual for ISG use of the techniques is offered.

Conclusions from the study include the following observations. The techniques are not hard to learn or use but are time consuming. With the exception of the IDEF technique, the techniques were applied at little cost to the Right-of-Way staff. The techniques by themselves did yield useful insights for ISG. Using the techniques in combination suggested insights not possible when they were used alone. The ISG users manual does provide a reasonable guide to further application of the techniques.

17. Key Words: IDEF, User Needs, Information Systems, System Analysis and Design, User Satisfaction, Information System Utility

18. Distribution Statement: No Restrictions. Available to the public through the NTIS, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	54	

Form DOT F 1700.7 (8-72)

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INTRODUCTION

Effective information systems are those which satisfactorily address the true needs of users performing important functions of the organization. This report addresses this issue by exploring the user needs, user satisfaction and perceived utilities concerning information systems of a significant component of users within the Arizona Department of Transportation (ADOT), Right-of-Way Section. These individuals are assisted in their work through many reports, some of which are produced cooperation with the Information Systems Group (ISG). In order to determine their information needs an in-depth study was performed utilizing a number of tools that have been developed over the last five to ten years. An analysis of the utility of these tools was conducted to determined their more general value for the ADOT environment.

The completion of this project provides an important tool to ISG to allow them to improve and refine the ways in which they determine user needs and develop systems for other elements of ADOT. Therefore, the principle objective of this research study was to adapt a methodology to document existing user needs the effectiveness of existing systems within ADOT. The resulting methodology will allow ISG to monitor and better serve ADOT's information requirements.

The Manual for Evaluation of Needs and Attitudes fo EDP Users (Users Manual) Manual (presented as Volume II of this report*) will enable ISG to gather data and analyze seven different aspects of the user

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*The questionnaires used in this study are presented as sub-appendices of the Users Manual. Accordingly, they are identified as: 1) Appendix A-1 The Bailey and Federle Questionnaire, 2) Appendix A-2 The Krobock Questionnaire, 3) Appendix A-3 The Pearson Questionnaire.

environment. These seven aspects are shown below and are listed as objectives on page one of the Users Manual. In practice, a member of the ISG team first determines which objective(s) he/she wishes to pursue. The team member then turns to the part of the manual which suggests which measurement instruments to use. He/She then turns to the section on administration of those instruments. Complete step-by-step directions for administration and data compilation are detailed for each instrument in part III of the manual. The directions are specified for manual data compilation.* After data compilation is completed, the reader refers to section II of the manual for suggestions on how to interpret the data and the possible inferences which can be derived from the data. Each methodology section also contains a suggestion portion for possible further or expanded uses of the data.

USER OBJECTIVES

1. To ascertain general user satisfaction with the present information environment

2. to ascertain causes of satisfaction or dissatisfaction through a detailed analysis of satisfaction factors

3. To identify potential new computer applications through a detailed analysis of user needs

4. To ascertain user perceived utility value of existing reports by analysis

5. To ascertain activities which may be candidates for microprocessor applications

6. To prioritize specific new application requests

7. To ascertain information about the user community through a general audit

The purposes and objectives of the project, which were achieved, were to:

(1) Adapt for ADOT, the methods by which user needs, satisfaction and utility could be evaluated with respect to information systems

(2) apply the methods for determining user needs, satisfaction and utility to a specific section of ADOT

(3) analyze the results of this application and interpret the results in a manner which would be both understandable and usable to members of the ISG group

(4) expand the analysis to develop a general model which shows these user needs and utilities in a manner that can be disseminated to others who are interested in this same field

The steps accomplished in this study based on a review of the available literature, were:

(1) a functional analysis of the Right-of-Way Section of ADOT using the IDEF methodology (LeClair, 1982)

(2) for three specific Services of this Section, a user needs analysis using the Bailey and Federle methodology (Bailey and Federle, 1983)

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*In addition, a diskette containing the computer programs to compile the data has been made available to ISG.

(3) a systems utility analysis of existing applications in the Services using the Krobock methodology (Krobock, 1981)

(4) a user satisfaction analysis of these Services using the Pearson methodology (Bailey and Pearson, 1983)

(5) an analysis which combined the results of these tools and served as a basis for a more general model of the information environment of this section.

The general hypothesis which was explored, and can be supported, is that these tools are effective and efficient ways to evaluate the information environment. In addition, they may be utilized by the deliverers of information (ISG) to members of ADOT to improve that information environment.

BACKGROUND OF THE STUDY

Function Modeling

A significant need in ISG is to prioritize the requests for its services. It is difficult to look at the long list of user application requests and determine which have the highest return on ISG development time. A needed first step in resolving this problem is to model the functions of various user groups. Instead of concentrating on how a particular user does some task (applications), a functional analysis concentrates on what needs to be accomplished (functions), which other functions are affected (relationships) and what information is needed (information flows). It is important to note that applications change and are technology dependent while functions are more permanent. Seeking a best way to support an application accepts that the task needs to be done in about the way it's done now. The resulting information system is generally an automated version of the old system. Seeking the best way to support a function allows the analysis and user to step back and ask, "how should the function be accomplished if we apply the computer." It also allows the analyst to see if the function stands alone and could be best performed with a microprocessor. For these reasons, ISG needs a functional modeling capability.

Such a modeling methodology called IDEF was developed for the U.S. Air Force to model the functions and information flows required to manage a manufacturing facility (LeClair, 1982). It is a flexible methodology and can be used in any environment. The end product of the IDEF methodology is a pictorial model which aids in a better understanding of the inter-functional environment than could be had with an organization chart or other types of function modelling. Boxes are drawn to portray functions performed in an organization and arrows are drawn between the boxes to indicate relationships and information flows.

The IDEf methodology does not contain descriptions of what happens to information. However, this is not a necessary element for the modeling of information flows among functions. The IDEF model does not show time connected with functions or activities, nor sequence as does the flowcharting method. Of more stportance, the IDEF methodology shows which functions exist, what relationships among functions exist, and what the information flows among the functions are. It need not be concerned with time or sequence of functions or transformation of information. Indeed, for the purposes of this study, these elements would serve only to clutter the visual display desired. The desired methodology is to be used simply for giving a general picture of an environment's functions, relationships among functions, and information flows among functions.

Needs Analysis

Rockart (1979) defined a method for determining user needs, called the Critical Success Factor Method. This method focuses on individuals and on current information needs. Key jobs (applications) that must be done exceedingly well for a company to be successful (Critical Success Factors) are identified. These are the areas of activity that should receive constant and careful attention from ISG, including the fulfillment of the important information needs associated with the Critical Success Factors. The Critical Success Factors are ranked according to importance, which helps to prioritize information system development. Barnett (1981) agreed that importance was a major factor in prioritizing needs. Critical Success factors are the same as a manager's critical activities discussed by Ein Dor and Segev (1978).

Similarly, Gorry and Scott Morton (1971:58) recommended that activities first be analyzed, then identification of information needs could begin.

Decisions made in an organization are associated with specific activities. Simon (1965) differentiated between programmed (repetitive, routine, procedurally defined) and nonprogrammed (novel, unstructured, not procedurally defined) decisions. Gorry and Scott Mortion (1971:63) use the terms "structured" and "unstructured" for programmed and nonprogrammed, respectively. They added another class of decisions in those which are neither totally structured or totally unstructured, calling them semi-structured. They developed a framework for MIS, focusing on managerial activities. They said that the focus of attention should be on the critical decisions in an organization and that to any extent that decision making phases could be structured, systems support could be designed.

There are many sources available which discuss the subject of user needs. Most discuss concepts rather than addressing the need for a methodology which can help to identify user needs as well as provide a way to quantify the needs. Quantification is desired in order to determine if the associated activities are amenable to computerization and to prioritize needs.

Federle (1979) developed a taxonomy of managerial activities to help the systems analyst and the manager recognize key managerial activities. He used a set of managerial roles identified by Mintzberg (1973) to classify the activities. The taxonomy provides a classification system that can be used to provide insight into the nature of work and can be used specifically to determine information needs. He then developed a taxonomy of information attributes. He stated that there are two factors that determine significance of work activities; importance and amount of time spent on an activity. He also included the concepts of variety of task circumstances and structure of individual responses.

This work was expanded upon by Bailey and Federle (1984). The four factors which they identified as being necessary to successful application of this computer are importance, time-consumption, structure of response, and variety of circumstances surrounding the activity.

A questionnaire was developed for managers to respond to questions about what activities they perform. The questionnaire asks managers to select from Federle's list of managerial activities the most critical activities they perform in their jobs. They are then asked to rate the activity in terms of importance and time-consumption. Lastly, a semantic differential technique is used for managers to indicate the variety of task circumstances and the structure of their responses to problems encountered in the course of their work. A model is suggested for evaluating results in a quantifiable manner.

No other methodologies were found which provided a means for quantifying results. Since the Bailey and Federle Methodology includes the generally accepted concepts for determining important user needs and has the desired property of quantifiability, it is used for this study.

Utility of Information

Bedford and Onsi (1966:17) and Taylor (cited by Griffiths (1982:270)) agree that the value of information has meaning only in the context of its usefulness to users. Krobock (1981:10) agrees with this sentiment, saying that a user's perceptions of a product's utility are the best measures of true utility since a product has value only if the user can understand and use it. Therefore, it would be reasonable to ask users how useful existing information is to them.

Krobock (1981:8) noted the lack of an adequate instrument for measuring EDP utility. He defined utility as "the worth of EDP reports as perceived by the user during the accomplishment of his job responsibilities." He adapted a measurement instrument using a technique developed by Honeywell called Planning Assistance Through Technical Evaluation of Relevance Numbers (Alderson and Sproull, 1972). The technique uses a relevance tree structure to determine relative usefulness of specific EDP output. Participants in a study divide 100 points (which can be though of as percentages) among all elements in a level of the tree (each representing an independent but related variable, such as "amount of information currently received which is computer generated"). According to Alderson and Sproull (1972:263), using the PATTERN technique allows large numbers of complex interrelated variables to be broken down into simple decision factors that can be expressed numerically. They also state that the resulting "relevance numbers" can be manipulated to present logical conclusions and that "conclusions and extrapolations of the analysis of the relevance numbers can be made from information that was inherent in their assignment but not yet explicit in the minds of the decisions-makers when the parameters were inserted".

Krobock believed that outputs have utility because of specific characteristics of attributes of utility; namely being on time, current, accurate, relevant, adequate, easy to use, and handy. For different pieces of information, particular attributes will be more useful than others. Krobock concluded that the results of his research successfully demonstrated that his methodology measures user perceived utility of data processing reports. It included the important concept of measuring multiple criteria, and asked users for input. This was the methodology selected for measuring utility of currently received computer generated information.

User Satisfaction

As with measuring instruments for user perceived utility of information and user needs, there is literature available concerning concepts of user satisfaction but literature concerning measurement of user satisfaction was scarce.

Ives, Olson, and Baroudi (1983) discussed several methodologies. Some were single scale measurements which were criticized for their unreliability and because they do not provide information about what is satisfactory or unsatisfactory. They reviewed methodologies with multiple item scales and found problems with most of them. Ives, Olson, and Baroudi's intent was to select a methodology to replicate and extend. They chose a methodology developed by Pearson (1977). The criteria they used to select the methodology were that it was empirically derived and supported, most complete, and used multiple factors for evaluation.

The methodology that Pearson developed was a user satisfaction measurement methodology using a semantic differential technique to rate 39 factors which cause satisfaction or dissatisfaction with information systems. Pearson reviewed the literature extensively and used a panel of expert judges to find a complete set of factors. He chose the semantic differential measurement technique over several others because of its many advantages, some of which are; it indicates the direction, positive or negative, and the intensity of the respondent's feelings, it allows direct interpretation of reactions because the intervals on the scale are equidistant, it is reliable and valid and is robost against rating errors, economical on subject test time, and is objective. Pearson's methodology was found to be a reliable and valid methodology. Knowles (1982) used it in a study of personnel information systems user satisfaction. She found no problems with the methodology nor did she find any different results than did Pearson in his original study. Land (1983) found the questionnaire to be valid and said that the semantic differential technique yields precise values which give information. She found the methodology applicable to a range of users. Because of its acceptance and many advantages over the other methodologies studied, this methodology was selected for use in the current research.

APPLICATION OF THE RESEARCH METHODOLOGIES FOR ADOT

Background

The four methodologies selected for this research were applied to three services of the Right of Way Section of The Arizona Department of Transportation (ADOT). Approximately 60 users of computer generated information had an opportunity to voluntarily participate in the research.

The research began by obtaining the consent of the participants to use their responses in the analysis. A copy of the consent form can be found in Appendix B. Each participant was assigned a code number. This code number served two purposes. First, it ensured confidentiality of responses to questions and second, it facilitated data reduction and analysis because the numbers were short and easy to list on a page and distinguish among. All code numbers were assigned the prefix "100". Therefore the first possible participant was coded as 101 and the last participant was coded 161.

Methodologies as Applied

IDEF Methodology. The first methodology used in the gathering of data for this research project was IDEF - The Integrated Computer Aided Manufacturing Definition methodology. The purpose in using IDEF is to model an organization's existing functions, showing relationships and information flows among those functions. $IDEF_{\emptyset}$ is a model showing functions of an organization and relationships between those functions. It is not concerned with how long a function takes to be performed or with the sequence of functions. $IDEF_{\emptyset}$ alone gives a clear indication of the functions and information flows in the environment.

The construction of the $IDEF_{\emptyset}$ model is illustrated in Figure 1. A box is drawn for the major function of the organization being modeled. The box is labeled with the name of the function, using a verb, since a function is something that is performed (i.e. an activity). Inputs into that function (such as "request for information") are indicated with an arrow going into the left side of the box. Controls (influences on the function which do not themselves produce output, such as written procedures) are indicated with arrows coming into the top of the box. Outputs are indicated with arrows going out of the right side of the box. This first model is called the A-0 (A minus zero) diagram.

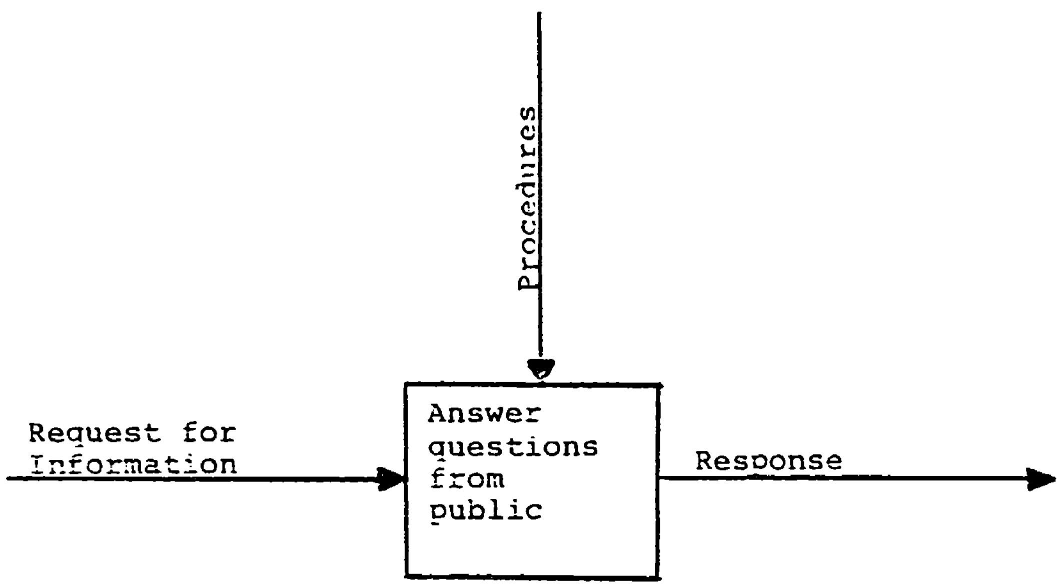

FIGURE 1 Construction of the $IDEF_{\emptyset}$ Model

From the A-0 diagram, major subfunctions are identified. Boxes representing these functions are drawn on a new diagram, called the A0 (A zero) diagram. The same procedure is applied to these functions as for the organization's major function but now relationships are identified among the functions. An output of one function may be an input to, or a control on, another function. Any of the functions on this diagram may be hierarchically broken down into further subfunctions. Only those functions the analyst is concerned with need be broken down. Figure 2 illustrates the identifying of relationships among functions.

Each diagram is given a number which identifies its place in the sequence of diagrams. The first diagram showing the single major function of an organization, is the A-0 (A minus zero) diagram. The next diagram, where the subfunctions of the major organizational function are drawn, is the A0 (A zero)

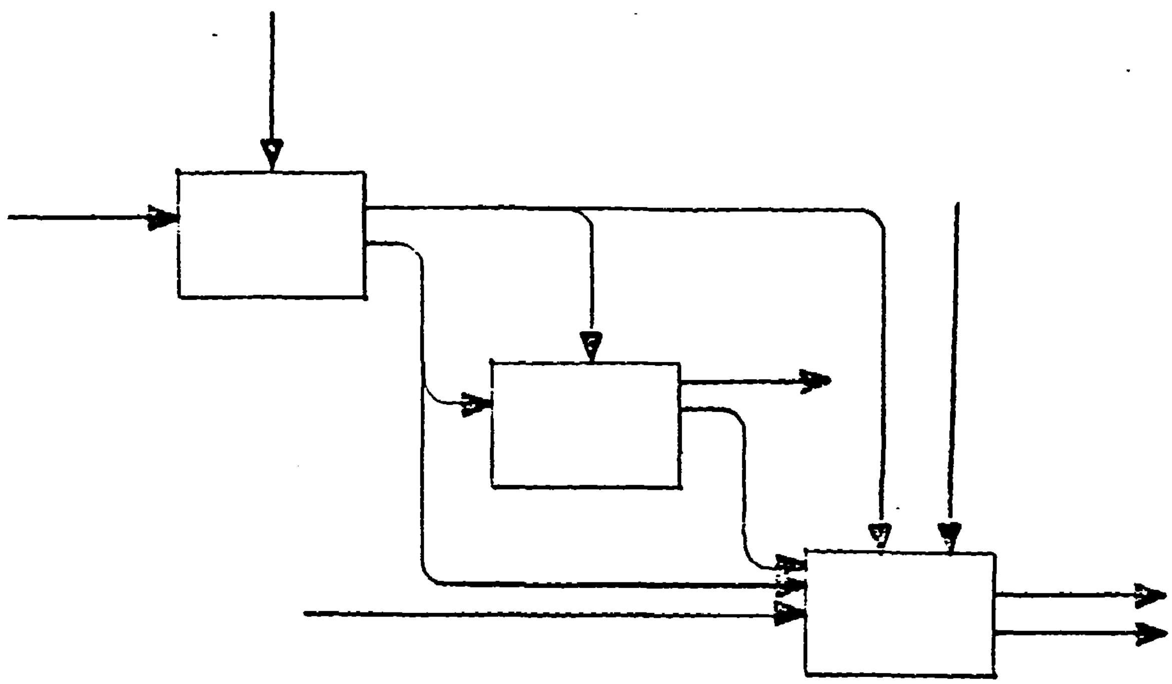

FIGURE 2 Relationships Among the Functions in an $IDEF_{\emptyset}$ Model

diagram. Each of the subfunction boxes is given a number (1, 2, 3, etc.). Any of these boxes which are further broken down will carry its number into its new diagram. For example, if box 1 on diagram A0 is to be broken down, its new diagram will be A1. The boxes in this new diagram (A1) will also be numbered

(1, 2, 3, etc.). Should any of these boxes be further broken down, their new diagrams will be numbered A11, A12, A13, etc., concantenating to the last diagram number the number of the box being broken down. In this way, a diagram can be traced back through all of its breakdowns to the original diagram. Because new diagrams are broken down from previous diagrams, the diagram being broken down is called the parent diagram and the new diagram is called the daughter diagram. The breaking down of functions into subfunctions and the numbering procedure is illustrated in Figure 3.

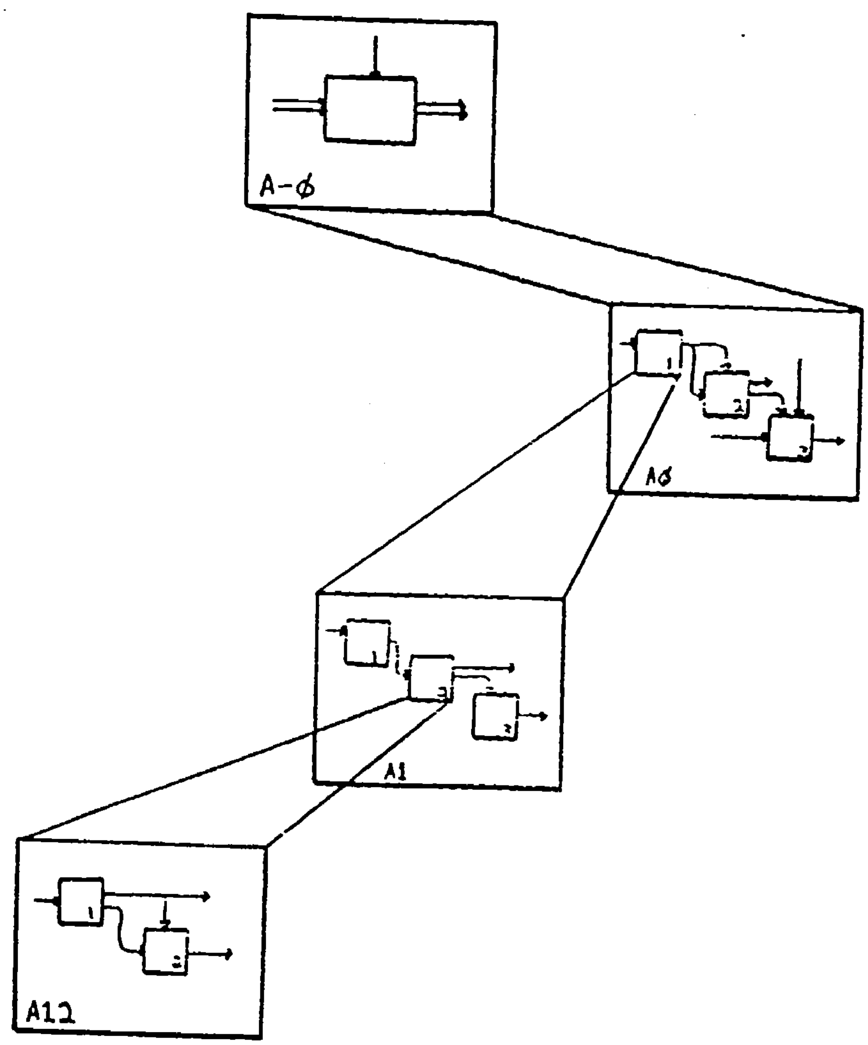

FIGURE 3 Breaking the Functions into Subfunctions and the Numbering Procedure in an $IDEF_{\emptyset}$ Model

In order to show which loose-ended inputs, controls and outputs on a parent diagram are the corresponding loose-ended inputs, controls, and outputs on its daughter diagram, codes may be used. The codes number the inputs I1, I2, etc., the controls C1, C2, etc., and the outputs O1, O2, etc. The same code number would be used on the corresponding loose-ended arrows in the parent and daughter diagrams. This is illustrated in Figure 4. In a situation where the codes make a model easier to read, the codes should be used.

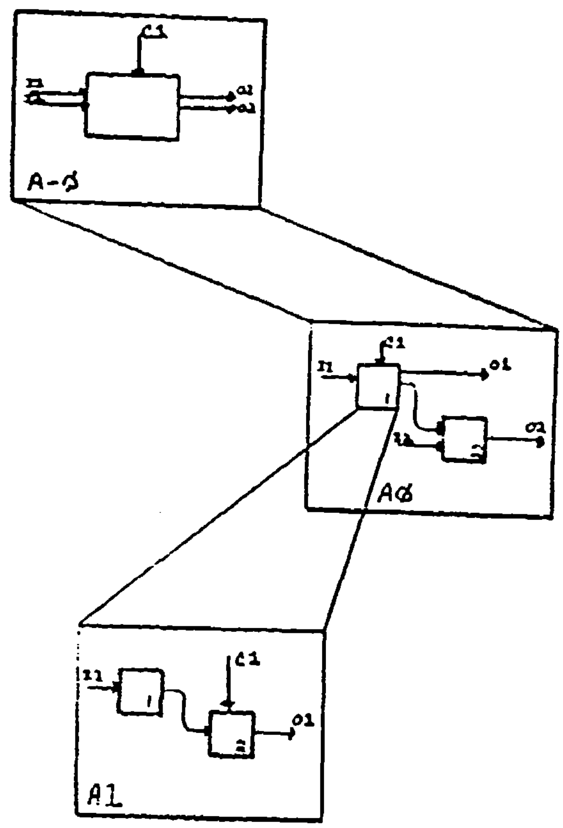

FIGURE 4 Coding Loose-Ended Arrows in an IDEF$_{\emptyset}$ Model

Besides the actual IDEF drawings, several other items are included in an IDEF model. The purpose and viewpoint should always be stated so that anyone reading the model will understand the perspective taken in modeling. Any terms used in modeling which need clarification can be defined in a glossary, preferably on the page on which the term was used. For explanations of functions which do not lend themselves to specific IDEF modeling techniques, an "FEO" or "For Exposition Only" diagram may be created. These diagrams may use any technique necessary to clarify the function and are simply attached to the IDEF drawings.

IDEF models may be general or specific. An entire organization may be modeled without consideration of who performs what function or a specific position in an organization may be modeled. The purpose for creating an IDEF model determines what kind of a model it will need to be. Information flows for an organization as a whole may be needed in some cases, and in other cases an analyst may wish to model a single position. For inputs. outputs, and controls in a general model, general terms such as "report" could be used and in a specific model, actual report titles could be used.

Bailey and Federle Methodology. To facilitate the task of analyzing user needs and whether or not these needs can be supported by computer-generated information, the Bailey and Federle methodology was used. With this methodology, needs were assessed whether or not the needs are currently being satisfied with computer generated information. Needs were assessed by determining what activities users perform. Then, how important and time-consuming the activities are is determined. Finally, the variety of circumstances in which the activity occurs and the structure of the user's response were determined. Each participant was asked to list ten or fewer activities which are most critical to his or her job success. Since managers as well as non-managers participated in this study, they were encouraged to select from a provided list or add new activities they perform which were not represented on the list. Each activity was by the participant according to the relative importance (X_I) of the activity (compared to the other selected critical activities), with all X_I's adding to a total of 100 points. Next, the individual rated the relative time spent performing the activity (X_T) (compared to the other critical activities), with all X_T's adding to a total of 100 points. Therefore, X_I and X_T could take on any integer value between 0 and 100. Individuals were then asked to rate the variety of circumstances (X_V) surrounding the activity (i.e., the frequency of unexpected and novel events that occur) and the structure of response (X_S) required for the activity (i.e., the stability of the process followed in performing the activity). For the variety of circumstance and structure of response ratings, participants respond on a set of seven-interval semantic differential scales. These scales as shown in Figure 5 were assigned values from left to right of 1 through 7. Therefore X_v and X_s take on values from 2 to 14.

Krobock Methodology. To determine the user's perceived utility (or usefulness) of currently received computer generated information and address the question of whether or not more computerized information might be beneficial, the Krobock methodology was used. In this methodology, several questions are asked. First, the user was asked to indicate what percentage of the information he or she currently receives is computer generated and what percentage is not. Next, the users were asked to estimate what percentage of the information they now receive which is not computer generated could be computerized and the percentage that could not be computerized. They were then asked to list all computer generated sources of information they currently receive and divide 100 points among those sources of information as to the relative contribution each makes to their computerized information needs. For each item on this list, participants were asked to divide 100 points between several attributes affecting utility of the information (the terms 'aspects of usefulness' of information were used in this study in order to make clear to

VARIETY OF CIRCUMSTANCES

(Variety indicates the frequency of unexpected and novel events that occur in the activity.)

	EXTREMELY	QUITE	SLIGHTLY	NEITHER	SLIGHTLY	QUITE	EXTREMELY	
CONSISTENT								WIDE VARIATION
SIMILAR								FREQUENTLY NOVEL

STRUCTURE OF RESPONSE

(Structure indicates the stability of the process followed in doing the activity.)

	EXTREMELY	QUITE	SLIGHTLY	NEITHER	SLIGHTLY	QUITE	EXTREMELY	
PROCEDURAL								INTUITIVE
CONSISTENT								CHANGING

FIGURE 5 Semantic Differential Scales to indicate Variety of Circumstances and Structure of Response

participants the meaning of what was being asked of them). The points were divided according to the relative affect of each aspect when compared to the others. The aspects were:

1. Item must be delivered on time
2. Data must be current
3. Data must be accurate

4. Item must be relevant to use

5. Data must be adequate

6. Item must be easy to use

7. Item must be handy

In addition, participants were asked to provide information about how often they receive the information and how often they use the information, and were provided with an opportunity to comment about the information currently received.

The relevance tree pictured in Figure 6 shows the divisions of utility points for this application of the Krobock methodology.

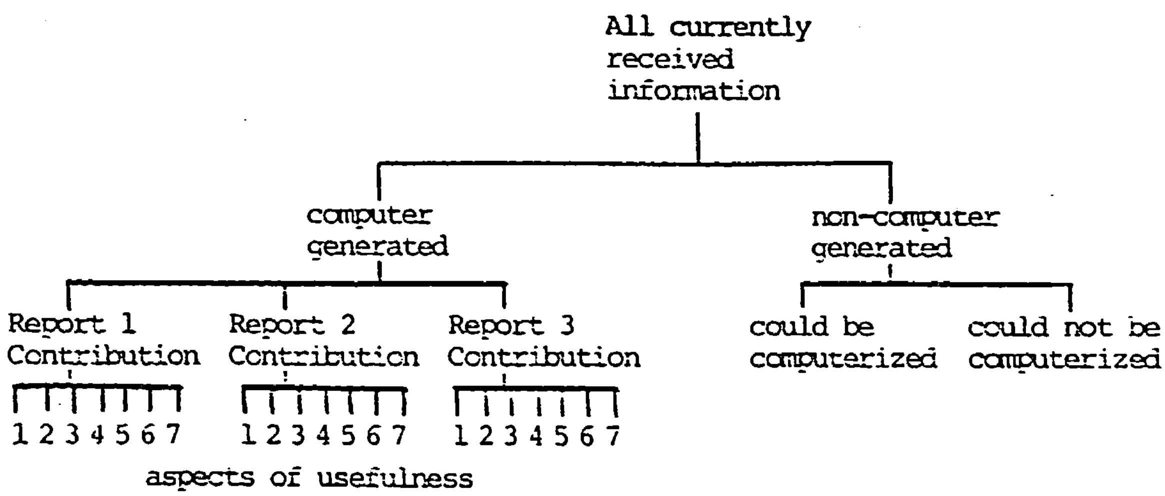

FIGURE 6 Relevance Tree showing the divisions of utility points for this application of the Krobock Methodology

Pearson Methodology. The Pearson Methodology was used to measure user satisfaction with existing systems and to identify factors causing satisfaction or dissatisfaction. According to Bailey and Pearson (1983:531), satisfaction is the sum of a person's feelings or attitudes about factors affecting their situation. In the Pearson Methodology, this sum is a total of the user's weighted reactions to each of 39 questions (each a factor in whether or not a user is satisfied with the existing system). In order to find this sum, participants responded to each factor on a set of three semantic differential scales. An example is shown in Figure 7. Adjective pairs, one at each end of each scale, described the factor to be measured. The first two scales measure the user's reaction or feelings about the factor, while the importance/unimportance scale provides the weighting of the factor which will be used in a satisfaction score. The resulting normalized satisfaction score can take on integer values from -3 through +3.

Completeness: The comprehensiveness of the output information content.

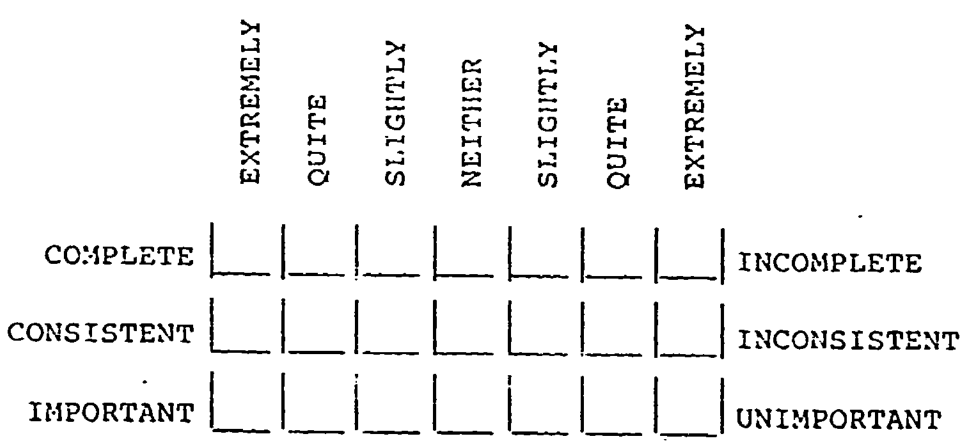

FIGURE 7 An example of a Semantic Differential Scale used in the pearson Methodology

Data Collection. The methodologies used in the research were organized in a way to help facilitate efficient data collection. First, the IDEF Methodology was applied. All 22 of the managers and supervisory personnel in the Right of Way Services were interviewed. Since the objective of the research was to develop an instrument for future use by ISG for ADOT, the viewpoint selected was that of an information systems specialist who wishes to understand the functional relationships and information flows. A draft of the IDEF diagrams were drawn and distributed to all participants for their review and comments before a final model was created.

The model created was comprehensive rather than specific because an overall picture of what the organization does was desired. No specific applications were to be analyzed. The completed model may be found in Appendix C.

In order to make the rest of the data collection process convenient, yet not require lengthy sessions, two questionnaires were developed to contain the Bailey and Federle Methodology, the Krobock Methodology, and the Pearson Methodology. The first questionnaire contained the Bailey and Federle Methodology in its entirety and part of the Krobock Methodology. The results of the Krobock portion of this questionnaire were utilized in the development of the rest of the Krobock Methodology which was contained in the second questionnaire. Also contained in the second questionnaire was the Pearson Methodology in its entirety. Questionnaires 1 and 2 are contained in Appendices D and E, respectively.

At the suggestion of the advisory committee, the first questionnaire was distributed at a large group meeting. Instructions were given and smaller group meetings were scheduled to allow participants to ask questions or simply return their completed questionnaires. Due to heavy workloads in the organization, some difficulty was encountered in getting the questionnaires returned. Because of this difficulty, the second questionnaire was completely administered at two group meetings. Participants completed the questionnaires and returned them as they left the room.

Twenty-five completed sets of data were gathered and used in the analysis. The code numbers assigned to the original 60 possible participants (101 to 161) were maintained.

DATA ANALYSIS PROCEDURES

This section will discuss general analysis procedures. Since human responses are subjective, the data did not give absolute conclusions, thus the analysis used was logical in nature. The next section will apply the analysis to the data collected and discuss the creation of the ISG Users Manual.*

Application of IDEF

For this research, the IDEF Methodology does not require extensive analysis. It's main purpose is to model the functions and information flows in an environment in order to provide a better understanding of what these functions and information flows are. One other use was observed; that of using the IDEF models to look for possible applications for microcomputers. When studying a model of a particular function (or group of functions) in the same geographical area, it may be observed that the function has few if any inputs, outputs or controls which flow to or from it to other positions. Since the position does not share information needs with others, it may benefit from the use of a microcomputer, rather than requiring access to a mainfrom computer for its information needs.

Bailey and Federle Methodology

Each of the activities listed by participants in the Bailey and Federle portion of the first questionnaire was assigned a code number in order to facilitate efficient data reduction and analysis. These activities and corresponding code numbers are shown in Appendix F. In this Appendix, the

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*The programs developed for this analysis and the data collected were implemented on an IBM-PC. A diskette is provided as a final report deliverable. This diskette may be used on an IBM-PC or any IBM compatible PC.

activities developed by Federle are numbered 200 through 231, the remaining activities were suggested by participants in this study.

Scaling the intervals measuring consistancy and structure was accomplished by numbering from 7 through 1 from left to right. Higher values indicate higher degrees of consistency of circumstances or structure of response. The values for the individual's responses for all four scales for an activity were added together, resulting in a total of between 4 and 28. This total is X_{Vij} where i indicates the specific individual and j the activity. In order to make the consistancy and structure measures more consistent, X_{Vij} was normalized to result in a score with a maximum of 100. The formula used to normalize X_{Vij} was $\frac{100}{28} X_{Vij}$. This score was labeled NX_{Vij}.

Federle (1979:216) developed his model to lay out key activities with the greatest importance which may benefit from computerized information systems. Therefore, it was felt that the importance score X_{Iij} was likely to be the most significant score in consideration for computerization for activities in this study. Therefore, for each activity, X_{Iij} was multiplied by the sum of X_{Tij} and NX_{Vij}. Mathematically stated:

$$X_{ij} \text{(the final score per individual)} = X_{Iij}(X_{Tij} + NX_{Vij})$$

where

i - A specific individual (for this study i=1, ..., 25)

j - A specific activity (for this study j=1, ..., 58)

NX_{Vij} - The normalized total of an individual's responses for all four semantic differential scales for an activity.

X_{Iij} - The relative importance of an activity when compared to all other critical activities

X_{Tij} - The relative amount of time spent performing an activity when compared to all other critical activities

X_{ij} - The final score for use in comparing responses.

The scores for each activity individual combination was computed and three matrices were produced; one showing all NX_{Vij} scores and two showing all X_{ij} scores, sorted in different ways. These matrices are shown in Appendices H, I and J. In addition, the average X_{ij} and NX_{Vij} and the total X_{ij} and NX_{Vij} for all participants were computed for each activity. One more column was added to facilitate the analysis; the number of non-zero entries for each activity. This shows the numbers of participants who perform a specific activity.

The NX_V matrix was sorted by the average score. This was done to show which activities may be key candidates for computer support. The higher scores here show highly structured and consistent activities, which according to Bailey and Federle (1984:13), are the types of activities which are more likely to find computer reports useful.

The X matrix was sorted in two ways. The first sort was by the number of non-zero entires for an activity (shown in Appendix I). The activities performed by the most participants are shown at the top of this matrix. Systems supporting these activities will affect the greatest number of users.

The activities at the top of this X matrix were compared to those at the top of the NX_V matrix. Activities which appear near the top of both these matrices would probably greatly benefit from computer support, as these are the activities which have a high likelihood of successful utilization and have the potential to impact large numbers of people in the organization. In addition, if the average X_{ij} is relatively high, the activity is likely to have a large impact on users, as achieving a high average X_{ij} requires a high X_I as well a fairly high sum of X_{ij} and NX_{Vij} scores. This appears to be the most promising type of activity for effective computerization because it is important, time-consuming, structured, consistent, and has a large impact on a large number of users.

Although the activity which fits the above description may be almost an ideal activity for computerization, there are other activities which can be successfully computerized. Other information can be inferred form the matrices. This will now be discussed.

There are two types of activities which will appear near the top of the NX_v matrix and not near the top of this X matrix. One type is an activity which is highly structured and consistent, but not important or time-consuming and/or which is not performed by a large number of people. These types of activities will have relatively low average X_{ij} scores. Computerizing this type of activity would probably be more costly than it would be worth.

The other type of activity which may appear near the top of the NX_v matrix and not near the top of this X matrix is an activity which is highly consistent and structured as well as important and time-consuming, but is not performed by many people. These activities may be amenable to computerization to support smaller numbers of people. In some cases, this can indicate the use of microcomputers instead of requiring access to mainframe computers. For example, if only one individual or small group of individuals perform an activity in a small geographical area and the information used for the activity is not needed elsewhere, a microcomputer would probably be a better choice than requiring these people to spend the time and money required to use a mainframe to support the activity. Because this information may be difficult to see when examining average scores on this matrix, it is important that individual scores be examined.

On this X matrix, there will be activities near the top which are not near the top of the NX_v matrix. These are the activities which large numbers of people perform, but may not be amenable to computerization because they are neither structured or consistent. As a result, the users would likely not find a computer report useful even though they may request it (shown in Appendix J).

The second sort which was performed on the X matrix was by average X_{ij}. The activities high on this matrix and the NX_v matrix are those which are of high importance and have a fairly high sum of time-consumption and consistency and structure. Computerization of these activities would probably be beneficial to the organization.

This matrix can also be compared to the NX_v matrix. An activity that is important and time-consuming, but not structured or consistent may appear high on this X matrix but not on the NX_v matrix. The importance and time-consumption scores can push the X value up and cause the activity to appear near the top of this X matrix. Some type of computer support may aid this type of activity, but it must be kept in mind that its lack of stability may make it difficult to computerize or more costly than beneficial.

The column containing the activity totals for the X matrices can provide information about impact on an organization. A relatively high number in this column indicates that there are probably many people performing this activity and that the activity is probably important, time-consuming, structured, and consistent. These activities are probably amenable to computerization.

Krobock Methodology

For each individual, the first four percentages described previously were coded as follows:

i - Individual participant (i=1, ..., 25)

A_i - Percentage of currently received information which is computer-generated

B_i - Percentage of currently received information which is not computer-generated

C_i - Percentage of currently received non-computer-generated information which the participant feels could be computerized

D_i - Percentage of currently received non-computer generated information which the participant feels could not be computerized

The following computations were performed and their meanings are described as follows:

B_i*C_i - The percentage of currently received information that is not now but could possibly be computerized for an individual

$\frac{A_i}{A_i + (B_i*C_i)}$ - The fraction of computerizable information that is presently computerized.

In the next part of the Krobock Methodology, individuals listed their computer generated information outputs.* They then divided 100 points among them, according to the relative contribution each source made to their information needs as compared to all other outputs of computer generated information. This will be referred to as the information score. The information score given to each piece of computer generated information was multiplied by A_i. This number represents the relative contribution of that output towards the participant's total information needs (computerized and non-computerized). According to Krobock (1981:118), it also represented the utility of that piece of information to the individual.

*The coded list of computer generated information sources is shown in APPENDIX G. The codes assigned ranged from 300 to 364. Where it is necessary to identify a specific source the counter k(=1, ..., 65) is used.

According to Alderson and Sproull (1972:263), the numbers generated using this technique can be manipulated to present logical conclusions. A matrix was produced showing the A_i, B_i, C_i, D_i, $B*C_i$, and $\frac{A_i}{A_i + (B_i*C_i)}$ for all individuals. This matrix is shown in Appendix K. This matrix can be studied to determine if people's needs are being met with the currently received computer generated information.

If B_i*C_i for an individual seems to be a high percentage, this person believes the computer is falling far short of its potential in his situation. A high B_i*C_i suggests the user wants far more than he or she is getting.

The $\frac{A_i}{A_i + (B_i*C_i)}$ value suggests how much more information could be provided when compared to existing outputs. For any individual whose score for this computation is 0, the B_i and D_i scores should be examined. If they are both 1, the individual does not feel that any more of his or her work can be computerized; therefore, in this case, it probably would not be beneficial to provide this individual with more computer generated information.

A printout was produced for each computer generated output used by any participant. These printouts show the A_i values, the information scores for each output and the utility score (A_i*$Score_i$) along with averages and totals for all outputs. A high average utility score indicates that the output which received the score is of major importance as it supplies a high percentage of information needs. On the other hand, it may be wise to consider discontinuing outputs with low utility scores. (These printouts are shown in Appendices K, L and M.

Scores as to relative usefulness of the utility factors listed in The application section (delivered on time, current, accurate, relevant, adequate, easy to use, and handy) were printed for each piece of information for each individual who uses it. Krobock's analysis procedures show that these scores give an indication of which factors are most important to an individual for a particular piece of information. For example, a score of .85 for "Data must be accurate" for a certain report indicates that 85% of that outputs usefulness is due to the data being accurate. Very low scores in this area can be due to lack of importance of an factor in determining usefulness of computer generated output to an individual.

It is important to look at the individual scores here. An average score may hide a very high individual score. In a case such as this, perhaps the information will be found to be useful for only one individual, but not necessary for the others. An average score may also be diminished by one very low score. In this case, the information may be useful for most of the individuals who receive it, but not for one particular person. Such data suggest who must be satisfied and who is les important among a given output's set of users.

Printouts were produced for each individual. For each report the individual used, the A_i values, information scores, utility scores (A_{ik}*$Score_{ik}$), and scores for all of the seven factors of utility were listed. In addition, totals and averages for each of these were computed. In these printouts, the average utility scores should be closely studied. A high score here indicates that, on the average, this individual finds the information provided very useful. A low average may be an indication that the information provided to an individual may be largely wasted, either because it is not needed or because it is just not used. Looking at the aspects of usefulness can give an indication of why the information is not being used. Low scores here may indicate that certain aspects need improvement.

Utility scores for individual pieces of information should also be examined on this printout. Some pieces of information may be more useful than others, therefore increasing the average. A low utility score for an individual piece of information may mean that producing that piece of information is not worthwhile.

It is important to examine the questionnaires to gather information about frequency of receipt and frequency of use of particular pieces of information. A piece of information that received a low score for "Data must be current" from the aspects of usefulness section may need to be delivered more often. Frequency of use responses can lead to the determination that a piece of information is not necessary for an individual. Lastly, the comments concerning a particular piece of information should be reviewed. Comments can bring up problems which were not able to be identified in following this methodology. They can also back up conclusions made about the results of the use of the methodology.

Pearson Methodology

Responses to the Pearson Questionnaire were scored as was prescribed by Pearson (1977). To find the satisfaction sum (or score), the user's responses on the semantic differential scales were assigned values. For the first two scales, the leftmost interval (the most positive reaction) was assigned the value 3. Moving to the right, each interval was assigned the next lower integer value, i.e. 2, 1, 0, -1, -2, -3. The numbers are interpreted as shown in Table 1. Any positive (+) sign indicates satisfaction to some degree and any negative (-) sign indicates dissatisfaction to some degree. The score itself is indicative of the degree. The levels of satisfaction identified in this table are thus far unweighted as far as how important or unimportant they are. In determining the satisfaction score, weights are included, as will be explained shortly.

TABLE 1 - Unweighted levels of satisfaction for individual participants for individual factors

Value	Level of Satisfaction
+3	Extremely Satisfied
+2	Quite Satisfied
+1	Slightly Satisfied
0	Neither Satisfied nor Dissatisfied or not applicable
-1	Slightly Dissatisfied
-2	Quite Dissatisfied
-3	Extremely Dissatisfied

The intervals on the importance scale were assigned the values 1.00, .85, .70, .55, .40, .25, and .10 from left to right (extremely important to extremely unimportant). These numbers are interpreted as shown in Table 2.

TABLE 2 - Levels of importance

Value	Level of Importance
1.00	Extremely Important
.85	Quite Important
.70	Slightly Important
.55	Neither Important nor Unimportant or not applicable
.40	Slightly Unimportant
.25	Quite Unimportant
.10	Extremely Unimportant

For each factor, the average of the values assigned to the user's reactions for the first two scales was determined. This is denoted R_{i1}. This average was multiplied by the importance value for that factor W_{i1}. This gives a satisfaction score for each factor for each individual. These scores could range from -3 to +3, in steps of .075.

To arrive at an overall satisfaction score for each user, the scores for all of the 39 factors were totaled. Stated Mathematically:

$$S_i = \sum_{l=1}^{39} R_{il} W_{il}$$

where:

i = individual (i=1, ... 25)

l = factor (l=1, ..., 39)

R_{il} = The average reaction to factor l by user i.

W_{il} = The importance of factor l to user i.

S_i has a range from +117 to -117. A user may be very satisfied with all factors he or she considers important and yet have only a slightly satisfied score because only a few factors were scored other than neutral or were important. Those factors to which the user reacted neither positively nor negatively add nothing to S_i. Therefore, viewing S_i with respect to the earlier-mentioned range can be misleading. In order to eliminate consideration of those factors to which a user had no particular reaction or which were not applicable, S_i was normalized, using the following formula:

$$NS_i = \frac{S_i}{Fi*3.\emptyset}$$

where F_i = The number of meaningful factors (a meaningful factor is any factor with a reaction other than those assigned the value 0 for either of the first two scales).

F_i was multiplied by 3 to give the maximum score possible for all factors affecting a user's satisfaction either negatively or positively (3 being the highest possible average for the first two scales for each question).

This operation results in a normalized satisfaction score (NS_i) ranging from -1.00 to +1.00.

Using NS_i, each user's satisfaction for all responses averaged can be determined using Table 3 as a general guideline.

TABLE 3 - Normalized general level of satisfaction

NS	Level of Satisfaction
+1.00	Maximally satisfied
+0.67	Quite satisfied
+0.33	Slightly satisfied
0.0	Neither satisfied nor dissatisfied
-0.33	Slightly dissatisfied
-0.67	Quite dissatisfied
-1.00	Maximally dissatisfied

The following variables have been identified:

i = Individual (=1, ..., 25)

l = Factors (=1, ..., 39)

R_{il} = The average reaction to factor l by user i

W_{il} = The importance of factor l to user i

$R_{il}W_{il}$ = The satisfaction score for each factor for each individual

S_i = The sum of the satisfaction scores of all 39 factors for an individual

NS_i = The normalized S_i

F_i = The number of meaningful factors included in an individual's NS_i

The $R_{il}W_{il}$ scores were displayed in a matrix format, showing the scores for all individuals for all factors. This will be referred to as the NS matrix. In addition to these individual scores for each factor, $\overline{NS}_i$ was computed for each user in order to show each individual's general level of satisfaction, using Table 3 as a general guideline. An entire group's general level of satisfaction of each factor can also be determined using its average.

The average $R_{il}W_{il}$ for each factor was computed, showing an overall satisfaction of users toward each factor. The average $R_{il}W_{il}$ for all users for all questions was computed to give an overall level of satisfaction for the entire group. An average NS_i was also computed, giving the normalized overall level of satisfaction for the entire group. Finally, the number of $R_{il}W_{il}$ scores of 0 for each individual were noted on the matrix. It was observed that a number of participants had no reaction to many of the questions or answered only a few, leading to many 0 averages. It might be argued that such individuals were not interested in answering the questions.

Sorts were performed on this matrix by average individual satisfaction score and by average factor satisfaction score in order to show the most satisfied individuals and the most satisfying factors in the upper left hand corner which was used in further analysis as will be explained later in this report. This matrix is shown in Appendix N.

Another matrix was produced listing only the importance values for each factor for each user and computing the averages for each user and each factor along with an overall average importance score. Sorts were performed on this data by average individual importance score and by average factor importance score. This matrix is shown in Appendix O.

These two matrices were used in combination with each other in the following ways. The most satisfying factors were identified. Those are the several rows at the top of the NS_i matrix. These factors were then found on the importance matrix to discover whether or not the most satisfying factors were also the most important. This comparison gives information on what factors ISG has been successful with.

The least satisfying factors were identified next. These were found on the importance matrix. If any of the least satisfying factors are not important, it may not be worthwhile to effect a change. However, if any of the least satisfying factors are important, an information systems department would be well advised to seek correction of the problem. The factors which are least satisfying are those which are causing negative feelings, and correction of the problem could improve effectiveness of an information system as well as employee relations.

Next, the most important factors were identified from the top of the importance matrix. These factors were found in the NS_i matrix and studied in order to determine whether or not they were satisfying or dissatisfying to users. If the factors are not satisfying, corrective action is again advisable.

Combinations of Methodologies

Methodologies can be combined to support each other or to gain information that cannot be gained by looking at just one methodology. When examining individual scores on the Bailey and Federle NX_v matrix, an individual may be discovered who performs activities which are important, time-consuming, consistent, and structured where no other individual performs the activities or individuals who do perform them do not find them to be important, time-consuming, consistent, or structured. As was pointed out earlier, this individual may be a candidate to receive a microcomputer. Looking at an IDEF model of this position can support this. The IDEF model will show if the position shares information needs with other positions. If it does not, it supports the conclusion that the individual could benefit from the use of a microcomputer.

As noted earlier, activities which are found high on both the NX_v and the second X (sorted by average X) matrices of the Bailey and Federle Methodology can be called highly computerizable. For the individuals who perform those activities, the Krobock Methodology can provide information about whether or not the individual feels they could use more computer support. If the B_i*C_i score (potential computerization) is high or the amount of possible computerization which is now computerized is low, the activity is a good candidate for computer support for this individual.

After identifying dissatisfied individuals on the Pearson NS_i matrix, studying results of the printouts for individuals from the Krobock Methodology can help to show where improvements can be made in specific pieces of information to increase the satisfaction of these individuals. This is done by noting which aspects of usefulness have particularly low scores. Improvement in these areas may increase user satisfaction. This is especially true if, when looking at the printouts for those specific pieces of information, all individuals who use them have low scores for the same aspects. This can be supported by checking individual satisfaction scores for factors 15, 16, 17, 20, 21, and 25 of the Pearson NS_i matrix against the aspects of usefulness easy to use (aspect 6 on the Krobock matrices), accurate (aspect 3), on time (aspect 1), current (aspect 2), adequate (aspect 5), and relevant (aspect 4), respectively. These factors and aspects correspond to one another. If individuals are particularly dissatisfied with one of these factors and have a low score on Krobock matrix for it as well, this can show that improvement of that aspect could increase user satisfaction.

Individuals with high B_i*C_i scores or low scores for the Krobock Methodology can be identified on the Pearson NS_i matrix. If an individual's level of satisfaction is low and his or her scores from the Krobock Methodology fit this description, it can indicate that more computerization may increase this user's level of satisfaction. In addition, this individual may be identified on the Federle NX_V matrix. If his or her NX_{Vi} scores are high, this supports the idea that this person could benefit from increased computer support.

ANALYSIS OF COLLECTED DATA IN THE RIGHT-OF-WAY SECTION

IDEF Methodology

The completed $IDEF_\emptyset$ model is contained in Appendix C. When examining it, a function was found which does not share information needs with any other functions. This can be seen on diagram A6. The function is "Assist Local Agencies," box number 1, which is further broken down on diagram A61. A further investigation revealed that this function is performed by one individual. This individual may benefit from the use of a microcomputer. On the Federle NX_V matrix, this individual shows four activities, only one of which has a high NX_V. It is possible that this individual could benefit from a microcomputer, but it must be kept in mind that this may be difficult due to the lack of a high degree of consistency and structure of the activities.

Federle Methodology

The matrices produced for the Bailey and Federle Methodology can be found in Appendices H (NX_V matrix), I (X matrix sorted by number of non-zero entries), and J (X matrix sorted by average X_L).

Activities* 221, 223, 213, 210, and 212 were found to be high on both the NX_V matrix and the X matrix sorted by number of non-zero entries. These are the activities that are highly structured and consistent and impact large numbers of people. These activities would be good candidates for computerization. In addition, activity 221 had a high average X_{ij} making it the prime candidate for computerization.

Activities 233, 234, 202, 241, 242, 243, 254, 219, and 238 are high on the NX_V matrix but not on this X matrix. These activities do not impact a large

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*Names of these activities are shown in Appendix F.

number of users. Of these, activities 233, 202, and 219 have low average X_i scores. Since the activities are not performed by a large number of users, the people who do perform them may benefit from the use of a microcomputer, especially if they do not share information needs with other areas.

Those activities which are high on this X matrix but not high on the NX_V matrix are 230, 214, 217, 218, 221, 229, 220, 228, 216, 220, 204, 222, and 209. These activities are performed by large numbers of people but are not structured or consistent so may not be amenable to computerization. This is especially true for activities 217, 218, 200 which have quite low NX_V scores.

When comparing the NX_V matrix and the X matrix sorted by average X_i, activities 234, 254, 221, 231, and 241 are near the top. Computerization of these activities would probably be beneficial as they are of high importance, time-consumption, consistency, and structure. Other activities high on this matrix which do not have high NX_V scores are 245, 231, 252, 253, 255, 220, 236, 232, and 256. These may benefit from computer support, but may be more difficult to computerize because they are not consistent or structured.

The activities with high X_i totals on the X matrices are 221, 234, 220, 214, 218, and 230. These activities are probably amenable to computerization because they aree likely to be important, time-consuming, consistent, and structured activities which large numbers of people perform.

Krobock Methodology

The Krobock printout containing A_i, B_i, C_i, D_i, B_i*C_i, and $\frac{A_i}{A_i + (B_i*C_i)}$ scores is contained in Appendix K.

The only individual with a high B_i*C_i score is individual 103. This person could probably benefit from the use of increased computer support, as he or she feels there is a large amount of information that could be computerized but is not.

Individuals 103, 111, 120, 135, 153, and 155 have low $\frac{A_i}{A_i + (B_i * C_i)}$ scores. These individuals could benefit from increased computer support, as they feel that low amounts of potentially computerized information are presently computerized. In addition, individual 147 has a low $\frac{A_i}{A_i + (B_i * C_i)}$ score. In this case, however, the individual's B_i and D_i scores are both 1. This means the individual does not feel that any of his or her information can be computerized.

The printouts of Krobock scores for specific reports are contained in Appendix L. Reports* which have high average utility are 302, 303, 306, 310, 313, 315, 319, 320, 323, 334, 345, and 348. They represent a large percentage of information needs. Reports on which have low average utility are 304, 307, 349, 350, 351, 352, 353, and 354. It may not be worthwhile to continue to provide this information using a computer.

Information may be found on which aspects of usefulness are most important to specific reports according to the users of the information. As an example of what can be found for report number 303, aspect 3 (accuracy) has an average score of .5 and is important, where aspects 2 (currency), 5 (adequacy), 6 (ease of use), and 7 (handiness) have low average scores and are unimportant or need more attention to make this report more useful.

In order to find high individual scores which are hidden by average scores, each individual would have to be examined for uses of specific report. An example of what can be found for report 313 is that it is not very useful

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*Identification of these reports is shown in Appendix G.

for individual 155 (it has a utility score for this individual of .005). Its utility scores for individual 161, on the other hand, is very high. while it is probably worthwhile to continue to provide individual 161 with this information, it may not be worthwhile to continue to provide it to individual 155.

The printouts of Krobock scores for individuals are contained in Appendix M. High average utility scores indicate that individuals find information useful. For example individual 156 receives one piece of computer generated report, number 156, and finds it very useful. This is indicated by its utility score of .65. A low average utility score means that information is not very useful to an individual. An example of this is individual 155, who receives 13 reports. The average utility score for this individual is .008, quite a low utility score. One way to see why information is not useful is to study the scores for the factors affecting utility. In the case just described, factor 6 (ease of use) and 7 (handiness) received the lowest average scores. Perhaps attention to improving these aspects for the reports this individual uses would make the information more useful to this person.

Studying utility scores for each piece of information for an individual can show that some pieces of information are not useful, although the average for all of the information is fairly high. An example of this for individual 101 is that report 303 has a very high utility score (.8245) while report 304 has a low one (.0255). Averaged, it appears that they are both quite useful.

There were no unusual findings when the questionnaires were consulted to examine answers to frequency of receipt and frequency of use questions. There was one comment which served to back up information which the methodology obtained. For individual 121, report 323's highest scored aspect of usefulness was currency. There was a comment for this report, that the information was being continuously updated. This shows that the organization is serving the need for currency of this particular piece of information.

Pearson Methodology

The matrices produced for the Pearson Methodology are contained in Appendices N (NS_i matrix) and O (importance matrix). The $R_{i1}W_{i1}$ scores on the NS_i matrix show individual satisfaction levels for individual factors. For example, individual 100 has a satisfaction level of +2 for factor 16. (Accuracy - The correctness of the output information). This individual's NS_i score (the normalized general satisfaction score for all factors) is .635, which, means the individual is quite satisfied.

Average $R_{i1}W_{i1}$ scores give information about which factors are most satisfactory to users as a group. Factor 16 (Accuracy) was the most satisfying factor to the group as a whole. Its average $R_{i1}W_{i1}$ score is 1.68 or quite satisfying to the group.

The average NS_i gives the normalized overall satisfaction for the entire group of individuals for all 39 factors. That score for Right of Way was .279, slightly satisfying.

There were several individuals who had a large number of 0 scores of $R_{i1}W_{i1}$. One case was individual 157, who had 0 scores for 38 of the 39 factors. It appears that these individuals had no interest in completing the questionnaire, therefore the data may be unreliable. For the purposes of this study, these individuals were left in the data analysis.

From the importance matrix, it can be seen that factors 16, 19, 7, 15, and 5 (accuracy, reliability, technical competence of the ISG staff, convenience of access, and relationship with the ISG staff, respectively) are the most important factors to the group as a whole.

Examining the two matrices together can give valuable information. For Right of Way, all of the factors which were very high on the NS_i matrix were also quite high on the importance matrix. This is an indication of the success of the ISG department.

In the upper left hand area of the NS_i matrix are the most satisfied individuals and the most satisfying factors. If any negative numbers are found in this area, than some individual is dissatisfied with a generally satisfying factor. For Right of Way, there is one such number. The tenth most satisfying factor (technical competence of the ISG staff) is dissatisfying for the fourth most satisfied user (individual 159). If this research was replicated without anonymity, this individual could be consulted to try to determine the cause of the dissatisfaction.

The least satisfying factors are found at the bottom of the NS_i matrix. For Right of Way, there were only two factors which were dissatisfying. They were factors 10 (time required for new development) and 35 (degree of training given the users). These factors were also quite low on the importance matrix. It may not be worthwhile to affect any change, because these are not among the most important factors. If any of the most dissatisfying factors are among the important ones, it would probably be very worthwhile to try to improve them.

For Right of Way, there were no positive scores in the bottom right hand area of the NS_i matrix, where the least satisfied individuals and the least satisfying factors may be found. If there were, it would mean that a generally dissatisfied person is oddly satisfied with a generally dissatisfying factor. In such a case, if the research were done without anonymity, this person may be able to provide some information about what is satisfying about the factor and what might be done to improve it.

The most important factors were identified from the importance matrix as noted earlier. These were found on the NS matrix to discover whether or not the important factors were being satisfied. Factors 16 (accuracy) and 19 (reliability) were at the top of both matrices, indicating that the top two most important factors are also the most satisfying ones. All of the most important factors were high on the NS_i matrix except factor 15 (convenience of access). This is a factor which needs to be improved in order to improve user satisfaction.

Combinations of Methodologies

As indicated earlier, one individual was found whose activities were performed by no others and there were no reports shared with others. This individual may benefit from the use of a microcomputer. This was determined using the IDEF and Bailey and Federle Methodologies.

In another case, one activity was very high on both the NX_i and the average X matrices of the Bailey and Federle Methodology, meaning it is a very computerizable activity. This was activity 221. The Krobock printout (Appendix K) was consulted to discover if the individuals who perform this activity (105, 106, 109, 114, 135, 146, 153, and 156) have either high B_i*C_i scores or low $\frac{A_i}{A_i + (B_i * C_i)}$ scores. Individuals 135 and 153 had low $\frac{A_i}{A_i + (B_i * C_i)}$ scores. This means they feel that much more of their information could be computerized. Since they perform an activity with a high potential for computerization, it may be beneficial to provide them with computer support for this activity.

The most dissatisfied individuals on the Pearson NS_i matrix were 119, 147, 103, 133, 120, and 111. (These are the individuals with negative overall satisfaction scores) The Krobock printouts for those individuals (Appendix M) can show which factors affecting utility could be improved in order to increase utility of the information for the individual and increase the satisfaction of the individual. For example, individual 120 finds aspects 2 (currency) and 3 (accuracy) most important, as indicated by a scores of .45 each. The same individual finds aspects 4 (relevancy), 5 (adequacy), 6 (easy to use), and 7 (handy) useless, as indicated by scores of 0 for each. In order to see if this individual is satisfied with these aspects, all but one of which (aspect 7) corresponds to satisfaction factors on the Pearson NS_i matrix, the individual was found on NS_i matrix (Appendix N) and comparisons made. In this case, aspect 6 (ease of use) was a cause of dissatisfaction for this individual. Aspects 4 (relevancy) and 5 (adequacy) were not dissatisfying to this individual. If the information this individual is provided with had improved ease of use, the individual might be more satisfied and find more utility for the information through an improved aspect of usefulness. None of the most dissatisfied individuals shared pieces of computer generated information. If they did, and the same aspects of usefulness received low scores, this could build a stronger case for improving aspects of usefulness.

Using the Krobock printout for computation (Appendix K), individuals with high B_i*C_i scores or low $\frac{A_i}{A_i + (B_i*C_i)}$ scores were identified. These scores indicate unfulfilled computer needs. These individuals are 103, 111, 120, 135, 153, and 155. They were located on the Pearson NS_i matrix (Appendix N). If an individual was dissatisfied and has one of these scores from the Krobock Matrix, it can indicate that more computerization may increase this individual's level of satisfaction. This may be true in the case of individual 103, 111, and 120, who all have negative overall satisfaction scores. In addition, individual 103 had high NX_v scores for activities 214 and 230 on the Bailey and Federle NX_v matrix (Appendix H). These activities are highly computerizable, the individual feels that more computer support could be helpful to them, and the individual is generally dissatisfied. This person's satisfaction level could probably be increased by providing computer support for these activities. This is also the case for individual 111, who performs two activities with high NX_v scores, and individual 120, who performs six activities with high NX_v scores.

Users Manual

The results of the analyses presented in this, and the preceeding section of this report led to the creation of a Users Manual for ISG of ADOT. This Users Manual may be found in Appendix A. The Manual will be introduced to interested members of the ISG by a minimum of two training sessions to be scheduled on acceptance of this report.

The Users manual lists seven specific objectives which might be accomplished through the techniques used by this study. These objectives are:

1. To ascertain general user satisfaction with the present information environment
2. To ascertain causes of satsifaction or dissatisfaction through a detailed analysis of satisfaction factors
3. To identify potential new computer applications through a detailed analysis of user needs
4. To ascertain user perceived utility value of existing reports by analysis
5. To ascertain inferences about activities which may be candidates for microprocessor applications
6. To prioritize specific ne application requests
7. To ascertain information about the user community through a general audit

For each of these objectives, specific instructions as to which questionnaires to be used; how the data from the questionnaires should be reduced; and, what inferences may be drawn from the data are shown.

The questionnaires used in this study (Questionnaire 1 and Questionnaire 2) were found (see this analysis) to be unsuitable for efficient use by the ISG group. Therefore modifications were made in these questionnaires. The modified questionnaires; identified as the Bailey and Federle Questionnaire (Appendix A-1), the Krobock Questionnaire (Appendix A-2), and the Pearson Questionnaire (Appendix A-3) are presented as sub-appendices to the ISG Users Manual. As shown in these analyses the modifications made in these questionnaires do not alter their validity or reliability, therefore data gathered through their use will not alter the methods of reduction or interpretation as shown in this report.

The questionnaires presented in the ISG Users Manual are formatted for direct use by the ISG, however it is suggested that appropriate cover pages for specific uses be prepared before these are used.

RESULTS

Summary

Recognizing that effective information systems are the goal of many organizations, needs to be addressed in reaching for that goal were studied. There were several areas of need that were found to be of great importance. Those areas are:

1. Understanding of the environment, functions performed by individuals in the environment, relationships among those individuals and their functions, and information flows among the functions.
2. Understanding user needs and potential for fulfilling those needs.
3. Determining utility of information systems.
4. Determining the satisfaction level of users of information systems.

After a literature review encompassing all of these areas, several methodologies were shown to fill the needs described. They are:

1. The IDEF Methodology: for understanding an environment, its functions, relationships, and information flows.
2. The Bailey and Federle Methodology: for user needs and potential for computer support.
3. The Krobock Methodology: for determining utility of information systems.
4. The Pearson Methodology: for determining user satisfaction with information systems.

These four methodologies were applied to three services of The Right of Way Section of ADOT. An IDEF model was drawn for the Right of Way Section and the remaining three methodologies were applied to three services. The data acquired from this was reduced to matrix form for ease of analysis.

With the aid of a team of experts, the data was analyzed. Implications of the results were discussed.

Conclusions

Application of the methodologies selected for use in this research and verification of the results has shown that they do indeed measure what they are intended to. It has been shown that the methodologies can work separately and in harmony with each other. The important methodological questions raised in the introduction to this report may now be considered.

1. Are the methodologies easy to learn to use? When learning about the methodologies in order to perform this research, time was taken to understand the many facets of the methodologies. They were not difficult to learn to use, but required lengthy study. Since questionnaires, administration procedures, and analysis procedures have now been prepared and outlined, learning to use them will require only a short time.

2. Are the methodologies easy to apply? The first methodology used in the gathering of data for this research project, IDEF. IDEF's main disadvantage is that it can be a time-consuming project to undertake. For this research project, approximately 150 manhours were spent interviewing 22 people, drawing the IDEF model, recirculating the model for review, and preparing the final model. This was a relatively small project and it is evident that for a large project, using the IDEF methodology would be extremely time-consuming. The IDEF methodology gives a picture of the functions and information flows in an organization; therefore, it can provide valuable information to a systems analyst. If a long-term, complete analysis is to be performed, it is

recommended that the IDEF methodology be used to aid in giving a clear understanding of an environment. If a short-term analysis is to be performed, IDEF may not be a feasible methodology. The time required to perform the methodology would not be available in this type of analysis. A possible solution to this problem would be to do a long-term general study of an entire organization, then as specific applications needed analysis, those areas could be modeled with a more specific technique. The analyst could then relate the two models to extract whatever information is needed.

Using the questionnaires developed for use in the study, the remaining three methodologies are easy to use. Programs have been written to reduce the data into matrix format and require only entry of data and specification of parameters, such as the number of respondents. Evaluation procedures have been established and can be followed easily.

3. Are the methodologies useful in improving effectiveness of information systems? The methodologies have shown their usefulness in providing insights necessary to implement improvement of information systems.

4. Are combinations of the methodologies useful in improving effectiveness of information systems? Combinations of the methodologies were analyzed and recommendations have been made concerning interpretation of the results. Combinations of the methodologies can add to the information gained from the use of a single methodology. They can also support results from the usage of a single methodology.

5. Can a reasonable method of improving their operations within ADOT be provided to the ISG group of ADOT? This is definitely answered in the positive through an examination of the Users Manual. This manual provides many guides to the ISG to help them improve their interrelations and responsiveness to the rest of ADOT.

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