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Monitoring System Development: A Framework and Application

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MONITORING SYSTEM DEVELOPMENT: A FRAMEWORK AND APPLICATION

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Prepared for
Experimental Technology Incentives Program

ETIP

THE EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards pursues an understanding of the relationships between government policies and technology-based economic growth. The pursuit of this objective is based on three premises:

- Technological change is a significant contributor to social and economic development in the United States.
- Federal, State, and local government policies can influence the rate and direction of technological change.
- Current understanding of this influence and its impact on social and economic factors is incomplete.

ETIP seeks to improve public policy and the policy research process in order to facilitate technological change in the private sector. The program does not pursue technological change per se. Rather, its mission is to examine and experiment with government policies and practices in order to identify and assist in the removal of government-related barriers and to correct inherent market imperfections that impede the innovation process.

ETIP assists other government agencies in the design and conduct of policy experiments. Key agency decisionmakers are intimately involved in these experiments to ensure that the results are incorporated in the policymaking process. ETIP provides its agency partners with both analytical assistance and funding for the experiments while it oversees the evaluation function.

Because all government activities potentially can influence the rate and direction of technological change, ETIP works with a wide variety of agencies, including those that have regulatory, procurement, R+D, and subsidy responsibilities. Programs are currently underway with the General Services Administration, Food and Drug Administration, Veterans Administration, Securities and Exchange Commission, Department of Energy, Environmental Protection Agency, Occupational Safety and Health Administration, and other Federal agencies as well as various State and local agencies.

The accompanying report was prepared from an internal study of system developments conducted within ETIP programs. The purpose of the study was to examine the problems of developing complex systems in the ETIP environment and provide an approach for improved management of those problems. Statements contained in this document represent the views of the author and do not necessarily reflect those of ETIP or the National Bureau of Standards.

Director
Experimental Technology Incentives Program
National Bureau of Standards
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ABSTRACT

MONITORING SYSTEM DEVELOPMENT: A FRAMEWORK AND APPLICATION

Projects aimed at developing new systems where there are substantial uncertainties as to system requirements, development processes, and ultimate ownership can present project managers with a range of complex, unstructured problems. A process to help identify and solve these problems in a timely, controlled manner is of central importance to the successful conduct of a development with these circumstances.

This dissertation describes a research project devoted to examination of problems in complex system developments and to the development of a process managers can use to deal with them. Conducted within the Experimental Technology Incentives Program (ETIP), the research includes analysis of several ETIP projects, a review of the system literature, presentation of a monitoring framework to help manage complex developments, and a brief application of the framework to one ETIP project.

The proposed monitoring process consists of a framework of thirty factors and a set of five functions which monitoring can serve. The factors are divided into three main categories -- design, process, and user commitment characteristics -- which reflect the general types of problems found to be important in the ETIP environment and the

systems literature. The functions of the framework, designed to serve both administrative and research purposes, include problem identification, strategy development, research, documentation, and dissemination. A model of how the framework might be implemented within a project is also described.

The research makes several contributions. For ETIP, the identification of the problem and the studies of specific projects represent the first detailed examination of system development processes within the program. In addition, the proposed monitoring framework offers an approach for the improvement of future development projects.

For others outside of the ETIP environment, the results may have both administrative and research value. Other system developers are expected to find the framework useful for improving the management of complex system developments in their own situations. For instance, the framework factors may suggest several new considerations important in their projects. In addition, the functions monitoring can serve may suggest ways that a structured, routine information gathering process can improve their own management processes.

For researchers interested in system development processes, the dissertation results provide several contributions. First, the identification of the monitoring problem represents a more detailed examination of the problem than has been undertaken in many parts of the literature. Second, the proposed framework offers researchers a mechanism which may assist in the design and implementation of future studies. By combining research objectives with administrative use of the framework, researchers should be able to conduct structured investigations of system developments in real-time rather than having to rely on the more common retrospective approaches.

More generally, the results of the dissertation may be of value to developers and researchers involved with a wide variety of complex developments.

PREFACE

"There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old system and merely lukewarm defenders in those who would gain by the new one."

Machiavelli, The Prince, 1513
(Adapted from Crandell, G. M.
Why EDP projects miscarry.
The McKinsey Quarterly, 1978,
pp. 67-74)

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Numerous people have been involved with the conduct of this research both inside and outside of ETIP. I want to recognize many of them for their support, encouragement, and comments.

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Next, I want to thank several people within ETIP who have supported the research over the years it has been underway. Bob Parsons, the ETIP Director, and Daniel Fulmer, my supervisor, have both been very supportive in the final stages of my research and have given me the space to finish it. I would also like to recognize Jordan D. Lewis, the past director of ETIP, who provided the opportunity for me to conduct the research, and Victor N. Berlin, my past supervisor in Experimental Methods, who helped me develop my skills in ETIP projects, provided much guidance and encouragement for my research, and provided comments on the final document. Bud Libman and Roland Weiss (formerly of ETIP) both receive my thanks for their numerous comments and ideas on my research. Mary Mogee receives my thanks for her support and my hope that her dissertation proceeds well and successfully. Finally, special thanks to Madge Cooksey, my typist, who has been with me the whole way. Thanks for sticking with it Madge, I could not have done it without you. Best wishes for your future.

Next, I want to thank my special friend Warren Frederick. Warren has provided immeasureable help as a close friend and colleague during this project. The final outcome reflects a lot of his thinking. Warren, in relation to our "beasties" contest, I still think you win hands down.

There have been many friends who have provided support to me in the past several years during this long project. I want to thank them for listening to me and showing me what friends truly are. My heart felt thanks to Kathleen Flaherty, Ken Davis, Francois Alouf, Jon Mundorff, Mary Stewart, Eileen Kahn, Donna Tobias, Rich Freeman, Dee Seymour, Karen Stoyanoff, Nancy Remley Whiteley, Eliot Roseman, Dave Rittenhouse, Elise Blumenthal, Lonnie and Donna Au, Jim deBettencourt, Jane and Paul Mandel.

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CHAPTER 1

INTRODUCTION AND SUMMARY

1.1 OVERVIEW OF THIS CHAPTER

The development of systems where there are substantial uncertainties as to system requirements, development processes, and ultimate ownership can present managers with complex, unstructured problems. Recent developments of this nature in the Experimental Technology Incentives Program demonstrate that managers need a mechanism to handle these problems in a manner which promotes timely awareness and resolution of the problems as well as increased attention to both their short and long term implications for strategy.

This dissertation is devoted to an examination of the types of problems which can arise in complex developments and to the development of a monitoring mechanism managers can use to more effectively control them. The specific focus is on system developments conducted within the Experimental Technology Incentives Program.

The following sections of Chapter 1 outline the activities, results, and contributions of the research into those problems. References are made to the chapters where more specific details are presented and a directory to the dissertation is also provided.

1.2 INITIAL DESCRIPTION OF THE PROBLEM

1.2.1 The Experimental Technology Incentives Program [1]

The research being reported in this dissertation took place in the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. Created in 1972, ETIP's goal is to develop a better understanding of the relationships between government policies and technology-based economic growth. This goal is pursued through the conduct of studies and experiments with government agencies whose policies have a linkage to technological change in the private sector. In recent years, ETIP has focused on regulatory, economic, R&D, and procurement policies.

The primary research approach used by ETIP is that of administrative experimentation (Campbell, 1969; Thompson and Rath, 1974). ETIP and an agency join together as partners in projects where there is a shared interest in various elements of a policy-technology relationship. Where a policy change offers the potential to learn more about the elements and linkages of a specific policy-technology relationship, an experiment is then defined. In the research role, ETIP offers funding and analytical support for all phases of an experiment, including experiment development, design, implementation, and evaluation. In the administrative role, the respective agency offers

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[1] More specific information on ETIP can be found in APPENDIX A.

the action setting, policymaking power, and resources to help support the experiment and its evaluation. Using this approach, ETIP and the partner agency learn more about agency practices and impacts in a manner which meets the interest of both participants.

1.2.2 ETIP System Development Projects

Some ETIP projects involve the development of information systems as part of the experimentation process. For example, an agency partner may want to improve the process by which it implements a policy. In this case, a system constitutes the primary objective of a project and it is expected to lead to an on-going means for studying a policy-technology relationship. In other situations, development of a system may be tied to a pending policy change where a process is needed to monitor and evaluate the effects of the change. Some recent examples of these types of projects have included a data base system, an impact monitoring system, an information distribution system, and a planning system.[2]

One particular systems project involved the development of an evaluation system that was to be used in conjunction with the experiments underway in the Procurement Program of ETIP. This project was initiated by ETIP over the need to develop a more formal program of evaluation for the procurement experiments that could meet agency

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2 Several of these are described in more detail in Chapter 2 as part of this research.

and ETIP information needs over an extended period of time.[3] It was expected that, with the continuation of the Procurement Program, the system would eventually be institutionalized within one or more agencies involved with procurement experiments.

While this system development was similar in some respects to other ETIP experiences, it also represented a fairly new approach in ETIP that presented project managers with several novel problems. These are further explained below.

1.2.3 ETIP's System Development Problems

The evaluation system project discussed above presented ETIP project managers with several special problems. First, there were substantial uncertainties as to the requirements for the system. These were due to several circumstances:

- The Procurement Program was highly fluid in that the number and type of experiments (and agency partners) were variable.
- There were numerous objectives for evaluation from specific and immediate (e.g., what happened in an experiment) to broad and long term (e.g., the implications of a series of experiments for policy changes in the agency).
- There were numerous stakeholders in the procurement work, including Federal, State, and local partner agencies, and related public and private institutions with a stake in procurement policies.

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[3] More background on the initiation of this project is presented in Chapter 6.

Generally, the requirements for the evaluation system could be characterized as broad, changing, and complex. It was unclear what evaluation would be needed as well as what system design would be needed to conduct evaluations in the long term.

Second, there were also substantial uncertainties in the system development process. A development of this nature had not been conducted by ETIP before and similar experiences in other environments were unknown or nonexistent at that time. In addition, the development team was new and had to be integrated into the already established relationships between the Procurement Program and its partner agencies. There were two aspects to this problem. First, the project managers in ETIP were new and had to establish ties with the Procurement Program. Second, as contractor support was acquired to help in the development, a third set of personnel outside of ETIP had to be included as another party to the procurement experiments.[4] Those characteristics combined with the aforementioned uncertainties over system requirements necessitated a flexible, evolving approach to the development as both relationships and knowledge of evaluation needs increased.

Finally, the project was further complicated by the uncertainties over eventual ownership of the evaluation system. While ETIP was

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[4] Acquiring contractor support for the project was itself a novel problem. See Chapter 6 for more discussion of the procurement and Libman (1980) for a complete examination.

fully supporting the development and expected to derive information from the system in the long run, it was not expected nor planned to be the primary user and owner. One of ETIP's long term goals was to institutionalize the experimentation process in agencies which found it to be a value in their continuing development and implementation of policies. The system development was thus planned with this goal in mind and an objective was established to turn-key the system after its development. However, when the project was initiated, it was unclear who the eventual owners would be and what form the institutionalization process would take.

1.2.4 A Monitoring Problem

ETIP project managers were faced with a system development in which there was substantial uncertainty in system design, development process, and ultimate ownership. As the project began, these uncertainties, and the numerous activities which were underway, presented managers (one of which was the writer) with a need for a mechanism for project control. Day-to-day problems and progress often consumed the time and attention of managers at the expense of maintaining a more overall perspective on the direction of the project. Problems were difficult to anticipate in advance and problem solving often had to be conducted under pressure and with limited examination of both short and long term implications. In addition, strategy was being developed incrementally, often in response to short term problems, leaving some uncertainties as to whether the project was on course and leading towards a successful development.

The need for a control mechanism was the earliest idea for the research project reported in this dissertation. At first, the problem was characterized as one of the need for a strategy model. Project managers were seen as needing an ideal model on which to judge whether the project was on course and to better anticipate and plan the specific activities that should occur. It was also viewed as a means of anticipating problems and providing a longer term perspective to their solution.

Various initial studies of other ETIP projects and the systems literature were then conducted to develop a strategy model. It was expected that these other experiences would provide "proven" elements of strategy that would assure the chances of success for ETIP managers in the evaluation system project.

However, a model for development strategy was not identified in these sources that could be readily adapted into the particular ETIP situation. If anything, it was clear that no one model existed or could be developed in detail that would reflect the changing and complex circumstances the development presented. It thus came to be seen in the research that the real need of the management team was for some way to develop strategy over time, based on a more complete awareness of project activities as they unfolded.

The problem of concern in the dissertation therefore was changed from one of developing a model to one of developing a mechanism which managers could use to monitor progress. Further research was aimed at developing this mechanism and applying it to the ETIP environment.

1.3 RESEARCH DESIGN AND SELECTED RESULTS

This section summarizes the research design which was used to develop and explore the usefulness of the monitoring framework. The discussion includes a review of the objectives and the specific tasks which occurred, and an overall classification of the research design.

Presenting this information has been a problem to some extent since the research was exploratory and involved the concurrent activities of examining the monitoring problem and developing a specific monitoring approach. This section thus provides an overview of what was done without too much regard to the order with which activities occurred. A more detailed presentation of the actual process is presented in Chapter 4.

1.3.1 Objectives

With the initial problem identified, as described above (Section 1.1), there were two main objectives for the research described in this dissertation. These included:

1. To develop a framework for monitoring system developments that would provide managers with a basis for assessing and revising project strategy, and

2. To explore the usefulness of the framework as a management tool in actual system projects.

Most of the emphasis in the research has been devoted to framework development. This was primarily due to the need further refine the problem of monitoring and then to devise a mechanism as a proposed approach. The extensive time consumed in this process eventually eliminated the opportunity to explore the usefulness of the approach in real-time in an actual ETIP case. A retrospective application was then conducted to at least initially examine the merits of the approach.

1.3.2 Specific Tasks

This section summarizes the various elements of the research design which occurred under each main objective. More specific details and results of these tasks are provided elsewhere in the dissertation, and references to the appropriate chapters are made.

1.3.2.1 Monitoring Framework Development

The first objective of the research was to develop a monitoring framework that ETIP managers could use to assess and revise strategy for a system development. Work within this area consisted of two main components -- that of further refining the monitoring problem while simultaneously developing a specific monitoring approach. Overall, there were five tasks which were conducted in this portion of the research. These included:

1. Analyzing several ETIP system developments.

   Three ETIP cases were examined for factors important in system development (see Chapter 2). Examples from the cases were later used to illustrate the specific factors of the monitoring framework (Chapter 5).

2. Reviewing the systems literature.

   The systems literature was also reviewed to identify more factors important in developments (Chapter 3). Problems and gaps found in this review influenced framework design. Later, the literature was scanned more closely for ideas on monitoring (Chapter 4).

3. Reviewing ETIP management needs.

   The ideas generated by the reviews of ETIP projects and the literature were compared against the needs of managers in the specific case which initiated the research (Chapter 4).

4. Organizing factors into a monitoring framework.

   The factors identified in ETIP projects and the literature were refined and organized into a framework structure. Thirty factors were identified in three main categories --design, process, and user commitment characteristics (Chapters 4 and 5).

5. Developing the monitoring functions.

   A set of procedures to accompany the factors was also developed. Five main functions for monitoring were identified -- problem identification, strategy development, research, documentation, and dissemination. A general model of how the framework might be applied was also developed (Chapters 4 and 5).

1.3.2.2 Exploring the Usefulness of the Framework

The second objective of the research was to explore the usefulness of the framework as a management tool in actual developments. Specifically, it was desired to examine whether the framework could assist managers with problem identification, strategy development, or the documentation and dissemination of progress in the course of conducting a development.

While the original expectation was that one on-going project in ETIP would be used (the evaluation system project), the duration of framework development activities eliminated this opportunity. A less effective retrospective approach was then designed and applied to the completed evaluation system development.

Three tasks were conducted in the retrospective application of the framework to the ETIP evaluation system case. These included:

1. Developing a case history of the project.

   A case study of the project was conducted to familiarize the writer with events and to identify selected periods where the framework might be applied (Chapter 4). One period was selected. A brief chronology of the project was written for the dissertation (Chapter 6).

2. Mapping the framework onto the project.

   The preliminary task of the actual framework application was to map the framework factors onto project events during the period selected earlier (Chapter 4). This demonstrated that the factors were relevant to the case and prepared the way for exploring how the framework might have helped managers (Chapter 6).

3. Examining how the framework might have helped managers.

   The mapping was used to show that use of the framework might have helped managers identify a critical problem of the period (Chapter 6).

1.3.3 Classification of the Research Approach

The research approach taken to meet the objectives described above can be classified according to three research dimensions developed by Thompson and Rath (1974) --Exploratory-A Priori, Normative-Empirical, and Study-Experiment. Each of these dimensions is discussed below.

1.3.3.1 Exploratory-A Priori Dimension

The Exploratory-A Priori dimension measures the extent to which the researcher predetermines the effect of new data on his results. Exploratory situations are those characterized by many unknowns in data, methods, and results while a priori situations tend to be more predictable, controllable, and reaffirming.

On this dimension, the research was exploratory. There was not much orderliness to the problem at the beginning of the effort (Roseman, 1978, pp. 1-9). Concepts needed to be identified and developed in order to provide structure to the problem. While sources in ETIP and the systems literature contained many elements related to the problem, a detailed recognition of its dimensions and components was not uncovered. The dissertation has both identified a problem in more detail and proposed a specific approach where neither has been explicitly recognized or developed previously.

1.3.3.2 Normative-Empirical Dimension

The Normative-Empirical dimension measures the extent to which the researcher obtains new data directly from the phenomena under study (i.e., system developments in this case).

On this dimension, the research was somewhere in the middle. Ideas, models, and concepts related to system development have been used to help define the problem and the framework, thus the research is somewhat normative. In addition, the primary contributions of the research are ideas and not empirical data. On the other hand, some more direct experiences have also been a part of framework development and its preliminary application. Several system projects in ETIP have been examined and used to illustrate factors in the framework. An additional case has also been used to explore the usefulness of the framework in an actual case. Although this application relies on a retrospective analysis of project records, the writer's experience with the project as it unfolded also adds a more direct connection to the specific events. These cases thus add an empirical element to the research, although a more thorough testing directly in a project is still needed.

1.3.3.3 Study-Experiment Dimension

Finally, the Study-Experiment dimension measures the extent to which the researcher manipulates the phenomena under investigation.

On this dimension, the research is more of a study than an experiment. The ideas and experiences of others as reported in ETIP records and the systems literature have been the primary source of material on the system development process. Problem definition, framework development, and exploration of framework usefulness have thus relied to a large extent on sources not directly controlled by the writer as part of the dissertation research.

However, it also should be noted that the research has closely interacted with the writer's experience in a system development (the evaluation system project). The experience in this project provided the impetus to begin the research as well as a continuing benchmark against which to "test" understanding of the problem and ideas on the monitoring framework. While not an experiment in the formal sense, this interaction represents an element of control which likely has affected the implementation of this research.

1.4 VALUE OF THE RESEARCH

The dissertation makes several contributions of value to both administrators of system developments and researchers of system development processes (Chapter 7). For ETIP, the identification of the problem and the studies of specific projects represent the first detailed examination of system development processes within the program. In addition, the proposed framework offers an approach for the improved management of future development projects.

Other system developers are expected to find the framework useful for improving the management of complex system developments in their own situations. First, developers may find the factors of the framework useful for suggesting new considerations important in their projects. Second, developers may find the functions monitoring can serve useful in improving their own management practices. The proposed framework may be able to supplement existing practices for the identification of project management problems, the development and revision of strategy, or the documentation and dissemination of progress for decisionmaking on project implementation.

For researchers interested in system development processes, the dissertation results are of value in several areas. First, the identification of the monitoring problem represents a more detailed examination of the problem than has been undertaken in many parts of the literature. Second, the proposed framework offers researchers a mechanism which may assist in the design and implementation of future studies. By combining research objectives with administrative use of the framework, researchers should be able to conduct structured investigations of system developments in real-time, rather than continuing to rely on case studies and retrospective approaches.

Finally, the results may be of value to administrators and researchers of a variety of complex developments. While the framework is specificallly designed for the ETIP environment and its information system developments, its components are based on ideas and experiences associated with a wide variety of systems. The dissertation may thus offer guidance for other kinds of developments, or at least promote an increased awareness of the similarity of problems often encountered in distinctly different types of developments.

1.5 A GUIDE TO THE DISSERTATION

1.5.1 How to Read the Dissertation

The organization of the dissertation has generally followed the progression of research activities as they occurred. For example, Chapters 2 and 3 review ETIP projects and the systems literature which were used to help define the problem and support development of the monitoring framework. Chapters 5 and 6 present the resulting framework and explore its usefulness in an additional ETIP project.

Depending on the interests of the reader, there can be several approaches to reading the dissertation. Most readers may find it best to review Chapter 1 first in order to obtain an overview of the dissertation. Chapter summaries are provided below to further identify contents in each chapter.

Researchers of system development processes may find several components of the dissertation useful for their work. Therefore, researchers may want to scan Chapter 4 next to examine the monitoring problem which has been identified and the research process which has been used. Following this, researchers should turn to Chapter 3 and examine how the systems literature has been used to define the problem and to develop an approach to project monitoring. Some researchers may also find the ETIP case studies of Chapter 2 interesting as detailed descriptions of actual projects and as models for the documentation of future projects. Finally, researchers should examine the monitoring framework of Chapter 5 and a shortened "how to do it" manual located in APPENDIX B. They should find the factors of the framework which relate to their current research. Researchers should then determine whether the framework offers an approach for structuring future research projects and gaining access to actual projects for the conduct of research.

Managers of system development projects will most likely find the monitoring framework the primary contribution of the dissertation. Thus, they should turn to Chapter 5 directly and examine the monitoring factors and the monitoring functions which are proposed. A preliminary draft of a "how to do it" manual has also been prepared from Chapter 5 and included in APPENDIX B. System developers may find this shortened version more appropriate for their review. Finally, if further ideas on the application of the framework to a project are needed, developers may want to scan Chapter 6 to examine how the framework might have been used in an ETIP project.

1.5.2 Chapter Summaries

1.5.2.1 Chapter 2

This chapter reviews three ETIP projects which involved system developments. The reviews were initially conducted to develop a list of factors important in an ETIP development, thus documenting the background knowledge available in the program. Examples from these cases are later used in Chapter 5 to illustrate factors in the monitoring framework.

1.5.2.2 Chapter 3

This chapter reviews the systems literature which was also consulted in the pursuit of factors important in system development. The chapter is divided into two main parts. The first part provides an overview of the systems literature in general to demonstrate the types of materials studied. This portion also includes several examples of those materials which are later referenced in support of the framework factors identified in Chapter 5. The second part of the chapter reviews problems and gaps in knowledge in the literature which were relevant to and influenced the development of the monitoring problem and framework. The items are tied to the respective actions taken in the research.

1.5.2.3 Chapter 4

This chapter describes the research design as it unfolded, from development of the problem to the exploration of the usefulness of the framework in a specific project. References are made in the discussion to other chapters which resulted during the process.

1.5.2.4 Chapter 5

This chapter presents the monitoring framework which has resulted from the research. The thirty factors in the framework are described and illustrated with examples from the three ETIP projects discussed in Chapter 2. Also, the five functions monitoring can serve in a system development are described. A model of how the framework might be implemented in a project concludes the chapter.[5]

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[5] A shortened "how to do it" manual for applying the framework has been prepared from Chapter 5 and is included in APPENDIX B. The manual is a preliminary version and essentially summarizes materials presented in Chapter 5.

1.5.2.5 Chapter 6

This chapter presents the retrospective application of the framework to a specific ETIP case. The first portion of the chapter presents a brief chronology to familiarize readers with the case. The second portion of the chapter then shows how the framework might have helped managers identify a critical problem during one selected period of the project.

1.5.2.6 Chapter 7

This chapter reviews the results of the research conducted and the contributions made. In addition, some extensions to the research are discussed.

CHAPTER 2

SYSTEM DEVELOPMENT EXPERIENCES IN THE EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

2.1 INTRODUCTION

2.1.1 The Need to Review ETIP Experiences

As described earlier in Chapter 1, this dissertation evolved out of a need for guidance in a specific system development in the Experimental Technology Incentives Program (ETIP). [1] It was found that system developers needed a device to help them monitor and control the numerous, evolving activities and problems of the project.

One of the first tasks in the formation of the monitoring device was to examine the guidance available in other ETIP projects which involved similar information system developments.[2] Three projects were selected for in-depth study, including:

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1 This was the project to develop an evaluation system for the ETIP Procurement Program. See Chapter 6 for more details on the project.

2 ETIP had conducted a number of similar projects before. Since they were completed already or nearly completed, it was expected that they might provide some guidance for the management of the newer evaluation system development.

- A data base system for the Small Business Administration (SBA).
- A planning system for the Public Buildings Service (PBS).
- A procurement information system for state and local government agencies.

These three were used because:

- Each project had the direct or implicit objective of developing a system which would become institutionalized within an organization (similar to the evaluation system project).
- The writer was assigned to review or monitor most of the projects.
- The projects were either completed or nearly completed, making it possible to study a project from the beginning to the end.
- The projects were fairly well documented, and where records were weak, contact with original participants was still feasible.

Each project was reviewed in detail to determine what had happened and what key factors had influenced progress. Project documents were reviewed and many of the principal participants were interviewed. In some cases, the writer's notes and observations in the conduct of ETIP business were used as sources of information for the case studies.

Important factors in development from each case were then collected and used to help develop a preliminary monitoring device for ETIP managers in the evaluation system project. Later, examples from each case were used to illustrate the factors in the monitoring framework (see Chapter 5).

2.1.2 This Chapter

This chapter presents some of the results from the three case studies to help set the stage for their use in later chapters. Specifically, this chapter provides the general history on each project and the major lessons which were found relative to their conduct. Examples from these projects are used later in Chapter 5 to illustrate the factors important for monitoring. Readers may also find this chapter helpful in providing an introduction to the ETIP environment and the systems of interest in this dissertation.

Each case is presented by itself and contains several sections. First, project background and objectives are described in order to show how the work was initiated. These sections are followed by others which discuss implementation. A final section in each case describes the major factors found to be important to project success. Major events in each project are summarized in Figures 2.1, 2.2, and 2.3 for easy reference. Major lessons learned are summarized at the end of the chapter.

Readers will note several things about the case descriptions. First, they tend to be brief and highlight only major issues. This was done in order to make the cases simple to understand and more easily usable in Chapter 5, where they are used to illustrate fac-

Date	Event
March 1974	Public Buildings Service (PBS) indicates interest in a project to ETIP and sends a preliminary plan.
May 1974	ETIP issues a project plan and obligates resources. Project is to develop a space acquisition model and procedures for PBS.
July 1974	Prime contractor and subcontractors acquired to help build new system.
September 1974	Prime contractor submits proposal to PBS to expand system development.
October 1974	Contract revised and extended to provide for more extensive modeling and integration with PBS processes.
April 1975	Preliminary model prepared for PBS review.
December 1976	Basic model procedures completed.
July 1977	Model computerized, first demonstration run.
September 1977	Prime contractor completes project and issues final report. Model in operation in Special Studies unit of PBS.
November 1977	ETIP begins review to determine evaluation needs. A number of applications reported by Special Studies unit.
February 1979	The General Accounting Office issues report on the model and suggests several improvements.
May 1979	ETIP issues report (Lawrence and Garrity) on model development and lessons learned for Procurement Program. Model still in operation in Special Studies unit, but not yet permanently institutionalized.
February 1980	Project account closed by ETIP.

FIGURE 2.1 CHRONOLOGY OF PUBLIC BUILDINGS SERVICE - ETIP PROJECT TO DEVELOP SPACE ACQUISITION PLANNING MODEL

Date	Event
Early 1974	ETIP discussions underway with Small Business Administration (SBA) for a joint project.
June 1974	ETIP issues plan to develop a data base system with SBA. Plan approved by Department of Commerce.
September 1974	SBA drafting a request for proposals for contractor support to develop the system.
November 1975	Contract for development awarded. Work begins on six main tasks.
December 1975	Task 1 completed: a review of set-aside cases in SBA.
February 1976	Task 2 completed: a preliminary plan of system and its operation to support set-aside cases.
April 1976	Task 3 completed: specific system design (manual system) and sites for preliminary field testing identified.
June 1976	Task 4 completed: design of field tests. SBA administrators briefed on tests. Field workshops planned.
September 1976	Task 5 completed: preliminary field tests. Eight cases obtained, system accuracy and reliability confirmed. Operational testing phase started for manual system.
October 1976	Several workshops held. Some opposition to using system arises in west coast site.
November 1976	ETIP begins new strategy to coordinate NASPO and NIGP procurement package developments. Proposes new joint schedule. NIGP issues Phase 1 report.

FIGURE 2.2 CHRONOLOGY OF ETIP PROJECT WITH NIGP AND NASPO TO DEVELOP STATE AND LOCAL AGENCY PROCUREMENT INFORMATION SYSTEM

Date	Event
December 1976	ETIP plans review process for both contracts to determine whether they should be renewed at end of Phase 2 in June 1977.
February 1977	ETIP requests special reports from NASPO and NIGP to answer several questions in continuing review.
March 1977	ETIP, NASPO, and NIGP meet to review progress of Phases 1 and 2.
April 1977	ETIP decides to terminate NASPO project after June. NIGP project extended at no cost to continue work on promising procurement information packages.
June 1977	NASPO project ends. NASPO issues final report. NIGP projected extended for one year.
June 1978	NIGP project ends (Phase 3 not funded).
January 1977	Workshops planned on east coast to build track record of use.
April 1977	SBA begins discussion with one agency to use system in pending procurements involving set-asides.

FIGURE 2.2 (Continued)

Date	Event
June 1974	Plan for state procurement information system development by the National Association of State Procurement Officials (NASPO) issued by ETIP and approved by Department of Commerce.
November 1974	Plan for local agency procurement information system development by the National Institute of Government Purchasing (NIGP) issued by ETIP and approved by Department of Commerce.
January 1975	NASPO project begins Phase 1. Information needs examined and task forces formed to develop information packages.
April 1975	NASPO reports task forces underway but problems with obtaining time from volunteer participants.
June 1975	NIGP project begins Phase 1. Information needs to be identified.
July 1975	ETIP organizes a meeting with NIGP and NASPO to discuss information system development. NASPO task forces working slowly.
August 1975	ETIP outlines problems with NASPO project, referring to lack of progress on work statement items.
October 1975	NASPO issues new work plan for rest of Phase 1.
November 1975	NASPO begins to distribute procurement information packages from several task forces. NIGP decides to develop packages in-house instead of with a contractor.
July 1977	Computerized version of system completed (with an added data base) and demonstrated in the agency. Test successful and applications started.

FIGURE 2.3 CHRONOLOGY OF ETIP PROJECT WITH SMALL BUSINESS ADMINISTRATION TO DEVELOP A SYSTEM TO SUPPORT SET-ASIDE PROCESS

Date	Event
September 1977	Task 6 completed: operational testing phase. Ten manual tests and five computerized tests completed. SBA decides not to fund operation of system further due to lack of demand for use. SBA awards independent contract to develop more comprehensive system for wider range of set-asides.
November 1977	Contractor issues final report. Concludes computerized version of system with data base best approach to supporting set-aside processes.
June 1976	Phase 1 of NASPO and NIGP projects ends. Phase 2 begins for both (12 months). NIGP selects 18 product areas for potential procurement information packages.
August 1976	NASPO issues Phase 1 report. Concludes that package development more complex than expected and proposes refocusing project on development of an institution to work with problems in longer term.

FIGURE 2.3 (Continued)

tors in the monitoring framework which has been developed. Second, readers will note that the illustrations in Chapter 5 often exceed the details provided in this chapter. This is partly due to the fact that Chapter 2 was written much before Chapter 5 and partly due to the desire to leave the intricate, intertwined details out of Chapter 2.

It should also be noted that work on Chapter 5 caused some refinements in these case descriptions after they were written. For example, in the PBS case below, readers will find that the speed and versatility of the computer system was one factor favorably influencing user acceptance of the system. Subsequent refinements of the monitoring framework as shown in Chapter 5 later transformed this factor into two components: response time and input/output operations (see section 5.2.1). Thus, to some extent, the examples of the cases in Chapter 5 can differ from the original perspective demonstrated in this chapter. While some modifications in Chapter 2 have been made to promote consistency, the case descriptions below are mostly in their original form. As such, they also provide a record of the writer's early thinking on the critical system development problems and the key factors to monitor.

2.2 A PLANNING SYSTEM [3]

A project was conducted between ETIP and the Public Buildings Service (PBS) to explore the benefits of using life cycle costing

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[3] The following sections draw heavily from Lawrence and Garrity (1979).

in the planning and acquisition of Federal space. The project was to develop a computer system to calculate these costs and institutionalize the process into the agency. ETIP money was obligated to PBS to initiate the development. PBS later added much more money of their own to the project as the requirements of the system expanded.

The project lasted over five years and resulted in a computer model and procedures using the life cycle costing strategy. Several test cases were conducted with the system. Limited portions of the model, particularly the economic analyses of specific space configurations, were accepted by users. Other portions of the model were not as successful due to data limitations. In addition, full user acceptance of the system was not obtained by the end of the project. This was partly due to their lack of control over system development and to low level support by top agency managers.

2.2.1 Background and Objectives

Several years before PBS project began, the Federal government made some policy changes in the acquisition and management of Federal facilities. The initiatives were primarily aimed at improving these processes through the requirement of more systematic, explicit, and detailed planning. The initiatives were also expected to increase innovative responses from contractors to Federal space needs and lower the overall costs of acquiring and operating office space.

The Public Buildings Service (PBS) of the General Services Administration (GSA), an agency responsible for the design, building, leasing, appraisal, and maintenance of Federal buildings, became increasingly interested in life cycle costing (LCC) techniques as a means to meet the requirements of the new directives. This was particularly the case for the Office of Management and Budget (OMB) Circular A-104 issued in 1972. A-104 required PBS to conduct cost analyses of property lease or purchase options. It also mandated analyses of costs over time, including those of operations, maintenance, taxes, and insurance. While many of these considerations and analyses were already being conducted in PBS, the agency wanted to develop a comprehensive LCC approach that could be computerized. This would facilitate evaluating and comparing costs of alternatives.

Also, at about the same time, the ETIP program was developing its interest in government procurement policies and practices. ETIP was especially interested in how procurement policies and practices could stimulate technological innovation in the private firms selling to the government. ETIP perceived that the PBS situation might offer an opportunity to implement an LCC procurement and collect data on the effects. Accordingly, a project plan was developed and agreed to by PBS and ETIP. The objectives of the project were (ETIP, Note 1, p. 2):

- To develop and test, through actual experience, the use of life cycle costing in the planning and acquisition of Federal space.
- To stimulate, through Federal leadership, desirable building system innovations in the non-Federal sectors of the economy.
- To develop a basis of future policy recommendations regarding the use of life cycle costing in Federal space planning and procurement.

While systems development was not an explicit objective in the project, the idea of utilizing the model and accompanying procedures over the long term was in the minds of project designers. Early versions of the project plan had statements such as "GSA/PBS will use the system in their planning process" and "if successful the experiment will provide justification . . . to institutionalize the use of life cycle costing in these processes (PBS, Note 2, p. 2). Later, as the needs for and architecture of the system became clearer, the project was expanded considerably to provide more resources directed towards system development (Mariscal and Company, Note 3).

2.2.2 Project Implementation

A model was developed and operational in PBS about three years after starting. Its capabilities were much in line with the original project objectives. The model consisted of three parts: a space analysis component, a cost analysis component, and a cost stream (LCC) analysis component. Theoretically, users could specify functional requirements for space and then run the model to help them further refine designs and develop cost figures. The analyses were all easily altered in order to change assumptions or create new alternatives.

Over a period of 18 months, the model was run about 40 times. Users were more interested in the LCC estimates for specific space configurations than they were in using the model as a design tool. Even though the model's capabilities were not fully utilized, the LCC figures were respected and accepted by users. Many of the operational runs produced figures later incorporated into PBS space acquisition proposals.

Actions were taken near the end of the project to build support for the model within PBS and with other agencies (Ostrander, Note 4). The General Accounting Office conducted a review of the model and supported its use in PBS. PBS provided money and the two staff members to run the model. Users continued to make requests for LCC estimates. ETIP's role eventually diminished until the model essentially became wholly supported by PBS itself.

2.2.3 Important Factors in Systems Development

The LCC modeling project was an ambitious undertaking. While the model was building on many existing procedures, it was adding computerization to work normally done by hand and capabilities previously difficult or impossible to develop. Results from model use were expected to influence the agency's planning and acquisition processes and possibly affect the building technologies bid on specific acquisitions by private contractors. The model was supposed to be used in three test acquisitions, with an evaluation following to compare actual versus forecast costs.

The development was successful to a degree. The model was built and tested numerous times, as mentioned earlier. Users accepted some results from the model and included them in their proposals for space acquisitions.

Several factors stand out as having facilitated implementation. The model, supporting procedures, and computer programs were developed closely with PBS staff and the PBS project leader. The project leader had a very high interest in the model and its techniques. He saw them as promoting better cost analyses and in the end possibly improving competition and innovation in the bidding on specific building, leasing, or renovating contracts (Ostrander, Note 4). The model would help meet the requirements of OMB Circular A-104 as discussed earlier.

In addition, the system reduced the time needed to do cost analyses on various designs from weeks to hours. The analyses were more easily adjustable for changes in designs and costs and thus allowed more rapid turnaround for estimates.

However, some portions of the project objectives were not achieved. First, the system was not fully tested in three space acquisition problems. It was originally expected that the model and its results would be part of three acquisitions which could be followed long enough to allow comparisons between planned and actual costs. It had also been expected, as mentioned earlier, that the system would be more fully utilized in the planning processes and possibly become a routine part of them. Initially this had meant using the system as a tool in generating specific design alternatives. Later it was hoped that the system would influence the contracting, building, and operating of specific sites.

These plans were not fulfilled. The system was used primarily to generate LCC figures. Other costs were still being calculated by hand. The capabilities to compare and alter designs within the system, or to use it to monitor contractor costs, were not utilized. Overall, the comprehensive integration of the system into PBS was not achieved.

A number of factors contributed to the changes in course from original expectations. First, while the system functioned within an important part of the acquisition process in PBS, its role was small relative to all the other events which were part of the process. Numerous political, economic, and design issues are part of any space acquisition problem, and life cycle costs influence only some of these. Initial costs were the primary consideration in decisionmaking. Ties with the final contracting, construction, and building operation stages were small or non-existent. Thus, while the system dealt with a problem important to PBS, its role and its potential to influence acquisitions were smaller than expected.

Another contributor was that the system was developed and operated within the Office of Special Studies, a staff office attached to the Commissioners of PBS. Since this office was not normally responsible for conducting the cost analyses, the system was essentially developed outside of the units of which it was to be a part. While this separation did not have to be a problem, in this case it may have hindered gaining commitment from the user units. Several reasons were behind this problem. First, the model had the appearance of a black box to users (Ostrander, Note 4). It was difficult to make comparisons between the normal manual procedures and the newer machine programs. Second, users were mostly concerned about initial costs in a proposal, as this reflected common agency practice. Since the system considered a range of costs in addition to initial cost, users had to shift to an entirely new approach. Training for users was needed, but it had not been a part of development (Ostrander, Note 4).

Contributing to skepticism about the utility of the system was that data for the model were hard or impossible to obtain. PBS had committed itself early on to provide its own operations and maintenance data (Galuardi, Note 5). However, requirements of the model exceeded the capabilities of current data bases. The model utilized a new structure for classifying major building subsystems and data were not yet commonly aggregated in this manner (Penn, Note 6). Thus, it was difficult to validate the model by comparing its analyses to actual cost figures (Ostrander, Note 4).

Finally, the model was not fully supported by top management, the Commissions of PBS (Ostrander, Note 4). This was partly due to uncertainties over what acquisition policies they were to implement. The model had been approved by the GAO in its investigation and it appeared commensurate with the requirements of OMB Circular A-104. At the end of the project, however, another policy, OMB Circular A-109, was being promulgated for application to large scale systems acquisitions. The role of A-109 in PBS was unclear. There also was uncertainty over the match between the A-109 requirements and the LCC system.

Commissioner support was further "inhibited by normal management reaction to the increased specificity, logical consistency and accountability implied in new applications of computer technology to decision procedures" (Lawrence and Garrity, 1979, p. 17).

2.3 A DISTRIBUTION SYSTEM

For several years ETIP conducted a project with state and local governments to develop and test the effect of procurement techniques on industry suppliers. The project included objectives for developing an information system that would serve both the procurement community and ETIP. It would develop and distribute information needed by state and local officials and provide a channel for ETIP to have influence on techniques used. ETIP contracted the system development with two nationwide procurement organizations having access to state and local agencies. Several information packages were produced by a pilot system and used by a number of agencies. Development was very slow and difficult however and the needs of agencies were found to be much broader than expected. A system to meet the original project objectives could not be developed.

2.3.1 Background and Objectives

As part of its research on government procurement and technological change, ETIP became interested in studying procurement policies at state and local agencies. There was considerable interest in the procurement community to initiate the ETIP research in this area. Federal, state, and local procurement officials saw that increased coordination and cooperation among all levels of government would upgrade procurement techniques and performance for everyone (Sampson, Note 7; Timbers, Note 8; Holding, Note 9).

While the basic ideas to be tested in the project were the same as those in previous Federal level research, the state and local environment presented some new problems for project designers. ETIP had very little direct contact or experience at the state and local levels. It would be difficult to establish this quickly with a large number of agencies, especially considering the limited ETIP budget and manpower. In addition, state and local agencies used a variety of techniques and had a variety of problems. The market was seen as very fragmented and this was a major barrier to developing the market force ETIP wanted in order to test its hypotheses (ETIP, Note 10, pp. 1-3).

Several strategies were used to overcome these problems in project design. First, two projects were developed, one at the state level and one at the local (county, city, local agency) level. ETIP used the advice and services of two nationwide professional procurement organizations to help in the developments. These were the National Association of State Procurement Officials (NASPO) and the National Institute of Government Purchasing (NIGP). Both had extensive contact and experience with the procurement officials ETIP wanted to reach.

ETIP then contracted the projects to NASPO and NIGP. Each project had three main lines of work (ETIP, Note 10; ETIP, Note 11). One was to develop a system that could identify procurement problems, develop information to solve the problems, facilitate collaboration across agencies, and generally improve procurement practices. ETIP viewed the system as the key to gaining access to agencies and building the coordinated market it needed. The system would both enable work to be done and build support for the project at the agency level.

A second line of work was to conduct experimental procurements testing the technological change hypotheses. These experiments were to be part of the system development and one activity the system would support in the long term.

The final line of work was to develop a means of supporting the system in the long term. All parties envisioned that the system would continue functioning after project resources were expended (Cornett, Note 12; ETIP, Note 11, p. 10; ETIP, Note 10, pp. 6-7).

2.3.2 NASPO Implementation

NASPO began its work by conducting a survey of state procurement agencies in order to identify products which involved procurement problems the state needed to solve. A long list was produced and then refined down to seven common products, including, for example, air conditioners. Using volunteers from interested states, NASPO formed task forces to develop the techniques, product information, criteria, tests, or other items needed for procureing the products.

Developing the packages proved to be more difficult than expected however. The needs of each state were often too different for the development of a consensus package (Cornett, Note 13, pp. 21-24). In some cases the items needed in the package were not readily available from other sources as originally expected. Since the task forces were dependent on the voluntary efforts of busy state officials, it was difficult for them to generate new information on their own.

Eventually four product packages were produced and sent to states for use in their next procurement cycle. A significant number of buys occurred with the packages, although in most cases the packages needed further onsite modifications before they were used (Wagner and Zeldis, Note 14). The major conclusion to be drawn from the package developments was that each agency had its own preferred procedures and that the differences among them were fairly wide. Aggregating the market by standardizing procurement methods and timing was not very likely.

2.3.3 NIGP Implementation

The NIGP project began several months after NASPO and followed the same approach. For about a year, procurement problems were solicited from NIGP members. Sixteen common products were identified among the list of these problems. NIGP then began to develop procurement packages for the sixteen products. Like NASPO, NIGP did not start out with the internal technical capability to develop the packages. However, instead of the field task force approach used in NASPO, NIGP chose to hire a coordinator of their own and work closely with individual officials in the field. This process had the same problems as experienced at the state level. It was slow and difficult to sustain constituency interest in the packages or the products. Only four product efforts survived and packages were not completed for any of them.

2.3.4 Project Reviews and Revisions

Over a period of time within the first year of both projects, it became apparent to ETIP and others that some of the barriers identified in the project plans were more significant than anticipated. Development of the procurement packages had proven to be very time consuming and difficult. New information had to be developed, packages had to be specifically designed for individual units, and in many cases other state and local officials besides those in procurement had to be involved in order to switch to the new methods (Cornett Note 13, pp. 23, 42-44). This was a more active role than originally planned. In addition, too much attention had to be devoted to the packages over system development and financing (Berke, Note 15; Berke, Note 16).

Eventually ETIP decided to change the structure of the project and assert more control (Berke, Note 17; Berke, Note 18). Package development would continue only for industry products of interest both state and local agencies. The most innovative agencies would be selected instead of trying to reach everyone. ETIP would try to find more technical assistance in other Federal and private organizations. Above all, ETIP would push much harder for experimental buys.

While these changes were not significantly different from previous strategies, they did bring out a philosophical split in the project team. Originally everyone had agreed that a system was needed both to facilitate change in procurement practices and implement experimental buys. Development of the system was to be based on early studies of state and local problems and a small number of experimental purchases. Successful, innovative procurements would increase the attractiveness of change to other agencies and thus promote more experiments and more market aggregation. This in turn would lead to a larger, popularly supported system which would remain beyond the duration of the ETIP projects.

NASPO now believed that the problems they were encountering with package development were indicative of a considerably larger resistance to change. Pushing experimental buys using different techniques was probably premature in most cases. A wider scope of change in agencies was needed before experiments would be feasible (Cornett, Note 19). NASPO felt that a better approach would involve more emphasis on developing a system that could support slow, incremental changes in procurement when agencies decided to make them. The project should build up contact and trust with state and local officials and market the system capabilities. Experiments would evolve out of influencing the design of agency initiated changes.

NIGP agreed with the difficulty of making changes in state and local procurement, but they continued to push the package development - experimental buy approach to change (Spangler, Note 20; NIGP, Note 21, pp. 4-5). NIGP staff felt that new packages were in demand and only needed to be more specifically designed and marketed to agency users (Cornett, Note 19; O'Connor, Note 22; Arnold, Note 23). This would take more time than originally expected and thus a viable program of experiments would also require more time to evolve.

ETIP took a harder stance on the need to have procurement experiments. This was based partially on the belief that experimentation was the best approach for learning about the state and local environment and on the desire to have some specific results (procurement changes) in the project (Lewis, Note 24; Lewis, Note 25). This emphasis prevailed and subsequent work became almost totally oriented around products, innovative agencies, procurement packages, and schedules for experimental buys. The philosophical differences remained, however, and working relationships became somewhat strained (Wagner and Zeldis, Note 14, pp. 111-1 - 111-4).

Even with an increased emphasis on packages, experimental buys, and NIGP-NASPO coordination, the remaining months of the second year were no more productive than those of the first. This, along with the fact that both NIGP and NASPO contracts would soon terminate, precipitated an entirely new internal review of the projects at the end of the second year. Work on product packages was continued, but a significant amount of ETIP, NASPO, and NIGP attention was focused on producing reports of accomplishments and projecting future payoffs for ETIP managers. Work on the systems aspects of the project was very minimal during this period.

ETIP finally decided to end its involvement at the state and local level. The barriers to experimentation were considered larger than ETIP had originally expected or wanted (Lewis, Note 26). The state agency project was terminated shortly thereafter when the contract ran out. The local agency project was extended at no cost for another year since a few of the package developments appeared likely to result in experiments (Lewis, Note 27). Not much progress was made during this extension, however, (Hulick, Note 28).

2.3.5 Important Factors in Systems Development

The state and local procurement projects were some of the larger undertakings in the ETIP program. The project was to develop a system to identify procurement problems, set up a means to develop and transfer information between agencies to help solve these problems, and promote the use of improved techniques with potentially hundreds or thousands of individual agencies. In addition, this system was to facilitate coordination between agencies in order to develop an aggregated market. This was to permit a powerful test of the ETIP hypothesis that government procurement could act as an incentive for industrial suppliers to improve the technology embodied in their products.

Adding momentum to the project was the universal agreement among project participants and the procurement community that a system was really needed. Both the top administrators of FSS, ETIP's Federal procurement partner, and GSA, its parent organization, expressed great interest in the potential to exchange information routinely with state and local agencies. Both saw a long term Federal commitment to such a system. NASPO and NIGP each thought that a system was needed to work with the procurement problems of their constituencies and would increase their organization's influence on policies and practices (Hall, Note 29; ETIP, Note 30). Other procurement and industry officials expressed a need for a system to promote information exchange across agencies (ETIP, Note 31).

In addition, the items needed by agencies seemed specific enough to be producible within the modest resources envisioned for the project. It was thought that many of the items already existed in some of the more innovative Federal, state, or local agencies. Meeting the needs of individual agencies would simply be a matter of identifying the specific information problem, an information source, and exchanging materials. Little modification of existing procurement items would be needed.

Thus it would appear that several factors important in developing and obtaining commitment to a system were present in early project stages. First, there were real problems in state and local agencies and a system appeared to be a good way to handle them. The concepts of the system were supported by a wide range of officials representing Federal, state, and local procurement agencies. A long range perspective was taken early and objectives for assuring post-project support were explicitly included in both state and local project plans.

Second, by working with organizations made up of people the project wanted to influence, ETIP was able to integrate user concerns into project design, achieve early credibility with users, and obtain a natural route to keep them involved in system development. With NASPO and NIGP having large roles in systems development, it appeared that the system was being built in the field by users for users.

Later progress with system development did not meet the early expectations however. As described earlier, significant difficulties arose in trying to produce information to meet agency problems. Building support for the system was hampered by this lack of success and eventually the system aspects in the project were downplayed in order to concentrate resources on specific procurements and agencies. After three years of work, ETIP terminated the project, unable to develop a system that could meet the planned technical and research objectives.

The lack of success clearly demonstrated how important problem identification can be to a system development. Project planners had thought that a simple system to exchange information packages would help solve procurement problems and provide a channel for influencing agency practices. This thinking was too narrow. Agency practices were found to be fairly unique and experience in one agency was not always readily transferable to another. Procurement officials often needed well tailored technical guidance, new facilities and/or equipment in addition to new information.

Achieving a long term commitment from users to support the system also proved to be more complex than expected. The original idea for institutionalization was that agency users would gradually increase their support to operate the system over the life of the project. At the end of project, ETIP would no longer provide any funding. It was found however that procurement officials were not the only ones who might have to be involved in making a commitment of resources. Many different officials in state and local government could have a role in procurement policy and practice. For example, legislators controlled procurement through laws and appropriations. Their direct knowledge of procurement could be small or nonexistent and yet they would be key supporters for a system serving their respective procurement officials (Spangler, Note 20).

The reality of the procurement environment presented a critical problem to the project team. The system development had been conceptualized, designed, and funded around one small facet of the problem. A much expanded scope was needed and it exceeded the resources available in the project. Funding had been set early in the project plan phase and no flexibility was built in to accommodate major shifts. The technical expertise needed to work closely with agencies was not readily available.

There were also significant implications for institutionalization of the system. With different groups involved in procurement, some direct users and others only supporters, gaining commitment to the system in the long run would involve an expanded number of decisionmakers. The influence NASPO had outside of the procurement community was much weaker and the evidence needed for gaining support unknown. The project was not really organized for a coordinated drive to find and influence the key officials in each case.

Some changes were made in project design to compensate for these problems. New staff were hired into NASPO and NIGP. Attempts were made to establish ties with government and private organizations possessing technical capability in procurement. The number and types of procurement problems to be handled were reduced and only innovative agencies were selected for participation. Finally, NASPO turned to industry representatives to gain more support for the system.

Unfortunately, these changes did not alter the basic outcome of the project. It was too difficult to compensate midway into the development for the lack of knowledge at planning stages. The flexibility needed to meet the broadening problems was not built into the development at the start.

It should be noted however that a firm case was not made for or against developing a system. The problems at the state and local level were real and things could be done that were not being done. A new system to handle these problems might have been designed given the proper timing and resources. This system would have probably been much different than the one planned in the ETIP project, and it is likely that developing it would have exceeded the capability and interest of the parties involved.

2.4 A DATA BASE SYSTEM [4]

ETIP discussions with the Small Business Administration (SBA) revealed that the agency was concerned about the small share of government research and development (R&D) work contracted to small businesses. An initial study of the problem showed that SBA field

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[4] The title of the system may be somewhat misleading. The system started out more as an evaluation process than a data base storage center. However, the data base aspects became increasingly important during the project. The system title was chosen to reflect this changed emphasis.

officials needed help justifying R&D set-asides to Federal agencies. ETIP and SBA then agreed to conduct a project that would develop a system field officials could use to improve the set-aside process.

A system was designed to match the needs of an agency procurement with the technical experiences or capabilities of firms. This would help generate a list of technically competent sources that could be used to justify a set-aside. Two versions of the system were created, one manual and one computerized. Each had some success in identifying competent firms. The computer version was eventually more successful since it combined speed with a data base of sources users also needed. Outputs of the computer system were used in some real set-aside cases. It did not, however, gain wide acceptance among users since it was expensive to operate. The project ended without any long term commitments to either the computer or manual versions.

2.4.1 Background and Objectives

In 1974 ETIP was discussing several potential projects with the Small Business Administration (SBA). ETIP was interested in small businesses because it was widely claimed that they were major sources of technological innovations in the U.S. There was concern that these sources were being underutilized by Federal agencies. ETIP thus undertook an effort to learn how SBA policies were affecting small firms (ETIP, Note 32).

Discussions between ETIP and the central SBA office led to ideas for increasing the share of research and development funds (R&D) to small businesses. The central office felt that small businesses were not getting enough of the government's R&D work (Charney, Note 33). This was partly because (Innovative Systems Research (ISR), Note 34, p. A):

- Proposal preparation for a small firm would be relatively more costly for them than for a large firm.
- Contracting with unknown small businesses was risky compared to contracting with the known larger firms.
- It was difficult to determine when a R&D project should be set-aside for small businesses.

It was decided that this last area, set-asides, was one where SBA interests matched those of ETIP. SBA, through set-asides and the related certificates-of-competency, influenced the flow of funds to small businesses. A set-aside action could be taken by a government agency to allocate part or all of the work in a contract to competitive bidding by only small businesses. A certificate-of-competence could be issued by SBA to document a firm's capability, primarily in financial matters, to perform the work in a contract to be awarded the firm. These actions provided ETIP a limited sector in which to investigate the assertion that small business capabilities were being underutilized. Specific government policies could be identified, agency actions under them traced, and resulting impacts on small businesses studied within specific set-aside cases.

The major problem with R&D set-asides was that SBA field representatives were having a difficult time identifying R&D work that should be set-aside and then making the case to the procuring agency (ISR, Note 35, pp. 1-4 - 1-6). SBA representatives, known as procurement center representatives (PCR's), had to maintain liaison with agencies procuring R&D services and learn what would be solicited and when. The PCR then had 15 working days to justify a set-aside to the agency contracting officer. This justification had to show that there were small businesses capable of performing the work. Finding these businesses, or sources, and evaluating their technical competency was difficult, especially with the uncertainties of R&D work.

It was thought by ETIP and SBA that some system could be developed to help the PCR find sources and make set-aside cases to the agency. This system might also assist in certificate-of-competency cases since data common to both actions might be stored and easily accessed. A project was developed around this theme and the objective was to develop and test a means for regularly and routinely determining the competency of small R&D firms to perform contract R&D for the Federal government (ETIP, Note 32, p. 1). SBA was to conduct the project with the support of a contractor. There were to be six main tasks:

1. Review set-aside and certificate-of-competency cases to learn how they are done and the problems involved.

2. Develop a preliminary plan for the operation of a system to support the set-aside and certificate actions.

3. Develop an operational plan including the specifics of system design.

4. Plan tests of the system.

5. Conduct tests and refine the system.

6. Operate the system with real cases for 12 months and evaluate its performance.

The project was scheduled to last 22 months from the date of award to the contractor.

2.4.2 Project Implementation

Work began about one year after the plan was completed. A small firm was hired by SBA to perform the tasks and they kept to the original schedule fairly closely. Within half a year, the project was in the operational planning stage. The system, called the Preliminary Determination of Qualifications (PDQ) system, was designed and ready to be tested in the field.

Briefly, the system worked as follows. Field representatives first were to identify pending agency R&D contracts and obtain the statements of work. A procedure had been designed for PCR's to then classify the statement of work in a manner which would identify the major items involved, such as actions and products. Once this set of descriptive items was identified, PCR's were to place this information on a questionnaire to be sent to potential small business sources. The officials also had the option of calling the firms. Small businesses receiving the form were to classify their experiences or capabilities similar to the structure for the work statement so that their experience could be compared to agency needs. SBA officials were to receive this information, determine if there was a match, and finally develop a list of potential sources. The lists were to be used in set-aside justifications made to agency contracting officers.

The system was presented to the Associate Administrator of SBA to gain approval of the field work. With this approval, the contractor then held the first field workshop in Philadelphia with SBA staff from several regions. The workshops were designed to train the staff in the PDQ system and promote testing on set-asides contracts already completed. This would allow the project team to observe how well the various procedures, forms, and concepts of the system worked under nearly actual conditions.

The workshop went well and several SBA personnel became involved in trying the system on additional retrospective cases (ISR, Note 36, p. 4-22). Eight cases were tested with the system and the results were good. In most cases, the firms that had been selected in the actual procurement were identified as technically competent by the PDQ system. This result dispelled the fear by PCR's that the system would be inaccurate. However, participation in the testing was smaller than expected and a number of implementation problems surfaced (Braudy and Albert, Note 37). PCR's claimed that the system did not really help them with two major problems: that of finding sources to begin with and assuring bids from competent firms once a set-aside was made. Also, it seemed that the firm data needed by the system might not be readily available within the 15 day limit the PCR had to make a case. The contractor felt that the first two problems were not solvable in the system and that more data was needed on the time limit issue before a change could be designed (ISR, Note 36, pp. 3-1 - 3-2; Braudy and Albert, Note 37). It was here that the idea of establishing a computerized system first arose.

Since the system had generally been accurate in the tests and did not require any major changes, it was decided to move into the operational phase of development. The purpose of this phase was to run the system for one year using real cases underway in the field. PCR's were to be trained to use the system and then given the materials to apply it to new solicitations. The contractor was to monitor the applications, verify results, and evaluate system performance.

Two different lines of work evolved in this phase. First, the contractor and the SBA central office began pushing for real time applications of the system. Two more regional workshops were conducted in the western United States to introduce the system and train personnel. The receptions at these sessions were not as favorable as those in the east, however. Opposition to using the system in actual set-aside situations arose, primarily because it seemed to SBA personnel that the system overlapped their "turf" and conflicted with their expertise role in the set-aside process (ISR, Note 36, p. 21; Penn, Note 38). Attention was returned to the east where implementations appeared more likely.

On returning to eastern regions, it was decided that more emphasis on retrospective cases would be made. It was expected that this would be easier to accomplish and would build a track record that could in turn make it easier to get real time applications. A few retrospective cases were obtained in this switch, but they were very slow coming in. The poor response prompted the SBA central office to send a letter to the non-participating regions. In the end only 10 cases were obtained in the operational phase. This was disappointing to the project team, but the PDQ system nevertheless maintained its accuracy record and good standing.

The limited success with real time cases was compensated somewhat by another development which opened up a whole new line of work. Several months after the western workshops occurred, the SBA central office in Washington began discussions with one agency in the Denver region over a potential system application. The agency had a large number of procurements to make in order to obtain several environmental impact statements. They had a short amount of time to get the contracts out and were open to considering small business set-asides (ISR, Note 39, p. 3-1). There was a good chance that this situation would provide the project with the real time applications it needed.

A number of retrospective cases were obtained from the agency in order to redesign the PDQ system for impact statements instead of R&D contracts. Four cases were examined and then tested in a revised

PDQ approach. Results were promising in that the system produced technical competency ratings in line with the judgements of the agency. The problem was that the PDQ process took time which most PCR's could not provide.

To overcome this problem, the contractor proposed, and SBA accepted, the idea of trying to computerize the PDQ. A data bank of small businesses with the potential capability to perform agency work would also be developed. PCR staff within the agency would then take a specific solicitation, analyze its requirements, and quickly search the data bank for sources. The resulting source list would establish a case for a small business set-aside, hopefully well within the 15 day limit given to PCR's.

Given the press of the agency business, project focus shifted almost exclusively to the computer system. A number of new obstacles had to be overcome. First, the contractor found that it was impossible to classify impact statement work in a general way that would allow each firm to be rated as capable of producing a class of statements. Each procurement for an impact statement was unique, and had to be compared with specific experiences in the firm. Thus the system would have to search each firm in detail for each procurement rather than turning out a subset of firms considered generally qualified.

Another problem involved the actual comparisons of procurement requirements and firm experiences. This was to be done by the computer and it, therefore, required an elaborate scheme for matching words. For example, a firm's previous experience in producing an impact statement had to be judged as the same, similar, or unlike the requirements needed in the new procurement. Only word by word comparisons were possible, and the context of phrases of sentences was lost.

Nevertheless within about a month, the contractor had an operating computer version of the PDQ system. A data bank of 125 firms who could perform impact statement work was developed. A number of demonstrations were then held in the agency. In one test case, a completed set-aside procurement was used. The qualified firm resulting from system processing was the same one that had actually been awarded the contract. This was a great success for the project and established support for the system in the agency (Braudy and Albert, Note 37). Subsequently, the system was used in five real time cases for the agency and five for other SBA locations. The information generated by the system was used in decisions to make set-asides and to establish a source list for sending solicitations (ISR, Note 39, p. 3-24).

The project came to a close several months after the computer system was developed. A final report and system documents were delivered to the SBA central office (ISR, Notes 40, 41, 42). It was concluded by the contractor and SBA that the computer PDQ was the only viable approach to generating sources and facilitating the set-aside process (ISR, Note 39, pp. 4-4 - 4-7). The manual system worked, but was slow and unattractive to PCR's since it required too much of their time to analyze documents.

The computer system was not supported beyond the project's end, however. Even though the Denver region and the test agency were both interested in using the system further, they did not have the resources to support it. The computer version was expensive to run since there had to be long searches through all the firms (Penn, Note 43). In addition, PCR's outside the Denver area generally didn't see the need for the system or thought it was too complex to implement (Charney, Note 33). These circumstances didn't generate much momentum to continue supporting the system and the SBA central office decided not to do so. Although no further plans were made to implement the system at the time, some staff at SBA thought the system might resurface years later when another national source system was completed (Charney, Note 44). This system was to be similar in design and function to the computerized PDQ, but was to cover a broader range of contract work (SBA, Note 45). Thus the concept of a PDQ system was, in the end, further supported by SBA.

2.4.3 Important Factors in System Development

The PDQ system development with SBA nearly achieved the objective set out in the project plan. A means for evaluating the technical competency of small R&D firms was developed on schedule and tested in the field with ultimate users. Tests results were promising and under certain conditions the computerized PDQ system seemed to meet a real need.

On the other hand, the system did not achieve the popularity and support desired by ETIP and SBA. Portions of development which depended on close contact and cooperation with field personnel, the end users of the system, were not especially successful. The PDQ system was not generally seen by users to be a regular and routine option they could use to meet their set-aside objectives. In the end, the SBA decided not to institutionalize the system.

The mixed success with the PDQ development seems to have been partly a function of problem focus. Initially, the project team conceptualized the system around the difficult problem of matching small business firms to the requirements of a specific solicitation. The system was to help establish the case for the PCR that technically competent firms existed to do the work. Even though the resulting PDQ manual system had some modest success with the problem, it did not gain wide support among PCR's. The procedures were seen as too time consuming for already busy officials (ISR, Note 39, p. 3-31).

More importantly, PCR's, the system users, viewed technical evaluation as their key function in the set-aside process. The system not only overlapped their "turf", but tried to reduce their complex function to simple, standard procedures. It was difficult for them to accept and use the system as a substitute for their skills.

The resistance was moderated in the one case, however, where the development shifted to the problem of finding sources. The agency involved needed to procure several contracts quickly, but it did not have the source list to start contacting firms. The PDQ process was computerized in this case along with a data bank of sources. This system was able to find potential sources rapidly and it gained support from the agency and the PCR (Charney, Note 33). Unfortunately, it could not be expanded to cover other agencies and gain wider support. The system was expensive to run, especially considering the narrow field of set-asides it covered, and the project at this point did not have the resources to build more.

The importance of finding sources might have been noted sooner in the project had backgrounding been more extensive before project design. A more thorough study of the environment in which the system was to be embedded might have demonstrated the need for a system to find sources. It might have at least provided more guidance on how to enhance the critical matching and evaluation functions which users felt were their main contribution to set-aside actions.

Involving the users earlier in the development probably would have compensated some for the lack of backgrounding. As it was, the field workshops for introducing the system to users were the first chance users had to see and react to it (Charney, Note 33). It was in these sessions that the contractor learned how great the need was for a system that would find sources (Braudy and King, Note 37). By this time though, the system design was fairly advanced and a changeover to the source problem was difficult. It was also a critical period in which to be uncovering basic resistance. Further development according to the original strategy depended on gaining user support and confidence so that both retrospective and real time cases would be made available to test the system. In the end, the quest for cases was not that successful and a solid track record could not be established.

Extrapolating from this example, one might conclude that the project strategy in general was ill-suited to the desired objectives. The original strategy included developing a system in the central office around the problem of matching firms and solicitations. Test cases and data were to be obtained from the field as needed. The system was then to be tested in the field with users by applying it to real time cases. While this wasn't a bad strategy by itself, a number of field characteristics made implementing it difficult. For example, the relationship between the central office and the regions was not that strong (Charney, Note 33). This made it very difficult to obtain the field cases needed to design, test, and validate the system. The situation was further complicated by the pressure PCR's were under. Generally there weren't enough of them available for every agency to have one in residence. PCR's often had to maintain a number of liaisons with different agencies and this didn't give them much time to act in each case. Finally, R&D contracting was only a small portion of the total of all contracting. While these characteristics had provided the justification for the development in the first place, the resulting manual system unfortunately did not really help PCR's. The project might have benefited from more early and extensive contact with the field conditions and thus have avoided the problem of investing in one design too early.

It also must be noted that the strategy lacked plans for implementation. Tasks were neither set out in the beginning nor added later which would have guided resources towards developing long term support for the system (Penn, Note 44). While it is unlikely that the manual PDQ would have gained this support, the computer version was attractive to the one agency where it had been developed. More resources might have allowed the project to gain the track record originally desired with the manual system. This might have then generated the follow-on applications needed and the user acceptance desired.

Even though the PDQ system was not institutionalized, its concepts were very much supported within the SBA central office when the project was over (Charney, Note 44; SBA, Note 45). A new system similar to the PDQ was to be created which would apply to many kinds of set-asides and contain a very large data base of firms to scan with a computer. If anything, the PDQ project demonstrated that such a system could be constructed, that it would have to be computerized, and that it would have to be matched more closely to the environment in which it was to be used.

2.5 SUMMARY AND COMMENTS

Three example system development cases from ETIP have been reviewed in this chapter. The purpose of the cases was to identify factors in development which are important to project success. Each case included a history of the project and a section on important development factors.

A number of different factors have been identified. For example, one major factor that influenced progress in all three cases was the need to know the user environment. Developers conceptualized and committed themselves to a system design based primarily on their initial understanding of the environment. Later exploration showed that the environment was more complex than originally thought. In all cases, the original information problems were often related to many other internal agency problems, with the latter being of higher priority to users. Developers found that it was difficult or unwise to isolate the project from other agency problems, and equally difficult to deal with them under the allocated resources. In one case, developers also found that the agency worked much differently than expected (i.e., the PBS planning system). Even though parts of the PBS system were successfully developed, the system could not be tied to the agency processes developers originally planned to influence. Its impact on the agency was thus greatly reduced.

Another common development problem was that developers did not discover key problems, or realize their significance, until well into the projects. Generally, it was too late to compensate at these points by redesigning the system or the project. Significant portions of the allocated resources were already expended or committed, leaving little flexibility. From a management perspective, the projects might have benefited from earlier, intensive reviews of strategy and objectives and more routine monitoring of progress. Resources might then have been redirected in time to fit the changing circumstances.

Factors like these from each of the cases have been used to develop a framework of important factors for ETIP managers. Other systems literature has also been used and this material is presented in the next chapter. Chapter 5 presents the resulting framework. Factors in the framework are supported by references to the three ETIP cases just discussed.

CHAPTER 3

SYSTEM DEVELOPMENT PERSPECTIVES AND PROBLEMS IN THE LITERATURE

3.1 INTRODUCTION

The purpose of this chapter is to review the perspectives and problems for system development that are found in the various sectors of the systems literature. The underlying goal of this work has been to conduct a broad review of the literature that would capture the diverse views offered in the many different kinds of sources. Some literature sectors have not been adequately examined, such as the defense system literature and the materials from systems firms in the private sector. In addition, no attempt has been made to review in depth each literature area. This task was beyond the needs and resources of the research project. It is hoped that the following descriptions give the reader a "feel" for the literature available and establishes some of the background which helped develop and support the dissertation research.

The following sections both review the literature and identify key problems and research needs. First, an initial section briefly overviews the system development literature. Some of the different sectors of the literature are identified. Next, several sections describe and illustrate in more detail the materials available in the different literature sectors. Examples of sources have been selected that are referenced elsewhere in the dissertation. Finally, several sections in the second half of the chapter identify and review the key problems and research needs found in the systems literature. These issues have been a central part of the development of the dissertation and readers may want to review them in order to gain the proper perspective for succeeding chapters.

References are made in Chapter 3 to the objectives and approaches of the dissertation. These have been included in order to link the dissertation research more closely with the needs found in the literature. Readers may also find it valuable to review these sections (particularly the key problems and research needs) to understand the research design in Chapter 4 and the resulting monitoring framework in Chapter 5.

3.2 SYSTEM DEVELOPMENT LITERATURE

3.2.1 The Systems Literature in General

There is a large and varied amount of written material available on systems and their development. Discussions can be found in many different types of literature from both public and private sector sources and covering both hardware and software applications. For example, system development is discussed in literature areas devoted to management science/operations research (Ackoff, 1967; Boland, 1978) adoption of innovations in organizations (Air Force Systems Command, 1966; Dietrich, 1977; Patterson, 1977), and the acquisition of systems in government agencies (Comptroller General, 1976; Office of Federal Procurement Policy, 1976). There has especially been a long term interest in systems in the defense related systems acquisition literature (Air Force Systems Command, 1966; Hill, 1970; Peck and Scherer, 1962; Peterson, 1980).

Interest in systems is increasing in many areas (Chestnut, 1967, pp. 361-378) and the literature is expanding rapidly. This is particularly the case for information systems, where much more attention is being devoted to their development and use. Several forces behind this expanding area are:

- The success in automating many routine clerical activities in the early applications of management information systems (Chervany, 1978; Gorry and Morton, 1971; Karger and Murdick, 1977).
- Technological advances in hardware and software which can be used to process and store information (Chervany, 1978; Edelman, 1977; Mumford, Land, and Hagwood, 1978).
- Increasing interest in decisionmaking tools which depend on information systems, including the emerging interest in decision support systems (Alter, 1977; Arnovick and Gee, 1978; Karger and Murdick, 1977; Keen and Morton, 1978; Vazsonyi, 1978).
- Increasing numbers of factors needing consideration in planning and executing public and private programs (Welsh and Lee, 1979).
- The need for more data obtainable only by routine long range monitoring, such as needed in program evaluations (Comptroller General, 1978; Kraemer and King, 1978; Lorenzen and Braskamp, 1978; Miller and Willer, 1977).

A number of different professional and academic areas have arisen or taken interest in information systems and have become important centers for development methods and experiences. For example, Keen and Morton (1978, p. 79) identify six professional groups from which have evolved different perspectives on information systems: computer science, management science, behavioral science, data processing professionals, management, and decision support.

Many different problems and factors in system development can be found in these areas. Some of the more common factors are the need for user involvement in a design project, identifying the information needs of managers, tailoring system outputs to different decisionmaking levels, and the need for top level management support in system development. Since system developments can be large and complex undertakings, a large number of factors like these can potentially be applicable in any one specific situation. This has led to elaborate reviews or models of development which attempt to cover the many important factors in detail. For example, Ein-Dor and Segev (1978) review 120 organizational variables they have found to be related to information system implementation. Taggart and Tharp (Note 1) present 50 different models of initiating information system developments. A developer reviewing the literature for important factors will find more than enough to work with.

Relevant literature for information system developments is not limited to these several specialized groups however. Literature produced in other sectors for other kinds of systems can also be very useful for information system projects. First, many of the development problems are very similar. For example, the need for top level management support is a fairly common factor found across a diverse number of sources. Slightly different perspectives or applications of this factor can be valuable in gaining an understanding of its importance. Second, there can be differences in the kinds of factors considered between sectors. For example, project management issues are more commonly discussed in defense related literature than in behavioral science literature. Concentrating on one sector may thus provide a narrower perspective on the relevant factors than needed.

It is beneficial then to take a broader approach to reviewing the literature. There are several other ways to divide the literature which make it easier to describe and categorize.

3.2.2 Different Sectors of the Systems Literature

Literature relevant to systems development can be divided by a number of different dimensions. Three which seem most generally useful are:

- Factors considered.
  Literature sources can be divided by the range of variables considered. For example, computer science literature often concentrates on technical aspects of design while behavioral science sources concentrate human impact or behavior problems (Keen and Morton, 1978, p. 34).

- Type of systems.
  This can include any type of hardware or software system: weapon system, management information system, computer system, evaluation system, decision support system, etc.

- Major perspective on development.
  Systems literature can be divided into case studies of development, factor studies on important aspects of development, models of system development, and descriptions of specific designs or design issues (Ginzberg, 1978a, p. 57).

Developers needing guidance for specific information system projects, or other kinds of system projects, will find a range of sources along these dimensions. They will also find that it is useful to review a broader range of sources than simply ones specifically related to their respective application.

In order to discuss the literature further, it appears most useful to divide sources by the kind of perspective taken on development. Several reasons are behind this approach. First, the categories on this perspective dimension are fewer and broader than the others. Second, these categories capture techniques and experiences from the diverse sectors of the literature. Third, this approach is the easiest way to generally categorize the literature.

The following sections review in more detail the systems literature relevant to development by describing and illustrating the different categories of perspective. The latter half of the chapter then describes a number of problems for system development based on these areas.

3.3 A REVIEW OF SPECIFIC LITERATURE AREAS

The following sections review in detail literature relevant to system development. The literature is characterized using four different perspectives:

- Case studies of specific developments.
- Factor studies which examine limited numbers of variables important in development.
- Models of system development.
- System design sources which describe specific systems or more general technical design problems.

Each perspective is generally described and then followed by specific examples which illustrate the kind of material available. It should be noted also that some sources overlap these areas. In some cases the same literature source may be used to illustrate two different perspectives. This characteristic is discussed further in section 3.4.2.

3.3.1 Case Studies of System Developments

Reports on actual system developments can offer the most detailed picture of what a development is actually like. One could consider much of the literature as consisting of case reports, since many authors use an actual experience to develop lessons, strategies, or specific designs. For the purposes of this section however, a case study was considered to be a report which focused on the details of how a development was actually conducted, including parts on the information problem, day-to-day events, key stages and incidents, management and organization, and user interaction. Case studies emphasizing other factors, especially on design, will be discussed in later sections.

Even with the narrow focus just discussed, there is a considerable spectrum of case studies available, from extremely short to very lengthy and from hardware to software. Many articles, particularly in management science literature, leave out most of the events between the initiation of a project and its final conclusion (e.g., Fudge and Lodish, 1977; Chen and McCallum, 1977). Others leave out the perspectives of different groups involved, such as explaining a development from the manager's viewpoint and including little if any user information (e.g., McGrath, 1970). Often times lessons are included in a report which appear to go beyond the evidence available in the report (e.g., Krasnican, 1971). These shortcomings are not serious deficiencies, however, since the perspectives and lessons offered can be quite valuable in gaining an understanding of what really happens.

Three examples of management information system developments were abitrarily chosen to illustrate the cases available and their variability in content and style. As pointed out earlier, developments from both hardware and software systems are relevant to the concerns here. Any mix of these could have been selected for use here. For example, an interesting example of a weapons system development is provided by McNaugher (1980) who reviews the background and influencing factors in the development and deployment of the M16 rifle. Mann and Williams (1960) also provide an excellent case history of the changeover to an electronic data processing system.

The first example below is a brief case study of an information problem in a corporation and the system designed to solve it. The second example is a description of a computer system development which provides more detail about the case than commonly found in much of the literature. The third example provides a description of a failure.

3.3.1.1 A Brief Case Study

On the briefer side there are reports exemplified by Fudge and Lodish (1977) on a planning system. The authors were involved in developing a system for the national sales force of an airline. The problem behind the system was to help the sales staff allocate their time among their clients such as to maximize sales and profits for the airline. This particular report does not include much on how the authors got involved in the development or how the problem was defined, but refers to earlier articles which do not provide these details either (Lodish, 1971, 1974).

The narrative starts at the point where a model for designing a strategy has been developed and is about to be introduced to sales personnel. A 1 1/2 day seminar led by corporate managers was used to acquaint sales staff with the model. Managers and salesmen spent much of the time discussing sales estimates and strategies. Salesmen tried the various input materials to the model and found them to be similar to the materials they already used in their current methods. Initial reaction was one of caution, but the development was continued by conducting an experiment where the new model was run simultaneously with the current ones and the effects on sales measured. The new model apparently improved sales and provided impetus for the airline to continue disseminating it to other sales personnel, albeit cautiously. The authors conclude that the computer model was really only a complement to the salesman's and manager's own information, not a replacement for it.

Although the system in this article is not complete, there are a number of benefits to sources like this. First, even though the report is brief and leaves out much key material on development, it provides an overview of strategy. One might deduce from the article that the strategy included definition of the problem, development of a computer model, dissemination through structured face-to-face seminars, high level management support, and a small, low risk field experiment approach to testing the model with ultimate users. However, there are a number of shortcomings to the article also. It is not clear from sources like this how the problem was defined early on, how the authors and others were involved in development or whether the model went through revisions. In fact, the lack of problems in the development is conspicuous by its absence in the article. There is an appearance that the new model was favorably received by users, although management and user caution are emphasized a number of times. One does not learn how well the model continued to be received by other sales personnel and if it did in the end help solve the problem.

3.3.1.2 A Detailed Case Study

A more detailed case study is provided by Lucas and Plimpton (1972) on the development of an information system for the United Farm Workers (UFW). Lucas used this case to test the creative system design approach he had developed over the years based on an organizational change model from Kolb and Frohman (1970).

The report starts with a review of the creative approach and then begins a narrative on what happened in the application. The UFW problem involved record keeping and since the organization did not have the expertise to build a system in-house, they turned to outside consultants. With a lack of resources to support a study, the UFW decided to use a student team headed by Lucas to design the system. Besides experience for his students, Lucas saw the case as an opportunity to conduct research on his design process.

Given the circumstances of the site, the team recognized early that the system would have significant impacts for the staff. They decided to survey a sampling of staff at most levels of the organization and conduct interviews with top managers. The team found that interest in the system was strongest at the top management level and that changing procedures with the actual users, especially older ones, would constitute a significant intervention. Users had not had contact with computers before and the idea of bringing them in left them with concern about their own replacement.

At this point, the team desired to continue in the diagnosis phase of their approach and further study what users needed. However, additional pressure from UFW managers forced the team to also begin the design phase as well. A deadline to complete the system had been set by the managers in order to meet some records requirements for an outside agency. The team began making suggestions on how to improve the records process at the same time they were learning about it. Working between the managers and the users was further complicated by the loss of the first liaison with the UFW and an ineffective relationship with the replacement.

The first meeting between the team and top managers was held about this time. The team received its first official feedback since the start of the project. The managers reported that the surveys and interviews being done were causing disruption in the organization. The change in students on the team was further confusing the staff. The team recognized that the information gathering raised the level of concern about the system, but the contact was considered beneficial overall in establishing a trust with users and gaining valuable insight to system design. The team requested a new liaison staff member from the UFW to improve the relationship between them. They needed a "system champion" in the UFW.

UFW managers decide to assign a new liaison to the project and this person had some amount of experience with computers. Unfortunately, the first task assigned to the liaison was to reevaluate the contract with the team. Work slowed down during this review, but project approval was obtained without much further delay. Diagnosis activities were continued.

Soon the team began to plan for the first general staff review of the team findings and suggestions for systems. Since this was to be a major briefing, the team wanted to see top managers first in a smaller pre-briefing meeting. Apparently as this was being set up, top managers learned about the impending suggestions to be made by the team. These suggestions did not include switching over to a large computer system that management had originally expected they needed. This caused great concern with the managers and they decided to cancel the pre-briefing meeting. Instead they had a computer manufacturer provide a demonstration of a system they might buy. The team was instructed to redesign their suggestions with the proposed computer system in mind. They went along with this, but insisted that the UFW withhold final judgement on the computer. This apparently happened.

The general review meeting was then finally held. It was a key meeting for the team's approach since they wanted to maximize input from users on the system design. Also they wanted the union to accept the idea of gradually increasing ownership and expansion of the system. Thus they were proposing a small scale system which would later be expanded as it gained acceptance in the organization. All staff members came to the meeting and top managers began with assurances that no one would lose their job to the system. The session lasted a day and a significant amount of input was received. Interaction with the staff was favorable, a positive sign for the team approach and findings.

A number of smaller meetings were held following the general review in order to obtain more comments and refine the design. The union began considering how to procure the equipment it needed, but later decided to find as much free equipment as possible. The team's contact with the UFW was decreased over this time as the union took on more responsibility for implementation.

One of the final tasks the team had in completing their research objective was to survey the staff a second time. The purpose of this survey was to assess the impacts and success of the design approach they used. This had to be delayed however when the primary liaison with the union was again lost. The team had built a good relationship with their primary contact and it was expected that the contact would facilitate distribution of a final survey. Now the team had to reapproach union managers and review the original research objectives, which in their approach essentially constituted reentry into the organization.

Eventually the survey was administered to the staff. The most interesting finding was that users perceived a low level of involvement in the design effort. The team found this hard to believe after the amount of contact they had used in their approach. A few more final review meetings were held between the union and the team after this.

Case study reports like this one provide a rich level of detail on development which is often missing in other articles. The relationship between the development team and the organization are highlighted and the reader can begin to understand what happens on a day-to-day level in a complex development process. An overall perspective is also achieved in that Lucas' development approach, creative system design, is included for structure. Even though the authors lose some focus on the approach by laboring through the details of what they did, they do demonstrate that a simple design approach and its benefits can be altered significantly by the realities of the site. This is well emphasized in a very interesting table included by the authors which lists major events, dates, and stage of the approach.

3.3.1.3 An Instructive Failure

An interesting case of a failure in system development is provided by Ruth (1978). He reviews the development and cancellation of an advanced logistics system for the Air Force. His report is a little brief on the details of development, but he does emphasize some important factors that contributed to the failure.

The Air Force wanted to develop a very large information system which would coordinate all functions involved in the receiving, storing, and issuing of supplies. The system would include inventory control, stock and financial management, maintenance planning, and distribution and transportation analysis functions. The design would be based on the transactions which occur in these areas. The intent was to process transactions immediately and store them in a very large data base. To accomplish this, the Air Force depended on obtaining hardware technology which would be significantly better than their current systems. The Air Force planned to save a significant amount of money in personnel costs by switching to the system.

The major task in the project was to unite the numerous information systems already in operation which handled different parts of the supply process. This was a massive undertaking. Not only were there different, separate machines involved, but there were also five different computer languages in use. Thousands of computer programs had to be rewritten. In addition, a new communications network had to be developed to coordinate all the systems. The Air Force planned to develop all the components of the new system and then convert quickly to it.

The project did not proceed according to plan, however, as numerous unforseen problems arose. Since many programs had to be rewritten for the new centralized system, systems expertise across all units had to be combined and coordinated. The size of this effort overwhelmed the project. Another problem was the hardware. The system thought superior for the job by the Air Force was not obtained through the procurement process. Instead, the decision was to use a computer which had never been applied to a problem of this complexity. Later it was found that the system was unable to handle the large data base and processing load desired by the planners.

Eventually, the magnitude of these problems forced the designers to abandon the plans for a quick conversion and try a piecemeal development approach. This strategy also met with great difficulties. Congress finally canceled the project, some 15 years and $200 million after it had been started.

Besides the technical problems discussed above, Ruth also finds several other design and implementation factors which he feels contributed to the failure. These are:

- System Design vs. Organizational Design.

  The new system was to be based on processing transactions as they occurred. While Ruth considers this idea farsighted, he believes that in the end this objective was over emphasized in the design. The business needs of users and their methods of operating became of secondary importance in the development.

- Radical change.

  Numerous changes were planned in the development: in machines, languages, procedures, software, and eventually in people, since the Air Force expected to replace staff with the system. These changes affected every level of operation and were of a very fundamental nature. The size and speed of these changes presented a massive shock to the organizations involved. The scale of the human engineering problems was not well anticipated.

- Transition to the new system.

  Conversion to the new system was to be abrupt and rapid. The system was to be fully operational immediately. Unfortunately, as with most large scale developments, progress did not match expectations and delays occurred. Meanwhile the size of the development and the conversion strategy pre-empted any on-going work with the old system. When the new system could not be operationalized at once, the Air Force had to return to the old system, with no improved performance resulting from the project at all. There was no planning for delays or for the need for backup in case of failure.

- Management tenure.

  The management of the project changed often. The same development problem was shared across several managers. Ruth feels that, besides the continuity problems, the frequent changes made it difficult for anyone to be held accountable for the project.

Ruth recommends several improvements for future developments of this size. First, he believes that the needs of users should be the driving force in a development. In other words, designers should adapt the system to the user environment and not the other way around.

Second, projects of this size should probably be broken into several pieces which can be implemented sequentially. Subsystem modules should be institutionalized gradually. Rapid, massive, and abrupt change-overs have too many complicating implications for the organization, especially with the staff. Also, the great potential for delays or outright failures would seem to make an early major commitment too risky. At least a backup system should be planned or maintained so that the organization can continue to function even with problems in the development.

Finally, Ruth believes that a stable management team is needed to adequately control a project. Turnovers in personnel are to be expected. However, managers should be sought that can make a time commitment commensurate with the expected life of the project, or at least with a portion of it that can be implemented as a unit in itself.

3.3.2 Important Factors in System Development

Much of the literature relevant to systems development is written with the objective of identifying specific factors which are important to or greatly affect the success of a development. These sources usually demonstrate the relationship of variables like organizational characteristics, user involvement, or top-level management support to system usage, adoption, or implementation. Factors are often defined as independent variables and system implementation (or success, usage, etc.) as the dependent variable. Relationships between variables are used to provide lessons for developers.

Sources organized in this manner cover a wide range of factors and rely on a variety of methods to identify, study, and report on them. Everyone has their own perspective on what is important to successful system developments. Three categories which help demonstrate the variety available are:

- What methodology is employed in or underlies the article.
- How many factors are discussed.
- What factors are discussed.

Each of these areas are briefly described below and some examples given. Some comments on the factor approach in general then follow.

3.3.2.1 Methodological Differences

Sources which discuss factors important in the development of a system have a variety of research methods underlying their themes. These methods are used to identify factors and measure their impact on project success. Some authors rely on literature reviews, personal experiences, or surveys to study factors while others use some form of controlled experimental design.

One example of the non-experimental side of the literature is the often cited article by Radnor, Rubenstein, and Tansik (1970).

This is one of the early works on OR/MS implementation and it is commonly referred to in recent MS/MIS literature. The authors discuss key factors having an influence on the implementation of OR/MS models. They first present 17 factors related to successful implementation which they extracted from a review of OR/MS literature. Some of the factors listed are changes in management structure, the reporting level of the OR/MS group, urgency of results, or need by the OR/MS group to define results. The factors are not further defined.

The authors then present a model of OR/MS implementation which is based on the 17 factors. Some of the relationships between factors are highlighted in the model and used to formulate propositions about system development. For example, one proposition is that "the level of implementation of a project depends on the client's willingness to support the project's implementation, his ability to perform the necessary new tasks, and the availability of money and personnel to implement the project" (Radnor et al., 1970, p. 976). Thirteen propositions are listed using different combinations of the factors.

In studying these results, the authors were able to synthesize three new factors which seemed to characterize key aspects in implementation. These were used to study implementations in 60 business firms and 40 government agencies. The results of the study are presented in the article in the final sections. Each of the three factors, the type of environment surrounding the OR/MS implementation, the nature of the client-researcher relationship, and the level and type of top management support, is cross-tabulated with the degree of implementation problems found in all cases. Chi-square statistics are also computed and some are reported to be significant. Unfortunately, neither the factors or the problems are defined in the article so that the reader can understand what was measured. For example, client relations are listed as bad, medium, or good and implementation problems are listed as high or low. It is difficult to place much confidence in the results due to these problems.

An example of a more controlled design is described in an article by Lucas (1978a). He reports on an experiment to examine the relationship between a number of different factors and the success of a system implementation. Two groups in the same firm, one receiving a new system and the other keeping the old one, were surveyed before and after the changeover was made. The dependent variable Lucas used was salesman satisfaction with the system. This was used as a surrograte for system implementation success since the firm's managers had mandated the use of one system or the other. The independent variables were quality of information, benefits of making a change, and costs of making a change. After the data were collected, Lucas ran a cross-lagged correlational analysis on the variables. He found that user satisfaction with the new system had decreased while user perceptions of benefits had decreased and of costs had increased. These changes were significantly different statistically from those of the control group. Lucas concludes that the lack of success with the new system was caused by the changes in costs and benefits from the old system.

While the results probably do indicate some facets of the change, the situation was undoubtedly more complex than suggested in the article. Lucas himself admits that there were technical problems in the new system. The lack of success in implementation could thus also be plausibly linked to the fact that the system didn't always work. One wonders what other conditions were like, such as top-level management support, and whether they had an impact on success. Finally, even though Lucas specifies the timing of the research relative to the system change, it is hard to judge if the results reflect just the transitory conditions of start-up or the stable conditions of the longer term. A judgement of unsuccessful implementation and its causes may be a little premature.

These two studies demonstrate a key point about the factor literature. The credibility and utility of the sources vary greatly, but neither seems to be a function of the methods used to identify factors and relate them to project success. A report on personal experiences can appear just as credible or unbelievable as does one based on a more rigorous experiment. This is because of problems with definitions and the unrealistic, or simplistic, structure of factor research models. Terms like user involvement or top-level management support are rarely operationalized. While they probably do represent key factors in successful implementations, it is difficult to learn what behavior or actions are implied. In addition even if the factors are defined or the observations on them described, the linkages between them and eventual success are long and complex. A factor could be important to success one year and not the next. Attributing causality, such as demonstrated in the Lucas article, is very difficult and often lends a feeling of structure and influence to a project that isn't really there.

On the other hand, within limits, the structure and simplicity provided by the factor approach is its major benefit. A complex process like a system development is reduced to a few key factors more easily studied in one case or several. The value of studying the factor literature comes in understanding that, at least in some cases, factors like top-level management support are important. How, when, and where they are important will vary and probably should not be overly generalized by researchers or developers.

3.3.2.2 Different Numbers of Factors

There is great variability in the number of factors which are presented in literature sources. For example, in the practitioner literature one can find numerous articles like one by Fronk (1978) which lists five major problems in the development of data systems. These include unending feasibility studies, lack of problem understanding by the developers, and continual design changes by the clients as they learn more about what can be done. The key factor he emphasizes like most others is to involve the client early and routinely throughout the project. This might partly be accomplished by more explicit contracting between developers and clients. He also points out the difficulties that turnovers in staff can create.

More diverse and complex work can be found elsewhere, especially in academic presentations. Ein-Dor and Segev (1978) surveyed 10 years of scientific, managerial, professional, and trade literature and identified 120 different factors related to the success of management information systems. In the 1978 article, they focus on a subset of these consisting of 10 factors related to organizational context. These include organizational structure (number of profit centers; number of divisions), psychological climate (attitudes towards information systems; expectations from information systems), rank of the responsible executive for the system, and the existence of a development steering committee. Through a series of propositions and supporting literature citations, the authors relate these factors to MIS success, which they define as use. One proposition is that "the more mature the organization, the greater the likelihood of successfully implementing MIS" (Ein-Dor and Segev, 1978, p. 1071). The implication for developers is that mature organizations are more likely to have rational, formal structures with explicit decision and control processes. Developers should be able to understand these organizations more easily and quickly identify the processes needing an information system.

A similar example is provided by Zand and Sorensen (1975) who conducted a large study of the factors influencing success in applications of management science techniques and systems. Using a model of intervention proposed by Lewin (1947) which involves unfreezing, moving, and refreezing stages, the authors developed a list of factors applicable to the different phases of development projects. A survey was then sent to 391 management scientists who were asked to identify and describe one successful and one unsuccessful case. The resulting 140 cases were studied by the authors to associate their list of factors with project success. A final list of 44 factors was then produced, with most factors relating to technical problems and relationships between top managers and system developers. The importance of these factors in both successful and unsuccessful cases led the authors to conclude that problem identification and building good working relationships in early project stages were two of the more important factors in the development of management science processes for organizations.

3.3.2.3 Different Types of Factors

There is also a great variability across the literature in which factors are most important to a successful development. In an often cited article, Ackoff (1960) reports on four main problems in implementation that he experienced in 48 OR/MS projects, some of which were system design studies. These cover a broad range (Ackoff, 1960, p. 262):

- Turnover: Reorganization of the company, changing the persons responsible for the operations under study.
- Top-level Support: Lack of involvement in high enough levels of management in order to enforce interdepartmental coordination.
- Sabotage: Attempts by individuals to capture the project so that it can be used to serve personal rather than organizational objectives.
- Resource Support: Economic pressures that lead to a general reduction of expenditures for outside services.

To alleviate problems like these he suggests to system developers and researchers that contracts and contacts be made and maintained with the appropriate management level. These contracts should be breakable if development appears to be leading to an unsuccessful implementation.

Robey and Zeller (1978) concentrate on the relationship of user attitudes, organizational structure, and implementation process to successful MIS implementation. They report on the introduction of an information system to two neighboring plants. One plant adopted the system and the other didn't. The authors studied the user attitudes, organization, and implementation process at each plant. They found that users in the adopting plant had a more favorable attitude towards the system in terms of its ability to aid their personal performance and in terms of the system's importance and urgency. In addition, they found that the rejecting plant had a more complex organization, in structure and authority, than the adoptor. Interestingly, the implementation process was apparently the same in both plants. The system was designed and disseminated to users with no formal introduction or involvement. In the successful implementation, a key user with previous experience in the new system took the initiative and supported it. No one with enough influence did this in the unsuccessful case. Developers might conclude from the article that important factors in developments are the need to have users perceive a personal gain from the new system, the need to tailor a system to the organizational structure, and the significant positive effect of a system champion.

Lucas (1976) studied the implementation of computer based models in 25 organizations in order to develop factors applicable to MIS implementations. He examined a wide range of factors: model characteristics, attitudes towards the models, general attitudes, situational and personal factors, and decision style. Through questionnaires and interviews, he attempted to relate these to successful implementation, although his study was conducted after the models had been in use for over two years. He found that favorable user attitudes, user involvement, management support, nontechnical decision styles in managers, and model simplicity were strongly related to successful implementation. The major implications he draws for developers is that good attitudes towards a system are useful and should be cultivated at all levels of an organization. People resisting an implementation should be made a part of the design team.

3.3.2.4 Comments

The factor research literature applicable to system development maintains an important, albeit sometimes weak, position relative to other literature. To its credit, it provides a format for practitioners and researchers to disseminate key lessons or variables without having to necessarily detail entire cases or prove more general underlying theory. Practitioners and some researchers can offer their wisdom on important factors leading to success based on their own valuable experiences. Other researchers attempt to define the key variables and isolate relationships through more controlled research designs. Even though the results of both approaches can be unrealistic or simplistic, the emphasis on few factors enhances communication with the reader.

However, there is emerging concern as to how useful factor style literature is to both researchers and practitioners, especially considering the large amount of it that is available. Some complain that few commonalities can be found across the various perspectives. Keen and Morton (1978, p. 196) list the five factors which they feel are the only ones across the many studies and settings that have a plausible, demonstrated linkage to implementation success:

- Top management support.
- A clear felt need by the client.

- An immediate, visible problem to work on.
- Early commitment by the user and conscious staff involvement.
- A well-institutionalized OR/MS or MIS group.

Some of the criticism is well deserved. The factor approach does suffer from severe definitional problems. What is top management support in one case, is not in another. This, combined with the large number of factors potentially relevant in any one case, almost make each case unique and integration across them difficult. In addition, the methods used in factor research also differ considerably since both practitioners and researchers contribute to the literature. Practitioners often provide loose supporting evidence for their lessons, while researchers often add complex designs or statistics to support their claims.

The basic problem in factor research seems to be that the complexity of system development does not lend itself easily to general rules or patterns. Each situation can be unique and the relevant factors important to success different (Duchesneau, Note 2; Keen and Morton, 1978). Also, factors do not operate in isolation. Their interaction with other numerous variables builds any one case into a very dynamic situation where changes in relationships are likely. These conditions are probably some of the major reasons for weak results in the factor literature (Ginzberg, 1978a).

3.3.3 Models for System Development

A significant amount of systems literature is devoted to models which can be used to structure and guide a system development. These models generally outline the major stages and tasks users and developers might perform, covering everything from the initial problem identification to the operation of a finished system. Development models provide an overall view of the process not easily obtainable from the other literature sectors reviewed in this chapter. Operationalizing the models for a specific application can be difficult, however.

Models have evolved from many different disciplines and applications and it is difficult to describe the field succinctly. One could choose a number of different attributes to group models for discussion. For example, models might be categorized by source (behavioral science, computer science, etc.), decision level they are useful for (operational control, management control, strategic planning), decision methods they can work with (structured or unstructured), user location (government, private sector, etc.), or combinations of these (Anthony, 1965; Keen and Morton, 1978; Simon, 1960). Rather than try to cover all of the possibilities, a subset of three was chosen which illustrated several different perspectives, mostly by source.

First, a section is presented on system engineering models. Many of the systems concepts and procedures evolved from the engineering work conducted in military weapon system development in the early

1950's. As weapons became more complex, along with the agencies developing them, engineering projects required a new approach which would offer better overall coordination while allowing the development of new, complicated components. Systems engineering became one of the first models for developing systems, and it greatly influenced many other succeeding projects and models.

A second section reviews models used by the government to acquire systems. Two models, one from the General Accounting Office (GAO) of Congress and one from the Office of Federal Procurement Policy (OFPP) of the Office of Management and Budget, are presented and compared. The GAO model applies to the acquisition of computer software systems and the OFFP model applies to the acquisition of large scale hardware or software systems. The influence of the earlier system engineering models can be seen in these models.

A third section is then presented on development models specifically aimed at information systems. Two main subsections are included: one on models often labeled as conventional or traditional and one on models considered as alternatives to the conventional models. Conventional models have evolved primarily through computer system developments and concentrate on technical design problems. Alternative models attempt to increase attention to the human and organizational impacts of a new system and promote cooperative partnerships between user and developer. A third brief subsection is included on a problem both of these groups are concerned with: that of defining decisionmaker needs.

A final section summarizes the models presented in the above sections and provides other comments.

3.3.3.1 System Engineering Models

One of the original sources of concepts and procedures for systems development can be found in military/weapons system programs in the mid-1940's to early 1960's (Hill, 1970, p. 124). At that time weapons were becoming increasingly complex, especially aircraft. For example (Hill, 1970, p. 125; Peck and Scherer, 1962, pp. 37-44):

- Weapons development began to involve the design and development of many different subsystems, requiring the incorporation of a large number of technological advances all at once.
- Subsystems and their components were becoming more highly interrelated in size, shape, and input/output connections.
- Subsystems were becoming increasingly complex because of the increasing number of components in them. This was creating reliability problems with system wide implications.
- Engineers and scientists were having to specialize on smaller parts of a weapon increasing the number of people involved and the coordination problems.

The Armed Services also found it increasingly difficult to develop weapons when development and production were divided among several different military offices and contractors (Livingston, 1959, pp. 84-86). It was recognized that better and more sophisticated coordination would be needed to produce a "wholly functional" unit (Hill, 1970, p. 124). Similar changes in thinking were also occurring in industry, some because of its contracts and others because of its own needs (Hall, 1962).

Systems engineering was one of the concepts resulting from the early thinking. It was fundamentally concerned with deriving a system design that would achieve stated objectives (Chestnut, 1967, p. 37). However, many different ways of describing systems engineering have evolved over the years and no one definition is universal. General descriptions of it usually include phases like the following (Flagle, Huggins, and Roy, 1960, pp. 21-23; Hall, 1962, pp. 7-11; Hill, 1970, pp. 125-126):

1. Systems Studies (Program Planning).

   This is an initial phase which often may not be included in descriptions of systems engineering. In this phase, decisionmakers develop the broad context for ensuing specific projects. Problems needing engineering and development are identified and resource allocations made.

2. Exploratory Planning (Project Planning 1).

   This phase consists of a number of different tasks which are performed in any sequence. The basic objective is to identify the system development which will solve the problem defined in the previous phase. Other work needed to support a system development may also be identified. Specific tasks in the phase include problem definition, selecting objectives, systems synthesis, systems analysis, selecting alternatives, and communicating the results.

3. Development Planning (Project Planning 2).

   This phase is a recycling of the previous one except that attention is now shifted to a specific system development. Plans are formulated for the system and the management of the project. Design requirements and subsystem descriptions are specified so that the project can be adequately defined.

4. Studies During Development (Action Phase 1).

   A significantly larger effort is then started on development. Requirements are further detailed, studies are made, and prototype models are produced and tested in the working environment. Final evaluations of the system are made. If the evaluations are favorable, then the system is transferred to users.

5. Current Engineering (Action Phase 2).

   The primary development has now ended and an operational system has been set up with users. Follow-up work is done in this phase to further refine the system in light of operating conditions. Development activities may be initiated as needed to support changes in the system.

Other descriptions vary slightly from these phases. For example, Chestnut (1967) and Hill (1970) condense the five phases into four: Conceptual, definition, acquisition, and operational. These authors also point out that engineering design is often equated with systems engineering. However, they believe that engineering design is embedded within the systems process, covering activities found in the definition and acquisition stages (Chestnut, 1967, pp. 3, 36-37; Hill, 1970, pp. 124, 126).

Another key point made in most discussions about systems engineering is that descriptions of it specify functions performed and not what a group does (Hall, 1962, p. 11). This point is made in recognition that systems engineering involves numerous activities and people. The organization and management of people and activities is a related but distinct process. Systems engineering management identifies the hardware, facilities, personnel, training, and technical orders necessary in a systems project (Hill, 1970, p. 126). This aspect will be discussed more in a later section of this chapter.

3.3.3.2 System Acquisition Models in Government

The previous section in this chapter reviewed development models used in systems engineering and included some discussion on the military weapon system procedures. These defense related models represent one major approach developed in government. Several others have recently been designed, one from the U.S. General Accounting Office (GAO) on computer models and one from the Office of Federal Procurement Policy (OFPP) on the acquisition of major systems. The OFPP model is an update for procedures previously used in the military. This section reviews and contrasts these newer models.

GAO Model

The GAO model was developed from a study conducted on the acquisition of computer models (Comptroller General, 1975; Jue, Nowocin, and Mandelbaum, Note 3). Model developments were studied in organizations having access to government funds to develop or use models. The agency identified 519 models in some stage of development and closely examined 57 of them. While the developments represented smaller projects and systems than of central concern in this dissertation, they did have objectives similar to larger scale systems. They all were supposed to provide information for decision-making. Also, many were to play a key role in spending large amounts of money. The GAO study thus provides some lessons for more complex system developments.

The GAO found management problems in over half of the developments. The problems fell into three categories (Jue et al., Note 3, p.1):

- Planning.

  Planning problems included unclear definition of the problem, inability to obtain data, insufficient funds to complete the model, inadequate provisions for updating the model for future use, inadequate planning of evaluation procedures, and inadequate planning of documentation requirements.

- Commitment.

  Commitment problems included insufficient participation of the intended model user in planning, and insufficient knowledge of computer modeling techniques and applications.

- Coordination.

  Coordination problems included inadequate monitoring of model development, and inadequate user/developer coordination.

The GAO then surveyed all of the organizations to determine what procedures would improve the acquisition of computer models. They found few usable guidelines in the organizations they contacted and decided to create their own five phase procedure. The phases are

(Comptroller General, 1975, pp. 15-23):

1. Problem Definition.

   This phase concentrates on establishing characteristics of the problem and the model needed to solve it. Users should obtain management commitment to the model and define the changes that will be needed to support it. If contractors will be needed, competition for them should be implemented here and procedures for monitoring their work established. Updating considerations should be made. Overall, the phase should constitute a complete study of the factors justifying development, what will be developed, how and when it will occur, and what happens when development is over.

2. Preliminary Design.

   This phase includes defining the model inputs and outputs, logic, limitations, costs and benefits. Substantial revision of the problem in this phase could be grounds for terminating the effort. Users should be confident that all specifications are identified and will not need changing in subsequent phases. If needed, project should be redesigned to accommodate the specifications developed in this phase.

3. Detailed Design.

   The developer now prepares the actual model, conducts tests, and prepares user documentation. Periodic reviews of the project should be made by users. They should also decide if further development is warranted beyond this phase.

4. Evaluation.

   This phase is for more extensive testing of the model under operational conditions. Criteria developed in earlier stages are applied to model performance and the user determines if the model should be fully implemented.

5. Maintenance.

   The user agency continues to monitor the model's performance and makes changes as needed. The developer should remain available for assistance as agreed to in earlier phases. If the model becomes outdated, support for it should be terminated.

Two key points further stressed by the GAO are documentation and separate budgeting of some phases. Documentation is needed in each phase to demonstrate that the objectives have been met and to prepare the basis for following stages. The GAO also considered it important that the user have the flexibility to stop developments which appear to be unneeded or infeasible. Thus they suggest that users separate phases, especially problem definition and preliminary design, from the others (Jue et al., Note 3, p. 3). This could mean as little as putting a decision point at the end of each phase, or, more significantly, using separate budgets and competition for selected phases (Comptroller General, 1975, p. 15).

A number of considerations are missing in the GAO procedures. First, there is little discussion of the overall management and organization of a development. A few of the key items, such as contracting, are included as points to consider, but an overall perspective on the preparation and organization of the people, resources, and processes is not provided. Secondly, the report treats development as more of a structured, linear process than may be appropriate to the situation. In complex, uncertain efforts, even relatively small ones, defining the problem in the first stage and obtaining a managerial commitment to a solution may not be possible, especially if the user doesn't have the internal staff resources to do so. Contracting support may be needed early. Also, the process ignores the possibility of cycling through stages, refining different parts of a model independently, or having overlapping stages. Thus it appears that users must commit themselves to a significant amount of up-front work and specification before they obtain outside help or test their ideas with prototypes. Some reviewers of the GAO model also made this point (Comptroller General, 1975, pp. 25-26). They felt the procedures too structured for projects where flexibility and creativity are paramount.

Finally, the GAO model does not include much about what the users do after the problem definition stage is completed. For example, integration of a model with the user environment is rarely mentioned in later stages, especially from the user viewpoint. Most of the implementation issues discussed are found in the problem definition stage, where it is difficult to see how they can be finalized so early. More contact between user and developer would seem necessary.

OFPP Model

A more comprehensive approach to system development is provided for in the policy directive recently issued by the Office of Federal Procurement Policy (OFPP) of the Office of Management and Budget, and discussed in a shorter pamphlet from OFPP (Office of Federal Procurement Policy, 1976). The new policy, A-109, is intended to apply to all executive branch agencies. It is to improve the analysis of agency mission needs, the identification of needs for a system, the chances for innovative ideas from contractors, and the communication process with Congress. Typical systems covered by the policy include office buildings, energy demonstration programs, transportation systems, data processing systems, or defense systems.

The steps in the process are (Office of Federal Procurement Policy, 1976):

1. Mission Analysis.

   Government agencies are required to structure their budget data around missions and programs. The A-109 system acquisition process builds onto this structure by requiring continuous mission level analyses. Deficiencies in capabilities or new opportunities within the missions may thus be identified. A mission need statement is then created to define the problem. This statement does not include any proposals for specific means to meet the new need. Once completed, the statement is then forwarded to the agency head for approval. If it is approved, the statement is also forwarded to Congress through normal budgeting procedures. The intent is to have Congress review major needs comparatively across agencies and debate the problem before commitments are made .

2. Exploration of Alternative Systems.

   The agency establishes a system acquisition program and explores alternatives to meet the mission need. A parallel program on non-system alternatives may also be created. A program manager is selected and develops an acquisition strategy and plan based on items from the approved mission need statement. The acquisition plan is then used to communicate plans to agency staff and other relevant outside groups. The use of contractors is a major consideration in the plan. A solicitation may be used in this phase to acquire design concepts from outside consultants. The solicitation should be constructed to allow creative, innovative responses. A number of parallel short term contracts can be let to develop competing ideas. Criteria for selecting the most promising concepts that result are established.

3. Competitive Demonstrations.

   When a demonstration of the evolving system concepts seem feasible, the selected alternatives are submitted to the agency head for approval. Evaluations of the other non-system alternatives should also be included. Competitive demonstrations of approved concepts are then conducted. The purpose of the demonstrations is to verify concepts, check performance in an operational environment, and provide a basis for selecting concepts to enter full-scale development later. Demonstrations may involve prototypes. The program manager must assure that vendors can accomplish full-scale development and production if they are selected at the end of this phase.

4. Full-Scale Development/Initial Production.

   Proposals from contractors selected in the previous phase are submitted to the agency head for approval. At this point, competing design efforts may still be continued if it is beneficial to do so. The program manager monitors contractor progress and coordinates changes from original plans. The initial units produced are tested and evaluated, normally independently from the agency user group. Contractors should develop proposals for full-scale production.

5. Production, Deployment, and Operation.

   Test results and proposals from the previous phase are submitted to agency head for authorization of full production. As systems become available, they are deployed and made operational. The new capability provided by the systems then become a factor in the continuing mission analyses described in the first phase.

OFPP emphasizes flexibility throughout the process. Iterations through the phases may occur as more knowledge is gained on the problem, alternative solutions, or priorities, etc. The final production phase can be skipped if the system is not going to be produced in quantity. A building would be an example of this.

Comparing Models

Comparing the OFPP model with the one from GAO demonstrates a number of differences. Some of them are:

- The GAO model emphasizes more up-front specification of the problem and the solution. The OFPP model provides for more gradual specification. Early planning is emphasized in the OFPP model, but it is recognized that all phases can contribute to an understanding of the problem and the system needed. It encourages revision based on the increased knowledge of each phase. Final selection of the system comes late in the process.

- The OFPP model is written from the user viewpoint throughout all phases. Management and organization of the project by the user is discussed.

- The OFPP model suggests more liberal use of contractors to support the development. Contractors might be used in early planning as well as later design stages. Several contractors might be used within the same stage to develop competing ideas.

- Commitment of the user to the system appears to be more gradual in the OFPP model. The GAO model emphasizes early comprehensive planning and some level of commitment to an ap proach. Later phases do not include competition between ideas. If major changes occur in the problem definition or system design, then the project should be terminated. On the other hand, the OFPP model provides for change. It is recognized that as designs and tests become more specific, it is likely that changes in concepts, expectations and plans will be needed. OFPP seeks to maximize learning about the problem and the solution through competitive testing.

While the OFPP model is aimed at more complex systems than those studied by the GAO , the two models are aimed at similar problems and objectives. In each case, a need for a new set of procedures is identified and either a model or a system is acquired. The differences between these projects are probably mostly in dollars expended, people involved, and decisions and organization processes affected. An increase in these factors results in increasing complexity of the system. This may be the reason behind the flexibility of the OFPP model versus the GAO model. This also indicates a difference between smaller efforts and larger ones. Large scale system developments need more flexibility. Early decision on designs are not easily made or desired.

3.3.3.3 Information System Models

Models specifically designed to guide the development of information systems come from a number of different professional disciplines. For example, Keen and Morton (1978, p. 79) list six professional groups from which have evolved six different viewpoints on information systems:

1. Computer Science.

   Creates technology, both hardware and software. This is a necessary but not sufficient contribution to information systems.

2. Management Science.

   Represents the analytical viewpoint in structuring problems and develops the models so often necessary to drive information systems.

3. Behavioral Science.

   Provides insights into the implementation process and the human and organizational context of the system.

4. Data Processing Professional.

   Builds the application systems the organization finally uses.

5. Management.

   Understands the realities of decisionmaking and thus which systems can be effective.

6. Decision Support.

   Focuses attention on building systems in relation to key decisions and tasks, with the specific aim of improving the effectiveness of the manager's problem-solving process.

While discussion could be devoted to each of these groups and their models, it seems that the major points can be summarized by a fewer number of categories.

Several terms often used in the literature to group models are conventional or traditional and alternative or evolutionary. The conventional label is usually applied to those models in which the developer is in control of the project and most attention is focused on technical design problems. These models are commonly associated with computer systems, especially clerical or accounting types, since this was their origin. Data processing, computer science, and operations researchers are the groups typically found using the conventional approach.

Alternative models, on the other hand, refer to those development processes where users and developers share responsibilities and more attention is placed on the human and organizational aspects of design. They have particular application to higher level management decisions and situations where the information problem is more unstructured. Behavioral and management scientists have been primary sources of these models (Keen and Morton, 1978, pp. 44-52).

The conventional and alternative categories are used in the following sections to group development models. A further special section is devoted to models used for determining decisionmaker needs. The increased concern in the literature towards satisfying user needs has prompted some authors to specialize in models in this area.

Conventional Models

Many recent articles in the management science and management information system literature identify models for system development which are called traditional or conventional (Boland, 1978; Lucas, 1978b). Traditional models are aimed at situations where a system is first designed by a technical team and then introduced and institutionalized in the user organization. Developers and users have fairly separate roles in the process. Developers are responsible for assessing decisionmaking needs and designing the system, while users just supply information and approve designs. Managers are almost always seen in a passive role (Keen and Morton, 1978, p. 13).

Ackoff's early work in management information systems is often cited as exemplifying the traditional approach. His process involves five main steps (Ackoff, 1967, pp. B-153 -B-156):

1. Analysis of the decision system.

   Looking over the process of decision to be supported by the system. Decisions are studied in relation to each other. This step might clear up the information problem without building a system.

2. Analysis of information requirements.

   Define information needed by the decisionmaker and build a model to produce it.

3. Aggregation of decision.

   Group decisions with overlapping information requirements under a single manager.

4. Design of information processing.

   Build the data collection, storage, retrieval, and processing subsystems.

5. Design of the control system.

   Design flexibility and adaptability into the system. The system will need improvements and changes.

The characteristics that make this model "traditional" appear to be:

- The emphasis on the designer versus the user.
- The lack of iteration through the steps.
- The apparent lack of contact with the user for feedback.
- The complete design and acceptance of a system previous to any testing.
- The emphasis on technical issues versus organizational or behavioral ones (Keen and Morton, 1978, p. 49).
- The ready acceptance by managers of the designs (Zand and Sorensen, 1975, p. 533).

Patterns similar to Ackoff's are also commonly found in MIS literature which focuses on the use of computers. One frequently cited source in this area is Davis (1974). He describes the life cycle of computer systems and identifies three stages in their development. Briefly, these are (Davis, 1974, pp. 413-420):

1. Definition of the system or application stages.

   Feasibility assessment, information needs analysis.

2. Physical design stages.

   System design, computer program development, procedure development.

3. Implementation stages.

   Conversion, operation and maintenance, post audit.

Again, like Ackoff (1967), the emphasis of the model is on the designer. The user is in a subsidiary role until the time comes to institutionalize the system. Also, the impact of change on the user is not explicitly accounted for in each stage. Davis does recognize that there will be impacts on users and that they can be significant (Davis, 1974, pp. 425-429). He suggests several actions the designer can take to facilitate change for the user (Davis, 1974, p. 427):

- Encourage initiation of projects by the user rather than the information systems department.
- Include user personnel in the project group where feasible.
- Establish a user advisory/supervisory channel such as one person or group to assist and guide the project.
- Hold informational and feedback sessions with employees at each level who will come in contact with the system: prior to design, at the end of design, prior to implementation, after implementation.

However, these seem to constitute a weak strategy relative to the problem and only further emphasize the traditional nature of his model.

A third well known source in the traditional camp is Alexander (1974). Alexander specifies three major steps in MIS development:

- Information gathering and analysis of the existing system.
- Design of the new system and preparation of a proposal.
- Preparation of system specifications and implementation of a new system.

As with the other examples, implementation is emphasized late in the process, the impacts of change on an organization are not explicitly considered, and the analyst is in charge. Alexander does recognize that implementation is complex and that users should be involved. However, he offers little guidance on how to get them involved. For example, he advises that the system analyst should structure the new system in order to introduce enriching qualities to the user's job. This should make users more receptive to the changeover (Alexander, 1974, p. 165). This does not seem to facilitate user involvement as it only reemphasizes the control of the systems analyst.

Not all models labeled as "traditional" are like these three examples however. In what seems a paradox in the literature, much more elaborate development models which emphasize problem definition, user involvement, feedback and iterations are also placed in the traditional camp (Boland, 1978, p. 888). An example of this is the rather elaborate set of procedures for the development of large, complex computerized information systems written by Blumenthal (1969). Blumenthal recognized that information systems were evolving into more complex functions and that development problems were not only technical, but managerial and organizational (Blumenthal, 1969, pp. 103-104). He discerned that even though much had been written about planning large systems, little had been done to formalize a body of planning principles, especially in management science literature (Blumenthal, 1969, pp. 7-8). He thus developed an elaborate process of his own which involves numerous committees, project teams, design proposals, user reviews and acceptances, testing, and evaluation. The heart of his model is a six stage process. Within these stages, he delineates 14 specific procedures (Blumenthal, 1969, pp. 111-142):

	Stage	Procedures
1.	Preliminary Analysis	• Pre-proposal • Proposal Preparation
2.	Feasibility Assessment	• User and Systems Staff Assessment • Additional Study
3.	Management Consideration	• Presentation • Management Actions
4.	Systems Implementation and Control	• Project Planning and Control • Completion of Functional Requirements • Preparation of Systems Specification • Programming and Testing • Conversion and Cutover
5.	Data-Processing Organization Activities	• Hardware Planning, Technical Assurance • Hardware Procurement and Installation • Systems Operations and Maintenance
6.	Performance Evaluation	

Stages and procedures are linked to each other and often overlap in their timing. Users are heavily involved in the early stages as it is their responsibility to define the information problem and develop proposals. Interactions through the procedures are expected and some subsystems may be completed before others (Blumenthal, 1969, p. 100). Technical designers have no more than equal importance to other members of the development team even in the more specific design procedures. Blumenthal (1969, pp. 196-200) also acknowledges that systems must be adaptable to changes in functions, technology, or organization that may occur after development is over.

Blumenthal's model and others like it would seem to be in a different category than those presented by Davis, Alexander, or Ackoff. The latter models reflect some of the earliest MIS thinking and accomplishments which occurred in the system developments for clerical, bookkeeping, or accounting functions of organizations. These were among the first business activities to be computerized (Blumenthal, 1969, p. 1; Karger and Murdick, 1977, p. 72). The decision problems were structured, narrow, stable, and easy to convert to machine execution. While some claim that decisionmaking was hardly a part of these applications (Keen and Morton, 1978, pp. 2-3), it can at least be said that developing these systems required less work on problem definition and more on design and implementation. Keen and Morton (1978, p. 50) also suggest that the novelty of the technology in these first applications often overshadowed any human engineering considerations during development. Thus some of the traditional models can be said to reflect the needs of these early applications and probably still would be applicable to similar circumstances found today.

Blumenthal's model on the other hand is not a simple, step-by-step process which separates user and developer, or handles only routine, structured decision problems. Much more emphasis is placed on the problem formulation stages. Implementation is really on-going throughout the development process (Chervany, 1978, p. 176). These characteristics make the models more similar to the newer ideas for MIS developments coming from behavioral scientists in the academic literature and government decisionmakers in public sector. Behavioral science models will be presented in the following sections.

Alternative Models

Another major category of models for system development has been evolving from both behavioral and management sciences. The models have several different names, but most often are called alternative (to conventional) or evolutionary models (Davis, 1974, pp. 405-409; Lucas, 1978b; Urban, 1974, p. 224). Alternative models are different from conventional models because they place more emphasis on the human and organizational aspects of development. Problems and methods from areas like social change, organization design, systems analysis, organization behavior, cognitive processes of decisionmakers, and resistance to change are used to structure development strategies and reduce the over attention to technical design problems given by other models (Keen and Morton, 1978, pp. 44-52). Lessons from these areas are having an increasing influence on development models because it is being recognized that the success of a project depends considerably on how well the process of change to a new system is planned and managed (Youker, 1978, p. 12). The costs of ignoring the human and organizational problems with change are being discovered: more costly developments or reduced organizational performance overall (Mumford et al., 1978).

Several examples of evolutionary models have been developed from the Kolb and Frohman (1970) model of intervention into an organization. This model exemplifies many of the basic strategies behind the recent models developed in the alternative category. Kolb and Frohman expanded on models previously developed by Lewin (1952) and Schein (1961) which specify three stages for organizational change: unfreezing, moving, and refreezing. The Kolb/Frohman model consists of seven stages and demonstrates the increased front-end emphasis of the evolutionary approach (Alter and Ginzberg, 1978, p. 24):

1. Scouting.

   The user and designer assess each other's needs and abilities to see if there is a match, and an appropriate organizational starting point for the project is selected.

2. Entry.

   The user and designer develop an initial statement of the project's objectives, and commitment to the project is developed. They develop a trusting relationship and a "contract" for conducting the project.

3. Diagnosis.

   The user and designer gather data to refine and sharpen the definition of the problem and its solution. They assess available resources (including commitment) to determine whether continued effort is feasible.

4. Planning.

   The user and designer define specific operational objectives and examine ways to meet these objectives. The impacts of the proposed solutions on all parts of the organization are examined, and an action plan is developed which takes these into account.

5. Action.

   The user and designer implement the "best" alternative, providing the training necessary for effective use of the system in all affected parts of the organization.

6. Evaluation.

   The user and designer assess the degree to which the goals (specified during the Diagnosis and Planning Stages) were met, and decide whether to work further on the system (evolve) or to cease active work (terminate).

7. Termination.

   The user and designer assure that "ownership" of and effective control over the new system rest with those who must use and maintain it and that necessary new patterns of behavior have become a stable part of the user's routine.

As seen in these stages, users and designers work as partners and spend initial time developing their relationship. Much more time is spent considering and refining the problem which a system is to solve. The need to focus on the user-developer relationship has been echoed in many other sources as well. Some examples are Churchman and Schainblatt (1965) with their "dialectic of implementation", Mitroff and Emshoff (Note 4), Mitroff, Williams, and Rathswahl (1972), and Mason and Mitroff (1973) with their strategies for illstructured problem solving, and King and Cleland (1975) with their decision needs analysis.

Lucas has perhaps made the most extensive use of the Kolb/Frohman model in his work on system development. His earliest model, called creative system design, involves a combination of the Kolb/Frohman stages and his own user-oriented concepts. He emphasizes the importance of user control, user interfaces with the system, user criteria for evaluating the system, and the gradual commitment over time of a user to a design (Lucas, 1974b, 1978b). Lucas provides an example of these concepts in a development for the United Farm Workers (Lucas and Plimpton, 1972) and this is reviewed as a case study in Section 3.3.1.2.

His latest model, called evolutionary design, builds upon the creative design model and revises the series of stages (Lucas, 1978b). The major change in the evolutionary model has been the increased emphasis on interaction and feedback between user and developer, especially in early stages. The stages are as follows (Lucas, 1978b, pp. 44-46):

	Stage	Activities
1.	Inception	• User suggestions for a new system
2.	Initial Groping	• Response from developer on initial suggestions • Output (simple models, dummy report, simulated system)

3.	Mutual Progress	• Collaborative Development - define problems - design system - cycle through these - test system
4.	Conversion	• Transfer of ownership • Conversion • Installation
5.	Maturity	• Operation • Changes in design

As seen in the model, users produce suggestions and developers react quickly with models, dummy reports, or simulations based on the suggestions. This procedure gives users something concrete to react to, educates the designer more quickly, and helps clarify the problem to the user. Although this cycle isn't repeated in the model, Lucas expects it to be the basic pattern of interaction between user and developer throughout the project. Lucas also sees this model as mostly applicable to cases where the decision problems and system objectives are initially unclear.

Information Needs Analysis

Most of the literature devoted to information systems specifies the need to satisfy the user requirements for information. While this seems an obvious point, too many developers have experienced the failure of MIS projects specifically because of too little attention to this issue. Much attention is now devoted to the front-end stages of development where the initial work must be done to discover these requirements. Information needs or requirements analysis is now a specialty topic witin the various fields devoted to information systems development. For example, Taggart and Tharp (Note 1, 1977) identify and review 50 different models for information needs analysis. They also provide guidance on how to best select one for a specific situation.

There appears to be two different schools on needs analysis, one which uses the data analysis method and one which uses the decision analysis method (Boland, 1978; Davis, 1974, pp. 409-411; Munro, 1978). The data analysis method has the following steps (Munro, 1978, p. 34):

1. Examine all reports, files, and other information sources drawn upon by the manager.

2. Discuss with the manager the use of each piece of information examined.

3. Eliminate unnecessary information.

4. Determine unsatisfied information needs through interaction with the manager.

The data analysis method concentrates on the existing structure of decisions and gaps. It is implicitly assumed that the decisionmaker knows what he wants (Munro, 1978, p. 38). This method would thus be more applicable to situations where decisions are defined, stable, and routine.

In contrast, the decision analysis method has more of a normative perspective and is more relevant to situations where there is uncertainty in the decision problem (Munro, 1978, p. 38). It includes procedures to examine what decisions are made or should be made, and how they should be made. Munro (1978, p. 36) lists the following steps for the decision analysis method:

1. Determine major decision responsibilities through discussion with the manager.

2. Determine policy and organizational objectives relevant to decision areas identified.

3. Determine specific steps required to complete each major decision.

4. Develop a model (flowchart) of each decision.

5. Examine flowchart to determine information required at each step in the decision.

King and Cleland (1975) elaborate on these procedures even more.

Generally, the decision analysis approach does not assume things are "as they should be" and emphasizes broader analyses. Normative and descriptive information flow models are produced and gaps identified. Decision procedures as well as the decisions themselves may be restructured after the analysis. A test conducted by Boland (1978) showed this procedure to be better at identifying problems and stimulating ideas for appropriate system designs than the data analysis approach.

3.3.3.4 Comments

The last several sections have reviewed some of the different types of models available in the literature for systems development. Three main categories have been used to group models: systems engineering models, system acquisition models in government, and information system models. System engineering models evolved from the need to improve the development of military weapons systems. Many of the well known concepts in systems development were established in these efforts and models in other fields have been influenced by them. Government system acquisition models were established to help guide agencies through the development of large scale systems. The models reflect the agency environment: the need to rely on outside contractor support in a development, the need to satisfy Congressional and budgetary scrutiny, and the need to promote competition between alternatives before reaching final production stages. A final section reviewed models specifically aimed at developing information systems. Subsections were presented on conventional models, which evolved primarily from computer system applications, and alternative models, which were designed to increase attention on the human and organizational impacts of a system. A final section was included on information needs analysis models, which are specialty processes aimed at defining decisionmaker needs.

There are a number of similarities between the various models:

- All models have some form of initial planning stages where problems are studied, plans are developed, initial ideas on system design are suggested, and approvals from users are obtained. Most sources in the information system fields recognize the importance of information needs analyses at these early stages.

- All models have stages for testing and evaluating a system prior to final full scale operation. The concept of using prototype designs in these tests has long been accepted in engineering and government models and it is now appearing more in information systems literature as well.

- All models emphasize to some degree the need for decision points where users provide approval for continuing work or acceptance of a design. Some models locate these points in all stages, while others only occasionally mention them.

- All models of course emphasize the importance of user participation, although, as with decision points above, this interaction varies considerably across the different processes.

There are also a number of differences between models and the following list covers some of the major ones:

- Design flexibility/user commitment to designs.

  There are some differences between models on when technical specifications are accepted and finalized. The OFPP model is perhaps the most flexible in this respect since technical changes are routinely expected, competition between ideas is encouraged, and subsystems are developed as independently from one another as possible. The OFPP models attempts to keep the design options open as long as possible into a development. On the other hand, the GAO model suggests commitment to designs very early in development. Projects should be abruptly cancelled in later stages if the initial design specifications aren't met. Conventional information system models are somewhere in between: user commitment usually comes very late in development after the technical team completes its work, and the technical team maintains less and less flexibility in design over time. Alternative models emphasize gradual user commitment to a design.

- Development process - project management.

  System engineering models recognize that two separate processes are active in a system development: the actual strategy and tasks, and the management of these. These two areas are recognized to some extent in the government models, primarily because contractors are usually involved in developments and they must be managed by the user. Information systems models hardly recognize these issues at all.

- User activities versus developer activities.

  Each of the models is written from a slightly different perspective. Government acquisition and system engineering models generally have the user viewpoint in each stage. The user is in control of the project. The conventional information models take the opposite viewpoint and emphasize developer control of the project. Users primarily just supply information and allow the developer to have control of the process. Alternative models have emphasized a more equal partnership between user and designer, since both must be educated about what the other is doing. These models may overestimate the ability of users to participate equally in the various development stages.

- Use of contractors.

  Government system acquisition models include numerous considerations related to the use of contractor support. This reflects the fact that government agencies usually don't have the internal staff resources to develop large scale systems on their own. Information system development models have little if any mention of this kind of situation, except briefly in reference to computer system vendors. It seems likely that, with large scale systems most users, both public and private, will interact with a contractor at some point. The lack of attention to this in information system models may indicate some lack of insight as to how systems really get built.

- Human and organizational impacts.

  Alternative models for information systems development place the most stress on the impacts new systems will have on organizations; conventional models concentrate more on technical design problems. It is the lack of human engineering concern in these models that prompted the search for alternative models. Government acquisition models have their emphasis on organizational implications in early stages. System engineering models do not specifically mention these kinds of issues directly, but they are a long standing component of the systems tradition.

Each of these models has its own merit. Developers needing guidance on strategy can take lessons from them and their applications regardless of the various differences. A model's utility will be based on the match between its strategy and the prospective application.

The choice would probably be different for the decisionmaker levels like operations, management control, or strategic policymaking (Anthony, 1965), and depending on whether the decision procedures are structured or unstructured (Gorry and Morton, 1971; Keen and Morton, 1978; Simon, 1960). Other factors affecting choice would be how big and complicated the project will be, who will run the project, and the degree to which the system will be a new design versus a modest well known one (Thompson, 1974, p. 30).

3.3.4 System Designs

A final sector of the systems literatures is concentrated on the design aspects of systems. Generally, this literature is divided into two categories: sources discussing design issues at a general level, and sources presenting specific designs for example or real application. Many of the sources presenting general issues tend to focus on one basic point: that one particular design in not right for all situations. Developers must identify the critical design factors, such as the user managerial levels, the complexity of the information problem, or style of decisionmaking, in order to select the appropriate design. These are lessons applicable across most situations.

Specific designs, on the other hand, focus on one design and its application. These examples are most useful for understanding how the information problems were solved in a specific case. The lessons offered in other systems literature sources can be observed first hand with the actual result. These designs can be stimulating in that the approach may offer insight to another situation exhibiting similar characteristics. Generally, however, the transferability of designs in this sector of literature is low, supporting the idea usually discussed in other design literature that each situation is unique and requires a closely tailored design.

A note should be made about one source of confusion in the design literature. This is the often side-by-side use of design as a noun and as a verb. Design, when used as a verb, means the actual activity of specifying and developing the system components. Design as a noun clearly refers to the resulting specifications. This can be confusing, especially in exploring the literature. Sources discussing system design can mean either the process of specifying the design or the design specifications. In this section, design will be used as a noun.

The following sections review in more depth the two categories of system design literature introduced above. An example of a design has been selected for the section on specific designs. A closing section comments briefly on the two sections.

3.3.4.1 General Issues in System Design

One sector of the literature on system designs concentrates on general issues or lessons developers should consider in the process of creating a specific system. The most common point made in these sources is that one particular system design is not right for all situations. There are many factors in a user organization which will influence the kind of design needed, and these factors vary considerably. Specific situations are more likely to be unique in design requirements, and developers must acknowledge this by closely tailoring the design to the user.

Perhaps one of the more widespread frameworks used by authors to help categorize these differences is the framework developed by Gorry and Morton (1971). In this framework, Gorry and Morton list two dimensions which can be used to characterize the kind of information situation which developers may be encountering. One dimension defines the purpose of the system application and is divided into three categories adapted from work by Anthony (1965): strategic planning, management control, or operational control. Gorry and Morton suggest that the information requirements for each of these uses are quite different, and thus the system design must be different. The second dimension loosely defines the method of decisionmaking or information usage and is divided into three categories adapted from Simon (1960): structured, semi-structured, and unstructured. Structured methods of decisionmaking imply that information needs are well known, routine, and predictable. Systems to meet the information needs of a structured situation are most likely straightforward and quickly defined. Unstructured methods, on the other hand, imply that information needs are unknown, changing, or unpredictable. Situations which are unstructured tend to be found in upper level management where decisionmaking is complex and involves many factors. Systems serving users at these levels have to be much more flexible than in structured situations. The main requirement may be that they are quickly changeable by the decisionmaker in order to fit the decision problem at hand. Recent thinking on systems like this can be found in the literature devoted to decision support systems (e.g., Keen and Morton, 1978).

Gorry and Morton combine the two dimensions to form a matrix which can classify the information need and thus assist developers in determining what kind of information system design is appropriate. Many authors have also adopted this approach. Usually, structured situations are associated with the operational control level. Here decisions are routine and repetitive. Sophisticated, dynamic system designs are rarely needed. Similarly, unstructured situations are usually associated with higher decisionmaking levels where needs can be fluid. Systems to meet these requirements are becoming more of interest in the literature (Gorry and Morton, 1971, pp. 61-62) and can be seen in the aforementioned emerging decision system literature.

Other approaches to classification like that proposed by Gorry and Morton have been taken, although they still emphasize the same points. For example, Rich (Note 5) refers to the differing requirements dictated by the various decisionmaking styles that can be encountered. Managers have different information utilization patterns and problem solving styles. One system can not easily match the requirements of different people or different situations. Developers must be sensitive to the characteristics which contribute to these differences and bring these considerations into the design process (Rich, Note 5, p. 27). Rich also points out that not all needs can be met by an information system, clearly recognizing that there are limitations for designs which have to be recognized by both developer and user (Rich, Note 5, p. 27).

A more humorous but equally realistic treatment of design issues is provided by Gall (1975). Gall lists numerous axioms about systems with a heavy emphasis on why they often fail. Among his many axioms can be found some that relate to design:

- A large scale system, produced by expanding the dimensions of a smaller system, does not behave like the smaller system (p. 22).
- A system is no better than its sensory organs (p. 40).
- A complex system that works is invariably found to have evolved from a simple system that worked (p. 52).

Implications for design from these principles are useful and often supported by others. For example, the second axiom listed above implies the importance of input and output functions in the system design. These may often be the weakest link in the design, a point well recognized by others (Lucas, 1975b, p. 112; Malvey, 1977, pp. 191-211; Waller, Kemp, Scanlon, Tolson, and Wholey, 1976, pp. 13-

14). A rather interesting example of the third axiom, that concerning complex systems evolving from simple systems, is illustrated by Harrison (1978) who describes project control systems. Harrison suggests that large projects requiring control of multiple subprojects present complex management problems. He goes on to describe the major concepts and components in project control systems and reviews ones his firm has successfully applied. These systems are themselves complex, usually involving computerized routines. However, he describes one "special" technique they have found essential in the design of control systems: the use of a manual procedure of reporting cost changes which consists of writing changes on pieces of paper and delivering them directly to decisionmakers. This must be the one area where system designers found it difficult to replace a simple procedure with a complex computer program that produces impressive mechanical reports.

Lessons such as these are applicable across many situations, but application in a specific case requires the serious consideration of developers. Many of the suggestions about system design are essentially describing a non-event; they don't specify an action or behavior which is readily adaptable into a development process. These ideas can be turned into a process, however (Thompson, Note 6); this can provide useful suggestions on how to structure the development to avoid the problems implied by the authors.

3.3.4.2 System Design Examples

A wide variety of system design examples can be found in the literature. They range from general descriptions of certain categories of systems to more detailed discussions of specific systems designed for specific applications. Each type of example can provide insight to what designs look like and associated important development factors. However, experienced developers will find only the most detailed designs useful for guidance in their own respective situations.

One source of design examples is the literature devoted to general technical design characteristics of selected types of systems. These are most commonly found in areas related to information systems, especially involving computer machinery. One example is provided by Matthews (1971) who discusses the design of computer based management information systems. Matthews first reviews the system life cycle stages often found in computer related literature and then he describes general designs for systems, including descriptions of specific machinery components and how they work. Sources like this are most useful as introductory material or textbooks for general design courses. Experienced system developers will not usually find much information from which to derive guidance for specific applications.

Slightly more detailed design examples can be found that further illustrate applications of the kinds of systems introduced by Matthews. Sources can be found which provide an overview of specific systems that exemplify those in the field. For example, Palmer (1973) reviews a number of library information systems used for cataloguing, ordering, managing, and circulating library materials. While focusing on descriptions of the designs, Palmer also includes some details on development aspects and whether the designs met the expectations of users. Even though the examples are brief and the systems fairly small, readers can begin to assimilate important factors for development by observing the problems Palmer describes and how developers reacted to them.

A similar but briefer example in another field is provided by Alter (1977) who reviews categories of decision support systems currently being designed. Seven types are discussed: file drawer systems, data analysis systems, analysis information systems, accounting models, representation models, optimization models, and suggestion models. Alter describes the general designs of these systems, including hardware and software components, and how the systems operate. Some information is also presented on the problems of designing and implementing these systems.

Other examples similar to the one by Alter can also be found in other literature areas. Many of these occur in trade publications where system managers describe a specific system used in their company. For examples, Kronenberg (1967) briefly describes the evolution and design of an information system used by Weyerhauser.

Overall, sources like these provide a quick glance at specific applications and in some cases offer limited insight to key development problems encountered. Mostly, however, the examples are brief and useful mainly as an overview of where applications are occurring. It is difficult to derive and support key development factors from these sources.

More detailed and useful examples can be found in sources such as Keen and Morton (1978) who review the emerging field for decision support systems (DSS). Decision support systems generally are interactive computer systems designed to closely support a manager's problem solving style and need. In their book, Keen and Morton (1978, pp. 99-166) review six systems in operation that exemplify the DSS approach, including a portfolio management system, a financial planning system, and a management information system. Generally, descriptions of these systems concentrate on the technical design characteristics. They review data bases, system operation, and input and output displays. Other components of the systems, such as for maintenance, updating, or training, are not described in similar detail.

Some of their examples are notable for additional insight on development however. The most interesting example is presented for the portfolio management system, where one successful development is compared with one less successful development (Keen and Morton, 1978, pp. 101-126). In both cases, a system was designed and implemented in a bank. However, one system met the expectations of users and improved their operations while the other system was less successful. From the brief details supplied in each case, readers can identify several important factors influencing the development success for these systems. In the less successful system, several factors stand out:

- The heaviest users, although limited, were the people who participated in design activities. The lack of a training program for those not involved contributed to their lack of participation.

- A prototype system was a useful intermediate step in the design process. The low risk of testing a system without making a full commitment increased the number of users participating in the tests. However, it was also found that early participation did not guarantee later adoption of the system. A rapid changeover was not possible.

- Conflicts between the separate groups of users and designers, mostly a function of their different technical backgrounds, led to decreased user participation in testing.

- Use of the system required changing existing organizational routines. Little effort at overall change reduced the incentive to use the new system.

In the more successful case, several other factors can be identified, some of which contrast the conditions in the first one:

- One critical staff member became a system champion and pushed for the use of the system.

- Top level managers supported use of the system and created incentives to make the changeover to it.

- Top level managers considered the intangible benefits or future spinoff effects of use to be an important justification behind their support.

- Training was provided to integrate the sytem into day to day activities.

Examples like this one by Keen and Morton provide insight to both design and development characteristics which other developers can understand and possible apply to their own situations. While they are brief descriptions and leave out many details, they begin at least to demonstrate development implications for certain designs and to confirm in actual settings development principles identified elsewhere.

An example of a single more expanded design is provided by Nay, Scanlon, Graham, and Waller (Note 7) in their report on a system developed for the Law Enforcement Assistance Administration (LEAA). LEAA wanted a system to support the monitoring and evaluation of programs undertaken by its grantees. Viewing the information system as a knowledge production process, Nay et al. describe the development, design, operation, and performance of the system that resulted. While the descriptions of the design are general, this case is interesting because it:

- Demonstrates a "software" type system.
- Demonstrates a design for situations where there are changing data needs, many unknowns about field operations, and myths about what will be learned using a new system.
- Provides descriptions of development activities along with design descriptions.
- Provides examples of products and their impacts.
- Provides evaluations of the resulting design in terms of cost, time, and performance.
- Shows how the design changed with experience.

Nay et al. also include brief discussions on whether it is beneficial to create a system as a distinct unit in an organization with its own staff and on how the project worked as essentially an in-house development.

Examples like this are perhaps the most useful in the design related literature. They give details beyond simply the design requirements and technical details, including specifics on the associated development, testing, operation, and maintenance functions. Design concepts and specifications can be tied to other factors and traced over time, adding a dynamic perspective to the example. Experienced developers will find these examples interesting and illustrative and be able to use them as models for future applications. More of these examples are needed across all sectors of the literature.

3.3.5 Conclusion

The previous four sections have reviewed the systems literature in detail with a specific emphasis on what materials are available for guiding system developments. The literature was divided into four main areas: case studies of system developments, important factors of system development, models for system development, and system designs. Illustrations of sources in each of these areas were included.

The following sections review important problems for system development that are currently not well discussed in the literature. Three main problems have been identified in the review of literature areas: the lack of a comprehensive view of development, the need for a more dynamic perspective of the evolving, changing nature of development, and the need for a more comprehensive view of the process by which users decide to support, accept, and eventually implement a system. One section is provided for discussing each of these problems. In addition, a final section reviews the key problems as seen by authors in the systems literature. The structure used to describe the systems literature in this section will also be used to discuss these development problems.

3.4 KEY PROBLEMS IN THE SYSTEM DEVELOPMENT LITERATURE

3.4.1 Introduction

This section of Chapter 3 discusses the key problems for system development found in the literature. The presentation is divided into two main areas. First, the problems for development which are not adequately recognized in the literature are discussed. Three main problems are identified: the lack of a comprehensive view of development that integrates the various considerations potentially applicable in a systems project, the need for a more dynamic perspective of the evolving, changing nature of development, and the need for a more comprehensive view of the process by which users decide to support, accept, and eventually implement a system.

Next, the problems which are identified as research needs in the literature are discussed. Three major needs are identified: the need for more research on the management of system development projects, the need for frameworks which can help developers diagnose the management problems of their projects and find the guidance available in the literature, and the need for more empirical evidence which demonstrates how management techniques are used in actual situations.

Finally, sections are included which describe the approaches used in this dissertation in response to these problems and needs. Descriptions are included in all of the sections in order to more closely identify the dissertation approach in relation to the specific problem discussed in each section.

3.4.2 The Multi-faceted Nature of Development

The developer wanting to utilize the literature as a source of support for a new development will find it difficult to obtain a comprehensive view of the many important facets that need consideration. This is because much of the literature is segmented and specialized around selected issues, models, or designs. For example, typical discussions are those such as development strategy alternatives (Lucas, 1978b), system designer-use relationships (Boland, 1978; Patterson, 1977), or the five most important development problems from the user viewpoint (Fronk, 1978). Each of these perspectives provides valuable insight to a particular aspect of system development, but few sources attempt to interrelate these considerations in one place. It is interesting to note along this line that researchers themselves are now finding the need for more unifying frameworks (Bostrom, 1978; Ein-Dor and Segev, 1978; Ginzberg, 1978a; Zimmerman, 1977).

This section will review in more detail the kinds of perspectives taken in the literature and then discuss an approach which further enhances the contribution of each.

3.4.2.1 Limited Perspectives in the Literature

The systems literature overall is both broad and detailed on the many issues to be considered in a development. Readers can find numerous discussions on any range of topics, and those devoted to a comprehensive view will eventually be able to cover the important issues. However, the literature is segmented in certain ways which lead to a high degree of specialization in the presentations. Generally, the literature is divided by three dimensions.

The first is the main facet of development that authors select to discuss. As shown in the preceding descriptions of the literature, there are four prevalent perspectives used when discussing development: a case study approach which concentrates on the sequence of events, a review of key factors in a development, models of development processes, or descriptions of system designs. Each of these provides a distinctive viewpoint of development and has its limitations for providing a comprehensive view:

- Case studies of specific developments offer a detailed view of development, usually focusing on the sequence of major events. However, they are often poorly organized or without an overall perspective on strategy. Many are brief and leave out the complex series of events between initiation and final design. Major lessons from these experiences often appear to go beyond the evidence presented in the case.

- Factor studies identify and examine selected variables found to be important in system development. Commonly discussed factors include the need for user involvement and top level management support. Some sources further attempt to establish relationships between factors, usually focusing on the linkages to system adoption or usage. Factor studies offer more controlled and detailed examinations of variables and causal linkages than found in case studies. However, the complexity of development usually leads to weak study results (Ginzberg, 1978a). Claims made from the research give the appearance of structure where in reality little exists.

- Models of system development provide more overall structure to a development than usually found in other literature areas. Models are usually divided into several stages covering the entire development process. Each stage can be further specified by its respective changes in design or strategy. The major problem with models is operationalizing them in a specific setting.

- System design literature provides descriptions of designs used in specific situations or general design issues found to be important in an experience. These sources offer useful ideas on what a design looks like, but rarely include guidance on how the results were obtained.

The systems literature is also divided by the range of variables considered in the specific source. For example, the use of contracting to support development is a common, well recognized feature of development models used or promulgated by government policymakers. Models proposed in the behavioral and management science literatures rarely consider this as a critical component of a development project. Other differences can be found:

- The emphasis on user involvement in development is not often compensated by similar discussion of the design teams themselves, which might include users as well as other outsiders.

- Development models or important development factors may be presented from only one perspective, that of the user or that of the developer.

- Government development models emphasize competition among design concepts or subsystems and generally recognize the uncertainty pervading a complex development. Other models, particularly in the behavioral and management sciences, seem to portray a simply implemented process in which everything is done correctly and logically the first time.

- The concept of using prototype models is only beginning to emerge in behavioral science based systems literature (e.g., Fronk, 1978; Lucas, 1978b; Moore and Byrd, 1977; Zimmerman, 1977).

- Behavioral science development literature often overemphasizes human engineering problems and minimizes the concern on how to actually manage a development. Computer science literature concentrates more on the technical aspects of design than the human engineering components (Keen and Morton, 1978, p. 34).

- Literature concentrating on factors important in development may only discuss a limited number of factors, such as user attitudes, top level support, resources needed, or the kind of user environment needed. The relationship among factors like these is often left undiscussed.

Finally, the literature is divided into sectors according to the kinds of systems of interest to the authors. Literature sectors can be found for weapons systems, management information systems (MIS), computer systems, hardware or software systems, decision support systems (DSS), and many other kinds of systems. While the specific applications are quite different, the techniques and lessons in each sector tend to be similar. Thus, developers needing guidance for an information system development may benefit from a wider review of different literatures where analogous problems are discussed.

3.4.2.2 A More Comprehensive View

The complex, multi-factored nature of system development is not well represented in the various literature sectors described above. On the other hand, the complexity is difficult to present since there are so many factors to consider. Sources concentrating on selected factors are able to provide supporting detail not feasible in a more general discussion.

What is missing is the occasional, comprehensive view which attempts to interrelate the various factors in one location. Without these types of sources, readers of the systems literature must cover a wide range of material and assimilate for themselves the diverse, critical aspects relevant to their own situation.

Within the information systems literature, the best approach for tying together the various perspectives appears to be the combination of two or more types of sources: a case study with a model, a development model with important factors by stage, or the examination of selected factors in a specific case. A number of examples of these can be found in the literature:

- Lucas (1974b) describes his creative system design model and includes several brief case studies as illustrations.
- Lucas and Plimpton (1972) describe the creative system design model and illustrate it with a detailed case study of a development for the United Farm Workers (see section 3.3.1.2).
- Zand and Sorensen (1975) describe a development model based on Lewin's (1947) model of change and identify factors important in each stage (see section 3.3.2.3).
- Eveland, Rodgers, and Klepper (1977) describe a model of adoption and then illustrate it with case study details of system developments in eight locations.
- Alter and Ginzberg (1978) describe the Kolb and Frohman (1970) model for intervention in an organization and correlate important development factors with each stage (see section 3.4.3.2).
- Keen and Morton (1978) provide a comprehensive review of the evolving field of decision support systems. They use a combination of case studies, system designs, important factors, and development models to illustrate the design of these systems.

In addition, a wider range of variables should be considered. For example, the elements of contracting and project management prevalent in many hardware system literatures should be integrated into information system models that now exist. Techniques and lessons for information systems might also be further supported by examples from other kinds of systems.

The approach suggested above is used in this dissertation. First, the four main approaches, case study, modeling, system design, and factor study, are used in combination. The monitoring framework being developed for managing a project contains both design and process perspectives. Each of these areas contains a range of factors found to be important in the literature. Several case studies are used to illustrate the factors and their relationships. One special case study is used to trace these factors over time. Secondly, factors for the framework are based on the important issues found across the diverse systems literature. The different perspectives available in hardware and software developments of both public and private sectors are integrated into the framework and used on the information system developments of central interest in this dissertation.

3.4.3 Time Varying Qualities of System Development

Another perspective often lacking in the literature is the relationship of time to development activities. It is difficult to find sources which discuss how developments evolve over time and are changed to accommodate varying situations. The treatment of time also differs across the various kinds of literature.

The following sections review the dynamics of development as observed in the literature. First, the different treatments are discussed in each of the sectors used in previous sections: case studies of developments, development models, important factors in development, and system design. A second section presents the dynamic perspective rarely found in these sectors and how it will be treated in this dissertation.

3.4.3.1 Time Perspectives in the Literature

Case studies of system developments are one of the few sources of information which demonstrate how developments proceed over time and how changes occur in designs and strategy. The level of detail can vary considerably however. Many case descriptions are brief and focus only on the initial and final stages of a development. Intervening details between these points which would illustrate the evolution of strategy, problems, and changes are not included. It is more difficult to find the cases which provide the comprehensive review and allow the reader to trace all stages of development.

One example of the comprehensive case is provided by Lucas and Plimpton (1972) in their review of a development for the United Farm Workers (UFW) (see section 3.3.1.2 for a detailed description of this case). The authors describe the model of development they used and the implementation of the project. They include factors such as how they identified information needs, contact with users, problems with top management support, and deviations from their model. This level of disclosure, although brief and lacking many details, is rare in the literature. Readers are provided the opportunity to observe the problems and uncertainties which characterize a development and how developers compensated their strategy accordingly.

System development models are another sector of literature where some amount of time perspective is available, although it is less detailed than that available in case studies. Models provide a time perspective by outlining a sequence of project stages which characterize changes in design and strategy. Most models have stages such as problem definition, preliminary design, detailed design, transfer, and full operation. While these are valuable in providing an overview of development, they have limitations or underlying assumptions which detach them from an actual implementation. For example:

- Models can have a step-by-step linear appearance.
- Models can give the impression that once the sequence is initiated, it is always continued logically through each step until project conclusion.
- Models can assume that all things outside the project are held constant, such as resources or objectives.

These characteristics can easily misrepresent the delays, recycling, or overlapping and parallel activities developments commonly experience. It is difficult to represent these conditions in a model, however, unless greater detail can be provided through an accompanying case study or numerous caveats. Models usually are presented at a general level without these supporting descriptions.

A time perspective is even less common in literature devoted to describing important factors in system development. Factors such as top level support or problem identification are usually selected for specific emphasis in these sources. They are commonly given a static quality in that their description may be at a general level without reference to actual implementation or they may be discussed within a narrow time slice of development. It is thus difficult to gain a perspective on their importance throughout a project and their relationship to other proceeding or succeeding factors. For example, almost everyone agrees that user involvement is a key consideration in any system development. The question is what exactly this means during a project:

- User involvement could be extensive in some tasks and not others.
- Early project stages might be characterized by the involvement of high level managers, while later stages would mostly involve the operational levels.
- Users might be in charge of project teams and/or be participants.
- User involvement overall might not increase with time.

In addition, the implications or effects of various levels of user involvement may be unclear. This is because involvement may not always be tied to subsequent events, such as an accelerated development, expanding user involvement, or an improved design. Relationships like these must often be assumed in the factor literature.

Finally, time varying qualities are rarely of concern in the system design literature. These sources usually focus on specific design considerations or designs without reference to the needed development activities. It is difficult to assume the development requirements of a design unless the sources also include the background on how the results were obtained.

3.4.3.2 A Dynamic Perspective Needed

From a developer's perspective, it seems most useful to consider system development as a dynamic process (Eveland et al., 1977). Designs evolve from a process where there are changing objectives, alterations in the user organization and its environment, and changes in the development process itself (Arnovick and Gee, 1978, p. 371). The design and the organization will affect each other and cause changes in each other. Decisions about a design will be interrelated over time and affect each other (Eveland et al., 1977, p. 64). The systems literature provides pieces of this viewpoint, but it is rare to find them combined in one source.

One modest example of the dynamic nature of development is illustrated in an article by Alter and Ginzberg (1978). The authors view system development as a changing process where uncertainties and problems vary over time. These conditions add risk to the development at the stage in which they occur and can, if not resolved at this point, eventually threaten full implementation of the system.

Using the Kolb and Frohman model of development (see section 3.3.3.3 for a description), Alter and Ginzberg correlate risk factors with stages of the model. For example, they find two risk factors especially significant in the diagnosis stage. According to their model, diagnosis is the stage at which user and designer refine the information needs and establish the basic concepts of a design to meet them. Two factors, turnover and support for the system, are critical during this time. Turnover is critical because new participants at this point will likely cause changes in the agreements reached or cause the project to repeat earlier stages where initial work was performed. Similarly, lack of support for the system becomes critical at this stage since users and designers are attempting to specify more completely the design and move on to subsequent development. The authors suggest strategies which might be used to inhibit these problems in advance, or to compensate for them when they occur.

While this article has its limitations, particularly in the detail of the model and the lack of any supporting cases, it does illustrate the dynamic nature of development usually lacking in other sources. The authors emphasize the changing nature of a project and the need to change strategy. They attempt to pinpoint critical problems in a development and locate them along a time dimension. Development is characterized as a dynamic process which must involve dynamic strategies from system designers.

This dissertation attempts to include this time perspective in several ways so that the dynamic nature of development is more adequately represented. First, factors which can be used to measure and indicate the evolving process are designed. In addition, factors for measuring the concurrent aspects of system design and user commitment are also designed. By comparing process indicators to themselves over time and to design and commitment characteristics, the dynamics of process are demonstrated. Secondly, several actual cases are included to illustrate the factors. One set of cases is used to describe the factors (see Chapters 2 and 5), and one case is used to test the factors (see Chapters 6 and 7). These cases provide more detail on the difficulties and changing nature of developments than is usually found in the literature.

3.4.4 User Commitment During Development

A critical aspect of a system development is the process by which users decide to support, accept, and eventually fully implement a system. This process is not often well described or detailed in the various areas of systems literature. The developer interested in learning about the characteristics of the decision process will find it difficult to assimilate an overall view for use in his own situation.

This section reviews the perspectives on the user decision processes available in the literature and then describes an alternative model which developers can use. A note should be made about terms at this point so that the reader can understand the background to this section. The user actions or behaviors which are part of the process by which a system is accepted into an organization is described as user commitment in the following sections. Other terms could have also been used, such as adoption (Flaherty, 1980, p. 65), implementation (Weiss and Thompson, Note 8), use (Lucas, 1975a, pp. 910-913), acceptance, or even system "success" (Ein-Dor and Segev, 1978, p. 1065). These are all used in the literature and would appear to be almost interchangeable (Thompson, 1978b, p. 385). Commitment was selected however since it connoted more of a quality of process: it could evolve and build over time. It also emphasizes action: user actions which bind the organization to future use of the system.

Commitment is not an unknown term in the literature; many authors refer to it with the general meaning intended here (Alter and Ginzberg, 1978; Brown and Watson, 1977; Comptroller General, 1975, pp. 7-8, 16-18; Lucas, 1978b; Miller and Willer, 1977). However, the use of the term is often confusing; its true meaning must be implied from how literature sources use it in describing user behaviors. Many imply that commitment is a point decision, essentially the final decision to implement a system within the organization. Others use the term more broadly as a factor which is operational during all phases of development and at the final point where users must decide about full operation. The general meaning of the latter approach is the one which is of interest here. The following sections and chapters use the term in this sense and add more detail for its operationalization.

3.4.4.1 Commitment Perspectives in the Literature

An area which is poorly covered in the systems literature is that of how organizations decide to support and eventually accept a new system. Developers interested in this commitment process will often find limited detail beyond brief discussion of factors like the adoption or implementation of a system. For example, case studies of system developments often exclude details on the middle stages where the major design work is performed and user acceptance built (e.g., Fudge and Lodish (1977), see section 3.3.1.1). These cases instead concentrate on the initiation of the project and the resulting successful adoption. Case studies which include the intervening details on user commitment decisions are not very common. A modest example by Lucas and Plimpton (1972) demonstrates how users begin building their commitment to a system and how this is subsequently affected by later events (see section 3.3.1.2).

Other sectors of the literature provide differing, but similarly limited perspectives on user commitment. Development models specify stages and tasks for the different time periods of a project and generally include a decision point at the end of each stage. At these points, users are to acknowledge the accomplishments of the previous stage and set the directions for the next stage. This is a limited view of user commitment since it focuses entirely on managers and the few major decisions they make in a development. Other people and events are involved which both precede and succeed these decisions.

Factor studies in the literature often hint at user commitment actions missing from these models. For example, user commitment may be implied in such commonly discussed factors as top level management support, user involvement, user satisfaction or attitudes towards the system, or resource support to project teams. These factors may be relevant at any phase of a development.

It is more common however for factor study sources to discuss commitment type actions occurring at the end of a project. A distinctive, point in time, perspective may be taken, such as "the" decision to implement or adopt a system. Others discuss a more nebulous "use" or "success" factor. Both of these approaches are then treated as dependent variables which are influenced by independent variables occurring earlier in the development, such as user involvement or the degree of user training. These relationships create an unrealistic view of development in that causal linkages are established over great lengths of time. An expansion of this approach into other parts of development and with narrower portions of time would provide a more relevant model of interaction.

System design literature is perhaps the weakest sector for learning about user commitment. Most discussions leave the impression that only certain designs will achieve full commitment from users. Very little evidence is presented to demonstrate how the results were achieved, or that they were achieved over time.

Generally, few sources take the view that organizational decision-making on a new system is a process intertwined with other events in a development. This would appear to be a serious weakness in the literature since it is high ly unlikely that users decide to accept a new, complex system in one grand deliberation at the end of a development. A sequence of events leading to eventual full implementation seems more realistic.

Some literature sources support this view. One illustration is provided by Eveland et al. (1977) in their study of 53 system developments. The authors found that clear "adoption decisions" were missing from the development phases. Instead, there were sequences of decisions (either directly observable or implicit in actions), each further defining the system and usually becoming more narrow in scope over time. Others have also taken this perspective (e.g., Brown and Watson, 1977), emphasizing especially this sequence of broad to more detailed commitment decisions.

3.4.4.2 A More Comprehensive View of User Commitment

It seems most realistic in a complex development to consider user commitment to a system as a process which begins at the earliest stages of development and continues throughout the life of the system. The stages of the system life cycle concerning development should be characterized by an increasing user commitment which builds to a point where users are then ready to accept full responsibility for further support and operation of the system. This process is intertwined with the events of development. A cyclic interaction occurs: development events influence user commitment and user commitment influences development (Lucas, 1974a).

Two additional improvements to this approach are needed to make it comprehensive. First, the process should be considered as consisting of many different factors, direct or indirect. This recognizes that varying kinds of events can indicate user commitment, and not just the major decisions user management may make during development stages. It is also a recognition that commitment is still an elusive concept which is imperfectly represented by any number of specific user behaviors. Commitment should be represented by both direct actions, such as documentable use, and indirect actions, such as changes in the organization structure or functioning, which can be linked to system requirements.

Commitment should be further expanded to include user actions at the various different levels of the organization which are relevant in the development (Miller and Willer, 1977, p. 205). All of these have some relevance to an evolving user commitment and should be considered with more equal importance. For example, managers must devote resources to the system in order to support it, while operational levels must be willing to collect data to store for use in the system. Each of these would be a significant indicator for user commitment to a system.

The comprehensive view of commitment described here is used in this dissertation as part of a mechanism developers can use to monitor a project. User commitment is examined in several ways. First, a number of factors are identified which can be used to measure a range of user actions relating to commitment. Second, these factors are illustrated with examples from several retrospective case studies. Third, the factors also are used to explore commitment in a new case. By comparing user commitment factors to design and development factors, this new case helps to demonstrate the evolving nature of commitment and its interaction with other factors in system design or development processes.

3.4.5 Calls for Research in the Systems Literature

There are numerous research needs in the systems literature and they reflect both the breadth and depth of considerations potentially applicable in any system development. While many of them are relevant to this dissertation, several are particularly noteworthy since they relate to the general objectives and approaches of interest here. These are:

- The need for more research on the management of system developments.
- The need for mechanisms to help developers find and apply relevant systems literature.
- The need for more empirical evidence on the process of developing systems.

Each of these needs is discussed below. A final section summarizes how they have been included in the approach to the dissertation.

3.4.5.1 Research Needed on the Management of Developments

The major need in the literature seems to be to increase the amount of attention devoted to the management problems of system development. Some authors believe that the literature, particularly that related to behavioral, management, and computer sciences, has been concentrated mostly on the technical aspects of development (Kay, 1969; Lucas, 1974b; Lucas, 1975b). By this they mean that many sources only focus on the mechanics of design: developing technical specifications, building hardware or software, testing designs, developing training programs, etc. They see a need for more attention on coordinating the many people involved in a development, setting objectives, writing and revising project plans, or reviewing and controlling progress. Better management procedures in these areas is seen as improving the capability of developers to deal with the complex technical problems (Smith, 1972, p. 129).

While there appears to be some basis for these assertions, the problem may be overstated. Many of the factors commonly discussed in the literature already have either a direct or indirect relationship to these management concerns. For example, in a study on the management problems of information systems development, Sollenberger (1971) indicates that one major problem is the continuity of management. He concludes that continuity is a critical element for coordination, control, and vitality in a development project (Sollenberger, 1971, p. 11). Continuity is really another way of defining the problem of turnover that many other sources commonly recognize. Turnover is usually more closely associated with system users or owners, however, then it is with project managers.

In addition, some sectors of the literature are weaker on project management than others. Thus the perspective on the needs for more management research may be limited by a particular author's breadth of knowledge. This is easily demonstrated when comparing systems engineering or defense related systems literatures with others. Project management has long been a concern in these literatures and numerous techniques have arisen (e.g., Air Force Systems Command, 1966; Chestnut, 1967; Hill, 1970; Peck and Scherer, 1962; Peterson, 1980). Other models have also been developed in the public sector, such as for the A-109 policy on systems acquisition (Office of Federal Procurement Policy, 1976). All of these sources recognize the separate processes of design and the management of design.

Even a casual glance at the voluminous computer science literature related to information systems demonstrates the existence of many detailed models and ideas for the management and control of developments (e.g., Blumenthal, 1969; Davis, 1974; Hartman, Matthes, and Proeme, 1968; Jones and McLean, 1970; Murdick and Ross, 1971; Sollenberger, 1971). Some of the authors in this field may have also benefited from the lessons available in the defense systems literature (e.g., Smith, 1972).

Arguments about the lack of guidance and research on the management of system developments are not then completely justified. The problem can be better characterized by several other perspectives:

- Little recognition in some sectors of the literature of the complexities of managing large scale development projects.
- Little transfer of knowledge across the various sectors of the systems literature.
- Few methods or approaches to management in some sectors of the literature.

These problems appear to be especially acute in the management and behavioral science literatures. Some authors are beginning to recognize these gaps and are striving to generate new frameworks which developers can use to manage projects.

3.4.5.2 The Need for Management Frameworks

As demonstrated throughout this chapter, there are numerous considerations prospective system developers need to make in planning and implementing a development project. The systems literature is very broad and discussions on these considerations can be found in the many different sectors of the literature. Some authors, particularly in the behavioral and management science literatures, feel that practitioners who develop systems are having a difficult time making use of all the literature (e.g., Anderson and Narasimhan, 1979, pp. 512-513; Bostrom, 1978, p. 164; Lorsch, 1979). Some even believe that researchers are having problems organizing the extensive information already available and describing what is known (Bostrom, 1978, p. 164; Ein-Dor and Segev, 1978, p. 1064).

This has resulted in a number of new frameworks or calls for frameworks which in some manner can organize the important management problems of a development and offer the guidance already available in the literature. These frameworks cover a wide range of variables and in most cases they reflect the specific perspectives of the literature sector they are a part of. For example:

- Ein-Dor and Segev (1978) discuss user organization variables as they impact on the development of management information systems.
- Lucas (1975b) examines user behaviors and attitudes.
- Kay (1969) and Smith (1972) outline general project organizations.

- Alter and Ginzberg (1978) and Anderson and Narasimhan (1979) structure a framework of project implementation risk factors.
- Bostrom (1978) develops a metaframework to categorize many other frameworks from management and behavioral science literatures.

The basic theme behind these emerging structures is that each development situation is unique; project implementations must be tailored to meet these circumstances (Williams, Note 9). System developers need ways to diagnose the problems in their specific cases and locate guidance to help solve them (Lorsch, 1979; Williams, Note 9). This is especially the case for large scale complex system developments where on-going methods to meet evolving circumstances are needed (Alter and Ginzberg, 1978; Jones and McLean, 1970, p. 7; Kay, 1969, pp. 425-426).

Existing frameworks have begun to fulfill this need, but more comprehensive approaches must still be attempted. The models and techniques of development available elsewhere for large hardware or software projects offer guidance on project management that remains isolated from the perspectives of the behavioral and management science literatures. Future frameworks need to combine the various approaches and make them all accessible to prospective system developers.

3.4.5.3 A Need for Empirical Evidence

In addition to frameworks for guiding managers of developments, there is also a need for more empirical work to demonstrate how management problems are handled in actual situations (Lucas, 1976; Williams, Note 9). Management methods and ideas are rarely followed by evidence from real developments which identifies why these methods are important or what happens when they are used. For example, Kraemer and King (1978) find these problems in their study of urban information systems programs initiated by the Federal government:

- Failure to provide for learning from the past and integration of these lessons.
- Little transfer of knowledge between applications.
- No documentation useful to other managers.

Part of the problem is that research on system developments is difficult to perform. It is rarely, if ever, possible to conduct structured experiments with developments where various factors, such as different management techniques, can be tested or compared (Brown and Watson, 1977; Resnikoff, 1979). System projects can be large and uncontrollable; system developers may not be able to integrate a research approach into their projects. A related part of the problem may be that system developers have little incentive to document their experiences for others.

However, real applications are the only source for empirical evidence that others need. The best alternative for providing the evidence would be to develop a research structure prior to the implementation of a development so that the important aspects of management could be documented as they occur. Generally, this kind of research is difficult to locate. Case studies of actual projects are usually retrospective in nature and focus on many other issues besides project management. In addition, there are not that many case studies available. Nevertheless, these studies are valuable since they provide one of the few sources where readers can observe the inner workings of a project. Until researchers can become a part of the planning and execution of system developments, these retrospective investigations are the best source for empirical evidence on management methods and more need to be undertaken.

3.4.5.4 An Approach to Meeting These Needs

The approach used in this dissertation has been structured partially in response to these research needs. First, a specific facet of project management, monitoring progress, has been selected as the central problem of this research. The main idea has been to develop a procedure which can help developers gauge progress in the project, identify important problems early, and enable managers to revise strategy in light of evolving circumstances. Second, the factors selected for use in the monitoring framework have been identified and examined across a broad range of the systems literature. It is hoped that this coverage can demonstrate the range of knowledge already available and the applicability of the different perspectives to common, recurring management problems. Finally, a number of case studies are used to support the development and testing of the framework. These cases are intended to provide evidence of management problems at a level not commonly found in available systems literature.

3.4.6 Summary and Conclusion

The previous sections have identified key development problems and major research needs found in the systems development literature. Three major problems have been discussed. The first of these is the problem of obtaining a comprehensive view of the many considerations potentially applicable in a system development. The literature is segmented in certain ways which often lead to a high degree of specialization in the presentations. For example, literature sources can be divided by the range of variables considered in specific sources or by the specific systems (hardware or software) of interest. A more comprehensive approach is needed which interrelates the major concerns in the various sectors.

A second problem with the development literature is the lack of sources which demonstrate the time varying qualities of a complex systems project. Many sources concentrate on specific factors important in a development without identifying how they are affected over time by evolving circumstances and other factors. Models for system development often leave the impression of a step-by-step sequence to development which misrepresents the commonly occurring delays, recycling, and parallel nature of development activities. A more dynamic perspective is needed which relates development factors to a time dimension and demonstrates the changing, intertwined events and problems of a systems project.

A third problem with the literature is the lack of sources which describe the process by which users decide to support, accept, and eventually fully implement a system. This process, defined as user commitment in this dissertation, is intertwined with the activities of development and evolves over time. Many sources identify commitment as an end event of a project which is influenced by earlier factors such as user involvement or problem identification. Other sources which outline models for system development identify only a few major decisions in each stage where users are able to acknowledge progress and plan for follow-on strategy. A more comprehensive view of commitment needs to be integrated with these perspectives. This view should recognize the direct and indirect indicators of evolving acceptance and the user behaviors which occur at different organizational levels.

A final section reviewed some of the major research needs which are specifically identified in the literature. Three major needs were discussed. First, more research is needed on the management of system developments. Some authors believe that the literature has been concentrated too heavily on the technical aspects of design while avoiding the management problems relating to the coordination and control of development activities. This seems only partially accurate however, since some sectors of the literature devote more attention to management than others. The problem is better characterized by three perspectives: the lack of recognition in some sectors of the management complexities of development, the lack of transfer of knowledge between the various sectors, and the lack of methods or approaches in some sectors of the literature.

A second need is for frameworks which outline the management issues in development and provide guidance to practitioners based on the already existing, voluminous discussions available in the systems literature. This need is most recognized in the behavioral and management science literatures which are slowly beginning to identify the problems associated with the management of developments. These sources are finding that each development situation is unique and that developers need ways to diagnose the problems of their specific cases and locate guidance to help solve them. Existing frameworks in these sectors tend to focus on the specific aspects of their tradition, such as the behavioral science focus on user behavior and attitudes. More frameworks are needed which combine these perspectives with the experiences and lessons of other literature sectors that have devoted more attention to project management issues.

A final research need identified in the literature is the need for more empirical work which demonstrates how management problems are handled in actual situations. Sources presenting important factors or models for managing developments are not often complemented by others which attempt to operationalize these concepts and study their implementation throughout a project. Part of the problem arises from the difficulty of structuring research experiments to study these factors. Part of the problem may also be the lack of incentive developers have to report on their actual experiences. Real applications are the only feasible source to study management issues, however, and until research objectives are integrated with on-going occurring system developments, more attention is needed on documenting and studying development cases in a retrospective mode.

Finally, the approaches used in the dissertation in response to these problems and needs have been outlined in each section. The goal of the dissertation is to develop and test a framework developers can use to monitor system developments. The framework attempts to provide a comprehensive view of the many considerations important in a development and is based on the wide ranging perspectives and experiences available in the literature. It attempts to recognize the dynamic, changing nature of development by providing an on-going means for developers to identify problems and revise strategy in a structured manner. The need for more regular and routine attention to user commitment and its interrelationship to design and strategy has also been included as part of the monitoring framework design. It is hoped that the development and testing of the framework provides a basis for more research on the management of developments and offers an approach to the accumulation of empirical evidence that can be used to illustrate developments to others and organize further research in the systems literature.

3.5 CONCLUSION

This chapter has reviewed the systems literature for perspectives and problems related to system development. Four main perspectives towards development have been identified: case studies of system developments, important factors in system development, models for system development, and system designs. Each area has been briefly described and specific examples selected to illustrate the kind of material currently available.

The second half of the chapter has reviewed key development problems and research needs found in the systems literature. Three major development problems have been identified after reviewing the literature: the lack of comprehensive view of development that integrates the various considerations potentially applicable in a systems project, the need for a more dynamic perspective of the evolving, changing nature of development, and the need for a more comprehensive view of the process by which users decide to support, accept, and eventually implement a system. In addition, three major research needs have been identified by sources in the literature: the need for more research on the management of system development projects, the need for frameworks which can help developers diagnose the management problems of their projects and find the guidance available in the literature, and the need for more empirical evidence which demonstrates how management techniques are used in actual situations.

Some sections and paragraphs have been included in the problem identification areas that reference the objectives and approaches used in this dissertation. The purpose of including these references has been to establish the linkages between the dissertation research and already existing materials in the literature. Readers can follow the continuing development of these linkages by examining the next chapters on the research design and the monitoring framework design.

The next two chapters describe the objectives, approach, and the major outcome of the dissertation. Chapter 4 outlines how the research came about and what specifically was done during the research. Chapter 5 describes a framework for monitoring system development that is the primary result of the research. Both chapters reference the materials in Chapter 3 for additional background support.

CHAPTER 4

RESEARCH DESIGN

4.1 INTRODUCTION

As described earlier in Chapter 1, there were two main objectives for the research described in this dissertation. These were to:

1. Develop a framework for monitoring system developments that would provide a basis for assessing and revising strategy, and to
2. Explore the usefulness of the framework as a management tool in actual system projects.

Most generally, the research approach used to accomplish these objectives has been exploratory -- there was significant uncertainty as to methods, data, and results. As a result, the overall research design of the dissertation has evolved slowly over time as more was learned about the management problems of system development and about areas where a research contribution could be made.

This chapter summarizes the overall research design which has resulted from the exploratory approach. There are two main sections, one for each research objective. First, the development of the monitoring framework is described. This process is divided into several sections, which trace the research from the initial idea to construct a model of system development through to the resulting design of a monitoring framework. An overview of the framework and its functions is provided in this chapter while more detailed discussions of these results are presented separately in Chapter 5.

The second half of the chapter describes the efforts taken to apply the framework to actual system development cases and demonstrate its usefulness in project management. First, the initial effort to apply the framework to on-going ETIP projects is described, followed by a discussion of the change to a retrospective approach. The design of the retrospective application is then described in detail. The results of the application are presented in Chapter 6.

4.2 DEVELOPMENT OF THE MONITORING FRAMEWORK

The monitoring framework described in this dissertation is the result of a lengthy study of systems literature, ETIP system projects, and ETIP project management problems. The main ideas for the framework evolved slowly from the interaction of these areas and there were numerous revisions of the monitoring problem.

This section describes the research process behind framework development. An attempt has been made to present the process as it occurred, starting with the early ideas and ending with the monitoring framework. However, the narrative has been divided into several sections in order to provide a better focus on the general direction of activities during a given period.

The first two sections describe the initial perspective on the monitoring problem and the search for an ideal model of system development that ETIP managers could use as a guide for project strategy.

The next two sections then describe how the research problem changed to the development of a framework which managers could use to monitor the key areas of an evolving system project. The refinement of factors from the initial modeling effort is also described.

The fifth section reviews some of the literature that was consulted during revision of the research problem. Perspectives in the literature on the use of monitoring in system projects are described.

The sixth section presents an overview of the resulting monitoring framework. First, the three main categories of monitoring factors are briefly described. A discussion then follows on the five functions the framework can have in project management and research. A flow diagram is included to show how the framework can be implemented in a system project.

The seventh section provides a brief guide to the dissertation chapters which resulted from the backgrounding and development effort.

4.2.1 Identifying the Problem Area

The ideas for the dissertation began during a new system development undertaken by ETIP with several of its partner agencies. The purpose of the project was to develop an evaluation system that agencies could use to evaluate a series of experiments to be conducted with their policies or procedures. The project was to take three years, after which a turnkey system would be institutionalized within the agencies. Two contractors were hired by ETIP to help conduct the development work. (This project was the original target for the monitoring framework. The test application of the framework to this case is outlined in section 4.3 and fully reported in Chapters 6 and 7).

The development had been underway for a number of months when ETIP managers (the author was part of the management team) began to see a need for a way to improve the control and direction of the project. The type of system being developed was new for ETIP and a number of complex problems were arising for managers:

- ETIP was an outside third party to the development, primarily responsible for funding the project and managing the contractors. The contractors conducted the majority of development work and the ultimate users were agencies not related to ETIP.

- Working relationships had to be established among the two contractors, ETIP, and several agencies. The development depended on a close relationship between the contractors and the agencies. While this relationship had to be independent from ETIP, ETIP still had to manage the contractor's work.

- The design and ultimate home for the system were uncertain in the beginning, creating a level of uncertainty which had to be managed carefully in both the partner agencies and the contractors.

- Numerous short term, start-up, problems were arising as the working relationships developed. The partner agencies were anxious for early results and the contractors were searching for more specific definition of the products they were responsible for developing.

- Attention to short term problems was distracting project managers from developing longer range strategy. Managers needed a way to anticipate more of these problems and avoid a lengthy series of high pressure, short term problem solving episodes.

- ETIP had difficulty relating on-going problems and progress to overall strategy and making needed revisions in the strategy.

Initially, the general problem was considered to be one of strategy: how to run the project to assure eventual success. A model for strategy was needed to:

- Help identify in advance the typical problems that should be expected.

- Determine if the project was on course.

- Tie together short and long term perspectives during problem solving.

A study was initiated by the writer to identify the strategy guidance available in other similar ETIP projects. ETIP had already conducted a number of system developments with other agency partners, although these were not quite the same kind of system or necessarily of the same magnitude as the proposed evaluation system. Several of these cases were selected for in-depth study with the main idea of identifying the development approach of the project and tying the approach to the degree of success of the system. Factors inhibiting or facilitating the project were noted and attempts were made to trace the factors over time and determine their relevance in different project stages. It was expected that the variation in approach and success across the selected cases would ultimately provide ETIP managers with a model of development they could use for the new evaluation system.

While a number of important factors concerning the development process were identified in these initial studies, the case study approach eventually proved to be unsatisfactory. Tracing variables over time required more information about the projects than was usually available. It was difficult to reconstruct project events so that the interaction of problems, strategy, and success could be identified and used to produce a model. Also, it appeared that the level of guidance available from the few selected projects might be more limited than had been originally expected. This prompted a search of the systems literature for additional ideas.

4.2.2 Reviewing the Literature and Selecting Important Development Factors

A search of the systems literature was initiated after the ETIP case studies in order to identify additional guidance for the desired model of system development. Since the case studies had produced a number of important factors that managers should consider in a development, it was decided to continue the factor approach. Lists of factors were started in two areas, one for factors relating to the development process and one for factors relating to project success. It was expected that the expanded search would provide enough factors to then synthesize the strategy model ETIP managers desired.

A broad review of the literature ensued as it became obvious that a great amount of material was available from numerous perspectives and disciplines. Much emphasis was initially placed on the behavioral and management science literatures as these were of primary interest and familiarity to the writer. Later, the similarity of problems and ideas from different types of sources demonstrated that it would be useful to include literature from a range of backgrounds and systems. Thus the search was expanded to areas like systems engineering, weapon system acquisition, operations research, computer system development, and other miscellaneous hardware and software system literatures. These areas were scanned and probed briefly; an in-depth search of each area was considered unnecessary since the primary objective was to identify factors, not cover the literature (Frederick, Note 1).

Several guidelines were used to select factors for the development model as the literature was examined. The first guideline was to select factors which appeared relevant to the ETIP management and project environment, especially factors not previously identified through the ETIP case studies. The needs of the new evaluation system project were also a consideration under this guideline. Some important factors were already evident in the project as the dissertation started and the literature reinforced the need to include them in the model. Other factors were drawn from the procedure used to procure contractor support for the project. The parametric factor evaluation (PFE) procedure developed by Thompson (1976) for the procurement (later studied by Libman, 1980) contained a range of factors which were used to evaluate contractor proposals. Some of these were found to be useful indicators for on-going monitoring as well (Thompson, Libman, and Garrity, Note 2). For example, one key factor was the importance of the project to the bidder. Companies receiving a high score on this factor were considered to have a vital interest in the project, particularly in relation to their company's objectives and top level management support. This factor was considered equally important during the project; companies maintaining a vital interest in the project would likely continue to exhibit top level management support. Continuing contractor interest was one factor essential to project success, and thus it was included as an indicator to be monitored.

A second guideline was to select factors found to be common or important in the literature. For example, since user involvement was a factor most everyone considered important, it was included in the factor list for development process. However, factors did not necessarily have to be widely recognized across literature sources in order to be listed. For example, project management issues were considered important in defense related literature but rarely recognized elsewhere. They were also included in the model. Generally, it was found that literature sources could be very selective in the issues they emphasized, further supporting the need to review a broad range of literature. This selectivity also highlighted a number of gaps in the literature which were of importance to the model development. These gaps had an influence on the dissertation by indicating areas were a research contribution was needed (see section 3.4 for more discussion).

A final guideline in factor selection was the interest of the writer. In some instances, this involved noting factors not widely discussed in the literature, as described above. In other areas, factors were avoided which seemed to be tangential to the monitoring model being developed. For example, numerous models for defining decisionmaker needs were found (e.g., Taggert and Tharp, Note 3) as essential components to the development of an information system. Some of the essential characteristics of models like these were important to the monitoring model being developed for ETIP, such as the need to have users involved early in the definition of the information problem. However, the numerous intricacies of the problem definition models were considered beyond the detail required for the monitoring model. Other examples of uninteresting factors were organizational characteristics, such as organization size, budget, or decisionmaking structure, which were commonly used as key factors in system adoption studies. These factors appeared to fall outside the themes of development process and project success that were guiding the development of the strategy model.

It should also be noted that the lists being developed did not equally reflect all of the literature sectors. Sources in the defense related systems literature and in private companies developing major systems were not covered to the extent really needed. This was partially due to the initial focus on behavioral and management science literatures most familiar to the writer. Later, the literature search was curtailed to avoid going beyond the scope of the dissertation effort. Additional research covering the experiences in private companies and defense systems would have been useful, but had to be deferred until after completion of the dissertation.

4.2.3 Redefinition of the Monitoring Problem

A long list of variables, theories, and ideas on system development emerged from the literature review. Approximately 70 items were listed under the two categories of development process and project success. The wider range of items in these lists compared to those first obtained from the ETIP cases justified the long effort that had gone into searching the literature.

It was difficult, however, to assemble all of the items into a model usable by ETIP managers in the newer, on-going evaluation system development. Several problems were arising as the lists were reviewed and refined for the model:

- No one model for development was uncovered in the literature or emerging from analysis of the lists that seemed readily applicable to the ETIP situation.
- Many items overlapped each other, requiring detailed examination to determine which items were more encompassing in meaning.
- Items ranged in content from a linked set of factors to only one important factor. Synthesizing a model required refining these items into a form where they could be compared or combined (see following section 4.2.4).
- Many of the factors listed under the development process category were found to be more focused on technical design problems than on the operation of a project.
- Some factors were found to be very situation specific, making it difficult to place them in a general model for strategy.

In addition, it had been difficult to find sources which recognized the characteristics and problems of large scale projects of the kind undertaken by ETIP. Few sources discussed the strategy aspects of a project where significant, on-going change and uncertainty were components managers routinely had to face. Also missing were the comprehensive views of development which specified the broad range of factors managers might have to consider in devising a project strategy. Thus, models for strategy that ETIP could use were hard to find and difficult to create; available models appeared to be lacking in one aspect or another.

It was at this point that comparison of the lists with ETIP management needs began to show that a different kind of monitoring structure was needed. Initially, the structure had been expected to characterize a model for development, i.e., a strategy to guide ETIP managers in the conduct of the new evaluation system project. Based on strategies found to be successful in other projects, this model would have provided a basis for monitoring project activities and determining if the project was on course.

However, the real underlying problem facing ETIP managers was one of information, not strategy. ETIP managers needed better information about project activities to identify when and where problems were occurring and whether elements of their strategy needed revision. The structure for monitoring in this case had to focus attention on key project areas, areas likely to be sources of recurring problems and/or critical to overall project success. For example,the monitoring structure needed to contain a factor such as the structure of project tasks, advocating the need for ETIP managers to review the sequence and priority of tasks as the project unfolded. Included with the factor would be criteria for identifying task structure problems and guidance on what considerations were needed to make changes in tasks. A monitoring structure or framework of factors like this would be oriented more toward measuring performance than specifying an approach that had to be followed by project managers.

Definition of the monitoring problem in this form caused several changes in the background work and the design of the monitoring structure. First, the monitoring structure was renamed as a framework to better represent the concept of monitoring a project on selected factors, rather than implying a model for project strategy. Second, much of the material collected in the factor lists had to be refined to identify the key, underlying elements implied in the items (discussed further in the next section). Third, a category for design characteristics was added to the framework, recognizing the importance of design related factors in the success of system developments. The monitoring framework was thus designed to contain three categories of factors:

- Process characteristics.
  Factors specifying methods, organization, personnel, and procedures that are essential elements of management and control in a project.

- Design characteristics.
  Factors specifying the design and functioning of the evolving system that are key sources of technical problems during a development.

- User commitment characteristics.
  Factors specifying user actions related to the support and acceptance of the system; early indicators of success in institutionalizing the system in the user organization.

4.2.4 Refining the Framework Factors

One of the problems with identifying important factors for system development was that many items listed in the initial search were very general in scope or implied a number of underlying factors. This made it difficult to combine these items into a strategy model as originally intended; later, they were found to be too general for the redefined monitoring framework where more basic project elements were needed.[1]

Multi-factored items were most prominent in the list of development process factors where numerous models or strategies for development had been accumulated. A simple example of one of these models was the commonly discussed evolutionary strategy to system development (Davis, 1974, pp. 405-409; Lucas, 1978b; Mohan and Bean, 1979). Evolutionary in this usage meant the use of small, incremental steps in the process of designing the system: working on small pieces of the problem, developing subsystems individually and in series, changing over to a new system slowly, and minimizing the disruption to the user organization. This strategy was supposed to assure project success by keeping change small and achieving a series of modest successes.

Initially, it had been expected that items like this would be used to formulate a model strategy well suited to the ETIP situation. Thus

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[1] An initial test of the framework on the ETIP evaluation project at this point also demonstrated problems with the factors. See section 4.3.3.

elements of the evolutionary strategy would have been combined with other factors to produce a new model, similar in content to the stages and activities implied by models like the evolutionary strategy. However, revision of the monitoring problem required that these models be further decomposed into their basic elements. These elements had to identify key areas for monitoring the performance of strategy, rather than specifying the strategy required. An example of another model illustrates what had to be done for this approach.

In an article by Mumford et al. (1978), several models were found for the design of data processing systems. One model, outlined in Figure 4.1, described a small chain of events that characterized what some authors considered as the conventional, technical approach to system design. The model showed how a design group which is oriented more toward the technical aspects of a development can lead to a system which produces high user anxiety and dissatisfaction. Essentially, the authors were implying a number of factors about system development that could be divided into design, process, and user commitment categories. These were:

- The need to have a design team balanced with technical and human engineering skills (process characteristic).
- The need for user involvement in design activities (process characteristic).
- The need to have the design match the user environment (design characteristic).
- User actions indicating decreasing acceptance of the system, such as sabotage, non-use, or the lack of champions to defend it (user commitment characteristics).

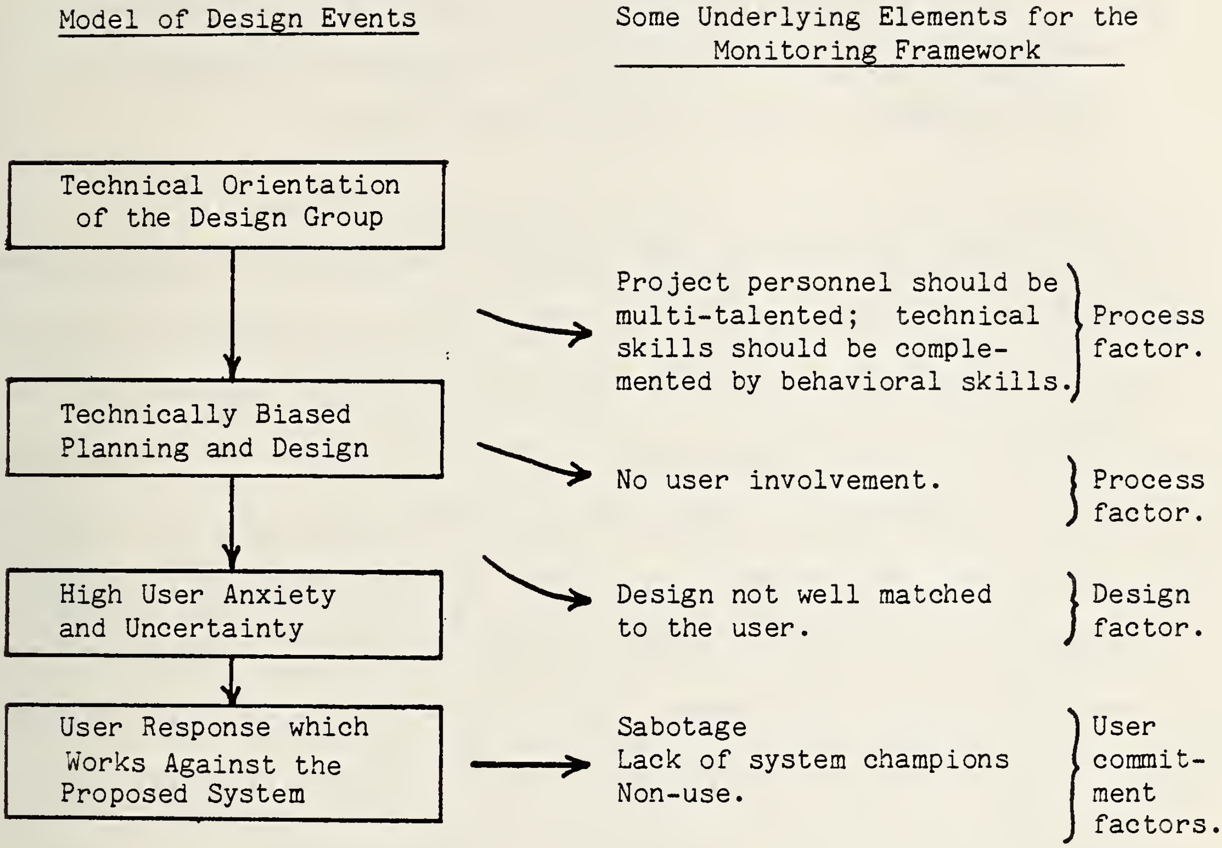

FIGURE 4.1 DECOMPOSITION OF A DEVELOPMENT MODEL [2]

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[2] Adapted frcm Mumford et al. (1978).

These were the kind of elements that the monitoring framework needed. Each model in the factor list had to be examined in the same way to identify the common core set of factors they implied.

Similar analysis was also needed for many of the items which specified only one factor. This was usually due to the general level at which the item was written, often lacking any operational implications. For example, user involvement was one factor often identified in the literature as essential to project success. However, few sources illustrated the concept with actions for different project activities or stages. Since users could have a number of different roles in the management and support of a development, these actions had to be thought through to establish what should be used to indicate user involvement. User involvement also had to be linked with other factors in the design, process, and user commitment categories so that the effects of involvement could be also monitored elsewhere.

4.2.5 Monitoring As Seen in the Literature

Redefinition of the monitoring problem made it necessary to return to the systems literature to identify how the problem was already discussed. As noted earlier, few sources seemed to capture the complex development situation ETIP faced; thus it was expected that locating relevant sources with the needed view of the monitoring problem would be difficult. However, the idea of monitoring a system development on key factors to help identify problems and revise development strategy was not examined in sources during the first literature search.

It was found that the general idea of monitoring a development was recognized in a number of different sources (e.g., Alter and Ginzberg, 1978; Anderson and Narasimhan, 1979; Comptroller General, 1975, 1978; Gordon, 1980; Keen and Morton, 1978, p. 204; Lucas, 1974b; Waller et al., 1976). Some of these sources presented a limited view of monitoring, such as simply to periodically compare project status with original plans (Comptroller General, 1978, p. 8; Lucas, 1974b, p. 136). Others considered a more active, evolving role for monitoring, seeing it as essential to ensuring project success (Alter and Ginzberg, 1978; Anderson and Narasimhan, 1979, p. 513; Keen and Morton, 1978, p. 208). These sources recognized that initial planning was important and could act as benchmark for gauging later progress. However, they saw monitoring as more than a simple before and after comparison:

- Active monitoring could provide early visibility to problems and timely action to their solution (Gordon, 1980, p. 32; Smith, 1972, pp. 129, 135; Waller et al., 1976, p. 9).

- Monitoring could provide a means of collecting project information to routinely keep developers informed of progress (Smith, 1972, p. 131).

- Monitoring could be used to guide revisions of strategy on a continuous basis (Alter and Ginzberg, 1978; Anderson and Narasimhan, 1979, p. 513).

- Monitoring could provide a means to better manage the problems of isolation (between managers, developers, and users), uncertainty (in project design, system design), and volatility (instability of design, environment, or personnel) (Ibrahim, 1978, pp. 34-36).

- Monitoring could be used to audit and evaluate a project implementation (Keen and Morton, 1978, p. 204).

These views tended to correspond more to the concepts of monitoring that were evolving in the dissertation.

Other views of monitoring were also identified from the researchers interested in the process of developing systems. Several researchers described a need for better organization of the literature so as to provide a means for busy practitioners to access the guidance in the literature (Anderson and Narasimhan, 1979, p. 513; Bostrom, 1978, p. 164). One approach suggested was to develop frameworks of important development factors which practitioners could use to identify problems in their projects and then locate relevant literature sources (see also section 3.4.5). While these proposed frameworks were usually less comprehensive in scope than desired in the dissertation, they did approach the idea of a structure of key factors which developers could use to examine their own situation on a regular basis.

Other sources described a need for more research on the management of system developments, particularly emphasizing the need for more empirical evidence on the development process (Lucas, 1976; Williams, Note 4). While these discussions did not explicitly mention monitoring, they did highlight the idea that monitoring might have a research role. Besides meeting the administrative needs of project managers, monitoring might also provide a means for researchers to collect data on developments in a structured, real-time manner. Researchers could thus join with administrators and use the framework as a channel through which they could explore or test concepts of benefit to the literature.

Beyond suggesting the administrative and research benefits monitoring might provide, the literature was fairly lacking in structures that might actually be used for monitoring. A comprehensive approach of the kind needed by ETIP, including design, process, and user commitment characteristics, was not available. Moreover, few sources really recognized the kind of elements a monitoring framework should contain. These gaps further supported the research underway in the dissertation.

4.2.6 The Resulting Monitoring Framework

The lengthy background studies finally resulted in a framework of 30 factors for monitoring system development along with some procedures for how the framework could be used.

The following sections briefly describe these results. First, an overview of the monitoring factors is presented. Then the five functions of the framework are outlined. Further details on the factors and functions are presented in Chapter 5.

4.2.6.1 Monitoring Framework Factors

Thirty factors important in monitoring system developments have been identified in the background studies (see Figure 4.2). The factors

DESIGN CHARACTERISTICS	PROCESS CHARACTERISTICS	USER COMMITMENT CHARACTERISTICS
• OPERATION AND PERFORMANCE FACTORS 1. Response Time 2. Quality 3. Cost of Operation 4. Input/Output Operations 5. Interconnection of Subsystems	• TASK STRUCTURE FACTORS 13. Task Size 14. Task Priorities	• SYSTEM USE FACTORS 25. Applications 26. Consequent Actions 27. Extent of Use
• BOUNDARY FACTORS 6. Capabilities/Limitations/ Expectations 7. User Groups and Their Interrelationships 8. Interfaces with Other Systems and Organizations	• TEAM PERSONNEL FACTORS 15. Skills 16. Turnover 17. Commitment	• SYSTEM SUPPORT FACTORS 28. System Champions 29. Resource Commitments 30. Changes in the User Organization
• ADAPTATION FACTORS 9. Flexible Specifications 10. Matching the System to the User 11. Novelty of the Design 12. Evaluation and Updating	• PROJECT CONTROL FACTORS 18. Organization and Responsibilities 19. Decision Points and Milestones 20. Reports and Reviews	
	• INTERACTION WITH THE USER ENVIRONMENT FACTORS 21. User Involvement 22. Problem Identification 23. Testing 24. Transfer	

FIGURE 4.2 THE MONITORING FRAMEWORK

are divided into three main categories as discussed earlier: design, process, and user commitment characteristics. Several subcategories have also been established.

Design characteristics are factors that developers can use to monitor what a system looks like and how it will operate. Numerous literature sources and ETIP experiences demonstrate that design problems can seriously affect development progress and thus should be a part of a system managers use to monitor a project. Common problem areas in design are factors such as response time or quality of output. Others areas less commonly recognized relate to system boundaries or the adaptation of the design to the user organization. Developers need to identify both problems and progress in these areas to determine if project strategy is working, if the evolving design is sound, and if the design is likely to gain user support.

Process characteristics are factors that developers can use to monitor the means by which the system is developed. Factors related to the development process are perhaps the most numerous in the literature; the well recognized need for user involvement is one example. Other important issues concern project management, such as staffing, reporting, or defining priorities. Developers need to monitor these characteristics to determine if they are matched to the needs of the evolving design and are ensuring the appropriate level of user involvement and support.

User commitment characteristics are factors that developers can use to monitor actions related to support for the evolving system. This support is seen as evolving over time. There are both direct and indirect events which can be associated with user interest and acceptance of the system design during each project stage. Developers need to monitor these actions to determine if support is increasing or decreasing, and whether changes in the design or the development process are needed given either of these conditions.

It should also be noted here that while the framework is intended to be comprehensive (in that an attempt has been made to include the major factors developers should consider), revisions and additions may be necessary and are expected. It is likely that gaps still remain in the framework elements and that there are alternative structures which might be an improvement for each of three main categories. The need for continuing revisions results from several circumstances:

- This is the initial attempt by the writer to define a comprehensive framework.
- The original intent was to identify as many important factors as possible. However, it was not expected that the framework would necessarily be completed within the limitations of the dissertation.
- The framework is oriented towards the information system developments at ETIP; other situations and systems may require revisions.
- Some literature sectors (especially the defense literature) have not been covered to the extent needed. Better approaches may be uncovered.
- Further revisions were expected during the test of the framework on the new ETIP evaluation system development (see Chapters 6 and 7).

Framework development is thus at an interim stage and changes are likely. Readers may find the current framework most helpful as a guideline to be applied, with revisions, to their own specific cases.

4.2.6.2 Using the Monitoring Framework

Overall, monitoring, as developed in this research, means both the collection (on selected factors) and the use (for selected purposes) of information on events associated with the project (Waller et al., 1976, p. 5). As discovered during the background studies, monitoring can potentially have two basic roles -- one administrative and the other for research. For administrators, a monitoring program using the framework can provide a means for better management control of a systems project. For researchers, the framework can also provide a means to conduct structured investigations of system development projects. These two purposes are seen as complementary. Research with the framework can provide a basis to support and evaluate management actions; management use of the framework can provide a test arena for research (Thompson and Rath, 1974).

Within this dual purpose context, the framework has been accompanied by a set of five functions, all of which overlap and support each other. These functions include problem identification, strategy development, research, documentation, and dissemination. Briefly, these functions are described as follows:

- Problem identification -- The tracking and assessment of key areas where development problems typically occur, both in the short and long range.

- Strategy development -- The identification and formulation of explicit management actions aimed at solving problems and revising strategy.
- Research -- The design and implementation of real-time studies of the development process.
- Documentation -- The implementation of an organized and stable recording process which can identify special or recurring problems, support decisionmaking, and research.
- Dissemination -- The distribution of key development information to those inside and outside the project.

The use of these functions in a system development project is modeled in Chapter 5.

4.2.7 A Guide to Chapters on Framework Development

Several chapters have been written to document the studies and results of the framework development effort. Chapter 2 describes the three ETIP projects used to initially define the monitoring problem and later to provide illustrations of framework elements. Chapter 2 briefly describes the history of each project and reviews some of the important development factors uncovered in each case. Besides helping to illustrate parts of the monitoring framework, these case studies may help familiarize the reader with the ETIP environment and the systems projects.

Chapter 3 reviews the literature used to help refine the monitoring problem and identify more factors for the framework. The chapter is divided into two main parts. First, the literature covered in backgrounding is generally described and some comments are provided comparing the different sources found. Several sources are selected to illustrate different sectors of the literature, and some of these are later used to support the descriptions of framework factors in Chapter 5. The second half of Chapter 3 describes several gaps in the literature which have influenced framework development. Included in this discussion is a brief review of calls for research that can be found in the systems literature.

Finally, Chapter 5 presents the monitoring framework and functions which have resulted from the background studies. The chapter is divided into two main parts. First, the framework factors are presented. Each of the 30 factors is briefly defined, discussed in more detail, and then, in most cases, illustrated with examples from some or all of the ETIP cases discussed in Chapter 2. The second portion of the chapter presents the five functions the framework can serve in a development. A general model of how these functions might be implemented in a project is also provided.

4.3 EXPLORING THE USEFULNESS OF THE FRAMEWORK

4.3.1. Introduction

The second objective of the dissertation research was to explore the usefulness of the monitoring framework in actual system development projects. This was to be accomplished through the application of the framework to several on-going development cases in ETIP and evaluation of the framework in helping to identify and solve project management problems. However, the lengthy development period for the framework altered the plans for these applications. Eventually, only one retrospective application was conducted.

The next several sections summarize the initial attempts to apply the framework in real-time and then describe in detail the design of one retrospective case ultimately conducted.

4.3.2 Application to On-Going System Developments

As described above in the framework development presentation (section 4.2), the research project began during the development of an evaluation system in ETIP that involved the writer. The idea at the time was to develop a model of system development that would prescribe an idealized approach or strategy based on the experiences in other ETIP projects and the systems literature. After developing the model, it was to be tested on several ETIP projects underway during the period, including the evaluation system project. The different projects were expected to provide a range of different conditions for testing the model.

However, the form of the model changed considerably as further study was made of the problem. Analysis of several completed ETIP projects, the literature, and the on-going activities of the evaluation system project showed that project managers really needed a means for monitoring key problem areas as the project unfolded, rather than a model that specified a strategy. This realization significantly changed the direction of the research underway at the time and further delayed any applications to the existing ETIP projects.

Eventually, the development of the monitoring framework exceeded the duration of the evaluation system project and precluded making a real-time test. Consideration then began on the possibility of conducting a retrospective application of the framework to the same project. Other additional applications to ETIP projects were also terminated at this point since it appeared that the amount of effort required to include them exceeded the bounds of the dissertation.

4.3.3 An Initial Retrospective Test

Initially, it was unclear how to conduct the framework application in the retrospective approach. The framework at that time simply consisted of a list of factors important for monitoring and the voluminous, unorganized records for the evaluation system project. It was uncertain what set of events was needed for the application and how events could be used to demonstrate the utility of the framework.

It was decided to examine the first six months of the project and to identify events that related to framework factors. This period was selected because of the writer's familiarity with it and the availability of extensive records. The approach was to identify events in the various sources and then classify them under the relevant framework factors. For example, events which related to reports and reviews were listed chronologically under that factor. This was expected to show that the framework could be mapped onto the project, and specifically, that:

- Elements of the framework were relevant to the system development case.
- Events often involved or related to a number of different framework elements.
- Elements of the framework could be traced over time and that the relationships between elements could change over time.

Documentation of these points was expected to demonstrate that the framework could be useful in monitoring and managing the complex problems often present in system developments.

Several months of the project were examined using this approach, but the application ultimately proved to be premature. It was found that the initial state of the framework was simply too undefined to result in a consistent classification of project events. For example, some elements of the framework overlapped considerably, making it unclear where a particular event should be listed. It was also found that some events were not easily classified under any of the elements. While these problems were expected under any framework design, the difficulties in this case were becoming too extensive for demonstrating that the framework could be mapped onto the project.

At this point, it was decided that further delay in the retrospective application would not cause any significant problems and that the framework should be revised.[3] Several changes were then initiated:

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[3] These revisions are discussed more fully in sections 4.2.4 and 4.2.5.

- Elements of the framework were reexamined and reorganized in order to decrease overlap or specify new areas.

- Further study was made of how the framework could be used in a project. Five functions were then identified: problem solving, strategy development, research, documentation, and dissemination.

- Framework elements were defined and illustrated with examples from the three ETIP cases initially studied to identify important factors in system development.

These changes resulted in an improved framework and documentation of the various materials used in its development and definition. These included Chapter 2 (the three ETIP cases), Chapter 3 (the literature background), parts of Chapter 4 (the framework development process), and Chapter 5 (the detailed descriptions of framework elements).

The retrospective application was then reexamined to determine the best approach for its accomplishment.

4.3.4 A Second Retrospective Application

4.3.4.1 Revising the Application Design

The initial approach to the retrospective application raised several other problems besides those associated with framework design. First, it was obvious that relying on project records for the application was going to leave gaps in events. In addition, project documents did not always present the overall perspective of events that project managers had during the periods of interest. These problems led to the question of whether project records would be sufficient in themselves to conduct a reasonably accurate application of the framework.

A second major problem was time. It was clear that an extensive review of the project over its entire period would require much more time than expected. This time would also be significantly increased if any additional efforts were taken to supplement the project records, such as in conducting surveys or interviews of project participants. An extensive amount of time had passed since the occurrence of project events and any renewed contact with participants involved problems of recall and reliability.

The third problem raised by the initial application was that the simple classification of events appeared to add little more to showing the usefulness of the framework than the examples already included in the descriptions of framework factors. Mapping the framework onto a new case such as the evaluation system project was considered useful in further demonstrating the relevance of the factors, but the additional illustrations seemed repetitious.

These problems prompted a revision in the design of the application since it was felt that no application would leave a significant gap in the dissertation research - both in demonstrating how the framework could be used and why it should be used. It was decided to attempt several smaller applications within the time period of the project rather than attempting to cover the entire period as one case. This led to the idea of working with selected periods of the project where there seemed to be a dominant problem that the monitoring framework might have helped project managers solve. An application would thus include descriptions of the problem, identification of the related framework elements, and analysis of how monitoring the elements might have altered the problem and its associated events. This approach provided two ways to demonstrate the usefulness of the framework:

1. Mapping the framework onto the problem and its related events would demonstrate the relevance of the framework to system development activities.

2. Proposing alternative courses of action based on the mapping would demonstrate how the framework as a whole could contribute to improved project management.

The specific activities undertaken in this approach are described in the following sections. First, the process used to develop a chronology of the project and help identify periods with a dominant problem is presented. The framework application procedure is then described.

4.3.4.2 Developing a Chronology of the Case

The first task of the framework application was to develop a chronology of the ETIP evaluation system project. This process was to serve several purposes:

- Outlining events in the project and familiarizing the writer with the history.
- Identifying events or periods of time which might be useful for illustrating the framework.
- Developing a brief description of the project to include in the dissertation.

Work began by collecting all available project documents in ETIP. The set of records obtained included the personal files of most ETIP staff directly involved in the project (including the writer's), the official project files, and the library of reports generated by the two contractors.

The documents were then filed by date and a listing of project events was generated. It was found during this process that while the project had lasted over five years, most of the system development activity had occurred within the first three years of the project.[4] Thus, it was decided to concentrate the chronology on the first three years and only briefly summarize subsequent periods.

It was also found that the first two years of the project were the best documented. There was an extensive number of reports, memos, notes on phone calls, and contact reports on meetings between various project participants for this period. The third year was primarily represented by several letters and final reports, leaving many gaps in events and thinking. The search for framework applications was thus subsequently focused on the first two years.

The final step of the chronology process was to write a summary of the project for the dissertation. Since the purpose of the summary was to help familiarize the reader with the basic project history, the

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[4] This was not unexpected since the project had been designed to last three years, ending with institutionalization. However, the project was extended several times after the third year and it was unclear whether development had been continued.

summary was designed to be a brief and factual overview of major project activities.[5] The following procedures were used:

- Emphasis was placed on events concerning project management, reports, and system development. Discussion of the technical evaluation activities in the project (i.e., events concerning specific evaluation reports) was minimized.
- Interpretations by the writer were minimized by avoiding broad summaries or comments as much as possible.
- The summary was divided into six month periods since the project had been divided in this manner during planning.
- Citations to specific documents were not used since the description was only to be a brief summary for readers. (Citations to project documents were to be used for the framework application, however.)
- Specific names of individuals were not used. In addition, neither contractor was specifically identified.

It was decided to include a section on the background and objectives of the project to help readers understand how the project was designed and the environment in which the system was being developed. Material for this section was adapted from the detailed background chronology of events developed by Libman (1980).

The resulting chronology is presented in Chapter 6.

4.3.4.3 Applying the Framework

Development of the chronology helped identify several periods in the evaluation system project where one problem tended to dominate and affect other events. For example, during the first six months of the

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[5] The focus on major events and problems helped identify areas where the framework could be applied (see next section).

project, July to December, 1976, a significant amount of attention was given to the development of a system for reports and reviews in the project. While this amount of concern seemed justified given the communication needs in the project, the resulting system proved ineffective and contributed to many communication problems. In addition, problems with the system affected several other areas of the project. Overall, this situation, along with several others, appeared to be excellent examples where the usefulness of the framework in project management might be shown.

A procedure was then developed to analyze these periods of the project and apply the framework. First, the period of interest was studied by tracing the events related to the dominant problem identified. For example, in the case of the first six months, events related to reports and reviews were collected in a list. This tracing provided the basic data to establish the evolution of the problem, the specific components of the problem, and the actions taken by project managers to resolve it.

Next, the same period was reviewed again to determine how the problem was tied to other events in the project. For example, the problems of reports and reviews were examined to identify any effects they had on events related to the design of the evaluation system. Areas of the project which were affected by, or had an effect on, the dominant problem were then classified according to the relevant framework elements in any of the three main categories: system design, development process, or user commitment. This procedure established the mapping of the framework onto project events.

Finally, using the mapping created, alternative courses of action were explored to identify how the actual sequence of events leading to the problem might have been altered with the framewwork to avoid the problem. The emphasis in the analysis was to show that:

- The framework might have helped identify the problem sooner.
- The framework might have helped decompose the complexity of the problem and its effects on other project areas into simpler, manageable elements.
- The framework might have helped design improved alternative courses of action.

Each of these separate studies were then documented as one application. Separate sections included evolution of the problem, specific components of the problem, effects on other areas of the project, how the problem was resolved in the project, and how the framework might have helped resolve the problem in a different manner. Since these sections relied on details of events not specified in the chronology, specific citations to project documents were included in the discussions.

Three different periods were initially selected as separate cases for a framework application. Each of these involved the dominant problem desired for an example:

- July-December, 1976 -- problems with reports and reviews.
- April - September, 1977 -- problems with the first prototype system design.
- March, 1978 - 1979 -- problems with institutionalization of the system.

However, only one application, reports and reviews, was completed for the dissertation because of the time limits allowed for the research.

4.3.4.4 Limitations and Biases of the Approach

The approach used in the retrospective application has its limitations and these should be noted by the reader as the application is reviewed. First, relying primarily on existing ETIP records for project information means that some events were probably not identified and that the overall importance, relevance, and/or priority of events as viewed by project managers at the time were not always known. Thus the selection and use of events in the application may be biased toward activities that were documented or the significance of some events may be incorrect.

Second, the project records used in the application are generally not available for readers to scrutinize. Many of the materials used are notes and memos which are not a part of the official record; even some of the official reports are not available outside of ETIP. Thus, to some extent, readers cannot easily verify that the events selected for the application actually occurred or that the usefulness of the framework is plausible given what actually happened in the project. The bias of the application is thus difficult to check.

Another source of bias is the writer, first from being involved with the project. The writer has special knowledge of the evaluation system project due to participation in the ETIP management team for the system project due to participation in the ETIP management team for the first 18 months. While this was an asset to the extent that it facilitated use of project records and supplemented them with an insider's perspective, it also established a particular viewpoint on events of the project. This viewpoint does not necessarily correspond to what other participants, such as the COTR, had during the project or would have now. Thus, all aspects of the retrospective application are from the writer's viewpoint, which is not necessarily complete nor totally accurate.

A second writer bias involves the selection and interpretation of events in the project record. The extensive records of the project have been carefully reviewed to identify a dominant problem for framework application, map the framework onto events, and suggest ways that the framework might have altered events. The events selected to document the application are examples the writer chose to use. The interpretations made on how the framework might have helped are the writer's, and have not been cross checked with other participants. The plausibility of framework usefulness thus rests only on the events selected and the interpretations provided by the writer.

In order to counter these limitations and biases, citations are made to project documents to support the actual framework application. Judgements made by the writer as the application was conducted do not contain supporting citations, unless an existing document was found that corroborated the writer's opinions. It should also be noted that specific names for all citations are not used, but are replaced either with COTR, the name of the organization the person was with, or the code names, Contractor A or C as appropriate.

Overall, it is felt that, even though there are potentially significant biases in the application, a reasonable case for framework usefulness has been made. This is because the application is based only on events which are cited and not others which are either left out of the application or unidentified in project records. Thus, the plausibility of how the framework might have helped managers is based only on the interpretation of events which have been adequately cited in the text.

4.4 CONCLUSION

This chapter has reviewed the exploratory research process used to develop a framework for monitoring system development and to apply the framework retrospectively to a specific ETIP system project. The first part of the chapter traced framework development from the early ideas on management needs in ETIP system projects through to the resulting framework design. This description showed how the research problem changed from the search for an ideal model of system development to the formation of a framework for monitoring key areas of a system project. The framework has been designed to be useful in project management as a means for problem definition, strategy formulation, and the documentation and dissemination of progress. The framework is also useful as a research tool since it provides a means for the study of important system development problems and practices.

The second part of the chapter presented the design of a retrospective framework application to a specific ETIP system project. The application has been designed to illustrate the usefulness of the framework in project management. This has been accomplished by developing procedures to first map the framework onto the project and then to show how use of the framework might have facilitated the resolution of major problems existing in the case.

The next two chapters present the results of these research efforts. Chapter 5 describes the 30 factors of the monitoring framework and the five functions it may serve. A model for implementing the functions is also presented. Chapter 6 presents the retrospective application of the framework to a fourth ETIP project, the evaluation system development.

CHAPTER 5

THE FACTORS AND FUNCTIONS OF A FRAMEWORK FOR MONITORING SYSTEM DEVELOPMENTS

5.1 INTRODUCTION

This chapter describes a set of factors for monitoring a system development and a set of functions monitoring can serve. The framework is designed to help project managers collect information on key project areas and use this information to identify problems, assess and revise strategy, support decisionmaking, and help promote awareness of progress. It also has a research function in that the monitoring process can be used as a mechanism for conducting investigations of the areas being monitored.

Thirty factors and five functions are identified for the monitoring framework. The factors are divided into three main categories, which reflect the overall types of factors which should be monitored. These are design, process, and user commitment characteristics. The five functions which monitoring can serve include problem identification, strategy development, research, documentation, and dissemination.

The following sections further describe the factors and functions at a level which should facilitate access to the more detailed sections of the chapter. A final section is also included to direct readers to these more detailed discussions.

Readers interested in learning how the framework was developed should consult Chapter 4.

5.1.1 The Monitoring Factors

As mentioned above, the factors in the framework are divided into three main categories -- design, process, and user commitment characteristics. These categories were chosen to reflect the general types of factors which need to be monitored and the specific needs of the ETIP situation for which the framework has been designed.

Design characteristics are factors which describe what a system looks like and how it works. Monitoring these characteristics is important for several reasons. First, the design must be sound, meaning that it actually provides the functions needed by users as well as meet the specific performance requirements. Second, the design must be attractive to users in order to gain their support and use. This means that the design must help users solve important problems in a manner which is matched to their style and other organizational processes. Problems in these areas are common in system developments and can jeopardize the ultimate success of the project. Developers need to routinely monitor design characteristics and decide whether revisions in the design or the project strategy are needed to ensure that a satisfactory system is evolving.

Process characteristics are factors which describe the methods, structures, procedures, and personnel used to conduct and control the development. Monitoring these characteristics provides developers with an indication of whether the process they are using to design the system is producing the appropriate design and leading to full implementation of the system at the end of the project. A widely recognized factor in this category is the need to involve users in the development as much as possible. Developers must decide for themselves what this means for a project and then ensure that the level of involvement is achieved; ultimate user commitment to a system may depend to a large extent on the earlier active involvement of users. This is only one factor among many, however. Other parts of the development process such as the priority of tasks, the level of turnover in key personnel, or the kind of reporting mechanisms used to document progress may also have an important role. Factors like these can be a problem at any stage of development and it is important that they be routinely reviewed. Developers may find that they have implications for eventual user commitment to the system and/or system design.

The third framework category, user commitment, consists of factors which characterize behaviors related to use and support for the system in the prospective owner organization. Commitment is viewed here as developing over time, making it essential to monitor it during the system project and determine whether it is increasing or decreasing. The final user decision to fully implement a system will be a reflection of the commitment already established during development. For example, an early sign of commitment would be the emergence of a system champion in the user organization who strongly supports development and institutionalization of the system. Champions will help locate the key user problems which need a new system as well as actively market the system to others. In contrast, continuing problems in defining system functions in the user organization may indicate an unusual degree of uncertainty or a change in commitment to specific design concepts. Signals like these need to be identified and considered by developers during a systems project and their implications determined for design or strategy.

Two figures are provided to summarize the factors of the framework. First, Figure 5.1 lists the framework categories and all of the 30 factors. Second, Figure 5.2 provides a brief description of each factor. These descriptions are also used in the more detailed discussions of the factors.

5.1.2 The Monitoring Functions

The monitoring framework is designed to serve both administrative and research purposes in a system development. Administrators can use the information collected through monitoring to help identify problems, revise strategy, make decisions, or to help make others aware of development progress. Researchers can use the monitoring process to collect data for investigations of the development process.

DESIGN CHARACTERISTICS	PROCESS CHARACTERISTICS	USER COMMITMENT CHARACTERISTICS
● OPERATION AND PERFORMANCE FACTORS 1. Response Time 2. Quality 3. Cost of Operation 4. Input/Output Operations 5. Interconnection of Subsystems ● BOUNDARY FACTORS 6. Capabilities/Limitations/ Expectations 7. User Groups and Their Interrelationships 8. Interfaces with Other Systems and Organizations ● ADAPTATION FACTORS 9. Flexible Specifications 10. Matching the System to the User 11. Novelty of the Design 12. Evaluation and Updating	● TASK STRUCTURE FACTORS 13. Task Size 14. Task Priorities ● TEAM PERSONNEL FACTORS 15. Skills 16. Turnover 17. Commitment ● PROJECT CONTROL FACTORS 18. Organization and Responsibilities 19. Decision Points and Milestones 20. Reports and Reviews ● INTERACTION WITH THE USER ENVIRONMENT FACTORS 21. User Involvement 22. Problem Identification 23. Testing 24. Transfer	● SYSTEM USE FACTORS 25. Applications 26. Consequent Actions 27. Extent of Use ● SYSTEM SUPPORT FACTORS 28. System Champions 29. Resource Commitments 30. Changes in the User Organization

FIGURE 5.1 THE MONITORING FRAMEWORK

DESIGN CHARACTERISTICS

Operation and Performance Factors

General Description: The functioning of the system design in the user organization.

Factors:

1. Response Time -- The amount of time it takes a system to respond to a user inquiry.
2. Quality -- The accuracy, credibility, and utility of input and output information in the system.
3. Cost of Operation -- The amount of resources needed to operate the system.
4. Input/Output Operations -- The mechanics of user interaction with the system.
5. Interconnection of Subsystems -- The interrelationships of system elements.

Boundary Factors

General Description: The borders of system and subsystem designs.

Factors:

6. Capabilities/Limitations/Expectations -- The conceptual boundaries of a system prescribed by the various groups of people involved in the development.
7. User Groups and Their Interrelationships -- The roles and costs and benefits of involvement with the system pertaining to the different groups of the user organization created by the system design.
8. Interfaces with Other Systems and Organizations -- The relationships between the system and other systems and organizations.

Adaptation Factors

General Description: The match between the system design and the user organization.

Factors:

9. Flexible Specifications -- The match between design specifications and the existing uncertainties over system objectives, processes ownership, products, etc.

FIGURE 5.2 BRIEF DESCRIPTIONS OF THE MONITORING FACTORS

10. Matching the System to the User -- The match between the system design and the user organization structure (structural), the abilities, methods, and personal styles of individual users (technical), and the personal relationships of individuals in the user organization (personnel).
11. Novelty of the Design -- The change a new system represents over the existing system.
12. Evaluation and Updating -- The provision of evaluation and updating functions in the system design.

FIGURE 5.2 (continued)

PROCESS CHARACTERISTICS

Task Structure Factors

General Description: The design of project tasks to develop the system.

Factors:

13. Task Size -- The amount of resources (money, manpower, and time) assigned and consumed in the performance of individual system development tasks.
14. Task Priorities -- The relative emphasis across tasks at a given point in time and the ordering of tasks over time.

Team Personnel Factors

General Description: The availability and functioning of project personnel.

Factors:

15. Skills -- The availability of technical and interpersonal skills in project teams as required by system development tasks.
16. Turnover -- The change of personnel involved with project teams.
17. Commitment -- The team member support for and implementation of the goals, strategies, and tactics of the system development.

Project Control Factors

General Description: The structures and processes used to control project activities.

Factors:

18. Organization and Responsibilities -- The structure of project teams and responsibilities in the system development.
19. Decision Points and Milestones -- The structure of specific events created by project managers to recognize or review progress and decide future courses of action.
20. Reports and Reviews -- The structure of written and oral communication mechanisms used to document and review development progress.

Interaction with the User Environment Factors

General Description: The involvement and contact between the project and members of the user organization.

FIGURE 5.2 (continued)

Factors:

21. User Involvement -- The participation of members of the user organization in the managerial and technical teams of the project.
22. Problem Identification -- The overall amount of attention to and the amount of contact with the user organization in the definition of user problems.
23. Testing -- The amount of concept and design testing conducted in the user environment.
24. Transfer -- The amount of attention devoted to the transfer of the system to the user environment.

FIGURE 5.2 (continued)

USER COMMITMENT CHARACTERISTICS

System Use Factors

General Description: User actions related to application of the system in organizational processes.

Factors:

25. Applications -- The use of specific elements of the system in specific units of work of the user organization.
26. Consequent Actions -- The actions resulting from areas of direct system use.
27. Extent of Use -- The amount of use relative to the number of potential applications.

System Support Factors

General Description: User actions related to supporting application of the system to organizational processes.

Factors:

28. System Champions -- The emergence of advocates for the system in the user organization.
29. Resource Commitments -- The type and extent of resources allocated by the user organization to support the system.
30. Changes in the User Organization -- The alteration of policies and procedures in the user organization in order to support system operation.

FIGURE 5.2 (continued)

These two main uses are combined into five functions for monitoring which overlap and support each other. These are:

- Problem identification -- The tracking and assessment of key areas where development problems typically occur, both in the short and long range.
- Strategy development -- The identification and development of explicit management actions to solve problems and revise strategy.
- Research -- The design and implementation of real-time studies of the development process.
- Documentation -- The establishment of an organized and stable recording process which can identify special or recurring problems, and support decisionmaking and research.
- Dissemination -- The distribution of key development information to these inside and outside a development as a means of facilitating coordinated actions and distributing knowledge gained.

5.1.3 Organization of the Chapter

The following sections of Chapter 5 more fully describe the factors and functions of the framework. Four main sections are used -- the first three describe the factors by category, and the fourth describes the functions and implementation of the framework in a systems project.

Each category of factors is separately described. First, the category is generally introduced. This is followed by subsections in each of the respective subcategories of factors (as shown in Figure 5.1).

Each factor is then described and cross references are made to other factors which are relevant. The brief descriptions of the factors provided in Figure 5.2 are included again in these discussions.[1]

As mentioned in earlier chapters, several ETIP system development projects have been used as supporting illustrations in the sections describing each factor. The three cases are the Small Business Administration (SBA) project to develop a data base system, the Public Buildings Service (PBS) project to develop a planning system, and the state and local procurement project to develop a procurement information system involving the National Association of State Purchasing Officials (NASPO) and the National Institute of Governmental Purchasing (NIGP). An attempt has been made to include sufficient background material in these illustrations so that they can stand alone without referencing to other sections; however, it may be beneficial for readers to review the case descriptions located in Chapter 2. These descriptions review the entire case and provide the contextual information in a more succinct manner. Reviewing Chapter 2 may make the illustrations of Chapter 5 more quickly understandable and allow the reader to skip material which is repeated. Also, readers will note that the specific illustrations presented in Chapter 5 often go beyond the details found in Chapter 2. This is intentional since Chapter 2 is intended to provide the general background which is too cumbersome for the illustrations needed in Chapter 5.

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[1] Readers will note that each category, subcategory, and factor description is started on a new page. This has been done to make it easier to quickly find any of the framework items.

Following the discussions of framework factors, the framework functions are presented. First, each function is discussed separately. A model for applying the framework is then presented to show how the monitoring functions can be implemented in a project.

5.2 DESIGN CHARACTERISTICS (FACTORS 1-12)

5.2.1 Introduction

At any stage of development, a system can be measured on certain factors which describe what it looks like and how it functions in the user organization. For the monitoring framework, these factors are called design characteristics.

The following sections identify and describe 12 factors. These factors were chosen for their importance to system development success as identified in the literature or ETIP experiences. They also appeared to be relevant factors for the ETIP evaluation system project discussed elsewhere in this dissertation (see Chapter 6). More specific discussions on the choosing of factors can be found in Chapter 4 (see section 4.2).

The 12 factors have been separated into three major categories: operation and performance, boundary, and adaptation. Factors in the operation and performance category are for monitoring how a design is planned to function or how it is actually functioning in an organization. Factors in the boundary category are for monitoring the various kinds of interfaces a design creates. These include the boundaries between the different user groups in the organization, boundaries between the organization and outside groups, and boundaries between the actual design and other "theoretical" designs. The final category of factors is adaptation. These are factors for monitoring the fit of a design to a user organization.

One section is devoted to each of the three major categories. The sections first present general discussion on the factors in the category. Then each factor is individually described and supported with citations to systems literature and to the ETIP experiences discussed in Chapter 2.

5.2.2 Operation and Performance Factors

General Description

One category of design characteristics measures how the system operates and performs tasks related to meeting information requests. These characteristics have an impact on people using the system and thus are ultimately linked to the success or failure of the system. Monitoring them during development may decrease the likelihood that inappropriate designs or poor performance stay uncorrected and act as barriers to obtaining full support of the system.

Several key characteristics have been identified in system literature and ETIP cases. These are: response time, quality, cost of operation, input/output operations, and interconnection of subsystems. Each of these is described below.

5.2.2.1 Factor 1 -- Response Time

> Description -- The amount of time it takes a system to respond to a user industry.

Discussion

The time it takes a system to respond to a user, usually in relation to a specific information request, is an obvious design characteristic which will affect use. It is commonly mentioned in the systems literature, often as a criterion for evaluating a system (Krasnican, 1971, pp. 54-55). While it also often appears as "timeliness of output reports" (Lucas, 1975b, p. 34), it also can refer to any reaction a system would have to any user request. Long delayed responses might be expected to gradually discourage a user from interacting with the system. Quick turnaround might accelerate introduction of the system and build user confidence.

ETIP Examples

Response time was definitely a factor in the ETIP cases described in Chapter 2, particularly in the small business set-aside data base system (see section 2.4). In that project, developers attempted to build a system that would help users develop a case to set-aside a government procurement to small businesses. Users normally had 15 days from the time they learned of a pending procurement to make their case. As described earlier, a manual system was first created to meet this need, but its time performance was unacceptable to users and it did not gain their support. A computerized version constructed later did solve the time problem, and this was partly responsible for its acceptance.

Response time was also an important factor in the ETIP case involving the PBS planning system (see section 2.2). While the computerized system did not meet the objectives of the project as originally planned, it did provide a new mechanism to calculate cost analyses, a subset of the problem. The computer program reduced calculation time from weeks to hours and also provided for much more flexibility in adjusting the assumptions used. Some users saw the value of this aspect of the system and started to routinely make cost analysis requests. Thus, even though the system was not being used as fully intended, it gained further support from users and remained in place after the close of the project.

5.2.2.2 Factor 2 -- Quality

<u>Description</u> -- The accuracy, credibility, and utility of input and output information in the system.

<u>Discussion</u>

The quality of a system, particularly in its response to a user request, is also one of the more obvious design characteristics for systems. It is often used, like response time and cost, as a criterion for evaluating a system. It is considered one of the most important factors in a development since it can have significant influence on user commitment to the system. A high level of quality (ensuring a high commitment) is not always realistic however, since the benefits obtained from it must be compared to the cost of achieving it.

For information systems, quality can mean many different things. Lucas (1975b, p. 34) defines information system quality as a measure of input and output including clarity of documents, input error, usefulness, accuracy, and timeliness of output reports. Quality is also associated with quantity to some extent. One of the major problems with an information system might be that too much information is given to decisionmakers, or that they may want more information than they actually need (Ackoff, 1967). The quantity of information may need to be controlled and irrelevant information eliminated (Lucas, 1975b, p. 112). Indirectly then, quantity would be considered as reflecting on quality also.

In this dissertation, quality is used as a measure of input and output information characteristics, especially as to their accuracy, credibility, and utility. These characteristics are important from two perspectives. First, the system itself must be sound, meaning that it provides the correct information. Second, the system must produce what is needed by users and lead to their support and commitment to institutionalization. While these attributes can be related, developers must ensure that the system has both since one does not necessarily follow the other.

ETIP Examples

Quality as a general factor was important in each of the three ETIP cases described in Chapter 2. In the small business case, the project began to make significant progress when the computerized system output matched the results obtained independently and previously by users. In the PBS case, the system was able to provide economic analyses on space configurations of a quality at least equal with the previous manual system. Since the computer system was overwhelmingly faster than the manual version, users quickly adopted the system into their routines. Finally, in the state and local procurement project, one of the original objectives was to upgrade the quality of information available to procurement officials. These officials often had few resources to do this on their own. However, system developers found it difficult to produce information at the level of quality desired by users. Some officials found system output to be less useful than what they could produce on their own. Other officials found it difficult to understand and/or accept the information. Developers had committed themselves to a design which produced information of insufficient quality to attract users. Earlier attention to this problem might have altered project strategy.

5.2.2.3 Factor 3 -- Cost of Operation

Description -- The amount of resources needed to operate the system.

Discussion

The cost of running a system is another obvious factor which will affect user commitment. If a system is going to cost too much to operate relative to its benefits or user resource constraints, users will be less likely to support it. However, it may be difficult to know the costs in advance and avoid this problem, especially if there is a little historical data on another systems or if there are great technical uncertainties (Chestnut, 1967, p. 180).

Operating costs are of considerable importance in both hardware and software systems. In weapons systems, a common major problem is the tradeoff between the quality of the end product and the economy in operating costs (as well as in development and production costs) (Peck and Scherer, 1962, pp. 461-580). Support of a complex, high quality system must often be tempered by the realities of how much it will cost to operate and maintain the system. Similar problems exist for information systems. In Ruth's (1978) development failure discussed in Chapter 3, cost was one of the original justifications for attempting the development. It was thought by managers that the system would reduce overall costs in Air Force logistics since it would replace numerous personnel. The system was designed around the innovative but previously untested idea of processing all logistics transactions quickly rather than by their priority. However, this system proved to be too costly relative to management's objectives. This was evidenced by their decision to return to the old inefficient system after some 15 years of development and $200 million of expenditures.

ETIP Examples

A further example of cost and its affect on development process and commitment can be found in the ETIP-SBA data base system project. The computerized system developed in the latter half of the project met some user needs and gained modest support. Unfortunately it was too costly to operate; users could not acquire the resources to support it. Some of them felt that the capabilities of the system were too small relative to cost. (It is also interesting to note that the project itself did not have the resources to continue supporting the system either.)

5.2.2.4 Factor 4 -- Input/Output Operations

Description -- The mechanics of user interaction with the system.

Discussion

Another factor under the operation and performance category is the operation of system input and output functions. The literature often includes this as a factor in the measurement of system quality, but usually this is in relation to the quality of data put into a system and the quality of information produced. The focus here will not be directly on these measures, but on the actual operational characteristics of input and output.

The operation of input and output functions is important to look at for several reasons. It must be mechanically easy for users to interact with a system (Lucas, 1975b, p. 112). If it appears too difficult for them to get a request in or out of a system, most likely they will not use it or will find ways to go around it. The same conditions apply to the personnel responsible for providing data to a system. It may be difficult to collect the data or there may be uncertainty as to how to put it into the system. These problems could have significant impacts on their support (Waller et al., 1976, pp. 13-14). For example, Malvey (1978, pp. 191-211) found that disgruntled staff responsible for input data failed to provide it or allowed numerous errors to remain in it. The important lesson, she concludes, is that the design of input and output functions may conflict with or enhance the way an organization works or solves problems (Malvey, 1978, p. iii). Developers should spend time considering this problem (Waller et al., 1976, pp. 29-41).

ETIP Examples

The importance of input and output operations was demonstrated in the ETIP case studies. In the SBA system project, initial designs required users to spend much time collecting and structuring information about small businesses. The system would then store this data for later rapid access when needed in set-aside cases. During pilot testing, however, it was found that users didn't have the time to perform the input procedures because they were usually busy just identifying potential set-aside contracts. There was also some question as to the appropriateness of the input forms. They had the potential of tipping off small businesses to an impending contract opportunity before it was announced through normal procurement channels. Finally, some users had difficulty with the input procedures themselves. A reliable system to classify all firms and contracts could not easily be developed. Each of these characteristics contributed to the lack of user interest in the system.

A contrasting example was found with the input operation of the PBS planning system. In this system, the economic analyses formally done only by hand were now available in an on-line computer program. Input procedures required typing in space configuration parameters and other constraints. It was simple and easy to change numerous assumptions in the program or to test slight alterations of the same design. The simplicity and flexibility of the input process (and of course the rest of the system) was attractive to users and helped gain their support for the new system.

5.2.2.5 Factor 5 -- Interconnection of Subsystems

Description -- The interrelationships of systems elements.

Discussion

One component of any systems definition is that system elements are related to each other and function in a manner which meets a common objective. Besides the breakdown of elements then, a key characteristic of system development is the interrelationship of the various subsystems.

Elements which are related by an overall objective are not necessarily related directly by input and output flows however. Elements may function independently of each other or be heavily dependent on each other. Malvey (1978, pp. 251-253) found that one factor in the failure of the MIS she studied was that the entire system had to be run for each type of request made. It was impossible to run elements (e.g., a sub-routine) separately and thus operations were costly.

An important characteristic to monitor then is whether and how elements are connected to each other. Developers should consider organizing subsystems such that interactions between them are minimized (Flagle et al., 1960, pp. 96-97). Besides allowing for easier removal and update of components, minimizing interactions may also help minimize the impact of changes to the user organization or personnel relevant to these subsystems (Comptroller General, 1975, p. 17; Fronk, 1978).

5.2.3 Boundary Factors

General Description

A system can be described by what is included and what is excluded. Similar descriptions can be used at the subsystem level. The boundary of a system is an important concept to developers and its placement can be very influential on development activities.

There are a number of ways to delineate the boundaries of an information system. For example, Chestnut (1967, pp. 98-134) suggests three different approaches: chronologically, physically, or functionally. Any of the various approaches can be helpful in formulating a design and their relative merits will not be discussed here. However, there are two categories which can be used to generally classify the different approaches: physical boundaries and conceptual boundaries. With information system, physical boundaries usually refer to the actual input and output devices through which a system will collect and disseminate information (e.g., terminals, file cabinets, etc.). These design characteristics are separate from the issues of interest in this section and are discussed under Operation and Performance (section 5.2.2).

The main concern in this section is the conceptual boundaries which define the system and the implications they have for the user organization. Conceptual boundaries are the words, thoughts, plans, objectives, expectations, models or roles represented in or guiding design characteristics. Several different strategies have been selected to examine where boundaries are located. The first category is capabilities, limitations, and expectations for the design. Developers need to monitor how well these match across and within different user groups. A second category is user groups inside the organization and their interrelationships. A design may conflict with or complement existing relationships and developers need to examine what the implications of either might be. The final category is interfaces with other systems and organizations. The system may eventually depend on or support outside groups, and thus the relationship between the system and the groups may be a critical factor developers should monitor to ensure project success.

5.2.3.1 Factor 6 -- Capabilities/Limitations/Expectations

Description -- The conceptual boundaries of a system prescribed by the various groups of people involved in the development.

Discussion

One way to identify the conceptual boundaries of a system is to identify the capabilities, limitations, and expectations for it in terms of design characteristics. How a system gets developed, or acquires capabilities, is partly a function of the interplay between the expectations and limitations various groups have for design. Capabilities in this sense are what a system is theoretically designed to do, rather than what it actually does. Actual performance is covered in the earlier section on Operation and Performance (sections 5.2.2).

The important issue to examine is the gap that may exist between these factors. Significant gaps may become a source of problems for developers:

- Limitations must be kept in mind such that the system's anticipated capabilities are not oversold (Krasnican, 1971, p. 55).
- Excessive expectations which are not met by actual performance may cause support to wither away or be unattainable (Ein-Dor and Segev, 1978, p. 1072).
- User expectations which are lower than those claimed by developers may cause the system to appear too grandiose to potential users and gain little attention or credibility for it.

Conditions like these would be further exacerbated if designers and users see the gaps differently (Meador and Ness, 1974). Developers need to identify the key gaps that exist and think through the implications they have for development strategy and system design.

Many sources in the literature advocate the need to identify and monitor boundaries and gaps early. At the very least, initial boundaries must be defined so that the information problem can be defined and components internal and external to the system can be identified (Chestnut, 1967, p. 133; Henderson, Note 1; Zimmerman, 1977, pp. 184, 189).

It is also important to monitor these boundaries later since unknown events may occur that affect them. They might shift due to changes in user commitments to designs, economic pressures experienced by the organization from outside, personnel turnover, or because competing systems become available (Ackoff, 1960; Thompson, 1978). Some development models, especially the newer ones used in government (see section 3.3.3.2), provide for changes like these since it is recognized that increasing knowledge about the problem and the solution will likely induce changes. For example, the cornerstone of the government model (A109) proposed for acquiring large scale systems is the decision point at each stage where system capabilities (planned or actual) are compared with original expectations. Significant gaps found in this comparison are supposed to indicate to developers a need to revise goals and strategy or cancel the project altogether. Alternatively, developers may strive for a consensus between competing positions (King and Cleland, 1975).

ETIP Examples

Gaps between capabilities, expectations, and limitations were found in all three of the ETIP cases described earlier. For example, one of the more significant gaps occurred in the SBA data base system project. The project had been developed around the concept of improving the ability of SBA officers to match potential government contracts with potential small business sources. This was to hopefully increase the number of small business set-asides being made by the government. Developers constructed procedures to help analyze potential contracts and small businesses in a similar manner, thus improving the process of matching. After creating a system to do this, however, developers found that the limitations in time and resources of field officials severely limited their ability to perform these procedures and made it unlikely they would use the system. What field officials needed and wanted was a simple system to help them find sources to contact, i.e., identify names and addresses. The boundaries of the two systems designs overlapped to some extent, but user acceptance of the developer system seemed unlikely until the design was molded to match user thinking. This gap significantly altered the course of the project.

Another significant gap occurred in the state and local procurement system development. This was a case where exceedingly high expectations in early stages were not met with actual capabilities in later stages. Project developers originally thought that procurement problems at the state and local government level could be solved by promoting the exchange of information between those needing help and those who could provide help. A simple exchange system was thus planned and created. However, as described in Chapter 2, much more work was needed to solve the user problems than just exchanging information. Many of the procurement problems were based on institutional factors, such as legislation or lack of money. Even in cases where there were few institutional constraints, the system was unable to produce the information needed because it had to be so closely tailored to specific sites. The internal technical expertise needed to do this had not been anticipated by project planners and was not easily available elsewhere. In the end, the gaps between limitations at the user sites, initial high expectations, and the limited capabilities of the design were insurmountable within the project and it was terminated. Earlier attention to these gaps might have dramatically altered the goals and strategy used by developers.

5.2.3.2 Factor 7 -- User Groups and Their Interrelationships

Description -- The roles and costs and benefits of involvement with the system pertaining to the different groups of the user organization created by the system design.

Discussion

A system design usually creates a number of different groups in the user organization. For example, there can be system owners, input sources, output users, system managers, performance evaluators, or system operators. These groups may cut across already established organizational lines. Each group has a specific role in the system and certain costs and benefits associated with it. Some groups may even have multiple roles, such as when owners and users are the same people. Another way to identify system boundaries then is to study these groups and their interrelationships. Keen (Note 2) has considered this issue by treating information as a commodity and then examining territorial questions: owners, users, designers, evaluators, and coalitions of these.

The issue of different user groups and roles is not widely discussed in the literature, particularly in relation to how developers handle the differences during a project. Many sources refer to the related problem of high level support, e.g., that a high enough level manager be in charge of the system so that coordination among the various groups can be enforced (Ackoff, 1960; Malvey, 1978, p. 20). Others suggest that no one unit be allowed to capture or subordinate a system to their own interests (Ein-Dor and Segev, 1978, p. 1074). Most sources agree that the design of a system must be different for different levels of an organization (Gorry and Morton, 1971; Katch, 1978, p. 54).

Perhaps the closest example in the literature to the issue of boundaries as seen in user groups is found in sources which describe problems the various groups may have in supporting a system. For example, Malvey (1978, p. iv) found that input sources had little incentive to produce information for the system. In this case, the costs and benefits of their participation may not have been in balance enough to gain their support (see also problems with matching, section 5.2.4.2). Similar cases are commonly found for users of the system. Generally, the focus is on a single group and the conflicts and differences between groups are not discussed. Developers need to address both the imbalances a design creates within a group (e.g., between the cost and payoff of participating) and any resulting implications for group interactions (e.g., cost/payoff differences between groups).

ETIP Examples

A good example of the problem is found in the state and local procurement project. System developers assumed that owners and users were the same people, namely, procurement officials in the executive agencies of state and local governments. Later they found that this was only particularly true. In order for the officials to acquire the system, they had to obtain approval from other higher officials, including distant legislators with control over appropriations. The system was not designed with this group in mind and thus had no capability at the time for reaching them.

Another example was found in the PBS planning system project. In this case, the system design was completed within a special studies unit of PBS outside of the line organizations intended to be the ultimate users. The special studies unit maintained roles of owner, manager, operator, and evaluator, while the real users had little if any control of the resource. Even though the system attracted users, the conflict between the units on system roles and organizational responsibilities remained as one factor preventing complete user acceptance of the system.

5.2.3.3 Factor 8 -- Interfaces with Other Systems and Organizations

Description -- The relationships between the system and other systems and organizations.

Discussion

Another set of boundaries developers may need to examine are those between the system and other systems and organizations (Ginzberg, Note 3). Outside systems or organizations may be sources of data to the system or recipients of system outputs (King and Cleland, 1975, pp. 288-289). Alternatively, they may have an indirect role through control of system resources or competition with the system (Comptroller General, 1978, pp. 9-10; Thompson, 1978, p. 329). The lack of an interface with outside entities may isolate the system from mainstream activities of an organization and reduce its importance (Nadler, Cammann, and Mirvis, 1980, p. 56; Rice, Note 4). In any case, establishing, monitoring, and refining relationships with these outside operations may be important to system success.

ETIP Examples

An example of the interface problem was found in the PBS project. The system met with user resistance and developers turned to outside groups with an interest in the system's methods. The system had been designed to analyze space acquisition alternatives for the agency in a manner consistent with the desired approaches of acquisition policymakers outside of the agency. Thus when the system was operational, developers began to market it to the outside policymakers in an attempt to have it qualified as commensurate with their desired acquisition policy. It was hoped that such an endorsement would further facilitate implementation of the system in the agency. In this case, an effective interface had to be established with outside groups. Early recognition of this situation allowed developers to orient the system design with this fact in mind.

5.2.4 Adaptation Factors

General Description

The third major category of design characteristics to be monitored relates to how well a system is adapted to the organization. A key problem in system developments is that an organization may be force fit to a system, rather than a system being matched to the users. This can create serious side effects in the organization and reduce the likelihood of success. On the other hand, large scale developments probably will identify weak spots in an organization which should be improved. In this case, changing the organization becomes a valid strategy in developing the system. Developers need to monitor how well the system and organization are fitting together and attempt to identify symptoms of a poor match early before problems arise. Developers also need to integrate the procedures to examine the match into the final design so that they can be used to continually improve the system during its operational phase.

Four major subcategories have been selected to further examine adaptation. First, the area of flexibility in design is reviewed. Flexibility is a lesson commonly mentioned in systems literature and the main concern is usually to ensure that a design is not finalized too early. Next, the need to match a design to the organization is discussed. The main goal of keeping a design flexible is to increase the likelihood of successfully matching the system and the organization. The degree of matching may be used as one test for determining whether a design is too advanced for that stage of the project. A third area is the amount of change a design represents relative to an organization. Designs which are significantly different from the existing system may be too radical for gaining user acceptance. Incremental changes might be needed in order to gradually adapt users to new procedures. Finally, the importance of institutionalizing updating functions in the design is discussed. The methods used by developers to review and revise a design should become part of the finished system. These procedures also need to be tied to other user evaluations of the system and to updating initiatives evolving from changes in the organization or its environment. Evaluation and updating functions should be thoroughly integrated in a design prior to its final acceptance by users.

5.2.4.1 Factor 9 -- Flexible Specifications

Description -- The match between design specifictions and the existing uncertainties over system objectives, processes, ownership, products, etc.

Discussion

A lesson for developers commonly mentioned in the literature is that a system design should be kept flexible in order to accommodate the uncertainties likely to arise throughout a project. Developers are advised to keep system specifications open or general, especially in early stages where system objectives are evolving. Specifications in this case are "living documents" (Chestnut, 1967, p. 64) which are not "cast in concrete" too early for the situation (Lucas, 1978b, p. 51). Developers are also advised to provide flexibility in system specifications so that the system can meet different user styles. This problem is considered in the following section on matching the system design to the organization.

The flexibility of system specifications is a difficult concept to operationalize for the purposes of monitoring. Specifications are basically descriptions of the system from different perspectives: technical, performance, organizational, processes, products, etc. (Haynes and Wheelwright, 1979). Flexibility is a quality specifications have relative to the degree of uncertainty in these areas. Uncertainties might exist from a lack of knowledge about an area. For example, unless a system is to handle routine, well-known operations, it is very likely that the kind of output needed is unknown even to the user. Other uncertainties could evolve from changes which occur during the project, such as in personnel, organization, or budgets. Whether a system design is appropriately flexible relative to these uncertainties is a difficult judgement and it is hard to quantify in advance. It should also be noted that in cases where there are few uncertainties or changes, flexibility may not even really be an issue.

This difficulty is reflected in the literature in that most sources resort to recommendations on process rather than criteria for measuring the flexibility of a design. For example, some sources advise developers to initially focus on performance specifications, or missions, rather than specific designs. This strategy is supposed to allow the various options and uncertainties to be freely explored before decisions are made detailing designs. The large scale system acquisition model developed by the Office of Federal Procurement Policy (OFPP) uses this idea (see section 3.3.3.2). Early stages of the model focus on missions of the agency and gaps in operations. Competition among designs is also encouraged as far into a project as possible.

The ideas behind these models are useful for enabling developers to provide in advance the "climate" needed for design flexibility. However, developers still need some way to gauge the design flexibility required as a project unfolds. One approach is to study the sensitivity of the design to the various changes expected during a development (Mumford et al., 1978, pp. 245-246). Developers should identify what changes could occur in personnel, objectives, or technical uncertainties, etc., and think through what implications they might have for the system design. Areas subject to great uncertainty or change will be ones where a design should remain changeable.

ETIP Examples

The importance of monitoring a quality like flexibility can be found in the ETIP development cases presented earlier. Generally it was difficult to retrospectively identify the degree to which specifications were flexible at a point in time in the cases. However, events occurred which indicate that a flexibility problem probably arose. For example, in the SBA data base project, developers committed themselves early to a manually operated design which later proved to be unpopular with users. This in turn stalled development since it had been expected that the design would be field tested extensively with users in order to refine its operation. Different strategies were attempted to gain user acceptance and field sites, but few test cases were obtained. It wasn't until a computerized design, somewhat different from the manual version, was completed that users became more interested. In retrospect, it would appear that developers finalized the design too early. The problems uncovered during the field stage indicate that there were many problems unanticipated by developers which had significant implications for project success. These uncertainties should have been reflected in a more flexible design which would have allowed developers to understand the situation before committing too many resources to one approach.

A very similar situation occurred in the state and local procurement project. Developers committed themselves to a set of objectives and system specifications early in the project before adequate knowledge of the problem was obtained. As described earlier in the case study, developers found that the design would not solve the user problems they thought it would and that gaining wide user support for it would be difficult. Developers attempted to compensate for the design deficiencies by allowing more variety in outputs and by attempting to acquire the more diverse inputs needed. Unfortunately, the project had not been planned with these contingencies in mind, and eventually it had to be terminated. Again it would seem that, relative to the uncertainty that must have existed at the time, the design was frozen too early.

5.2.4.2 Factor 10 -- Matching the System to the User

<u>Description</u> -- The match between the system design and the user organization structure (structural), the abilities, methods, and personal styles of individual users (technical), and the personal relationships of individuals in the user organization (personnel).

<u>Discussion</u>

The previous section outlined the need to keep a design flexible in order to accommodate the uncertainties likely to exist in a development. The major goal of monitoring flexibility is to increase the chances that the eventual design will match the organization and be accepted by users. Thus, as designs are created and detailed, developers need to also test the match between the design and the user and to determine whether satisfactory procedures are being developed. Developers need to avoid the problematic strategy of forcing users to adapt to a design (Malvey, 1978, p. iii; Ruth, 1978).

Matching can be analyzed at many different levels, however, and a comprehensive procedure for monitoring them all is probably too complex and inefficient. For these reasons, three categories which seem to capture the major overall concerns have been selected for discussion here. These are structural matches, technical matches, and personnel matches (adapted from Thompson and Rath, Note 5). The categories overlap to some extent and probably are part of any matching problem that arises in a development. They are described separately below.

Structural matching concerns the match between the structure of a system and the structure of the user organization. The way an organization works has important implications for a system design. Each user unit has its own goals, priorities, and ways to conduct its work. Similarly, the organization as a whole has established patterns of communications, relationships, and responsibilities. It will be hard to develop and institutionalize an information system which intrudes upon or ignores these existing conditions (Ein-Dor and Segev, 1978; Keen and Morton, 1978, pp. 69, 107-108; Malvey, 1978, pp. 264-265). On the other hand, a development may highlight deficiencies or previously unknown factors in how an organization works (Argyris, 1971; Krasnican, 1971). In this case, it may be beneficial for developers and users to consider changing the organization's structure as one part of developing a new system. McGrath (1970) for example reports on a development in which corporate headquarters learned it would have to recentralize itself in order to regain control of the operations it wished to include in a new system. Some user groups might of course withhold their support for a system if a change like this is proposed. In any case, the match between the system and the user is one design factor which developers should examine.

The second category, technical matching, concerns the degree to which a system design matches the abilities, methods, and personal styles of individual users. Individuals perceive and use information differently (Churchman and Schainblatt, 1965; Lucas, 1975b; Mason and Mitroff, 1973). Some individuals are more data-oriented while others are more intuitive. For example, top level managers probably need a design which is directed toward better processing features, like filtering and condensing, rather than one which merely overloads them with more detailed information (Ackoff, 1967; Meador and Ness, 1974). In contrast, people at operational levels need a design which is detailed and rigid, since more data is handled at this level and the same procedure will be routinely repeated. It is generally recognized in the literature that incompatibility between user habits, strategies, or abilities and the implicit "style" of the system will result in decreased system use (Keen and Morton, 1978, p. 73; Krasnican, 1971, p. 56; Zand and Sorenson, 1975, p. 545).

The third category of matching is that of personnel matches. This is the degree to which the people involved in a system are compatible with each other. Beyond matching a design to organization structure and to individuals' abilities, developers should examine whether system personnel will be able to work together as required and accomplish system objectives. System developments can fail because the relationships among the people are ignored, while too much attention is placed on technical problems (Keen and Morton, 1978, pp. 70-73).

This theme has recently been gaining support as behavioral scientists increase their attention on the organizational change problems associated with system development. New ideas on implementation, resistance to change, and organizational politics have been evolving for system projects (Keen and Morton, 1978). Much of this concern focuses on the user-developer relationship, especially since it is commonly assumed that both people belong to the same organization. Churchman and Schainblatt (1965) advise that users and developers need to develop a mutual understanding; Lucas (1978b) proposes a model for development based on this concept. This perspective needs to be extended to other people in the user organization as well.

ETIP Examples

The PBS planning system project demonstrated the problem of a mismatch between system and user structures. In this project, a system was built to help analyze the different options available for meeting Federal office space needs. The system was conceived, developed, and operated within a special studies staff unit of the agency. This group was attached to the upper levels of agency management and normally did not have a role in the analyses. The users of the system were the agency line divisions who did not have the responsibility for the analyses. To some extent, these users were involved in the development and did eventually start to use portions of the system. However, their lack of control over the system highlighted a role conflict that prevented full implementation.

The importance of a technical match between design and user is easily demonstrated in the ETIP-SBA data system project. Here, developers created a system to help users match potential government contracts with small business who could perform the work. A manual processing design was first used which required a lot of information about the contracts and the firms in order to perform the analyses. Unfortunately, the design was poorly matched to the circumstances users faced. First, users didn't have the time to do the matching because of the short schedule agencies allowed them to have. Second, they often could not get a complete, detailed view of the potential contract because the agency would not release them in full before the official announcement. Third, in order to make a match with a firm, a user had to outline the potential contract to the firm and gather information on their experiences with similar work. This was a problem because it exposed the contract before it was officially distributed by agencies, possibly violating their procurement procedures. Finally, users really wanted a system to help them find firms. They considered the problem of matching firms to contracts as part of their expertise and skill and not a process which could be routinized on a machine. All of these technical problems contributed to the unpopularity of the system and its later abandonment.

Demonstrating the importance of personnel matching in the ETIP case studies is difficult since the evidence for problems is indirect. However, the state and local procurement project offers some experiences from which personnel matching problems can be inferred. In this project, success depended heavily on the personal rapport and influence developers could establish with potential users. The developers, NASPO and NIGP, were two nationwide professional organizations representing state and local procurement officials. While they had no power over their membership, their professional relationship with officials was expected to be sufficient to attract user attention to the system and gain support. ETIP contracted with these two organizations and planned to have them assume full control of the system at the end of development. Thus NIGP and NASPO, and their relationships to users, were to become integral parts of the final design. Both NASPO and NIGP also expected to increase their stature and influence with officials by implementing the system.

Later progress did not fulfill these expectations. It was found that users were influenced by a host of factors and that the developers did not always have the leverage to effectively cause change and gain system acceptance. Neither NASPO or NIGP were able to motivate users to conduct many of the experiments ETIP had planned. System products became hard to develop and hard to sell to users. Technical problems with these products further decreased NASPO and NIGP influence.

It was also learned that the financial support planners had expected to obtain from users in the long run was dependent on decisions by executives or legislators outside of the immediate user agencies. NASPO and NIGP had little established contact with these groups.

Thus not only was their influence weaker than expected with procurement officials, but they also had little prior experience working with other key system supporters. Besides indicating a weak match for personnel, this also unfolded into a broader structural problem as defined earlier.

5.2.4.3 Factor 11 -- Novelty of the Design

<u>Description</u> -- The change a new system represents over the existing system.

<u>Discussion</u>

Another key indicator for monitoring the adaptation of a system to an organization is the degree of change a new system represents relative to the existing system (Thompson, 1978b). Incremental changes would mean simple, small improvements from current procedures, while more significant changes would mean the creation of previously non-existent procedures. Generally, one would expect novel changes to be more difficult to make. The resistance to change would probably be higher in users and the extent of implementation problems greater. In contrast, incremental changes would be expected to cause fewer problems for users and generally be easier to implement.

Since there are many types of change involved in system development, developers need to review a number of different aspects in order to gauge the degree of change involved. Significant changes in any of the following design factors might have important implications for development strategy (Thompson, 1978b, p. 329):

- System functions.

  Functions previously unavailable may represent a significant change to users. These functions may have been impossible to develop before, or maybe they were not considered. There may have been no preexisting need.

- Performance.

  Dramatic changes in performance over an older system may represent a source of significant change to users. While the actual performance improvement could represent a small design alteration, the implications of it may be much broader for all associated activities.

- Operation.

  New ways of doing things may be a significant change for users familiar with the older system.

- Other systems.

  The relationship to other systems may change with the implementation of a new system.

- Support.

  The organizational support for a new system might be very different than that given to the old one. A new system may create previously nonexistent barriers to its operation.

The importance of changes in these areas is well recognized in systems development literature, especially that evolving from behavioral and management scientists (Keen and Morton, 1978, pp. 61-98). Concern has been increasing for the impacts new systems can have as a result of the changes they make in an organization. User resistance to change and the broad area of implementation are two examples of literature sectors examples where discussion on change can be found.

Several development strategies have been created specifically around the problems associated with the degree of change involved in a new design. Most of these strategies emphasize or imply slow, incremental change from the old to the new system. New designs should start out as only modest alterations of procedures or structures users currently have. More complex functions can be added later (Alter and Ginzberg, 1978; Lucas, 1974b). The implication of this strategy is that fewer organization changes, and thus problems, will occur. Further elaborations of these ideas can be found in other similar models: the incremental approach, the bottom-up approach (Davis, 1974, pp. 409-410), or the evolutionary approach (Lucas, 1978b; Mohan and Bean, 1979, p. 147).

Other authors disagree with this strategy. Churchman (1954, pp. 162-163) points out that the simple, incremental strategy assumes that the "simple" design can be identified and that progress from simple to complex designs is possible. Mohan and Bean (1979, p. 147) suggest that the evolutionary approach may be most effective in early stages and that later on it won't make much difference in success. They believe that a revolutionary approach, e.g., one involving radical design changes, may be appropriate in cases where there is strong commitment for it from the user. Radical change might provide benefits more quickly than would be possible in a slower strategy, especially where it is obvious that a weak existing system cannot be improved significantly. This was shown to some extent in the development reported by Ruth (1978) (see section 3.3.1.3).

ETIP Examples

All of the ETIP system development cases involved one type of design improvement or another over the existing systems. Most of these changes would probably be considered somewhere between incremental and modest, since new designs did not significantly alter any established functions. However, this judgement might vary depending on who's perspective is taken.

For example, project planners probably thought that the proposed SBA data base system was a modest change in operations for SBA field officers. SBA wanted to increase the number of government contracts set-aside for small businesses. In order to do this, they had to improve the process by which field officers justified set-asides to contracting agencies. This involved helping the officials more easily match contracts to firms and demonstrate to agency decisionmakers on objective criteria that qualified small firms existed. Essentially, users (the field officers) did this work already, except that it was at a more brief, informal judgement level. Developers expected design stages to be short and that most of the project would be field testing.

Some users did not consider the new design to be quite so modest. First, they felt the problem of matching firms and contracts was complex and required their skill and judgement. It was a process that couldn't easily be formulated into a set of standard procedures. Second, the forms and procedures associated with the system represented a lot of additional work to users which they didn't have time to perform. As a result, very basic resistance to the design evolved and developers were prevented from gaining further acceptance of the system in many of the sites they were working with.

At another site however, this resistance was minimized when developers were able to give the users something they really needed. In this case, developers decided to supply a data base of firms, thus alleviating the significant problem of just locating sources. In addition, the matching procedures were computerized, also eliminating the time problem. These improvements apparently overshadowed the concern about routinizing field officer skills since the system was then used in real cases.

This case seems to demonstrate that design improvements over an older system should be monitored for the degree of change they imply. There will be different perspectives on the degree, however, and each should be noted. The case also demonstrates that different facets of change can affect each other. A change in one area, such as a function (e.g., matching firms and contracts in the SBA case), may be compensated to a degree by change in another area (e.g., including a new data base in the SBA case).

5.2.4.4 Factor 12 -- Evaluation and Updating

Description -- The provision of evaluation and updating functions in the system design.

Discussion

A final design characteristic for monitoring the adaptation of a system to an organization is the preparation made in the design for routine evaluation and updating. Users will most likely plan for some kind of evaluation before they fully commit themselves to a system. Periodic reviews of this nature may even continue after the system is made operational. In addition, changes in the organization and its environment are likely to occur throughout the life of a system. A design may become quickly outdated unless procedures for revisions are also established. It will be advantageous if provisions for these review and updating functions are considered early in designs and made an integral part of the system (Jue et al., Note 6, p. 1; Waller et al., 1976, pp. 63-64; Zimmerman, 1977, p. 190).

Developers may want to monitor several different aspects of the revision problem in order to assure that designs are being appropriately prepared. Some of these aspects are the following:

- Evaluation criteria.

  Assuming that some kind of evaluation is needed, developers should identify the decisionmakers involved and their criteria. These decisionmakers might include groups well outside of the immediate user units. These criteria may be uncertain in early stages and may need development. Developers should think through how these criteria can be applied and built into a design.

- Decision points.

  Several models for development (see Chapter 3 and Project Control, section 5.3.4) suggest the need for explicit decision points at the end of each stage for approving the continuation of the project. If this approach is used in a project, developers should examine early what information might be needed about the system. Implications from analyses like these may possibly provide the basic strategy for later system testing (see Testing, section 5.3.5.3).

- Other organization review processes.

  If the system is to become an integral part of an organization, its evaluation and updating functions may need to be tied to already existing organizational review procedures (Office of Federal Procurement Policy, 1976). This might include reviews of the organization conducted from the outside as well. Developers may have to adjust designs to accommodate changes from these sources.

- Freezing a design.

  At some point it may be advantageous to freeze a design in order to bring the full system into operation without continuing distractions for revisions (Flagle et al., 1960, p. 114). Developers need to examine where updates should be made and which ones can be delayed without risking problems. In cases where updates are put off, provisions should be made for users to initiate them when they assume complete responsibility for maintenance of the system.

- Mechanisms.

  Finally, developers need to examine how evaluation and updating function overall. They should study whether problems are identified, whether redesigning occurs in a timely manner, and whether changes actually are, or can be, made. This mechanism must be operational like any other system component when the system is finally institutionalized.

ETIP Examples

The kind of preparation suggested for this evaluation and updating indicator was not a significant part of any of the ETIP system development cases. While evaluation and updates of the designs were made during the projects, provisions were not made however to routinize these functions within the designs. Only in the PBS planning system were updating procedures considered in the overall design. Even so, this meant only that it was possible to revise the computer programs and that the agency systems department was given control to do so. There wasn't an overall process tying system operation, evaluation, or performance together in a manner which would promote needed and timely revisions. The evidence seems to indicate that revisions were expected to be performed on a more informal basis.

5.3 PROCESS CHARACTERISTICS (FACTORS 13-24)

5.3.1 Introduction

A system development can be described by the methods, procedures, personnel, resources, and structure developers use to operate the project. These factors contain a process perspective in that they are the means toward an end: the eventual design and institutionalization of the system. Factors which denote project activities like these are defined as process characteristics in the monitoring framework.

The following sections identify and describe 12 factors. These have been separated into four categories: task structure, team personnel, project control, and interaction with the user environment. Task structure factors are for indicating how tasks are defined and prioritized. Team personnel factors refer to characteristics of the project teams developers use to conduct the tasks. The three main factors in this category are the skills needed on teams, the turnover of personnel, and the related factor of commitment to the project. Project control factors indicate how tasks are being managed. These include the organization of the central management team, delegation of responsibilities, and mechanisms developers use to monitor and review project activities. The final category of factors, interaction with the user environment, characterizes the contact between users and developers. This especially includes the key factor of user involvement in the project.

A special note should be made here concerning the different groups which may be involved in a development. A development may be the responsibility of several different institutions which are normally independent of each other. For example, developers may need to enhance the technical skills on project teams because of the lack of in-house staff. Thus, contract support may be obtained for the duration of a project or for special selected tasks. In another case, developers may be supported financially by a third party, such as an ETIP, even though this group is not a part of their organization.

The development process under multiple group arrangements like these can be complicated. Authorities and responsibilities must be delegated among the various parties and relationships must be established. The different roles and capabilities must be closely coordinated so that project resources are allocated efficiently. Different perspectives on strategy may arise, as may other conflicts, and these will have to be identified and resolved in order to maintain momentum and commonality.

Complicating arrangements like these are not always considered part of the development process. For example, contracting as an issue has rarely been considered in the behavioral and management science literatures dedicated to system developments. Models from these sectors usually group everyone involved into either user or designer categories (Kolb and Frohman, 1970; Lucas, 1978b) and ignore situations where independent parties may be involved. On the other hand, contracting has long been a concern in military weapon system developments (Gordon, 1980; Hill, 1970; Livingston, 1959; Peck and Scherer, 1962).

Some of the following sections for each factor include discussion on how multiple group situations can affect a project, particularly in contracting cases. These discussions illustrate the additional characteristics developers should monitor when more than one group is involved. Many of the ideas in these sections have been adapted from the techniques used in military weapon system acquisition procedures.

5.3.2 Task Structure Factors

General Description

A system development can be divided into a series of specific tasks or group of tasks. Tasks are usually grouped into categories or phases, such as problem identification, design, or evaluation. These demarcations are fairly arbitrary, however, and disguise the true cyclic process and sequencing of development tasks.

Of more interest are the actual tasks which occur within and across phases like these. Identification and coordination of these tasks represent a significant problem to developers. For example, tasks related to different subsystems may be similar and need coordination. In other parts of the design, some subsystems may need to be fully developed before others. Task structure, then, is an area developers need to monitor in order to assure that the various development activities are properly sequenced and coordinated.

Two different characteristics of task structure are discussed in this section. One is the size of tasks in terms of manpower, money, and time. Developers should monitor tasks so that these resources are consumed as planned. Large changes in consumption may have significant implications for other development tasks underway or planned.

A second characteristic to monitor is the priority of tasks. Development tasks will have some order in which they should be performed. This order might be established by factors such as resource availability, time needed for accomplishment, or the priority of user problems. Since any of these conditions can change, it is useful if developers monitor them so that changes in priority can be quickly identified and controlled.

5.3.2.1 Factor 13 -- Task Size

Description -- The amount of resources (money, manpower, and time) assigned and consumed in the performance of individual system development tasks.

Discussion

The size of project tasks, or groups of tasks, is one characteristic developers should monitor throughout a project. The size of a task includes the amount of money, manpower, and time consumed in performance of the task. These characteristics together represent the "cost" of developing system components, a related but distinct factor from the cost of operating a system (see section 5.2.2.3).

One of the main reasons to monitor size characteristics is to control costs. Costs can easily expand beyond initial expectations if there are major technical uncertainties in the design or numerous changes of course in the project. Significant amounts of project resources may become tied into solving these problems without considering the implications for overall project goals. Developers may thus reach a point where they become locked into a design because most of the resources have been consumed in trying to make it work. The lack of success and the need for additional resources in order to finish the design may make further work less attractive. Early and progressive monitoring of resource expenditures may help avoid becoming overcommitted to a narrow portion of the project or running out of resources at key points (Jue et al., Note 6, p. 1; Flagle et al., 1960, p. 110; Thompson, 1978a, p. 129).

While there is no one right size for project tasks, many literature sources recommend dividing projects up into small, manageable steps which are easier to control (Chervany, 1978, p. 157; Krasnican, 1971, p. 55). There are some good reasons behind this strategy:

- Overall, system developments are complex undertakings which involve numerous, intertwined problems. Breaking off and working on small pieces of the problem can make the project easier to handle. As more is learned about the user environment, more complex and expansive tasks can be undertaken.

- In the early stages of a development, smaller investments of resources by users and developers can reduce the risks involved in choosing one direction over another. The chances of a large scale failure may then be reduced (Davis, 1974, p. 408).

- Developments are likely to contain a number of changes which can upset the flow of a project. Using smaller, discrete tasks and gradually moving towards more complex undertakings can help protect against major disruptions (Fronk, 1978).

- Overall success may be more easily attained when smaller lines of work are used. A strong track record of modest successes may increase the likelihood of overall success (Edelstein and Melnyk, 1977; Ein-Dor and Segev, 1978, p. 1073).

On the other hand, smaller, more numerous tasks imply more project control and monitoring than might otherwise occur. More effort must be expended to coordinate activities and to decide how to break projects apart. This could become most inefficient if carried to an extreme. Developers have to balance the risks in committing themselves to certain task sizes with the benefits they can achieve in work flow, control, and likelihood of eventual success.

ETIP Examples

Demonstrating task size problems in the three ETIP cases is somewhat difficult in a retrospective analysis. All of the cases experienced cost overrun problems. For example, in the SBA data base system development, the project ran out of resources before enough successes could be achieved to gain the needed user support. Monitoring task size, among other factors, might have helped avoid these problems, but it is hard to show.

The state and local procurement project does, however, provide some indication that developers were concerned about the task size issue. In this case, they discovered that resources were being spread too thinly across most of the major project tasks. Progress was very limited overall. In some areas, tasks were being ignored and resources needed for their accomplishment were being jeopardized by commitments in other areas.

Developers eventually elected to reduce the number of tasks in the project to a much lower level. It was hoped that more limited successes would be possible before project resources were expended. Unfortunately this did not occur and the project was subsequently terminated. In retrospect, it appears that developers may have become overcommitted to a strategy which diffused their resources too broadly.

5.3.2.2 Factor 14 -- Task Priorities

Description -- The relative emphasis across tasks at a given point in time and the ordering of tasks over time.

Discussion

A second characteristic of task structure which developers should monitor is the priority of tasks. This would include monitoring the emphasis and concentration needed across tasks at a point in time as well as the ordering of tasks over time. Besides influencing the flow of work, priorities can indirectly affect the level of support and interest that a project gains, both from the user and the developer. Gaps between the user and developer priorities may reduce the likelihood of successful development.

There are a number of factors which can affect what the priorities should be over the life of a project. One factor is resource availability. Developers should examine when project resources, like manpower and money, will be available. Project resources may be under various controls which affect the time at which they are available. This availability should be compared against the requirements of development tasks as they are planned and initiated. Developers may also choose to construct resource controls of their own while performing tasks. For example, it might be advantageous to be able to make some early accomplishments which are at a low cost to the project and the user (Kraemer and King, 1978, p. 30).

A second factor affecting task priority is the time needed to accomplish a task. There may be significant technical uncertainties concerning design requirements. Designs which are significantly different from current user procedures may also create a number of other organizational problems (see section 5.2.4.3). Developers should examine how long it may take to accomplish tasks and gauge their initiation accordingly. Changes in time requirements during a project should also be monitored so that implications for other tasks can be identified.

A third factor is the priority of user information problems. Problems of concern to the user organization must be identified and prioritized so that they are solved within a reasonable time horizon (Mohan and Bean, 1979, p. 147). These problems would of course have to be compared against overall project strategy. Major objectives should not become jeopardized by distractions on numerous quick-turn-around user requests. On the other hand, developers should avoid becoming mired in comprehensive information flow analyses which consume much time and produce few measurable changes. Some mixture of attention to high level concerns (the "top-down" approach) and to basic operational problems (the "bottom-up" or evolutionary approach) is probably needed (Davis, 1974, pp. 405-409).

A fourth factor affecting priorities is the interrelationship of subsystem components. Some parts of a system may need to be developed before others, while other parts can be developed independently or in parallel. As a consequence, development tasks may need some level of sequencing in order to obtain a finished design. Early attention to boundaries at the system and subsystem level will facilitate this ordering (Hill, 1970, p. 131).

A final factor affecting the priority of tasks is the need for accomplishments. In order to maintain momentum and build credibility for a design, it is useful to assure that measurable progress is made. For example, it may be important to have some early outputs to which users can react (Edelstein and Melnyk, 1977; Krasnican, 1971, p. 55; Moore and Byrd, 1977). These might include dummy mock-ups of reports or conceptual designs of the system. Items like these can help reduce the early abstract level of a development and refine the user information problems. They may also help build top management support and interest (Mohan and Bean, 1979, p. 147). Developers should monitor where and when accomplishments are needed so that adequate preparation can be made for them.

ETIP Examples

Several different examples of priority problems are available in the ETIP system development projects discussed in Chapter 2. In the SBA case, developers initially focused on the wrong user problem. First they attempted to establish a system to help match federal contracts with potential small business sources. Unfortunately, the priority problem for users was simply to find sources they could contact. Matching sources with upcoming contracts was a function they had little time to do and considered an important skill. Developers eventually had to accommodate their need before any significant progress was made in other areas.

In the state and local procurement case, a split over priorities among members of the development team inhibited progress in later stages of the project. Both sides had originally set the priority in development as one of making early accomplishments with users. This meant identifying several user information problems, developing packages to help solve them, and actively marketing the packages to users. Unfortunately, this strategy assumed that user problems could be easily and quickly solved. This was later found to be incorrect. User information problems were more complex and solving them seemed less certain. Developers needed more manpower, more time, and new subsystem components. Essentially, a new set of priorities emerged, since the early strategy for accomplishments had become less realistic.

Given these problems, the system contractors (NASPO and NIGP) recognized that a broader perspective was necessary. They envisioned more gradual change in the user environment and more limited accomplishments. ETIP, however, did not accept a significant change from the original priority. Eventually, the ETIP view prevailed as the working strategy, but a basic disagreement over priorities was initiated.

This affected the working relationships within the development team for the remainder of the project.

5.3.3 Team Personnel Factors

General Description

A second process characteristic developers need to monitor is the need and availability of skilled personnel to the project. Large scale system developments can involve a broad range of skills over a considerable time period.

Developers must first ensure that the skills needed in the project team are obtained. These will range from managerial to technical areas. Recent systems literature, especially in the behavioral sciences, has also been emphasizing the need for a mix of interpersonnel and technical skills. This is a recognition of the organizational problems which new systems can entail. Developers need to monitor whether the necessary skills are being applied.

Second, developers must monitor the turnover in personnel that is likely to occur. Turnover of key personnel can slow progress in a development by consuming time to transfer knowledge between incoming and outgoing personnel, or by bringing in new perspectives which must be accommodated with already existing strategies. While some protection might be made in advance to reduce this problem, developers need to find ways to minimize the impact of turnovers. This requires close monitoring and early identification.

A final area developers should monitor is commitment of personnel to the project. Commitment of the staff to a project is a predecessor to the more comprehensive commitments by users. Changes in these commitments, or differences between team members, may be an early indication of uncertainties in project goals or strategy. They also may be a signal of forthcoming problems for full scale operation of the system. Developers need to monitor the commitment of team personnel to identify changes and examine their implications.

5.3.3.1 Factor 15 -- Skills

Description -- The availability of technical and interpersonal skills in project teams as required by system development tasks.

Discussion

System developments require a range of skills which developers must ensure are available. At one level, there are the technical aspects of design which require people trained in specialized areas. For example, computer system developments would need technical analysts skilled in hardware design. At a second level, there are interpersonal aspects of design which require people trained in understanding and working with people. The importance of both types of skills is recognized increasingly in the information systems literature, especially in behavioral and management science sectors (Argyris, 1971; Miller and Willer, 1977; Nicholas, 1978). Development models prepared by authors in these areas place heavy emphasis on the interpersonal relationship between developers and users (see Chapter 3, section 3.3.3.3).

While it is useful to match people to jobs, developers must be wary of utilizing personnel who are too highly specialized. Systems people should have a mix of both technical and interpersonal skills so that they can more effectively handle the complex, intertwined problems that developments involve. Developments can fail because people on the development team have an uneven awareness of the different aspects of these problems. For example (Mumford et al., 1978, p. 235; Thompson, 1978b):

- Technically oriented system analysts and designers may have little knowledge or interest in human engineering issues.
- Managers, on the other hand, may be minimally trained on technical matters and prefer to concentrate on budgets and schedules. They may be reluctant to intervene in design decisions.

Developers need to examine whether the requirements of system tasks are being met by people with the appropriate skills and backgrounds to handle them. Contracting for these skills may be necessary, and this may present an additional number of problems developers should consider. For example, contracting requires developers to design a procurement procedure that specifies the kinds of skills needed. In addition, contracting for support results in a new, outside team that requires integration into the user organization.

ETIP Examples

Skill problems were prevalent in the state and local procurement development discussed in Chapter 2. The initial strategy used in the project was to identify user information problems, locate appropriate information sources, and then transfer the information. It was assumed that little or no modification of the information would be necessary, since planners expected that it already existed in other more advanced state and local user agencies. Developers, therefore, initally placed less emphasis on technical skills than on marketing and user contact skills.

Later, however, it was learned that user problems were much more complex and would require original technical work if they were to be handled. This expertise was not easily available to the project, either by contract or outright hiring and progress was delayed as a result. It can be argued that the complexity of user problems might have been identified sooner if technical expertise had been more prevalent on the development team in the beginning.

It is also interesting to note that it was well known in the project that the contractors had little experience in systems development. Even the contractors admitted this in the early phases. As a consequence, little broad thinking was done on user problems, overall system design, or different design options. The lack of systematic analysis was mentioned several times by ETIP, but few improvements occurred in the contractors. When project resources were dwindling and few accomplishments were on record, developers quickly dropped any further system considerations in favor of emphasizing a more limited number of specific projects. These were no longer tied to any overall system design strategy.

5.3.3.2 Factor 16 -- Turnover

Description -- The change of personnel involved with project teams.

Discussion

A major problem for a development team is turnover in its personnel (Ackoff, 1960; Fronk, 1978; Krasnican, 1971, pp. 54-55; Patterson, 1977; Thompson, 1978b; p. 329). Important knowledge can be lost in key project areas that would ensure continuity. Even in cases where no knowledge is lost, newcomers will need time tc familiarize themselves with a project. This can cause delays. If they also bring a different perspective to the design or the development process, then conflicts with remaining personnel may arise. In addition, in cases where users are key team members, turnover may affect the user organization as well as the team (see also User Commitment Characteristics, section 5.4). Support for the system may be affected.

Turnover in the project team is likely, however. Large scale system developments can easily take a length of time which exceeds the tenure of some people, especially when there are long delays (Ruth, 1978, p. 38). It is also possible that the more experienced systems people may leave when the interesting problems have been solved. For example, as development reaches the operational/maintenance phase, project activities may be relegated to lower level staff (Chervany, 1978, p. 177). Well experienced or qualified people are also likely to be in demand for similar projects elsewhere, and thus may be the first to leave (Ruth, 1978, p. 38).

Developers might prevent some turnover by initially obtaining long term commitments from key team members who would represent a significant loss to the project (Ruth, 1978, p. 38). If contractors are involved in the project, this is often done through the use of key personnel clauses in the contract.

Changes are, however, inevitable and developers need also to examine ways to minimize their impacts (Alter and Ginzberg, 1978, pp. 26-28). Several actions may be taken. Developers can establish an executive management team, and other teams for that matter, such that key tasks and responsibilities are shared among several people (Ruth, 1978, p. 38). This may help avoid the problem of having important project knowledge concentrated in one person. It may also minimize the uniqueness of any one job. Thus the skills needed in tasks become available in a team instead of depending on hard to replace, broadly trained individuals.

Another method for use during a project is for developers to continuously encourage people to remain throughout the development. Continuity in a project can be more easily ensured if the same team remains in all phases, design through implementation (Edelstein and Melnyk, 1977; Ginzberg, 1978a, p. 60; Comptroller General, 1978,

p. 8; Radnor et al., 1970).

Also during a project, developers should monitor task structure in relation to how personnel are assigned. Team members with numerous assignments over several tasks can have more of an impact on a project than those who are committed to a smaller number of areas. Developers may want to reduce broad assignments for project personnel. This may of course be a difficult strategy to use for top managers of the development, and other measures may have to be considered.

ETIP Examples

Some turnover occurred in the three ETIP cases reported in Chapter Chapter 2. However, it was difficult to analyze their impacts and the effect of the changes are thus unclear. No examples have been selected for presentation here.

5.3.3.3 Factor 17 -- Commitment

Description -- The team member support for and implementation of the goals, strategies, and tactics of the system development.

Discussion

One of the major themes in this dissertation is that user commitment to a system is a sequence of actions over time. It begins with the initial idea for a system and continues as long as the system is in operation. A number of different factors can be used to monitor commitment, and these are more broadly covered in the following sections on user commitment characteristics (section 5.4).

A portion of the commitment process of concern here is the commitment of personnel on the development team to the project. Commitment of project team members to the goals, strategies, and tactics of the development is an important predecessor to the eventual full user commitment to the system. A lack of personal commitment may result in key staff turnovers (see preceding section), or be evidence of a much broader problem in the home organization. Gaps in commitment between team members may be a source of confusion and uncertainty which slows progress. Gaps between team members and their home organizations may have the same effect. Developers (team members) need to be sensitive to the commitments of personnel in the project. Shifts or gaps need to be detected early and their broader implications handled in line with project goals.

Monitoring commitment to the project involves a number of indicators applicable to each of the different groups involved. Projects of interest in this dissertation usually involve several groups who have few organizational ties. First, members of the user organization usually manage the project and have other staff participating in specific tasks. Second, other outside groups, such as ETIP and system support contractors, also have a central role on the team. All of these groups are referred to here as developers and commitment characteristics are relevant for each.

If a project involves numerous uncertainties and is considered a novel endeavor, top quality people from each group are likely to be involved on the team. This includes both managerial and technical personnel. Contractors may commit their more experienced personnel initially if they envision the experience to be important for their future growth (Thompson, 1976, p. 43). Similarly, a user organization may view the system as a key resource for their work and thus may want their best people involved (Katch, 1978, p. 54). The initial lack of or later turnover in key personnel may be a signal that the project is off-target, or becoming increasingly isolated from the major concerns of the various home organizations involved. It also may simply be a sign of personal disagreement over strategy. In any case, developers should identify these conditions and openly consider the implications of any commitment changes in key personnel.

A related indicator of project commitment is top level management support from the home organizations. Most of the systems literature suggests that this is one of the more important factors related to successful development (Boland, 1978; Comptroller General, 1975, p. 8; Krasnican, 1971; Zand and Sorenson, 1975, p. 545). Large scale systems can have wide ranging impacts on an organization and can involve numerous, previously unrelated people. This may be the case both within, and between, the home organizations. Top level management support in each organization helps ensure that the broad range of personnel involved work together (Ackoff, 1960, p. 262; Comptroller General, 1978, pp. 9-10). Support at a high level may also act as an incentive to the various personnel to get involved (Lucas, 1975b, p. 34). Developers should monitor the extent of high level management participation and initiative as a sign of project commitment (Katch, 1978, p. 54).

A third indicator for monitoring commitment is the overall size of the project relative to similar work or competing work in the home organizations (Thompson, 1976, p. 43). The home organizations may have several on-going projects which are competing for the same personnel. Personnel may become too broadly committed to a number of different projects which reduces their effectiveness to the system development. Developers need to monitor the position of the development relative to other work in the home organizations and gauge changing commitments of personnel accordingly.

A final area to monitor is the difference between commitments across the groups involved. For the case of systems developed by several different organizations, one group may maintain commitment to the project, while it decreases in others. Differences over project goals, strategy, or tactics may cause changes in personnel with the result that the team then exhibits a cross section of talent, perspectives, or status. While a cross section like this is not inherently a problem, it may create a mismatch of personnel that leads to conflicts.

ETIP Examples

A good example of the project commitment problem is exhibited in the state and local procurement system case. This project began with a fairly strong commitment across all of the organizations involved. FSS was a key supporter of the project plans and expected to participate in the development and use system outputs. ETIP committed a high level of funding to the project. Top level people in the two contractors (NASPO and NIGP) were involved in the planning, saw the project as a means for further strengthening their ties to their constituencies (procurement officials, the end users), and committed much of their time to development. Support also extended across a broad range of the eventual state and local users.

Later points in the project did not exhibit this high level of interest, however. Federal participation was low, and motivating participation at the state and local levels was difficult. The organizational and technical difficulties involved in developing the system caused a split between ETIP and the contractors over the best approach to reach project goals (see Chapter 2 and Task Structure above, section 5.3.2). The contractors maintained a commitment to project ideas but changed their view of the strategy needed. They became convinced that slower, more gradual change was needed at the state and local levels before a system would be accepted as a routine mechanism for solving information problems. ETIP, on the other hand, continued its commitment to the original strategy, which involved achieving specific changes with users. ETIP also downplayed more of the "systems" aspects of the project in order to obtain results. The project was eventually terminated without much accomplishment in either area.

In retrospect, it appears that the differences within the project team should have been examined earlier by developers. The changes in participation were an early sign of decreasing interest in the project. Earlier attention to the problem would have enabled developers to consider other goals and strategies more attractive to the team. Unfortunately, the awareness of differences came fairly late in the project and probably made it more difficult to adjust the development and successfully complete the project.

5.3.4 Project Control Factors

General Description

One factor having a significant effect on a system development is the process used by developers to control the project. Large scale system developments are complex undertakings which involve numerous activities, problems, technical issues, opportunities, etc. They can be further complicated in situations where more than one organization is involved. In this case, new relationships will have to be established and the activities of unrelated organizations coordinated. Developers will need to examine in advance how to control the development and delegate responsibilities. They will also need to monitor the control processes used so that revisions can be made if they prove to be ineffective for accomplishing project objectives.

Three categories of process control methods will be discussed in this section. First, the organization of the control structure as to teams and responsibilities will be examined. Developers need to establish a management structure which matches the complexity of the development and the distribution of responsibility. Second, the use of decision points and milestones will be reviewed. Developers can use specific points in time or the accomplishment of selected tasks as control points where progress can be reviewed, problems can be identified, or approvals for further work can be obtained. Finally, developers can use reports and reviews to monitor work, document and discuss complex problems, or as a means of disseminating information about the project to relevant outside stakeholders who may have influence over the development.

5.3.4.1 Factor 18 -- Organization and Responsibilities

Description -- The structure of project teams and responsibilities in the system development.

Discussion

A key part of project control is the team structure used by developers to manage and conduct the project. Part of the structure should include a central authority which can coordinate and manage the numerous organizations and people involved. This central entity also needs to develop and refine objectives and strategies as the development proceeds. Another part of the structure will involve the distribution of responsibilities to the personnel actually performing the work. Day-to-day control of project activities will be located at lower management levels. Much of the technical problem solving and delineation of strategy in a large complex effort should also be conducted at these levels. Developers will need to examine early in a project the kind of structure they use to conduct and control the work and then progressively monitor its effectiveness in accomplishing project tasks.

Many literature sources, especially in the management and behavioral sciences, advocate the use of a small, central team for managing a systems project. This team controls development overall and reports to higher level decisionmakers in the organizations supporting the project. A common problem for the team is who has final authority. In projects where only one organization is involved, such as with an in-house development, the team should probably consist of both users and designers with users retaining ultimate control (Lucas, 1975b, p. 112; Lucas, 1978b, p.43). This would also help build commitments from users. The problem is more complex when multiple organizations are involved, however. For example developers may elect to use outside contract support to conduct the project, or a third party, such as ETIP, may be providing the resources for development. In these cases, the theme of user control may still apply, but project control may be more shared among the participants. For example, basic project control might be the responsibility of a single contractor, who must, of course, then report to and meet the needs of the contracting user. The central development team may then consist mostly or completely of personnel outside of the user organization, while the users themselves utilize their own team to control the contractors. Thus in the end, users do retain control of the development, but a large portion of the responsibilities are located elsewhere.

This problem of control in multi-organization developments can be a critical one for developers. Generally, it is probably advantageous in large scale developments to have central authority (management) located in one organization. For example, in military system developments, a number of different arrangements have been tried (Livingston, 1959):

- Central control in the government, with numerous associate prime contractors.
- Central control in one prime contractor, with numerous associate prime contractors.
- Team contracting, where one contractor assumes the lead role among a group of contractors committed to work as a team.

In each of these cases, one organization assumes the lead role of control and the others recognize their authority. Similar arrangements could be possible even within a one organization development where numerous in-house divisions are involved. Developers, and their respective home organizations, will have to decide in advance where the locus of control will reside and then use formal agreements, such as contracts or interagency agreements, to establish the structure. The effectiveness of the agreed upon structure will also have to be monitored during development to ensure that it works. Formal agreements shouldn't act as a barrier to revision of the structure if developers find that objectives are not being met (Gordon, 1980).

An additional, related problem is whether developers utilize new teams or existing ones to form the working level structure. Developers may choose to form new teams to conduct the work by drawing on personnel from existing organizational units. These teams can be designed to include the appropriate skills and levels of manpower needed to perform a task. They can be mobilized and demobilized as required (Flagle et al., 1960, pp. 102-103). On the other hand, these teams will be new to an organization and people will have to be shifted around (Chestnut, 1967, p. 39; Thompson, 1976, p. 44). The project will have to be placed at a high enough level so that transfers can be accomplished (Flagle et al., 1960, pp. 102-103). There may be a transition period as teams are formed and new relationships established. Personnel may not be available, especially if their loss would cause significant disruptions to their home units.

An alternative to the project structure is to rely on already existing groups or structures. In this case, project tasks would be assigned to the units who would then decide how to perform the task and staff up for the work. While this avoids the problems in creating a new project team, several others can emerge. First, existing groups may not have the needed skills or manpower to perform the task. They may have to rely on liaison with other existing groups in order to supplement their capabilities. This could create additional levels of authority and control which are far removed and possibly less affected by the central project authority. Already existing units will also have their own well established agendas which will compete for staff time. Staff loyalties will likely reside in their home unit. Developers may find a structure such as this too cumbersome for most project tasks. However, it may be useful for some of them and be workable in combination with other newly created teams.

Whichever approach is chosen, developers will have to examine how responsibilities are delegated to the working level teams. Centralized control of all project activities will likely be impossible, and for that matter, inefficient and unnecessary. Numerous problems and decisions can be delegated to lower level working groups where they can be effectively handled as they arise (Peck and Scherer, 1962, p. 455). It will be advantageous overall if working level groups can gain the ability to recognize problems and opportunities on their own and then have the flexibility to handle them as appropriate for project objectives. Large scale, complex system developments will involve too many problem areas for a central team to handle. In addition, the time to solve them through the central authority will slow progress and reduce the likelihood for creativity needed in complex problem solving.

It should be recognized, however, that some problems (or opportunities) may arise which fall outside the organizational lines chosen by the developers. Developers should consider the need for ombudsmen who can be assigned to these unique problems (Lucas, 1974b, pp. 80-91). These individuals might report directly to the central management team.

ETIP Examples

The state and local procurement project illustrates a number of control problems that systems projects can have, especially with multiple organizations. The development involved several different groups: ETIP, the two contractors (NASPO and NIGP), federal, state, and local agencies. The two contractors were responsible for developing the system and were to eventually provide its home. ETIP provided the resources to fund the development and expected to supply technical guidance as needed. Another federal agency was interested in the system and was to provide technical materials and support if requested by developers. However, there was no formal agreement with the agency on its role. Finally, state and local agencies, the system users, were to provide manpower and test sites for development activities.

The central control in the project was located within the two contractors. Each contractor was responsible for delineating the specifics of project goals and designing activities accordingly. This had the advantage of giving some user control to the project, since the two contractors were professional organizations representing users.

Since the two contractors began at different times, each contractor began with its own central team. These were loosely coordinated during phase 1 due to the similarity of objectives. This autonomy was altered in phase 2, however, when concern increased over the slowness of progress. ETIP then chose to bring the two contractors into a closer working relationship where they could share technical materials and resources. ETIP also assumed a more active role in guiding the contractors than had originally been planned. It would appear that central project control shifted some to ETIP.

At the working levels, both contractors formed task forces of volunteers from state and local agencies. These task forces were to develop information packages which would be pilot system outputs for use by procurement officials. Volunteers came from agencies with an interest in the development of a particular package. This mechanism was itself a pilot test of the process developers expected to institutionalize into the system. NASPO chose to have the task forces run on their own with minimal technical guidance from the central team. NIGP chose to control the groups more closely by hiring an in-house technical coordinator.

As described in Chapter 2, these teams encountered serious difficulties in completing their tasks. User problems were more complex than originally thought. NASPO, NIGP, and ETIP had little control over the task force volunteers and the project was competing for the time of busy officials whose priorities were still with their home agencies. Accelerating task force progress was a problem and acquiring more manpower from other organizations, especially those with a background in the relevant technical problems, proved to be difficult. As a result, ETIP had to again assume a more active controlling role to attempt to solve this problem. When additional manpower was not forthcoming, ETIP elected to reduce the extent of contractor activities so as to increase the manpower and resources on a few selected task forces.

Very similar manpower problems also emerged in each project concerning the conduct of system design tasks. Manpower experienced in the development of large scale systems was very limited in both contractors. In addition, most of the available manpower was directed toward managing and accelerating the activities of the volunteer task forces. ETIP first became concerned about the delays in systems tasks during the middle of phase 1. ETIP again chose to temporarily take lead control over the project and start the design activities. Eventually, a pilot design was produced for the information items to be included in the system. ETIP then returned to its support role.

ETIP reentered project control again in phase 2 when continuing delays in the task forces made further progress uncertain. At this point, ETIP elected to concentrate most project attention on the task forces and also began to have a more active role in decisionmaking. The two contractors did not completely agree with this narrow focus, however. They believed more fundamental, incremental changes were needed before task force outputs would be useful. This split in approach may have placed even more of the project control within ETIP instead of the contractors.

In retrospect, it would appear that one of the central problems of the project was the need for more manpower and technical expertise to be under the direct control of developers. Developers had little flexibility in their working teams to accommodate the technical problems due to the unavailability of their volunteer members. Developers also found expertise difficult to acquire elsewhere. More in-house staff with full commitments to the project probably could have accelerated the work and helped to identify the user problems more quickly. This might have altered project strategy much earlier.

5.3.4.2 Factor 19 -- Decision Points and Milestones

Description -- The structure of specific events created by project managers to recognize or review progress and decide future courses of action.

Discussion

Large scale system developments involve numerous activities, problems, and opportunities which need some level of ongoing recognition and approval from the central project team. For example, several occasional high level decisions will be needed to select from among the various design options and strategies available and then to allocate resources accordingly. Decisions like these may require formal acceptance by all of the different organizations involved in the project. Conversely, numerous lower level decisions on specific tasks and problems arising within project phases will also be needed. While these may not require recognition by all of the project participants, they might provide useful milestones for gauging progress. Developers first need to examine in advance where major and minor decision points should be placed and then actively monitor their occurrence.

For the higher level issues, decision points are often placed at the end of phases which denote changes in the development. For example, many system development models divide a project into phases such as planning, design, testing, and operation/maintenance. This structure implies an orderly transition from designs on paper to hardware assembly for all system components. Decision points are located at the end of each phase to mark the conclusion of the activity and to select the strategy for the next phase.

The exact placement of major decision points is fairly arbitrary, however. Activities implied by the name given to a particular phase probably recur throughout the development of a system, particularly if the progress on different subsystems varies or if cycles are made to refine earlier designs in light of new information about the user (Weiss, 1977, pp. 38-90). For example, planning on one subsystem may occur while others are being tested. Developers may have to select points at which the development is, in general, making a transition.

The flexibility in placement is not meant to indicate that major decision points have a minor importance. In developments with significant uncertainties and risks, placing decision points at the end of phases provides some protection against making commitments too early. This is more simply called the "fly before buy" strategy (Gordon, 1980, p. 39). Major decision points also provide a means of controlling a project, especially in assuring that organizations centrally involved in the development have the power of control. For example, the General Accounting Office (GAO) found that government systems projects often acquired a momentum of their own and were completed without any major approvals from users (Comptroller General, 1975, pp. 8-9) (see section 3.3.3.2 also). Projects moved along according to original plans and success or failure had little effect on the transition from one phase to another. The GAO recommended that formal decision points be included at the end of each major project phase and that separate budgets for the different project phases also be used.

Major decision points at the end of phases are not the only control points needed in a project. Developers will also need to emphasize sequential approval and acceptance of progress during each phase (Thompson, 1976, p. 49; Zand and Sorenson, 1975, p. 545). Problems and opportunities can be identified more quickly and acted on at a point when action is needed (Gordon, 1980, p. 34). Reworking, redesign, and argument after the fact can be avoided (Thompson, 1976, p. 49).

Within each phase, then, developers should select events or milestones as formal, recognized points for monitoring. Milestones can be either points in time or events (Gordon, 1980, p. 34). They might represent a series of events or a composite of actions which conclude with some identifiable accomplishment. The key is for developers to select milestones which provide insight to project activities and prediction power for future success or failure. They should be something which are (Gordon, 1980, p. 34):

- Objective, in that they are not subject to widely different interpretations,

- Material, or can be seen directly, and
- Significant, in that their accomplishment has some significance in the project.

A series of milestones can have the additional benefits of leaving a better documentation trail and improving the decisionmaking conducted periodically at the end of phases.

ETIP Examples

In retrospect, it is difficult to identify the selection, monitoring, and use of decision points and milestones in the three ETIP cases. Generally, documentation of actual progress is much briefer than that found in the original project descriptions, plans, and structures. A complete record of milestones and major decisions is not available. Thus, it is difficult to directly identify how they were used by developers for project control.

Nevertheless, some conditions can be implied from the available project histories and used to illustrate the decision point factor. For example, the SBA data base system project shows a degree of project control via a series of major decision points and project phases. The project had six phases: problem definition, preliminary design and planning, operational planning and full development, test planning, testing, and operation and maintenance. Each phase was marked by a final report from the contractor and a decision by ETIP and SBA to proceed to the next stage. The support contractor accomplished the stages on time and generally demonstrated orderly progress on the objectives. In addition, plans for subsequent stages were constantly updated at the end of each phase and thus were successively reapproved by the central development team.

This structure did not appear, however, to have been effectively used by developers to help control the project and assure success. By the time developers reached the operational testing phase, the numerous problems users had with the design slowed further progress considerably. Test cases from users were very difficult to obtain, even if the cases were retrospective and thus would not have been affected by a test. The preliminary manual system design quickly approved in earlier phases was not, in the end, very marketable to users. Progress remained delayed until major design changes were made and the computerized system developed.

Another example is found in the state and local procurement information system project. In this case, two contractors were acquired to develop a system for state and local procurement officials. The project was divided into two parts, one for state and one for local users; each was designed to run approximately three years. Each project had three major decision points built into the strategy and budgeting: (1) planning and staffing, (2) specific experiments to synthesize a system, and (3) institutionalization of the system with users. The use of more specific milestones in each project was different, however. In the state level project, specific milestones were developed, but they changed several times, especially in their specificity. It appears that they were developed late in the first phase, which was the planning and staffing phase, and were not used routinely after that. The structure and terms varied considerably in subsequent monthly reports. In contrast, a milestone structure does not appear to have been adopted in the local level case. However, since both projects were essentially consolidated to one during the second experimentation phase, the state level milestones were loosely applied to the local case.

In each project, the decision points located at the end of each phase were used to control the allocation of resources to the next phase. This provided the checkpoint at the end of phase 2 when ETIP decided to terminate the projects. While the use of these points helped avoid the problem of unbreakable momentum discussed earlier in this section, they did cause distractions from the main project work. This was because all of the groups involved in the development spent considerable amounts of time preparing information for the decision. This analysis time may have been the result of earlier inactive monitoring of milestones which could have developed the needed information base. This would partially demonstrate the value of successive approval and acceptances during each phase, as mentioned above.

It is unclear, however, what effect the milestones had for project control. In the state level case, specific milestones were available, but there was a delay in their development, and the structure does not appear to have remained consistent throughout the project. Their application appears uneven since they were used to signal slippages and lack of progress during phase 1, but not during phase 2. Also, it is unclear whether the progress in phase 1, according to the milestones, had an effect on the decision to proceed from phase 1 to phase 2.

In the local level case, milestones were not developed during phase 1, but the project was loosely gauged in phase 2 according to the general milestones designed for the state level case.

Overall, for both projects, it appears that the milestones provided some insight to progress and problems, and that developers occasionally used them as a background from which to measure progress. However, a comparison of the problems occurring with the milestones, interventions from developers, and the use of decision points, indicates that milestones were probably not actively monitored and used as control points to alter strategy and implementation as the projects unfolded.

5.3.4.3 Factor 20 -- Reports and Reviews

Description -- The structure of written and oral communication mechanisms used to document and review development progress.

Discussion

Decisionmaking and control of a large scale system development will involve some level of information transfer between the various groups involved in a project. Transfer and liaison with other groups outside of the project may also be needed (Thompson, 1976, pp. 46-49). Two common mechanisms for processing and transferring information are reports on project activities and periodic reviews of major technical and organizational level issues. Developers need to structure in advance where these reports and reviews occur over the life of a project and who may be involved. Developers then need to monitor whether these mechanisms prove to be sufficient for transferring key information of the level and at the timing needed to control the project.

Written reports on development activities or issues can be defined at a number of different levels. First, the content of reports can vary by purpose. Reports might be generated on schedules, costs, expenditures, designs, strategy, etc. Second, reports can be produced at various times, such as periodically or on a special, one-time basis. Third, reports can be produced by different groups, for different groups. For example, if the development involves contract support, there may be reporting required between contractors and the development team, and also between the development team and higher level members of the user organization. A key problem is proper identification of the organizational levels (on the team and in the user organization) at which reports should be directed (Ackoff, 1960).

Developers need to consider several factors when designing or scheduling written reports. First, reports require a significant amount of time to prepare. They can distract key members of the development team from the priorities of the project. Developers should keep the number and extent of reports small and monitor whether too much effort is being diverted to their production.

Secondly, reports may serve purposes beyond project control which need to be considered when reports are designed. For example, developers may want to document portions of the project for later review (Thompson, 1976, p. 46). This might be important in areas where uncertainties remain and developers choose to forego further work (Krasnican, 1971, p. 55); later exploration could be more fruitful. Reports might also act as marketing documents for the project and the system. Organizations or institutions outside of the system may have a central interest in it and developers might choose to disseminate information to them. As with groups internal to the user organization, a system may also appear threatening to these outside groups and developers should consider how reporting might reduce this problem (Thompson, 1976, p. 47).

Thirdly, developers need to consider the appropriate level of reporting. In some cases, more informal liaison between groups may serve the purpose of transferring the needed information, while in other cases more formal communication through channels is needed (Thompson, 1976, p. 47). This could affect the type of report needed.

Finally, since reports take time to prepare and revise, their utility in real time project control may be limited. Developers may need to rely on other means to help control a project (see design reviews below) and let reports act more as a record of already recognized and approved activity (Thompson, 1976, p. 49).

More direct real time control may be exerted through the use of face-to-face meetings and discussions which can quickly pinpoint problems and options. It is common practice in system developments to use design reviews for the purpose of reviewing general problems, strategies, and the like, and making changes. For example, military and system engineering system development models often use major reviews when there is to be a transition from one development phase to another. These can be called preliminary design reviews, critical design reviews, first article configuration inspections, demonstration acceptances, etc. (Chestnut, 1967, pp. 37-39, as adapted from Air Force Systems Command, 1966; Hill, 1970). The basic strategy of these reviews is to compare progress, either in specifying a design or actual construction, with previous design plans. Inspections, for example, mean comparing hardware with the paper design. Demonstrations can mean the review and acceptance of assembled subsystem components in comparison to expected overall system performance specifications. Reviews like these could also be extended to more narrow, specific problems or subsystems and occur more frequently than once during a phase. The extent of participation by the central development team might also vary in this case. Developers need to identify what reviews are useful and who should participate and contribute to them.

ETIP Examples

It is difficult in retrospect to determine how the reports and reviews structures of the three ETIP cases were used in project control. Numerous reports were produced in each case, primarily monthly progress and final reports, and various meetings and reviews occurred. The effect of these activities on decisionmaking and strategy is not easily traced. (Part of the problem is due to the fact that the case studies were conducted much before this section was written.)

However, the state and local procurement project illustrates a structure of reports and some of the issues of reports and reviews. In this case, reports were mostly produced by the two contractors involved in the project. Several different deliverables were specified in the contracts: monthly progress reports, quarterly reviews, special reports, final reports for each phase, and briefings. In the monthly reports, the contractors were to detail progress, problems, activities, contacts, and whether ETIP assistance was needed. Quarterly reports were to be more general statements on progress that would provide overall perspective on project objectives and strategies. Final reports were to be produced before the end of each phase and were to be used to support the decision points on whether to move into the next phase. Generally, this structure was followed in the projects.

It appears in retrospect that the monthly reports were probably more useful in documenting progress than for controlling project implementation. For example, in the state level project, the structure and content of monthly reports varied throughout the project. At first, monthly reports followed the outline specified in the contract and this was satisfactory to ETIP. Later, when a milestone structure emerged for project tasks, monthly reports were altered such that sections were written on each specific milestone. This format was discontinued after several months and was not immediately replaced. About one year later, midway into phase 2, monthly reports reemerged in a format similar to the initial one, except that progress was now reported by major task only. The structure of the tasks was different than that developed earlier in phase 1. This format continued until the project was terminated.

Using these reports to assist in project control would appear, in retrospect, to be difficult. First, the content of the reports varied and thus a consistent structure to gauge progress was not available. Second, the detail used in the milestone structure was probably too cumbersome to effectively monitor progress overall. Too much information was presented, and this may have been a greater burden on the contractors than intended. This may have caused the change back to a more general level. Third, it seems as though the items in the reports were being recognized at a time long after which they needed action.

Project reviews probably compensated some for the problems with the monthly reports, since records of numerous meetings were found. However, a planned structure of reviews was not found and only a few major design reviews occurred. For the state level project, one review was held midway during phase 1. At this time, progress on the major system development objectives appeared to be slow or inadequate, especially since little attention was given to them in the previous monthly reports. The review provided the first opportunity for developers to meet and discuss system design and strategy. Available documents show that developers outlined the contents of the information system they wanted and some of the procedures they expected to include. This meeting did affect project design in that the problems arising with users were recognized by changes in the planned information services. Subsequent monthly reports and other letters from the contractor included these changes. Attention towards these materials does not seem to have continued into phase 2, however.

One other major review occurred midway in phase 2 when an upcoming decision point was recognized by developers as a critical point for continued project support from ETIP. As discussed in the section above on Decision Points and Milestones, the groups involved in the project prepared a new set of materials for this review. It appears that the previous design specifications and other related materials did not have much of a role in these newer reviews. Subsequent documents prepared for the decision were at a general level and did not include many specifics about system design. It must be noted, however, that, at this time, ETIP had elected to concentrate more on individual experiments with users than on developing the system.

From an overall perspective, the state and local projects partially demonstrate the difficulties of controlling a project through reports without also including more direct contacts in project reviews. The various significant problems developers encountered with users had major implications for the expected system design. While these were recognized at different times in some of the reports and reviews, these mechanisms appear to have been ineffective since the problems reoccurred and the basic strategy for the development was only slowly changed. Developers may have needed to plan and structure more reviews in advance, with specific attention to overall objectives, in order to identify the problems earlier and adjust their strategy accordingly.

5.3.5 Interaction with the User Environment Factors

General Description

A key part of system development is the interaction developers have with the user environment. Interaction is needed in order to transfer information about the user problems to the design team and to progressively develop and transfer the system to users. Interaction is also beneficial for establishing relationships with users. Their openness and support will be critical for design and eventual institutionalization.

There are two related perspectives developers should monitor about interaction. First, there is direct user involvement in the project. User involvement is one of the main factors found to be important to project success in the literature (Keen and Morton, 1978, p. 196). Both the extent and type of their participation are important (Boland, 1978, p. 897). Enlisting their participation and support early and routinely will provide the basis for user commitment to the system (see also User Commitment, section 5.4). The first section below will discuss these considerations in more detail.

A second perspective for developers is that of contact with the user organization in general. Isolation from the user environment can lead to serious problems in the design that can threaten project success. Extensive contact should be made in order to extract the key user problems around which a system needs to be designed. As a project evolves, testing designs in the user organization will be critical for verifying concepts and checking actual performance. Accceptable designs will then have to be transferred to users by a means which minimizes disruptions in the organization. Sections on each of these processes -- problem identification, testing, and transfer -- are presented below.

5.3.5.1 Factor 21 -- User Involvement

Description -- The participation of members of the user organization in the managerial and technical teams of the project.

Discussion

One of the major factors found to be important in system development is the involvement of users (Keen and Morton, 1978, p. 196). Projects conducted in isolation from users or without the active participation of users have often resulted in designs which do not meet users needs and gain little support for institutionalization. Developers need to identify areas where user participation is required or beneficial and monitor project tasks to assure that participation is solicited and utilized. Special attention should be given to identifying key users who can articulate the demand for the system in the organization and whose support may influence the participation of others (Lucas, 1978b; Thompson, 1978b, p. 332) (see also System Champions, section 5.4.3.1).

One approach to user involvement is to include users on project teams, both at the managerial and working levels. This provides a mechanism for user control of the project and a basis for eventual ownership of the system (Lucas, 1978b). It also helps ensure access to the organization for the collection of information needed by design teams (Nay, 1973, p. 121). Soliciting involvement at this level of the project may be unnecessary in cases where developments are already conducted by users within their own organization.

Developers should also consider involving users from different levels of the organization. Managers and line groups may have different perspectives on the information problems and the appropriate system designs (Flaherty, 1980, p. 223). These gaps may hinder progress unless they are resolved (see also Boundary Factors, section 5.2.3). A formal user group composed of users with different perspectives may assist developers in building the needed consensus and momentum (Comptroller General, 1978).

Obtaining user involvement may be a difficult problem in itself, however. Users may not have the time to be actively involved due to the press of other business in the organization. It also may be unclear who should be involved, particularly if the system is a new entity for the organization and the final home unknown (Thompson, 1978b, p. 332). Early participation may be tentative and weak until more is known about project objectives and relationships between developers and users are established. As mentioned above, if there is little consensus on the need for a system, users may also resist involvement and continue to support other systems (Ruth, 1978).

Close involvement may also have some risks which developers should consider in soliciting participation. Early project stages are likely to be characterized by exploration, uncertainty, and shifting concepts.

Utilizing the limited time of users at this stage may be inefficient until clearer tasks emerge. In addition, high levels of involvement may raise expectations about the system. Difficulties or delays may lead to higher disappointments later if these initial expectations are not met (Lucas, 1976, p. 68).

ETIP Examples

The SBA data base system project demonstrates some of these user involvement factors. In this case, SBA contracted the development work to a consulting organization. While the contractors performed some preliminary studies of user problems, they essentially conducted most of the initial design work outside of the user environment. Their strategy was to first develop a system which could then be tested with users for an extended period. These tests would depend on heavy user involvement.

Developers found, however, that the system was not attractive to users. Some of their key problems were not solved by using the system. Also, since most users were very busy, it was difficult to enlist their participation in tests. The SBA central office, which controlled the development, attempted to improve participation by sending a letter to supervisors. This had little effect in the end because field users did not have a close relationship with the central agency decisionmakers.

It would appear that development might have benefited from earlier participation by users. The key problems could have been uncovered sooner and integrated into design considerations before significant investments in time and resources were made. In addition, developers might have attempted to formulate an advisory group composed of both field level and central office personnel. This group might have highlighted the different perspectives on the problems and resulted in the identification of common objectives. This would have probably assured more participation in the testing phase where developers depended heavily on user acceptance and support.

5.3.5.2 Factor 22 -- Problem Identification

Description -- The overall amount of attention to and the amount of contact with the user organization in the definition of user problems.

Discussion

One of the more important parts of the development process is problem identification (Comptroller General, 1975; Hall, 1962, pp. 7-11; Keen and Morton, 1976, p. 196; Lucas, 1978b, p. 51; Office of Federal Procurement Policy, 1976). Information problems are likely to be unstructured and complex. They will probably be closely intertwined with other problems in the user organization. Early definitions of the problem may be too general or simplistic and, in any case, will probably change as more is learned about the user environment and design options. Developers shouldn't necessarily expect to achieve early understanding of the key problems as many may be uncovered later. Nevertheless, project success will depend on how well the problems are defined and used to design a system. Attention to problem definition should be given early and routinely throughout the project.

A systematic approach to problem identification will benefit the development (Bostrom and Heinen, 1977). Emphasis should be placed on learning about the user environment from a number of different perspectives: how it works, goals, decisionmaking styles, decision processes, information flows, other information systems, etc. (Lucas, 1978b, p. 51; Mason and Mitroff, 1973). The goals and expectations for a new system would also be an important item to include here. Developers might start their analysis at the highest decisionmaking levels and work into the organization. Also, concurrently, they can examine the lower working levels of the organization and move up decisionmaking chains. The perspectives on the information problem may vary considerably across the different organizational levels (see Boundary Factors, section 5.2.3). In addition, adapting a system to the user will depend on accurate knowledge of these areas (see Adaptation Factors, section 5.2.4).

Problem identification should also be extended to the external environment of the user. The user organization will probably have relationships with outside groups that can have significant effects on the organization itself (Ein-Dor and Segev, 1978, p. 1073). For example, government agencies have budgetary relationships with the Office of Management and Budget. Developers should examine and monitor these linkages and determine how they might affect system design (see Boundary Factors, section 5.2.3). It would also be beneficial to determine what information about the system these groups might need during the development (see also Reports and Reviews, section 5.2.2.3).

As information is gathered from these areas, it may become useful to organize it by constructing some models (Gorry and Morton, 1971).

At first, these might be descriptive models about what is happening: the players, the decisions, and the information needs (King and Cleland, 1975; Munro, 1978). It may take several feedback cycles with users in order to obtain accurate models. Later, a second set of normative models can be developed to describe the decision processes users would like to have. These models might include changes in the organization itself as well as new mechanisms. Descriptive and normative models can then be compared to help identify key information problem areas.

Developers should also consider how the information they collect during problem identification can be used to help the organization directly (Thompson, 1976, p. 55). A system development may present one of the first times the organization has been closely examined, particularly by outsiders. Developers may uncover many factors about the organization that were not previously known (Argyris, 1971; Krasnican, 1971). Detailed feedback to users about current processes may identify improvements which can be made immediately without proceeding with a new design (Ackoff, 1967, pp. B-153 - B-156). Close study may also reveal widely varying knowledge or perspectives on organizational problems, including the information problem of concern (Flaherty, 1980, p. 224). It may be important to project success to reduce these differences. User recognition of the need for change has been found to be a key factor in successful development (Zand and Sorenson, 1975, p. 545). Developers should spend time communicating and selling the problem to the user (Moore and Byrd, 1977)

Spending time on problem definition with users may also have additional benefits besides locating the need for a system. It will begin to set a precedence for close user contact and involvement with the development. Some users may not understand what a systems project is or will have significant anxieties over how it will change their jobs (Argyris, 1971, pp. B-289 - B-291). They may resist providing information or access to their programs. Similarly, developers may be uncertain of what will happen or be inexperienced in what to do. Close contact betweeen the two groups can help reduce these problems by promoting a mutual understanding (Boland, 1978; Churchman and Schainblatt, 1965). For those users not directly involved, the perception of close contact may be important for their support (Lucas, 1975b, p. 34).

Other benefits might include the following:

- Establishing a language about problems and designs which users and developers understand (Zimmerman, 1977, p. 188).
- Identifying key underlying assumptions in problem definitions which need examination (Mitroff, 1972).
- Discovering areas where resistance to change may be great and organizational politics important (Keen and Morton, 1978).
- Starting to build user commitment to the system.

ETIP Examples

The importance of problem identification with users was demonstrated in the ETIP project on the SBA data base system. The project was aimed at the general problem of increasing the number of government R&D contracts set-aside for small businesses. SBA field officials were responsible for identifying potential set-asides and justifying them to government agencies.

Developers elected to concentrate on the portion of the problem related to matching contracts with firms. A system was developed to categorize the R&D work described in a contract work statement and then to acquire information from potential firms on the same items. Firm capabilities or experiences could then be analyzed in detail as to whether they were similar to the needs of the work statement. A good match would demonstrate that small firms were capable of performing the work, thus justifying a set-aside to them.

When developers reached the field testing stage, however, they found that the system was not attracting much interest from users. Developers had great difficulty obtaining cases, real-time or retrospective, on which to try the design. Users complained that the real problem they needed help on was simply to find firms whom they could contact. Matching firms and contracts was something they felt depended on their professional expertise, rather than simple, easily mechanized procedures. As discussed in the case history (see Chapter 2), further progress was delayed until developers produced a system design which addressed the source list problem.

In retrospect, it would appear that developers did not maintain an early close relationship to users that might have prevented the subsequent design problems. Even though developers had been in the field early to collect data on what was happening, the source location problem was not apparently discovered. It wasn't until developers brought the system to field workshops to introduce it and collect test cases, that the more pressing user problems were discovered. This was not easily compensated for by the developers since many of the project resources had been committed to the design already and the remaining strategy depended heavily on quick user acceptance. Early, more intensive contact and iterations with users might have prevented these problems and allowed developers more flexibility to alter their strategy and designs.

5.3.5.3 Factor 23 -- Testing

Description -- The amount of concept and design testing conducted in the user environment.

Discussion

As more is learned about user information problems and the user environment, concepts and designs for the system will emerge. Early designs may be formally or informally tested by developers within the project before they are presented to users. Also, user involvement on design teams may offer a chance to collect early user reactions to design options without having to make presentations to the user organization. Eventually, it may become necessary to directly test designs in the user environment as a means of substantiating design expectations or claims. Testing in the user environment may also be important and beneficial for:

- Competitive demonstration.

  Several competing proposals for a system design may emerge in the project and testing in the user environment may be critical for selecting among them.

- User involvement.

  Testing in the user environment can give users something to react to (Zimmerman, 1977, p. 190), especially those users not directly involved in project teams. Their knowledge and opinions may be critical factors for system designs. Participation in a low risk test may be an effective means of obtaining their ideas and support.

- Commitment.

  Favorable results from tests may be one important factor which eventually results in full user commitment to the system. In addition, opportunities may arise for early use of the system while it is still under development. These may provide an early payoff which should be taken advantage of.

Developers should establish an active program of testing with users and continue it as long as necessary in order to resolve uncertainties in design (Gordon, 1980, p. 35).

There are several different levels of testing in the user environment which might be considered by developers. One is to use models on paper or dummy mock-ups of the system and/or its products (Fronk, 1978; Lucas, 1978b, p. 44). The earliest of these might be descriptive and normative models of the user decision processes which evolve in problem identification activities (see above section). Rapid feedback to users of information like this can further educate users as to what is needed as well as provide a test to determine whether developers are understanding their needs (Fronk, 1978; Lucas, 1978b, p. 44).

At another level, working models of subsystems might be constructed and pilot tested under various conditions with users. Different parts of the overall design can be tested by themselves and at the appropriate stage of development. For example, developers might choose to focus on a particular decision problem or one facet of it and then produce a working model to test their design concepts for this one problem.

Other subsystems might benefit from the results of tests like this or be developed independently later.

Selecting particular problems and developing simple and limited subsystems independently of each other can provide certain benefits to system developers. For example:

- An incremental, evolutionary approach (Davis, 1974, pp. 409-410; Lucas, 1978b) reduces the degree of risk involved. Developers don't have to commit themselves early to one design concept or an overall design plan.
- Problems or failures in design can be localized and minimized (Davis, 1974, p. 408).
- A track record of modest successes may increase the likelihood of overall success (Edelstein and Melnyk, 1977; Ein-Dor and Segev, 1978, p. 1073).
- Tests involving designs that make small, incremental changes in procedures may entail less user resistance and open the way for a new approach (Thompson, 1978b).

Complex functions and their testing can be added later when the different, specific facets of a process have each been individually studied and understood.

Finally, as many of the system components become developed, a prototype system can be formulated and tested with users. A prototype design would be expected to include most or all of the functions developers had found to be needed by users. It would also include the various interconnections between subsystems or between the system and outside groups. The prototype design would provide for a full scale system test and check the emerging design against the original performance objectives.

An important part of testing at of any of these levels will be the development of user criteria to evaluate the performance of designs. Developers will need to identify in advance and progressively refine the criteria users prefer to apply. Besides inquiring directly about these with system users, developers might also consider examining organizational review processes which already exist. Also, there may be criteria originating from outside the user organization and developers may need to interact with these groups. Developers should also consider how the criteria and procedures used for one test can be used for future tests and updating. Some of them may be appropriate for institutionalization within the system for routine use after development is completed (see also Evaluation and Updating in section 5.2.4.4).

ETIP Examples

All of the ETIP system development cases included some form of testing in the user environment. In the SBA data base system and the PBS planning system cases, testing was most prevalent in the final stages where developers entered operational testing phases. Here the objective was to utilize the new system in both retrospective and real time decision problems where the system was needed.

These tests proved to be important to overall strategy. In the SBA case, developers found mixed feelings among the potential users. Many considered the system to be aimed at the wrong problem and resisted participating in any testing. Others provided some retrospective cases for developers, but were not attracted enough to attempt a real time test. These reactions were a major problem for developers since they had planned to test the system for one year using both retrospective and real time cases. The lack of participation left them few means to establish a track record of success which they could use to market the system to users. This was critical to developers since their own internal tests did not appear to be sufficient in themselves to attract widespread use. Given these kinds of problems, it might be argued that developers delayed too long before initiating active testing in the field with at least some pieces of the design.

In the PBS planning system case, testing demonstrated both problems and successes which were beneficial to project strategy. Developers were able to conduct tests on both retrospective and real time cases. Tests showed that users were not very interested in using the main analysis features the new system offered. However, the tests did show that some limited portions of the analysis capabilities were attractive to users and could easily become routine parts of user processes. This had not been expected earlier by developers. While it represented only a very modest success for the project, it did show promise for institutionalization at the end of the project. It was also possible that the parts of the system not being used might later become operational. It is hard to measure whether earlier testing directly with users would have achieved this same end result.

The state and local procurement system case had a slightly different approach to testing than did either of the other two cases. In this project, developers chose to test small models of the expected system process early with users. This was to help them test their ideas and gain an understanding of user needs. Special, common information problems were identified in early stages of the project and work was started to develop packages to help solve them. Developers were to then market the packages to users, along with the system design. Eventually it was hoped that users would begin to support the system.

This early testing strategy proved to be a good one in that developers learned the extent of user problems through direct contact. They found that user problems were more complex than originally thought.

However, developers apparently had difficulty translating these results into an improved development strategy. The same strategy was maintained throughout the project, with some minor variations, and user problems continued as before. Eventually, project attention was focused exclusively on the tests. It may be that too much attention was placed on the tests versus the system design, ignoring especially the implications for design based on the lessons being learned. Developers might have tried to improve their design and then reentered the user environment for more tests. Competitive testing of alternatives, or at least active consideration of alternatives based on available test results, might have resulted in a design better matched to the circumstances.

5.3.5.4 Factor 24 -- Transfer

<u>Description</u> -- The amount of attention devoted to the transfer of the system to the user environment.

<u>Discussion</u>

A key transition point in a systems project is the transfer of control and support from the developer to the user. Transfer of the system to the user is often referred to by several names: implementation, institutionalization, cut-over, or conversion. Conventional development models usually place these activities in late phases of the project (Ackoff, 1967; Alexander, 1974; Davis, 1974), while newer evolutionary models emphasize more gradual transfer of ownership (Lucas, 1978b; Office of Federal Procurement, 1976). These newer models recognize the human and organizational impacts changeover can have and the need to plan transfer as early as possible. Whichever approach is taken, developers need to think through the implications of changing to a new system and routinely monitor whether their strategy is leading to a smooth transition of ownership and full user commitment.

Transfer of a system to the user is an activity which can and should begin early in a project. As concepts and pieces of the design evolve during problem identification activities, developers should consider how the designs would become fully operational and institutionalized within the organization. The differences between the new design and current practice will help identify possible transition strategies and key problems (see also Novelty of the Design, section

5.2.4.3). Asking users directly about transfer related problems would also be a useful strategy. For example, involving users who will eventually support and operate the system when it is fully institutionalized may provide insights for the design which would facilitate its transfer to them (Katch, 1978, p. 59). Similarly, close user involvement on the design teams will provide a means to transfer concepts. This would help establish a basis for later transfer of the specific designs.

As designs are detailed, tests may be conducted to verify concepts and performance. This is another stage in which transfer considerations should be studied by developers. Tests in the user environment may be designed to include user participation in using and working the system. This will provide a temporary means of exploring how to transfer system components to users from the developer perspective. It will also provide a low risk means for users to explore the transition to a new system. Feedback from their perspective will be useful. Developers should be able to learn lessons about transfer from testing which can be used later in future tests and final institutionalization.

When it is appropriate or required, the system or individual components will be transferred permanently to users (the turnkey system). Developers may have the choice of transferring the system gradually component by component, or quickly making the transition from the old to the new system. Several factors can be considered in deciding which approach to take:

- Abrupt transition.

  Complete rapid transition to a new system may be too risky or unnecessary. If there are user problems needing quick attention, it may be beneficial to institutionalize key components as they are available. Radical changeover may create a number of side impacts with users that only complicate the transition and start-up periods.

- Backup systems.

  It may be beneficial to gradually phase in the new system while gradually phasing out the old. This will provide some backup or protection should unexpected problems occur. Users should not be left without any system if delays occur (Ruth, 1978).

- Training.

  Users need to be trained to work with a new system. Users should be involved in developing training programs (Thompson, 1978b, p. 332) and training needs should be a part of design activities (Lucas, 1975b, p. 112). The availability of these programs may influence the transfer point.

- Documentation.

  Documentation of the design and related matters should be complete as possible, especially before transfers are made. Areas where design problems remain should be thoroughly documented so that users can continue development later (Krasnican, 1971, p. 55).

- Management support.

  As the point for transferring a system to users approaches, it is possible that managers (both of the project and the user organization) may start assuming that the system is complete and its implementation routine. This may cause a lack of attention towards transfer which jeopardizes final stages. For example, lower level and less experienced staff may be assigned to transfer tasks and cause implementation failure (Chervany, 1978, p. 177).

When the system has been mostly or completely transferred to the user, a final stage of withdrawal and termination should begin for the project team (Kolb and Frohman, 1970). In termination, developers need to ensure that (Alter and Ginzberg, 1978, p. 24):

- Ownership and control of the system rests with those who must use and maintain it.
- Necessary new patterns of behavior have become a stable part of the user's routine.

The basic goal is to refreeze the organization (Lewin, 1952; Schein, 1961) by removing the disturbances of change and leaving the organization in a stable position (Zand and Sorenson, 1975, p. 545). Termination should probably not be abrupt. For example, developers might continue to monitor system performance under full user operation and help with any unusual problems that arise in start up. Also, developers should ensure that evaluation and updating functions become operational so that users learn to revise the design themselves (see also Evaluation and Updating, section 5.2.4.4).

ETIP Examples

The importance of transfer varied in the three system development cases. In the procurement information and PBS planning system projects, the systems were developed under the control of the eventual system owners. Direct users, however, were to be officials outside of the home organizations. Also, to some degree, the systems depended on outside groups for manpower, data, and technical support. It appears that neither project employed a transfer strategy to develop routine, on-going relationships with these groups. In the PBS case, developers met with resistance by users and support groups alike who continued to rely on their existing system. Developers did manage to enlist user interest in small parts of the system, but it is not known whether this eventually resulted (after the project was over) in developing the support needed to sustain the system. In the procurement system case, it became clear that the evolving design would depend heavily on voluntary manpower from users and other institutions in order to develop the technical materials users needed. Project documents indicate that developers had difficulty enlisting this support, but a transfer strategy is not observable. Developers may have needed to concentrate more on this factor since technical backup appeared to be such an important function in the design.

The SBA data base system was the only project where development occurred primarily outside of the user-owner environment. A contractor was selected by the SBA central office and ETIP to conduct the development. They designed two systems, one manual and one computerized, and essentially operated them during the entire project. As in the other two ETIP cases, a transfer strategy is again not observable. Developers found that the manual system was unpopular and not a feasible way to help solve user problems. It was deemphasized. The computer system proved to be more successful with a small set of users. However, it was expensive to operate and user support could not be generated to continue its development or to adopt it into agency practice. The central office also elected to end its support. Thus, transfer may have been an unimportant issue as it became clear that basic support for the system could not be obtained.

5.4 USER COMMITMENT CHARACTERISTICS (FACTORS 25-30)

5.4.1 Introduction

The final category of factors in the monitoring framework is for measuring the extent of user commitment to the system. Commitment to the system is viewed in this dissertation as a series of user decisions or actions over time which indicate increasing user interest, support, and acceptance of the system. Full commitment to the system will emerge when users elect to assume total responsibility for the operational system and the development project is terminated.

This section identifies and describes six factors for developers to use in monitoring commitment. These have been divided into two areas: factors relating to use of the system and factors relating to support of the system. Monitoring use of the system involves examining the type of applications made, the actions resulting from use, and the extent of use across the organization. Prior to actual applications during development stages, monitoring should be concerned with user decisions in these areas and the progress made in designs. Problems in defining use may signal changing or uncertain user commitment and require revisions in design or strategy. Later, as designs are finalized and components become available for implementation, monitoring actual use provides further signs of increasing user commitment. Wider, repeated applications indicate user acceptance, while disinterest, avoidance, or isolation of the system from routine organizational business may indicate a decreasing commitment. Problems like these in later stages may jeopardize reaching the ultimate goal of full user operation.

Numerous other changes or actions in the user organization may be needed during development to gain system acceptance and provide for full operational support. Developers can monitor these supporting actions for further signs of commitment. In early project stages, the emergence of system champions who strongly support the development and implementation of the system may be one of the first indications of eventual commitment. Another indicator is the level of resources users commit to the system. These allocations may first occur as direct support of the project and include manpower and money. Later, as components become available, users may decide to allocate resources to operate the system. Developers should also monitor the user organization for changes that indicate support for system operations, such as training programs or incentives to use the system, or changes made as a result of system use, such as in decisionmaking styles or the way the organization works. Changes like these indicate strong user commitment to the system. The lack of essential supporting actions or reactions may signal that commitment is minimal and full scale operation doubtful.

5.4.2 System Use Factors

General Description

One theme in this dissertation is that user commitment to a system consists of a series of user actions over time which gradually build to a full acceptance and support of the system. One set of user actions indicating commitment relates to system use prior to full implementation and the end of development. Early indicators of use are the decisions made about the types and extent of system applications users need. These influence both the design requirements and the project control strategy. In later project stages, such as testing and transfer, developers can monitor actual uses and gain feedback on how well the system meets expectations. Problems at these stages may have a significant impact on user commitment since they are likely to be very visible. Developers need to closely monitor use at this point so that the appropriate changes can be quickly made in design or strategy.

Three factors are described in this section. First, developers need to identify the types of applications of the system (or ones it is expected to have). This requires identifying system actions with specific user tasks. The second indicator of use is the activity resulting (or expected to result) from system applications. These actions need to be documented as they will likely play a key role in obtaining full user commitment to the system. Finally, developers should monitor the extent of use in order to gauge how frequent and widespread it is (or will be). This may be an especially important factor to the top level managers who will decide whether to provide the resources needed to fully support and institutionalize the system.

One ETIP system development case is used to illustrate these factors. For simplicity, the case is described in one section after all the factors are described.

5.4.2.1 Factor 25 -- Applications

Description -- The use of specific elements of the system in specific units of work of the user organization.

Discussion

Developers need to identify the applications of a system to user problems as one part of monitoring user commitment to the system. In early project stages when designs are being formulated, developers will have to rely on the expectations and plans about applications rather than actual cases. These plans can provide important insight, however, to the extent and type of commitment users expect to make. Later, as system components become operational in testing and implementation stages, developers can then monitor whether the applications are in fact occurring and are leading to full institutionalization of the system. Problems or changes in applications may indicate a need to revise the design or project strategy.

It is important that developers take a broad view of what constitutes an application. Many researchers confine their definition of an application simply to the use of the system in a major decision problem (Ein-Dor and Segev, 1978, p. 1065). This is a relatively narrow view since it can not inadequately describe numerous supporting, underlying, or follow-on applications which may also be involved. It is also possible that no major decision will occur (or does occur) as a result of a system application. Thus, an indicator based on use in a major decision would show no result when in reality numerous applications have occurred to support the decision process (Ginzberg, 1978b, p. 60).

Developers should also include unexpected applications and areas of non-use. For example, the availability of new data and capabilities may attract the attention of users outside of the primary user environment. Modest additions or modifications of the system design or project strategy may possibly solve some of their problems at a low cost to the project. This could provide additional support to the project and enhance the chances of obtaining full user commitment to the system.

Similarly, avoidance of the system or non-use should also be investigated. Users may perceive that the system will not (or actually doesn't) solve their problems. They may turn to other systems and withdraw their support from the project (Comptroller General, 1978; Ruth, 1978). Developers may also find that staff who operate the system are having difficulties doing so (Malvey, 1978, pp. 201-220). They might prevent or seriously impair further operation in an area unless the design is changed or they receive more training. User resistance at these levels may have serious implications for eventual user commitment to the system. Developers need to identify problems with applications early and revise designs and strategy accordingly.

The key problem in determining where applications occur (or will occur) is to match some unit of work in the organization, such as a decision, with some unit of system action. This matching can be greatly facilitated by the use of models which detail the information and decision flows of the user organization. Developers can take these models and identify places where the system interacts with the user. The range of applications can then be determined as can the specific user behaviors which define work tasks.

It is advantageous to start modeling early, such as during initial problem definition stages when extensive contact with users occurs (see also Problem Identification in section 5.3.5.2). Developers can then:

- Obtain an early indication of commitment by matching expected system products and applications. This can be compared to project goals (see also Boundary Factors, section 5.2.3).
- Plan the occurrence of applications as the project proceeds, possibly starting with simpler ones and then moving into more complex undertakings (see also Task Structure Factors, section 5.3.2).
- Obtain a basis for establishing measures of actual use which can be applied later during testing and implementation (see also Project Control Factors, section 5.3.4).
- Uncover any different perspectives as to what constitutes use. Differences among users may prevent agreement that an application has occurred (or will occur) and have an effect on eventual institutionalization (see also Boundary Factors, section 5.2.3).

5.4.2.2 Factor 26 -- Consequent Actions

<u>Description</u> -- The actions resulting from areas of direct system use.

Discussion

Further indicators of use are the user actions which come about as a consequence of system applications (Young, Note 7, pp. 3-10). These actions should be observable user behaviors which can be documented and shown to others. Changes in thinking may be a valuable result of system use, but these are hard to measure and probably would be considered weak evidence to justify support for a system. Credible evidence is of critical importance to both users and developers. User managers need proof that a system improves the operation of their organization before they provide full support. Developers need to evaluate performance and commitment and then determine whether changes are needed in design or strategy.

There are several categories of actions developers might consider monitoring in order to measure the effects of system use. These include the following:

- Follow on actions in organizational processes.

  Developers can identify the linkages of various organizational actions and trace the impact of system use down the line.

- Organizational changes.

Use of the system may eventually bring about changes in the organization, such as in structure or official procedures. Changes may occur in other systems or processes which support system use (see Changes in the User Organization, section 5.4.3.3).

- Performance changes.

  Factors which are used by the organization to measure performance might record changes which coincide with the introduction of a system. Performance improvements may consequently lead to high level commitment to the system.

- Avoidance or non-use of the system.

  Negative experiences in a particular application may lead some users to avoid further contact with the system, discontinue their support, or work against the system (see also System Champions, section 5.4.3.1).

As with identifying system applications, determining where actions like these may occur and then measuring them can benefit from initial detailed modeling of user processes. Models can help identify the flow of information or decisions and provide developers with a means of tracing user actions which emerge from specific system applications. Identifying these actions in advance also provides a means of determining what decisionmakers consider valid evidence of use. In addition, expected actions developed early through modeling can be compared with actual behavior during use and provide a means of measuring changes in user commitment.

5.4.2.3 Factor 27 -- Extent of Use

Description -- The amount of use relative to the number of potential applications.

Discussion

The third indicator for monitoring use is the extent of system applications to user processes. Measuring extent includes determining the frequency of use and the amount of use relative to the number of potential applications. These factors should be monitored over the life of the project and used to indicate changes in user commitment. Stable or decreasing levels of use might indicate dissatisfaction with the system design or loss of momentum in project strategy. Revisions in both of these areas may be needed.

One major question that developers and users alike have to consider is how much use constitutes acceptance of the system. User top management will likely have some threshold for the extent of use above which they will give serious consideration to full support and institutionalization. This threshold may be based on how often the system is used over the range of different applications as well as how this use affects the performance of the organization. Developers can begin to uncover thresholds like this early by spending time detailing the types and extent of applications decisionmakers expect to achieve. This may be best done by, again, modeling user processes where the system is to operate and determining what use specifically means. Developers should then continue to examine the extent of use as designs are implemented and determine whether the expected levels are achieved and prove to be significant enough to justify full institutionalization.

An ETIP Illustration

The ETIP-SBA project to develop a data base system illustrates the three use factors discussed above. The goal of the project was to provide a means for SBA field officials to increase the number of government R&D contracts set-aside to small businesses. This involved developing a system to help match R&D contracts to small firms. A contractor was hired to conduct the project and a system was built in a short amount of time.

On the basis of the three use factors, the development approach and the resulting design exhibited favorable conditions for obtaining commitment to the system. First the application of the system was fairly simple and well defined. The system provided procedures for users in the field to classify both contracts and firms on similar criteria. Matches on these criteria were defined and a score given to indicate the overall degree of matching. The location of system use within the set-aside justification process was identifiable and standard in each field site. Thus it was easy for developers to identify where applications would occur and how users would be involved. It was also simple to promote use and to measure it.

Second, the results of use were also easily measurable. Set-aside justifications based on use were to be submitted to agency contracting officials who then were to decide whether to make a set-aside action. If they decided to set-aside part or all of the contract to small businesses, well known, observable procedures were then used to implement the action. Alternatively, if they decided against setting aside the contract, a series of appeals to higher management levels were measurable. Thus the effects of system use were readily observable. Increasing success in set-asides would be noticeable.

Finally, there were numerous potential applications for the system since set-aside procedures were similar across the many field sites. Increasing commitment to the system could easily be measured by the expanding number of uses at the different sites. In addition, it was expected that repeated use of the system by field officials would build upon itself and lead to a better system. Developers expected that the system would gradually obtain a data base of firms that users could rely on for future R&D contracts. Thus commitment would be further observable by the creation of individual data bases.

Developers found, however, that the system as first designed was not attractive to users and that they could not induce user commitment to it. This was demonstrated during the field testing stage when the strategy was to introduce the system to field officials and to have it used experimentally in both retrospective and current cases. Testing was to have helped refine the system and build a track record of use that would lead to increasing user interest. Unfortunately, users considered the matching problem to be less significant than the one of simply finding firms they could contact. In addition, the matching process consumed a significant amount of the short time available to make a set-aside justification.

More modest success was achieved later when the procedures were computerized and a data base added from which to gather potential firms. This change was the result of an opportunity in one agency where officials needed to contract several projects quickly and felt that set-asides were appropriate. The system proved very successful in one retrospective test and was then applied, finally, to some real cases which resulted in set-aside actions. The success of the applications built considerable interest for the system in the one agency.

Unfortunately developers were not able to increase the extent of use and build a wider commitment to the system. The system was expensive to operate and direct users apparently did not have the resources to support it on their own. The central SBA office could not provide additional resources either.

In retrospect it would appear that the central office decision to discontinue the project was in part based on the problems with extent of use. First, developers had been unable to build a wide consensus for the system in the field that would have probably been attractive to central SBA decisionmakers. Second, R&D contracting was only one of the many sectors that field officials had to review for small business set-asides. Officials in the field and the central office both felt that the computerized system was too costly for the number of applicable cases.

This conclusion is further supported by the fact that the central office elected to continue developing the system for a broader range of applications. A computerized system, similar to the one for R&D set-asides, was to be developed for all types of set-asides. Thus, while the R&D system was unsuccessful, it did apparently demonstrate the need for some system and caused some level of SBA commitment, albeit in another form.

5.4.3 System Support Factors

General Description

Besides monitoring the direct use of the system to determine user commitment, developers should also monitor other user actions which indicate support for the system. These actions may include early signs of user acceptance such as the emergence of system advocates as well as longer range institutional changes which are needed to support the operation of a system. The lack of supporting actions like these may indicate that the system is isolated from the user organization and that it will not become fully implemented when the development ends.

Three factors for monitoring system support are described in this section. First, a system champion factor is presented. Champions are people who believe very strongly in the value of the system and actively work for its development and acceptance. Their early emergence may be one of the first signs of user commitment. A second factor relates to the resources allocated by the user during development. Early signs of user commitment are indicated by resource allocations to project tasks while later signs are the support provided to components made operational before the full system is completed. A third factor concerns changes in the user organization which result from system use during development or which are needed to support its use. These include actions to establish training programs for system operators as well as changes in how the organization works.

5.4.3.1 Factor 28 -- System Champions

Description -- The emergence of advocates for the system in the user organization.

Discussion

An important source of support for a system development can be a critically placed key man, advocate, or system champion (Keen, Note 2; Robey and Zeller, 1978; Thompson, 1978b, p. 332). A system champion is a person, perhaps best located in the user organization, who believes very strongly in the system: its concepts, design, performance, etc. The system most likely matches the champion's objectives and the organization's objectives. A champion has credibility inside the organization, hopefully across different levels. His credibility may even extend outside the organization as well. He can push the system into existence and also find the pull for it from users (Thompson, 1978b, p. 332). He should also be able to isolate the system from attack by others (Libman, Note 8).

Developers should seek out system champions and cultivate their participation. Their help can be a critical element for success throughout a project, especially in early stages when both the project and the system are being defined. Key support from a champion at this initial point may give the project the momentum and exposure it needs to get started. System champions may offer the earliest sign of user commitment and act as a catalyst for acquiring other user support.

Champions may emerge from different levels of the user organization and developers should actively seek this broad-based support. Champions from top levels of management are clearly important to a development since they may have great influence over resources, access to the organization, or project strategy. It is especially advantageous to find a high level champion whose credibility extends both up and down the lines of the organization. However, developers should seek champions at other levels as well. This can help gain credibility for the system with key groups and also expose project teams to different perspectives or expectations about system design or project strategy. These differences may present a barrier which developers should overcome. In addition, multiple champions, either within or across organizational levels, may help reduce the potential disruptions caused by the loss of any one of them (Lucas and Plimpton, 1972) (see also section 3.3.1.2 for an example case).

Developers must be skeptical, however, of champions who may be overly supportive or controlling. They may be attempting to capture the project, and thus the system, in order to use it for their own personal rather than organizational objectives (Ackoff, 1960, p. 262). In cases like this, developers may find that the champion has little if any credibility elsewhere and is regarded with suspicion from others. Actions which are associated with the champion may not be well received or desired elsewhere. Developers may ultimately find themselves locked into a strategy which has very little chance of succeeding.

Developers must also be aware of those who actively oppose the system. Just as the new system may have a key advocate, it may also have someone who is uninterested or critical. Opponents may fight development at each stage or stop it entirely. Alternatively, they may carefully and slowly build up opposition to the system and bring great pressures upon the project at key points, such as during decision-making on institutionalization. They may also elect to hamper an operational system as much as possible or sabotage system processes (Malvey, 1978, pp. 201-220). Developers should be open to the possibility that opponents exist, or will develop, and be prepared to actively counter the effects of their actions.

System opponents may not be limited to those who oppose development outright from the initial planning stages. Technical problems, infighting already existing in the user organization, differences of opinion over designs, or opposition to particular project decisions may create new opponents during a development. In these situations, it is critical that developers direct specific attention to the resolution of conflicts and consensus building. System developments can involve change and disruption to users, and the creation of an active opposition only makes strategy that much more complex and success that much more difficult to achieve.

ETIP Examples

Perhaps the best example of a system champion is found in the ETIP-PBS planning system development. The project was managed within the special studies unit of the agency by the director, who was very interested and active in the development. He believed that the concepts and the design of the system were central to agency business and compatible with emerging agency policies. He was very active in marketing the system to users, who were in line units outside of the special studies group, and to high level policymakers, who had to endorse and support the system. When user opposition appeared for the system, he turned to outside groups who were interested in concepts of the model and whose endorsement would have influence within his own agency.

As described in Chapter 2, however, this level of active support was apparently not enough to gain full agency commitment to the system. Users continued to operate with their old system and agency policymakers delayed approval. Difficult relations between the champion and user line units existed as well; the champion may have had less influence than desired. It is possible that the project might have benefited from additional champions in these other organizational levels.

5.4.3.2 Factor 29 -- Resource Commitments

Description -- The type and extent of resources allocated by the user organization to support the system.

Discussion

A key indicator of user support for a system is the type and extent of user resources committed during the development. The two primary resources users can provide are manpower and money. In early development stages, these might be supplied to the project to support design and testing. Later, as subsystems become available for implementation, user resources may be supplied to operate them. Each of these allocations is a sign of user commitment to implement a system after the development is completed. Developers should not rely totally on these signs, however. Many system projects have been characterized by large commitments of user manpower and funds during development, only to result in failure when the time came for full scale implementation and support.

There are several characteristics concerning user allocation of money to a project which developers may want to monitor. These are:

- Temporary vs. permanent allocations.

  In some cases, part or all of the development may be funded out of special user project funds and be combined with resources originating from outside third parties. A change in budgeting, where the system becomes a line item in a user budget, may be an important indicator of emerging support (Ein-Dor and Segev, 1978, p. 1071).

- Origin of money.

  Developers may want to compare the origins of financial resources with the location of primary users. Arrangements not following organizational lines could mean broad support or potential ownership problems. In addition, if multiple sources are involved, developers may want to consider the relative proportions of allocations versus expected use. Continuing support from all parties may be essential for full scale system implementation.

- Planned allocations/expenditures.

  Developers may want to examine how user allocations are planned over time and in what system areas they apply. Targeted resources may signal important areas where user commitment will be based. User expenditures should also be monitored. Success in the development will most likely be followed by increasing resource allocations (Ein-Dor and Segev, 1978, p. 1071).

These factors may not apply in projects which are entirely based on third party funding and where user resources are expected only after successful development.

Similar characteristics can also be monitored for user allocations of manpower. These may apply independently of any funding allocations and be essential for strategies involving close user involvement. Developers should consider:

- Temporary versus permanent assignments.

  User staff may only be temporarily assigned to project teams or to the operation of initially available subsystems. While these conditions would indicate an initial commitment, a transition to permanent assignments to operate system components would indicate a more significant level of support.

- Type of personnel assigned.

  The development may require the skills and involvement of users; and developers should monitor whether they are made available. The assignment of key people in an organization may signal a high degree of user commitment to the system (see also Commitment, section 5.3.3.3).

- Level of involvement.

  A key sign is also the extent of involvement. User personnel assigned to work on the system a small part of the time may be too distracted by other business to contribute effectively to project objectives. Allocation of significant portions of staff time may indicate a solid commitment to the system. Commitment would also be indicated by increases in the proportion of their time.

ETIP Examples

The ETIP projects had different strategies for user commitment of resources. The PBS and SBA projects involved both agency and ETIP funds for project initiation and it was expected that the agencies would assume full support of the systems at the end of the projects. These partial allocations did not result in final commitment to the systems, however. In the SBA data base system, developers were unable to obtain the support of field users near the end of the project and the central office elected to withdraw support when project funds ran out. In the PBS planning system, developers were unable to gain support from line users, who continued to support their own system, or from higher level managers, who could not support the system as normal agency practice.

The NASPO-NIGP procurement information system project depended entirely on ETIP funding throughout the development. It was expected that as the system's capabilities became available, users would begin to provide resources and at project's end they would be fully supporting it. The gradual transition to user support did not occur, however, as developers had problems meeting user needs. It was also discovered that direct users were not necessarily the only decision-makers involved in allocating resources to system support. In some cases, legislative officials had a key role in the budgeting of procurement agency operations and their support had not been considered in the system development strategy. The project ended without being able to obtain user funding to continue development.

The strategies for involving manpower also differed across the ETIP projects. In the PBS projects, development was essentially conducted outside of the user environment and did not depend on gaining user involvement in design or operation until the system was available. Users kept their distance from the project and continued operating their existing system. A similar strategy was used in the SBA project until the field testing stage was reached. At this point, developers planned to train users in the operation of the system and have them apply it to both retrospective and current cases on their own. User problems with the system prevented this kind of involvement and commitment to the system did not evolve. Developers were forced to operate the system and attempt to gain test cases on their own. The lack of widespread support and involvement probably was a key factor in the central office decision to discontinue its support for the system.

In contrast, the NASPO-NIGP procurement information project depended on close user involvement in order to develop the system. The strategy was to enlist volunteers from the pool of eventual users to participate on task forces and develop prototype system products. Since both NASPO and NIGP were national organizations representing users, developers were able to obtain volunteers, many of whom were recognized as leaders in procurement. Developers found, however, that the volunteer approach worked very slowly. Volunteers were available only for short time periods and the project competed with their routine agency business. Also, the evolving difficulties in meeting user needs under the project strategy probably made participation less attractive. Several task forces could not produce the expected products; in other cases where a package was developed, they were not always attractive to users who had not been involved in their creation. Developers learned, probably too late, that more manpower was needed which was fully dedicated to the project and which was located in-house.

5.4.3.3 Factor 30 - Changes in the User Organization

<u>Description</u> -- The alteration of policies and procedures in the user organization in order to support system operation.

<u>Discussion</u>

Other indicators of user support and commitment to a system are the changes which take place around the system. Systems are placed into complex organizations involving intertwined lines of communication, support, responsibility, and activities. Changing over to a new system likely causes and/or requires changes in other places and systems. New relationships and functions may be established. Developers should look beyond the immediate areas of system impact to other areas where change may indicate a positive or negative force for user commitment.

There are numerous potential changes inside the organization which developers can monitor. Some may occur in the areas which are to support the operation of a system. For example, the system may require new types of personnel or new positions which must be arranged for by personnel divisions. Some users may need training in order to operate the system and new programs may be created for this. Another similar change is the creation of an incentive system either to attract users to the new system or to acknowledge improved performance because of its use. Other changes may occur in processes, such as decisionmaking style (McGrath, 1970) or how the organization works. Changes may also be observed at higher management levels. For example, the system may support a new policy which high level decisionmakers must acknowledge and support. Finally, developers should examine changes in competing systems (Ackoff, 1960; Thompson, 1978b, p. 329). The continuation of competing systems may indicate a lack of support for the new system, while conversely, the gradual withdrawal of support from them may indicate the opposite.

Developers should also monitor actions or conditions outside of the user organization which may affect user commitment to the system. For example, outside institutions may mandate the use of the system. This is especially the case in the public sector where new systems can be supported by Congress or upper levels of the Executive branch. Outside organizations may also have a role as system users or suppliers of information. Changes in their roles or activities may be a direct or indirect sign of system acceptance and support in the user organization.

ETIP Examples

Perhaps the best example of organizational change among the ETIP system developments is found in the PBS planning system project. In this case, the system was developed around a policy that had not as yet been fully implemented within the agency. In order to gain credibility for the system, developers went outside the agency to higher level policymakers responsible for promulgating new policies. Developers hoped to demonstrate the system's compatibility with the new policies. It was expected that their support would have a significant influence over the agency's subsequent commitment to the system. Even though the compatibility was demonstrated, agency policymakers reserved their support in order to fully examine the implications of the new policy in their organization. Thus the system remained isolated within the special studies unit in which it was developed. Line units continued to operate their existing system. Little training occurred to educate line users in the use of the system and no incentives were created for them to make the changeover. In addition, it remained difficult to obtain data to support system functions since the system required figures aggregated in a manner different from normal agency practice. These requirements exceeded the capabilities of existing agency data bases and there was little incentive to make changes.

5.5 THE MONITORING FUNCTIONS

5.5.1 Introduction

The following sections describe the five functions the monitoring framework can serve in a system development. As described earlier in Chapter 4, background studies of ETIP projects and the literature demonstrated that a monitoring process was needed by managers of complex developments to assess and revise strategy as the project unfolded. The framework was thus designed to serve two main administrative functions, that of problem identification and strategy development.

The background studies also showed, however, that the monitoring concept might also be useful for researchers interested in studying system developments. In particular, monitoring could assist researchers in several ways:

- Provide a means to study system developments in real-time rather than retrospectively.
- Obtain better empirical evidence on developments that has been called for in the literature.
- Provide a means to test and utilize literature based concepts in actual projects.
- Promote the use of research and research processes by project managers.

These ideas suggested that the framework might also serve in a research function at the same time it was serving project managers.

With the addition of two more supporting functions, documentation and dissemination, the resulting monitoring framework was thus designed to serve five different functions. Each of these functions is described below in more detail. In addition, a final section presents a general model of how the framework, via the functions, might be implemented within a specific project.

5.5.2 Function #1 -- Problem Identification

Problem identification is the major function for the framework, reflecting the ETIP management need for a procedure to anticipate and pinpoint key problem areas. The framework is structured to contain key elements of a systems project, areas where problems usually occur and which are important to eventual project success. By routinely monitoring these areas, managers can identify problems more quickly and possibly earlier than would be the case without a framework. Use of the factors may also promote easier recognition of problems. In addition, problems which are new, complex, or multi-faceted, may be more easily decomposed into recognizable, manageable components by analyzing them with the framework factors.

5.5.3 Function #2 -- Strategy Development

The second major function for the framework is strategy development. The performance of a strategy can be monitored through the elements of the framework. Problems and progress identified in these areas may highlight the need to change some or all of a strategy in order to continue progress towards objectives. If strategy problems occur, the factor structure and the information base available from regular monitoring may then also assist in formulating the changes needed. In addition, the framework can promote better strategy by offering a means to consider longer term pespectives. First, retrospective analysis of the factors may uncover problems that are unidentified by constant attention to immediate circumstances. Similarly, by focusing on specific framework factors during strategy revision, managers may be encouraged to predict the effects of strategy changes in the future. Besides bringing a longer term perspective to problem solving, this can provide an opportunity to identify the conditions or points in time when a strategy should again be reviewed. The longer term cause and effect linkages which are identified through these analysis may also help managers avoid repeating mistakes.

5.5.4 Function #3 -- Research

The third function of the framework is to provide a means for researchers to study and contribute to on-going system developments. This reflects the finding that systems researchers see a need for closer contact with actual projects -- partly to gather empirical evidence not easily available through other means and partly to transfer the guidance available in the literature to practitioners who some claim have difficulty using the literature. While these two problems are to some extent exacerbated by the few incentives practitioners have to study their own experiences, it does appear that an approach which unites researchers and practitioners may be a good way to gain the access needed by the research community.

The monitoring framework provides a research opportunity by establishing a data collection process that researchers can use to define and implement studies. By adapting their studies to the framework structure and procedures, researchers can acquire a series of data points at the same time as project managers. They can then use this data to study changes and linkages between factors of interest and to produce valuable insights of use to others.

Researchers may find it beneficial to design their studies with the project managers. Besides helping to ensure continuing access to the project, this approach may provide researchers an opportunity to help managers with problem solving. Research studies could be designed to support problem solving. In addition, researchers might be able to bring in relevant guidance from the literature to help managers. This would help counter the claim that research in the systems literature cannot be used.

5.5.5 Function #4 -- Documentation

The fourth function of the framework is to document project activities for the administrative and research purposes discussed above. Documentation here means establishing an organized and stable written record of project activities as they occur in the key selected areas of the framework. In the short term, this function can help project managers identify current problems and progress and assist in finding ways to improve the project. For researchers, documentation of project events as they occur is one essential feature of the monitoring approach that makes it attractive over retrospective studies.

Documentation is seen as particularly useful, however, for tracing and analyzing selected factors over long periods of time. For managers, documentation of project activities can be inefficient for short term problem solving. In addition, documentation over the long term can provide several benefits that may be difficult to obtain from short term analyses of immediate actions:

- Routine documentation over the long term can help managers identify special, evolving, or recurring problems.
- Longer term analyses of management actions may help identify successful and unsuccessful approaches, promoting improved strategies or new ideas for current actions.
- Long term documentation can support decisionmaking in the project, particularly for major decisions at the end of phases. These decisions may rely on credible evidence of performance -- unattainable from quick retrospective analyses at the time of the decision.
- Documentation can be used to inform new staff or project history and thus ease the problem of turnover.

For researchers, the long term stream of data available from documentation provides the data base on which to conduct research. In particular, long range documentation provides:

- The evidence upon which to identify and test relationships between important factors in development.
- A basis of developing models of the dynamic, evolving process of a large scale system development presently missing in the literature.
- Empirical evidence about all project stages that is also needed in the literature according to some researchers. This may be especially important for other researchers who need better access to actual projects.

5.5.6 Function #5 -- Dissemination

The fifth and final function of the monitoring framework is to promote dissemination of information about the system development to groups not directly involved in oversight roles. The framework structure and resulting data base can facilitate the transfer of information to these groups by making it easier and quicker for managers to generate the information needed. This of course must be tempered with the need to avoid release of interim or uncertain information which might harm the project.

Managers may find the dissemination function useful both inside and outside a project. For insiders, dissemination of monitoring information can facilitate a common awareness of problems and progress and help promote united actions. In a large project, this may be especially important in coordinating groups working on different parts of a system. Dissemination of pertinent information about progress may also have the secondary effect of promoting or facilitating the monitoring activity. Project staff may come to rely on periodic reports of activities for guiding their own work.

For outsiders, dissemination of monitoring information can be essential to keeping groups informed about progress and building awareness and support for the system. This may be especially critical to user groups not directly involved in the development, but having some indirect role in future system operations. Other important groups can be top level managers or outside institutions who supply resources to the project, periodically review progress, and approve continuations of the work. These people may need current and retrospective reports on development activities, both easily supplied if monitoring has been routinized.

Dissemination is also important to researchers. By providing the opportunity to closely study on-going development activities, the framework can facilitate the transfer of information to the systems literature. For example, the framework can help provide a more dynamic, evolving view of development and other empirical evidence that some researchers believe are needed in this area. Besides helping other researchers, real time analysis of project activities may offer insights to other system developers who are looking for guidance of use in their own situations.

5.5.7 A Model for Applying the Framework

The framework has been designed with a set of procedures that managers can use to apply it to specific developments. This process is modeled in Figure 5.3 by a flow diagram of events which are generally expected to be a part of monitoring. The model is illustrative; modifications would likely be needed in order to match the process to the project.

As shown in Figure 5.3, the monitoring process begins when project managers identify the need for monitoring and proceed to specify the indicators, procedures, and staff needed to operate the monitoring system. To specify the monitoring indicators, managers need to examine the individual elements of the framework and decide what indicators are needed. For example, under the category of user commitment, managers need to identify events that will indicate use and support for the system. For the system champion factor listed under support, this will involve identifying where champions would arise and what actions will be considered supportive. This identification process will of course be influenced by what managers and others, inside or outside the project, need to know during a development. In addition, managers may find gaps in the elements or alternative factors which better match their specific situation.[2] Analysis of each framework

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[2] As mentioned earlier (section 4.2.6.1), the framework is intended to be comprehensive. However, this dissertation is still the first attempt at defining such a framework. Revisions and additions are expected.

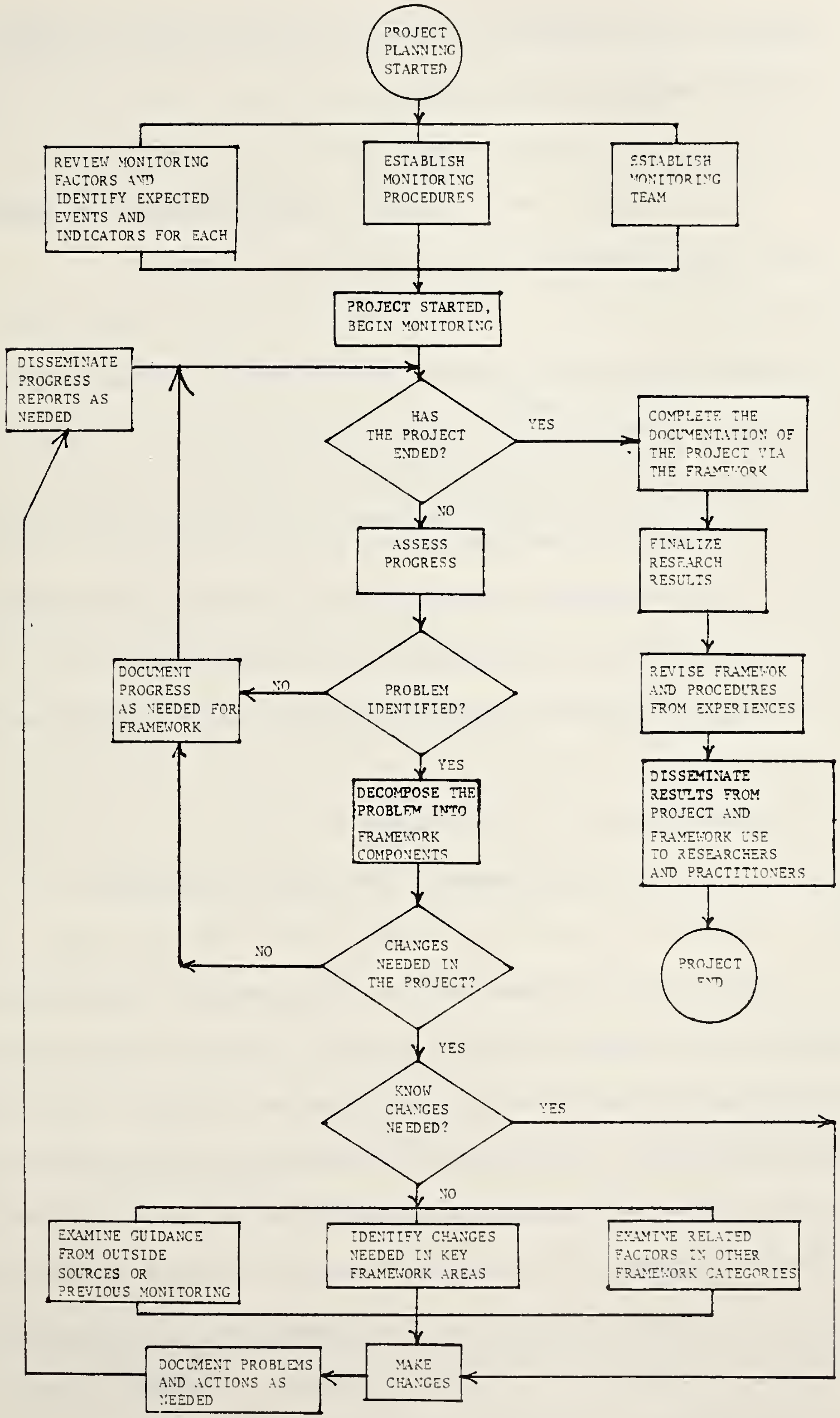

FIGURE 5.3 A GENERAL MODEL FOR APPLYING THE MONITORING FRAMEWORK

element in this manner will specify where monitoring should occur and what needs to be monitored.

Next, managers need to specify the procedures for monitoring. Some of the considerations include the following:

- How monitoring will be coordinated with major decision points in the project.
- How monitoring data will be collected.
- Who will receive monitoring information and what information will be supplied.
- The storage and location of monitoring information.
- What kind of documentation is desired.
- How research activities will be tied to management activities.

Operational details in these areas will establish how monitoring is to be performed and integrated into project management.

Finally, at the same time as these procedures are being explored, managers should also identify the team which will perform the monitoring. While top level project managers are the main users of monitoring information, their role in collecting the information should be minimal. This work should be delegated to the staff supporting project leaders. Managers will have to decide who will be on the team and how the different groups in a development should be represented. It will be beneficial if the team consists of members from all participating groups: the user organization, the development team, and the group of researchers (if present) studying the development. This should help ensure collection and use of monitoring information, while improving the credibility of the monitoring by bringing different perspectives to the process.

After these initial preparations are completed, the monitoring process is started. Problems and progress in the specific areas of framework are identified as they occur or at selected periodic reviews.[3] If the situation is new or not well understood, the monitoring team may need to decompose project events into smaller elements by identifying the relevant factors in each framework category. The relationships between different factors should also be considered. As appropriate, the monitoring team then produces a problem statement for project managers. This procedure is illustrated in Figure 5.4.

With the problem identified, managers then decide what, if anything, should be done. This is when the strategy development function of the framework can be useful. If managers know what should be changed, then no further analysis is needed and the changes should be made. In this case, the only remaining tasks for the monitoring team are to: document the problems and actions taken for future reference, identify future conditions when these actions should again be reviewed, and disseminate information as needed about the management activity.

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[3] It is assumed here that situations occur which require intervention by project managers.

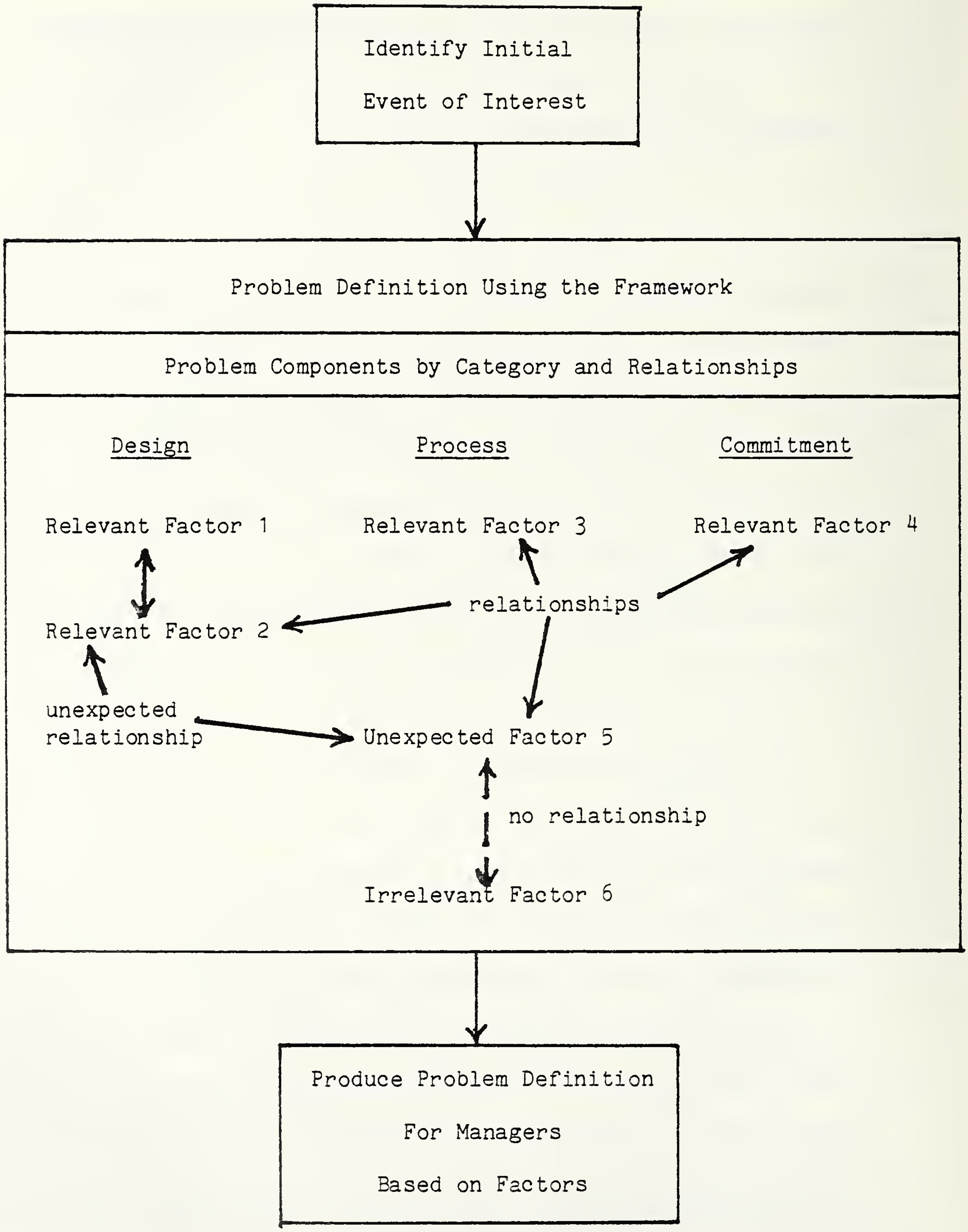

FIGURE 5.4 PROBLEM SOLVING USING THE FRAMEWORK

However, if the appropriate action is uncertain, further analysis of the problem using the framework may be beneficial for identifying options. In this case, the framework factors may provide a focus both for the problem and the management intervention. Managers can:

- Identify the key components of the problem using the elements of the framework and what actions might be targeted at these areas.
- Identify and examine the relationship between problem elements, using the different framework categories to decompose a complex situation.
- Examine guidance on the problem elements from previous monitoring information, project research underway, or other outside sources.

Once the interventions are specifically identified, the monitoring team then determines how to trace the effects in the future and whether special attention is needed to identify when a review of the changes may be needed (see illustration in Figure 5.5). Over the long run, tying the state of the project to management interventions should help the monitoring team identify successful approaches and promote better management control.

After the changes are made and plans for future monitoring are established, the monitoring team documents the activities and disseminates information about them as needed to others inside and outside the project.

This pattern of monitoring continues during the project until monitoring is no longer needed by managers. At this time, the monitor-

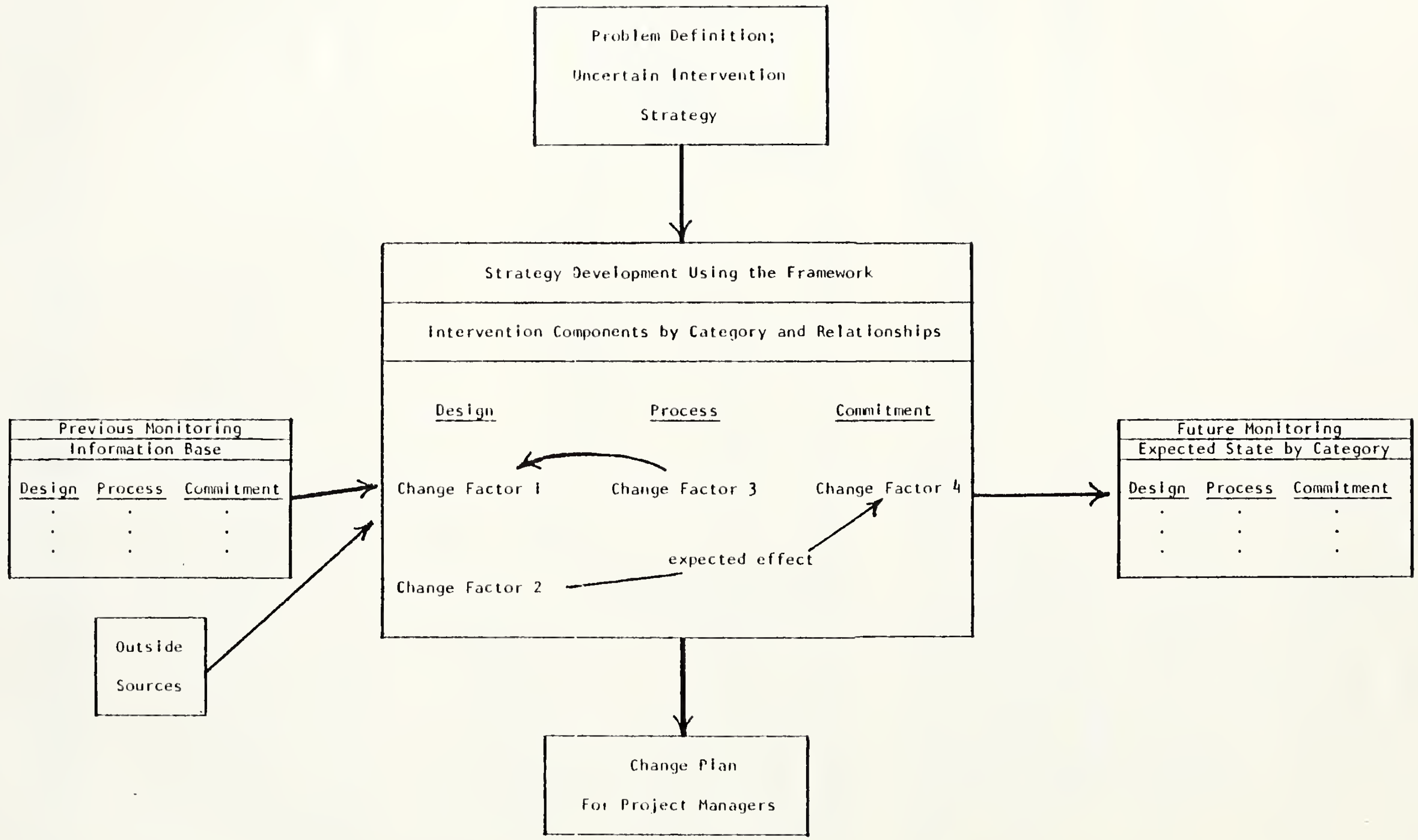

FIGURE 5.5 STRATEGY FORMULATION USING THE FRAMEWORK

ing team completes documentation of the project, emphasizing the final state of the project in terms of the framework elements. Researchers, if present, then conduct analyses of the data collected by the monitoring team according to their earlier plans. The monitoring team should also review the framework to determine how well it worked and whether changes are needed for future applications.

Finally, the results of the project are disseminated as appropriate to other interested researchers and practitioners.

5.6 CONCLUSION

This chapter has presented a framework that can be used to monitor important areas of a system development. Thirty factors have been identified for the framework along with five functions monitoring can serve in project management.

The framework factors have been divided into three main categories -- design, process, and user commitment characteristics. Design characteristics are factors which refer to what a system looks like and how it operates. Developers need to monitor the design since it can greatly affect whether users accept and implement the completed system. Process characteristics are factors which refer to the procedures, resources, structures, and personnel used to conduct and control the development. System developers need to monitor these characteristics because they also have an effect on user commitment to the system. In addition, the development process must be tailored to the evolving requirements of the design. Finally, user commitment contains behavioral measures of system use and support in the owner organization. These are actions which can occur throughout a development and are intertwined with the design and process characteristics. Developers need to monitor commitment in order to learn how it changes during a project and whether it is building up to full acceptance of the completed system.

The framework functions have been designed to support both administrative and research objectives in a system development. The five functions include problem identification, strategy development, research, documentation, and dissemination. Each function has been described separately. A model of how the monitoring process might be implemented in a project has also been presented. This model has shown how the monitoring functions would work and how they would relate to each other.

The following chapter presents a test of the framework in a different ETIP case involving the development of a large evaluation system. Chapter 6 presents a brief history of the project and an illustration of how the framework might have been used by managers during one selected period.

CHAPTER 6

AN APPLICATION OF THE FRAMEWORK TO A SYSTEM DEVELOPMENT

6.1 INTRODUCTION

This chapter presents the application of the monitoring framework to a specific ETIP system development. The purpose of the application is to illustrate the usefulness of the framework in the management of a large and complex system project. This is shown by first mapping the framework onto a selected period of the project where one particular problem tended to dominate events. The mapping is then used to show how the framework might have helped managers more effectively identify and resolve the problem. A more complete description of the applica tion design is presented in Chapter 4.

The chapter is divided into two parts. First, a general chronology of the ETIP project is presented to familiarize the reader with the case. The project involved the three phase, multi-yeared development of an evaluation system for ETIP procurement experiments. While the project lasted over five years, only the first three were aimed at development of the system. This period is presented in the most detail in the chronology.

The second part of the chapter describes how the framework might have been used during one period of the project to improve project management. The first six month period of the project was selected as the example because it contained a significant problem, that of establishing a communication system among participants, which dominated events and affected many areas of the project. The application shows how the framework might have contributed to an earlier and more effective resolution of the problem. The analysis includes descriptions of the evolution of the problem, specific components of the problem, effects on other areas of the project, how the problem was actually resolved, and finally how the framework might have helped managers.

Readers will note that only one period out of the three main years of the project has been selected for illustrating the framework. This example focuses primarily on the process factors of the framework and to a much lesser extent involves a few of the design and user commitment factors. Other examples were expected to illustrate design and commitment more completely. However, time limits on the research prevented further selection of examples.

6.2 A BRIEF CHRONOLOGY OF THE EVALUATION SYSTEM DEVELOPMENT

6.2.1. Introduction

This part of Chapter 6 presents a brief chronology of the evaluation system development. The purpose of this review is to familiarize the reader with the basic events of the project.

The project history is divided into four sections. First the background and objectives are reviewed. Then each phase of the project is described. A table is provided on the next page which briefly outlines

Date	Event
September 1975	Chief, Experimental Methods, joins ETIP and begins planning evaluations of experiments.
February 1976	Project plans for the development of an evaluation system for procurement experiments approved. RFP announced in Commerce Business Daily. (Two separate contracts, agency impact and commercial impact evaluation).
June 1976	Two contracts signed (agency impact - Contractor A, commercial impact-Contractor C).
July 1976	Phase 1 work begins - initial meetings.
October 1976	Contractors submit first deliverables - plans for Phase 1.
March 1977	Phase 2 planning begins. Reports expected for Phase 1 identified.
April 1977	Contractors prepare preliminary outline of prototype evaluation system.
June 1977	Contractors submit combined prototype design and management plan for Phase 2. COTR approves Phase 2 for both contractors.
October 1977	Phase 2 begins. Prototype system begins operation.
January 1978	Local Washington, D.C. office established for the system. System manager appointed.
June 1978	Contractors submit Phase 3 plans to ETIP.
July 1978	System designed to answer a set of 16 questions.
September 1978	Phase 3 begins. Phase 2 extended to April 1979.

FIGURE 6.1 BRIEF CHRONOLOGY OF THE ETIP PROJECT TO DEVELOP AN EVALUATION SYSTEM FOR THE PROCUREMENT PROGRAM

January 1979	Draft system design issued for comments.
February 1979	System pretested with several potential users.
March 1979	System design completed for Phase 2. Phase 2 ends.
May 1979	COTR leaves, new COTR appointed.
June 1979	Contractors submit Phase 3 plans, propose quarterly reviews to update system. Phase 3 extended to April 1980.
March 1980	COTR leaves. New COTR appointed.
September 1980	Phase 3 contract revised - update of evaluation system in Phase 3 no longer required.
December 1980	Contracts extended into 1981 to complete several technical reports.

FIGURE 6.1 (Continued)

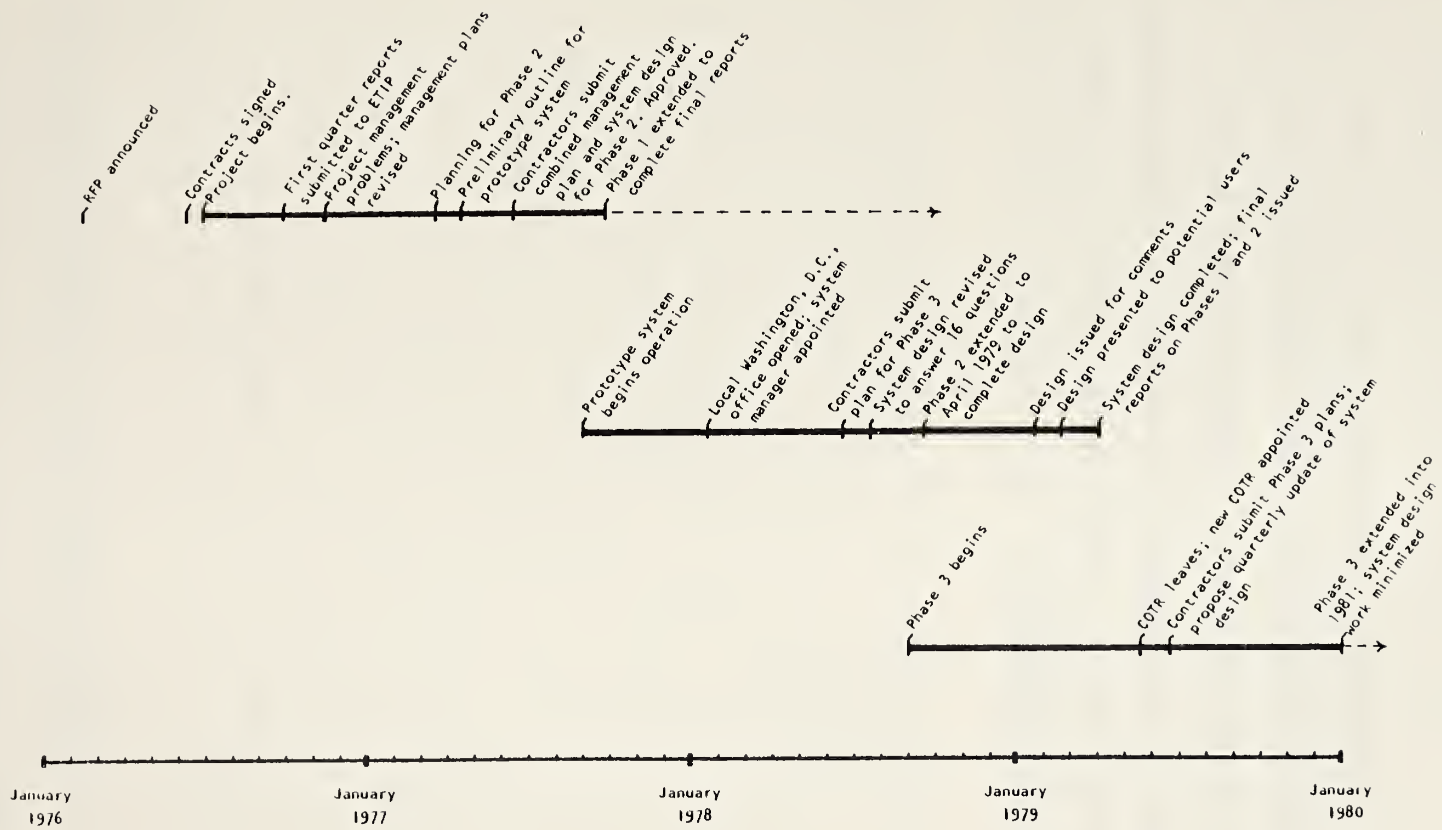

FIGURE 6.2 MAJOR EVENTS AND PHASES OF THE EVALUATION SYSTEM DEVELOPMENT ON A TIME LINE

the major events of the project. A figure is also provided to present these events graphically.

Readers should note that names of individuals have not been used in the chronology. Only institutional names are provided, and in the case of the contractors, artificial names are used. In addition, citations to project documents in order to verify events have not been used. Instead, the basic set of events on which the summary is based is included in the appendix.

6.2.2 Background and Objectives of the Project [1]

6.2.2.1 The Emergence of an Evaluation Program in ETIP

The impetus to develop an evaluation system began several years before the project was initiated. Early in 1974, ETIP managers became interested in more explicit integration of evaluation into ETIP projects. Earnest planning of evaluation activities increased later in September 1975 with the arrival of a methodological specialist to head a new evaluation area in ETIP called Experimental methods.[2]

During the ensuing months, the Director of ETIP decided that money should be made available to contract for evaluations of projects. This decision was partly based on the obvious problem that ETIP did not have the staff to conduct evaluations itself. While the COTR proceeded to plan an evaluation program with this approach, he also felt that a capability for conducting evaluation should be developed within the government rather than continually contracting for this support. This led to the thinking that the impending evaluation projects be conducted to both develop this capability and transfer it to agencies involved with ETIP work. This approach was later transformed into the idea of developing an evaluation system which could be institutionalized.

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[1] Portions of the description in this section are adapted from a more detailed chronology developed by Libman (1980, pp. 68-149).

[2] This person later became the ETIP manager in charge of the evaluation system project. The official project manager's title was to become contracting officer's technical representative (COTR). Hereafter, COTR will be used to identify this person.

6.2.2.2 Evaluation in the ETIP Procurement Program

The first application of the evaluation system approach occurred in the Procurement Program area of ETIP. The Procurement Program was conducting numerous projects with a variety of Federal, state, and local government agencies. These projects were designed to test different procurement incentives in these agencies and determine their effectiveness in both obtaining better products for government use and stimulating the commercial sector to improve their products. For example, many projects were designed around the addition of life cycle costing to an agency procurement (such as to buy air conditioners for agency use). In this case, ETIP and the procurement division of the agency would replace the simple initial cost criteria used to evaluate industry bids with a cost criteria that reflected both initial and on-going costs for operation or maintenance. Incentives like this were expected to affect the kinds of products proposed by industry, such as to encourage the offering or development of more energy efficient products in cases where energy consumption cost was now added to the procurement process.

Developing an evaluation program and system for the procurement area was not a straightforward project however. The requirements for evaluation were broad, changing, and complex. For example:

- The Procurement Program was highly fluid, in that the number and type of experiments (and agency partners) were variable.
- There were numerous objectives for evaluation from specific and immediate (e.g., what happened in an experiment) to broad and long term (e.g., the implications of a series of experiments for policy changes in the agency).

- There were numerous stakeholders in the procurement work, including Federal, state, and local partner agencies, and related public and private institutions with a stake in procurement policies.

These characteristics contributed a high degree of uncertainty as to what evaluation would be needed as well as the eventual design of a system to conduct evaluations over the long term. It was also unclear how many systems would be needed and who would be the owners. While ETIP had an interest in the long term results generated by evaluations from the system, it was not to be the primary user or owner of the system.

6.2.2.3 Developing a Work Statement

The high degree of uncertainty associated with the type and extent of evaluation to be conducted as well as the system design resulted in the development of a flexible work statement for the prospective project. By the spring of 1976, a Request for Proposals (RFP) for acquiring contractor support had been developed using a flexible statement. The work statement emphasized seven kinds of activity ETIP expected to occur, such as management or data collection,[3] but did not include specific design (either for evaluations or the system) requirements. However, an illustrative set of items which could be produced in the contract was included with the work statement to help describe the needed work.

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[3] The others included reports and reviews, objectives, background, evaluation design, and data analysis.

The prospective procurement evaluation work was divided into two main areas (and two contracts): one for conducting evaluation of agency impacts and one for evaluation of commercial impacts. Agency impact evaluation was to be concerned with the immediate and subsequent effects of ETIP procurement experiments or other related changes on the agency partners and others (Thompson, 1976, p. 1). Commercial impact evaluation was to be concerned with the immediate and subsequent effects of ETIP procurement experiments on the commercial sector and possibly on other related markets (Thompson, 1976, p. 1).

The general set of objectives was the same for each project and reflected the need for specific evaluation support as well as for development of system. These objectives included (Thompson, 1976, p. 1):

1. An overall description of the experiments as well as selected detailed descriptions.
2. An overall assessment of both the immediate and subsequent effects (impacts) of experiments, as well as selected detailed assessments.
3. An evaluation system or process which can be used by the appropriate government agency(ies) to obtain evaluations on a continuing basis of these as well as future, similar experiments.

The projects were divided into three phases, with the first two of each funded at a total of approximately one million dollars. Phase 1, to last 15 months, was generally to focus on the evaluation of selected experiments and the design and pilot testing of the related evaluation system (Thompson, 1976, pp. 2-3). Phase 2 was to continue specific evaluations, refinement of the system, and testing of a prototype system. Phase 3 was to focus on a "turn key" implementation of the system(s) by the appropriate agency and was to be funded when requirements were more certain. The phasing of the projects was provided as a formal checkpoint to determine whether the money was being spent effectively.

6.2.2.4 Awarding the Contracts

With the RFP completed, a process was then implemented to procure contract support. This process was known as parametric factor evaluation (PFE) and had been adapted for the procurements by Thompson (1976). PFE involved establishing a panel of evaluators to assess proposals on a selected set of factors. These factors had been determined earlier during development of the RFP after extensive interviews with ETIP staff and reviews of program documents (the seven factors mentioned above). A number of proposals were received and a bidder was selected for each contract.[4]

Contracts were awarded on June 30, 1976, and work was scheduled to begin immediately in July, 1976.

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[4] Readers interested in the PFE process used in these procurements should consult Libman (1980).

6.2.3 Phase 1

6.2.3.1 The First Six Months of Phase 1, July-December 1976

The first several months of the project were focused on various start-up activities. During July and August, a number of meetings were held to introduce the people involved with the project to each other (including ETIP staff, partner agency staff, the new contractors, and other contractors). These meetings were also used to exchange background information on ETIP activities and to begin planning the activities of Phase 1. Special concern was placed on project reporting requirements, schedules, identifying who (on the contractor teams) was responsible for different tasks, and the process ETIP expected to use for monitoring and reviewing progress.

Project activity broadened considerably following these meetings as contact between ETIP, the contractors, and the PAAs increased. Various requests for contractor support began to reach the COTR from the Procurement Program of ETIP and the PAAs as they identified their priority evaluation needs. Several of the requests were selected to begin work on specific technical projects. The contractors also devoted time to the preparation of the first quarter reports which were to specify their ideas and plans for Phase 1.

In late September, the contractors submitted their first reports to ETIP. Since these were the preliminary results from the contractors, ETIP and the PAAs reviewed them closely. Generally, the reaction to the reports was mixed. The management plan from Contractor A was considered very weak and it appeared to demonstrate little or no gains in knowledge of ETIP projects. In contrast, the management plan from Contractor C was much more detailed. However, it left out information on how key decisions had been reached. It was also apparent from the overlap of the reports that the contractors were not adequately coordinating their efforts.

These problems prompted a series of meetings over the next several months as ETIP attempted to obtain improvements in the reports and to educate the contractors on ETIP needs. While some progress was made toward these ends, other problems also began to surface. For example:

- The contractors were trying to pursue second quarter tasks while the first quarter results were still under question (the COTR had not yet accepted the reports).
- ETIP continued to press for more detailed financial information that the contractors were not obligated to produce.
- Some PAAs were giving mixed reviews of contractor interviews, emphasizing a seeming lack of knowledge about the purpose of the project and the payoffs for PAA participation.
- The ETIP Director began to comment on what he believed to be the poor performance of the contractors.

These circumstances added considerable pressure to the continuing reviews of contractor reports and progress, and communication became more difficult. Finally, in mid-November, ETIP and Contractor C met face-to-face to identify and resolve the range of problems. At the meetings, Contractor C emphasized the difficulties they were having determining ETIP objectives in the project, specifying the results expected by ETIP, and meeting the growing paperwork requirements. ETIP commented on is frustrations over the responsiveness of the contractor.

As a result of the meeting, ETIP and Contractor C agreed to several changes in project structure and communication procedures that would reduce paperwork and return attention to the central technical work of the project. Contractor C then developed a new management plan to reflect these changes. Contractor teams were reorganized and new milestones were proposed.

Similar changes were instituted by Contractor A over the next several months.[5]

6.2.3.2 The Second Six Months of Phase 1, January-June 1977

The second six month period of Phase 1 was more focused on the specific technical efforts of the project as attention increased on the contractor support requests made by ETIP and the PAAs. One specific project, an evaluation of an experiment with Federal Supply Service (PSS), was highlighted at this time since it appeared to be an important Phase 1 product and required complimentary efforts by both

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[5] The communication problems discussed here really dominated the project during the first six months. This time period was thus used as a test case for the monitoring framework (see section 6.3).

contractors. ETIP and both contractors began to work jointly on the conduct of this evaluation.

By the end of March, the COTR was considering the design of the approval process for Phase 2 initiation since Phase 2 could be started while Phase 1 was still underway. With the range of activities now occurring, the COTR had to determine which Phase 1 contractor products would be essential for approval and what schedule of completion was needed. A preliminary list of products and dates was then developed and distributed to each contractor. After several refinements, these lists were accepted by the contractors as the final requirements for Phase 2 approval, then scheduled for June.

Attention in the April to June period became increasingly focused on these expected products. Two of the main reports the COTR wanted were the prototype system design developed in Phase 1 and preliminary management plans for Phase 2. In early April, the COTR decided that each report should be a joint effort from the contractors since Phase 2 activities (i.e., implementation of the prototype evaluation system) would require joint efforts by the contractors. The COTR thus requested the development of a joint design and plan from the contractors and organized several workshops to facilitate coordination.

By mid-May, the first full drafts of these two reports were submitted by the contractors. Several changes for Phase 2 were proposed. First, the contractors proposed that the management of the project in Phase 2 be accomplished by a steering committee composed of ETIP and contractor staff. This structure was aimed at improving the coordination of the various groups as well as providing a regular forum for joint discussion and decisionmaking. The COTR was to be the chairman and final decisionmaker on the committee. This idea was accepted by the COTR and led to use of the steering committee approach during the rest of Phase 1.

A second proposal from the contractors was to restructure the evaluation system design into a set of procedures. Based on the types of evaluation activities required in Phase 1 (such as evaluability assessment), these procedures were to form the subsystem components. This idea was also accepted by the COTR and work began reformulating the prototype design to be reported in Phase 1.

As work on the Phase 1 reports continued in May, it became apparent to the COTR that the workings of the Phase 2 management plan were not well tied to the evolving design of the system and its Phase 2 development. The COTR therefore decided to have the plan and the design reports combined into one document which would then be used as the primary vehicle for management control in Phase 2.

By mid-June, the contractors submitted the combined plan-design report along with other technical reports on specific Phase 1 projects. While the COTR was not completely satisfied with the main Phase 2 plan, he felt that the Phase 2 approval requirements had been met and he thus approved Phase 2 for both contractors. Phase 2 was expected to begin around September.

Several changes were made by the COTR for Phase 2 on the basis of contractor performance in Phase 1. Most significantly, the COTR reduced the Contractor A funding level by 20% from earlier plans and transferred the amount to the Contractor C effort. This reflected the COTR's desire to shift more of the system design responsibility to Contractor C in Phase 2. Contractor C was thus given the role of system manager in the continued development of the system.

6.2.3.3 The End of Phase 1, July-September 1977

The last three months of Phase 1 were mostly concerned with the transition from Phase 1 to Phase 2. With the preliminary structure and plans for Phase 2 activities set in June, ETIP and the contractors began to draft Phase 2 work statements which would be signed by the contractors.

During this work, further refinements in the prototype system design were made. It was decided to divide the evaluation system into two main components -- a routine system and a non-routine system. The routine system was to meet the standard, well known, and on-going information needs in ETIP experiments. The non-routine system was to handle new types of information needs that required special skills and novel evaluation design work.

Division of the system into these two components then had to be coordinated with the division of responsibilities and resources set by the COTR in June. Since Contractor C was to become the overall system manager in Phase 2 and the routine system was the main component of the prototype system, the COTR assigned further development responsibilities for the routine system to Contractor C. The COTR then divided the responsibilities of further non-routine system development to both contractors according to their respective agency and commercial impact domains. Contractor C thus received the bulk of responsibilities and resources for Phase 2 while Contractor A was primarily limited to activities concerning the non-routine system.

The Phase 2 work statements were then accepted by the contractors and operation of the prototype evaluation system under Phase 2 resources began in September. An interim system manager was appointed by Contractor C with the understanding that a permanent system manager would be hired and located in the Washington, D. C., area within the next several months. It was also decided by the system management committee that the project would be aimed at a go/no-go decision on institutionalization of the system within PAAs in Phase 3 somewhere around February, 1978.

Phase 1 work was mostly completed by the contractors at the end of September. However, in order to complete final reports summarizing Phase 1 activities and lessons, both contractors were given no-cost extensions of their Phase 1 contracts.

6.2.4 Phase 2

6.2.4.1 The First Six Months of Phase 2, September 1977-March 1978

Phase 2 began with the formation of several new project teams as part of the management structure. Based on proposals made in Phase 1, these teams included one for each PAA experimental program, one for institutionalization of the system, and one to examine ETIP's role as a future system user. These teams began to meet during the final months of 1977 and assumed control over most of the technical projects underway.

The formation of the institutionalization teams also marked an increased focus on institutionalization in the project. As decided earlier, ETIP expected to make a go/no-go decision on a permanent lcoation for the system somewhere around February, 1978. The team thus began to formulate objectives, strategies, and milestones in relation to this goal. It was agreed that an important need in further project work was to focus system activities more on the key decisionmakers in partner agencies who might support the system in the long term. Several actions were then taken in this direction in December:

- A new information request procedure for system action was designed with the requirement that decisionmakers needs had to be clearly specified.

- The management committee directed the system manager to develop on evaluation subsystem to follow-up on system products.
- The PAA experimental teams increased their focus on decision-maker needs and related requirements in subsystem designs.
- The COTR began to interview one PAA to determine how the system might become more integrated with agency decision processes in the long term.

The COTR used information from these various actions to begin drafting an institutionalization plan.

This was followed in January by a review of Phase 2 plans and status in order update the direction of the project with the evolving institutionalization work. A particular concern at ETIP at this point was the need to establish a local office for the system in the Washington, D. C., area so that closer contact could be made with prospective system owners. ETIP reemphasized the need for a local system manager to Contractor C. A local manager was then proposed and established in February along with the office. Besides taking control of the routine system, the manager also began interviewing agency decisionmakers to help develop a system requirements document.

The COTR also became concerned around this time over the amount of project work being devoted to the design of new experiments or the identification of new agency partners. While this work was important, the COTR felt that it was limiting the development and testing of other evaluation procedures on already established experiments. The COTR thus decided in February to establish two accounts for the project. One was devoted to experiment design or "front-end" work and the other to further development of the evaluation procedures. In addition, the information request process used to access these resources was tightened by requiring a detailed (but informal) work statement and budget with each request. Allocation of project resources was thus more significantly controlled such that the system continued to be developed while some support was also offered on new experimental starts.[6]

6.2.4.2 The Second Six Months of Phase 2, April-September 1978

The next several months of the project involved further refinement of the system design in a manner which mostly set the agenda for the rest of Phase 2. In April, the COTR issued the first draft of a plan for Phase 3 in which he outlined a set of questions he expected the system to be able to answer (i.e., a list of information needs for evaluation). This was followed by a series of design reviews where ETIP and the contractors examined technical activities and subsystems.

As these reviews continued into May, it came to be decided that the questions proposed by the COTR would be the primary design requirements against which the evolving system procedures would be measured.

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[6] The need for new starts was a priority for the ETIP Procurement Program as many of the experiments in Phase 1 were close to completion.

Specifically, it was agreed that:

- The set of questions would be further explored and that a refined list would be used to test the system in Phase 2.
- The number of questions would eventually be fixed for the test, while others would be added afterwards if needed.
- The subsystems then under development would constitute the system for Phase 2.
- The system response to further information requests in Phase 2 would be limited to products similar to those already developed.

Thus, to a great degree, the system design was fixed for the remainder of Phase 2 and the specifications for a test were detailed.

With this structure established, the system manager then began to interview PAA staff and to analyze Phase 1 and 2 reports to further refine the set of questions for the system. By the end of June, the system manager and the COTR refined the set into 14 basic questions. Plans for testing the system on these questions were then discussed for Phases 2 and 3. With Phase 3 approved within ETIP by this time, the COTR also requested Phase 3 proposals from the contractors.

In July, a new information request procedure was designed around the set of basic questions. Several new requests from ETIP and the PAAs were tried in July and August as a preliminary test of the procedure and the rest of the system. It became clear in September, however, that Phase 2 would have to be extended (it was scheduled to end at this point) in order to more fully develop the system procedures and conduct the desired tests with PAAs. The COTR thus extended Phase 2 to March 1979.

Phase 3 was also initiated in September as acceptable plans had been received from both contractors. The COTR then requested Phase 3 management plans.

6.2.4.3 The Last Six Months of Phase 2, October 1978-March 1979

As work on system procedures and questions continued during the October to December period, ETIP and the contractors also began discussions on the final reports for Phase 2 and plans for Phase 3. It was decided in December that three main reports (besides the other specific technical reports related to individual experiments) were needed. These included a system design report prepared jointly by the contractors, a Phase 2 final report from Contractor A, and a combined Phase 1 and 2 summary report from Contractor C. It was also decided that, where technical work on specific evaluations was expected to continue past Phase 2, some projects would then be transferred to Phase 3 accounts.

As work then proceeded on these reports and the completion of most other technical activities, the system manager began the system test which was the final major task for Phase 2. The test consisted of obtaining user reactions to the potential usefulness of the system design in their procurement programs. The system manager met with several high level officials of agencies who might use the system and described parts of the design. These potential owners were then asked whether the system would meet information needs they had in the conduct of their procurement programs. Generally, the system manager found that:

- Potential users (or system owners) considered the basic system questions as important, continuing information needs in their procurement programs.
- The procedures outlined in the system seemed logical for obtaining answers to these questions.
- The data sources for obtaining information seemed valid.

These results concluded testing in Phase 2.

Phase 2 was finally completed in March with the submission of the reports planned earlier. All of these were accepted by the COTR. The system manager and the COTR then planned a review of the Phase 3 objectives starting in April.

6.2.5 The Remainder of Phase 3, April-December 1979

The remainder of Phase 3 was marked by a number of changes in ETIP management and goals, which had an effect on the directions of the project. By May, the COTR had resigned from ETIP and been replaced by the Chief of the Procurement Program (who had been involved with the project from the beginning). The new COTR began working with both contractors to define studies for the rest of Phase 3.

By mid-June the system manager, coordinating both Contractor A and C, submitted plans for Phase 3 work. The system manager also proposed that quarterly meetings be held to update the system with procedures from on-going technical work. These plans were accepted by both ETIP and Contractor A. The new COTR considered himself the primary turnkey user of the system in Phase 3 and moved quickly to use the system to generate new experiments.[7]

The search for experiments continued until October, when several candidates were selected by the COTR. The system manager then began to look for additional staff to assign to these new areas. Both contracts were extended to April 1980 so that these new projects could be finished. Generally, little if any system development work was conducted during this period.

The project changed again in March 1980 when the COTR resigned and another COTR was appointed. By this time, the Procurement Program was itself coming to a close. Some technical work on procurement projects continued in the following months to complete work already started.

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7 The turnkey declaration of the new COTR actually represented a significant change for the project. Originally, the goal of the project had been to institutionalize the system in one or more of the ETIP partner agencies participating in procurement experiments. The shift to ETIP at this point essentially reduced further efforts toward this goal.

In September 1980, the new COTR assigned several studies to the contractors which were unrelated to the procurement work conducted earlier. A contract change was then made to eliminate an update of the system as a requirement for completing Phase 3. Eventually, continuing work on the new studies required further extension of both contracts into 1981.

6.2.6 Conclusion

This section of Chapter 6 has presented a brief review of the ETIP project to develop an evaluation system. First, the background and objectives of the project were reviewed. Each of the three phases of the project were then discussed.

The purpose of the chronology has been to familiarize the reader with the basic events of the project. This general understanding is useful in the next half of Chapter 6 where one narrower period of time in the development is used to illustrate the monitoring framework.

6.3 APPLICATION OF THE MONITORING FRAMEWORK TO ONE SELECTED PERIOD OF THE SYSTEM DEVELOPMENT

6.3.1 Introduction

This section describes the application of the framework to one period selected from the evaluation system project. The purpose of the application is to demonstrate how the framework could have been useful to project managers during this period. In the retrospective approach to the application, usefulness is shown by mapping the framework onto project events and suggesting ways that the framework might have contributed to the resolution of critical problems.

The period selected is the first six months of the project where managers had problems establishing an effective system of reports and reviews for the project. This problem tended to dominate the project and had effects on many other areas of the project. The dominance of the problems with reports and reviews and the complex relationships to other areas of the project appeared to be an excellent situation in which the contributions of the framework could be demonstrated.

The application is divided into several sections. These include the following:

- An initial summary of the major points in the application.
- A background description on the evolution of the problem.
- A review of the specific components of the problem.
- An analysis of the relationship between the problem and other areas of the project (these other areas are identified by framework factors).
- An analysis of how use of the framework might have helped with the problem.

Readers may find it useful to first review the summary and concluding sections of the application before scanning the details of the intermediate sections.

6.3.2 Reports and Reviews, July-December 1976

6.3.2.1 Introduction and Summary

A major area of concern during the first six months of the project was the establishment of a system of reports and reviews for project communications. Early emphasis was placed on developing the system in order to assure adequate communication between the various groups involved (i.e., ETIP, contractors, PAAs, and other groups) and to identify the specific reports expected during Phase 1 of the project. ETIP especially wanted a system of communication that would ensure close interaction with the contractors over the numerous technical uncertainties involved with developing evaluations and the evaluation system.

The initial system for reports and reviews developed during the first quarter led to many communication problems, however. These included too much paper work, misunderstandings over the types of reports required, and disorganized feedback concerning progress. In addition, the first set of major reports submitted at the end of the first quarter was initially considered poor by ETIP staff.

Activities and problems with the reports and reviews system also affected other areas of the project. In terms of the monitoring framework, these areas included:

- Design characteristics -- system boundaries.

- Process characteristics -- task size, task priorities, team personnel commitment, organization and responsibilities, and decision points and milestones.
- User commitment characteristics -- system champions.

Use of the monitoring framework during this period might have helped establish earlier a more workable system for reports and reviews. A project monitor located in ETIP might have been able to identify the growing problems with the initial system and its increasing effects on other areas of the project. Alternative approaches, possibly similar to those eventually established in the second quarter, might then have been suggested. In any case, the time and energy expended in creating and revising the first approach to reports and reviews might have been alternatively channeled into work on the central technical problems of the project and accelerated progress overall.

6.3.2.2 Establishing the System for Reports and Reviews

Expectations concerning a system for reports and reviews were established early by ETIP in the RFP for the project. In this document, ETIP proposed that a reporting system be developed by the contractors within the first quarter (Thompson, 1976, p. 34). Parts of the proposal included the types of reports expected (such as for progress or system design) and a rough schedule for when these reports might be produced.

An important part of the reports and reviews system was also to be a process of progressive review and approval (Thompson, 1976, p. 49). ETIP wanted to have a close involvement in project activities (COTR, Note 1; ETIP, Note 2), particularly because of the technical uncertainties involved with developing evaluations and an evaluation system. ETIP proposed to minimize the significance of reports in the evolution of the technical work and instead emphasize more continuous interaction over time. Final reports were mostly to document already established and approved progress.

These expectations were reemphasized during the first several meetings with the contractors (ETIP, Note 3, Note 4). In addition, ETIP began to propose other ideas for the system which the contractors were to consider. These included:

- A specially structured financial accounting system.

  ETIP wanted a financial accounting system that would enable project managers to control resources as well as learn the costs of performing various evaluation activities (COTR, Note 5). This was seen as essential to developing the requirements for the eventual evaluation system.

- The use of report dummies.

  As part of its desire for close involvement, ETIP proposed that a dummy mock-up of each expected report be established early and updated as it evolved (ETIP, Note 6, Note 7; Contractor C, Note 8). These dummies would be located at both ETIP and contractor sites. Final reports would thus be based on the final state of the progressively refined dummy.

- Using reports to market the project.

  Reports were expected to be used both for internal communication and external marketing of the project (system) to potential system owners (Thompson, 1976, pp. 46-49; COTR, Note 9).

ETIP proposed to make reports available to everyone unless there were confidentiality problems (ETIP, Note 10).

- Using the RFP factor structure for reporting.[8]

  ETIP proposed using the seven factor structure of the work statement as the overall structure for the types of reports expected (ETIP, Note 11, Note 12, Note 13). The illustrative work statement was also used to discuss the specific reports needed. Finally, the COTR emphasized ETIP's desire to use the factors to measure project performance.

Many of these proposals were later adopted by the contractors as they developed their management plans for Phase 1. Both contractors endorsed the ideas of progressive review and close interaction with ETIP and felt they were essential to successful conduct of the project (Contractor A, Note 14, pp. 51-52; Contractor C, Note 15, p. II-6). Report dummies for the first quarter reports were developed and the factor structure was accepted to broadly define the kinds of reports to be produced (Contractor A, Note 16; Contractor C, Note 17). Progress and first quarter reports followed the factor structure closely (Contractor C, Note 18, Note 19; Contractor A, Note 20, Note 21).

6.3.2.3 Problems with the Reports and Reviews System

Despite the early attention to reports and reviews, the resulting system began to have serious problems at the end of the first quarter.

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[8] As discussed earlier in the chronology (section 6.2), seven factors (management, reports and reviews, background, objectives, data collection, data analysis, and evaluation design) were used to define the statement of work in the RFP. These factors specified the types of activity to occur in the project, not specific evaluations or system designs. An illustrative work statement was also included that proposed more specific tasks.

The primary event at this time was ETIP dissatisfaction with the first quarter reports from both contractors (COTR, Note 22, Note 1). Contractor A had not provided much detail on their plans for Phase 1 nor had they demonstrated much of a gain in knowledge of ETIP activities since the beginning of the project. Contractor C provided more details and plans for their effort but did not include supporting information on how they had selected priorities. In addition, several reports which had been expected were not submitted (e.g., preliminary evaluation designs from Contractor A or industry background analyses from Contractor C).

Over the next several months, ETIP and the contractors attempted to resolve these problems through a series of reviews and written feedback. While some understandings were reached during this period, the difficulties with the reports or with the ensuing discussions highlighted several problems concerning the reports and reviews system. In particular, ETIP and the contractors found that there was:

- Too much paper work.

  The series of monthly, quarterly, special, contact, and financial reports were becoming very burdensome on the contractors, but ETIP was also frustrated because it couldn't obtain the information it wanted (ETIP, Note 23, Note 24). This problem may have been enhanced in part by the large physical distance between the groups, resulting in fewer face-to-face meetings.

- Misunderstandings over the reports required.

  Both contractors had assumed that the items in the illustrative work statement were required (COTR, Note 25;

Contractor A, Note 16; Contractor C, Note 17; ETIP, Note 23). While this had not been the intention of ETIP (ETIP, Note 6), the contractors felt that numerous signals from ETIP reinforced their assumption.

- Delayed commitment to or acceptance of reports.

  Contrary to the spirit of progressive approval and acceptance, ETIP was delaying acceptance of first quarter reports while work continued well into the second quarter. In addition, the contractors felt it was difficult to obtain commitment to report dummies or outlines as final versions were prepared (ETIP, Note 26; Tape of Meeting, Note 27).

- Disorganized feedback on reports.

  The contractors felt that feedback was very slow from the various groups in the project (i.e., ETIP divisions and PAAs) and that it was not easy for them to process it without better coordination (ETIP, Note 23; Tape of Meeting, Note 27). It was also unclear how to treat feedback from the COTR (e.g., as a requirement or a consideration) (COTR, Note 28), or who had the final authority to make changes.

In short, the system for reports and reviews were exhibiting many of the characteristics which ETIP and the contractors had attempted to avoid during the design of the system.

6.3.2.4 Effects on other Areas of the Project

Problems and actions concerning the system of reports and reviews also had effects on other areas of the project. For example, contractor adoption of ETIP proposals for reports and schedules (in the illustrative work statement) essentially set the team structure and tasks for Phase 1 before the contractors were able to formulate their own proposals. In another example, the numerous paper work requirements established by ETIP and the contractors eventually led to noticeable frustrations in the project teams who were attempting to produce these documents.

The following sections describe seven areas of the project which were primarily affected by events with the reports and reviews system. These areas correspond to elements listed in the monitoring framework, and include the following:

- Design characteristics -- system boundaries.
- Process characteristics -- task size, task priorities, team personnel commitment, organization and responsibilities, and decision points and milestones.
- User commitment characteristics -- system champions.

The relationship of these areas events concerning reports and reviews are summarized in Figure 6.3.

Boundaries. The definition of boundaries for the evaluation system was affected to some extent by the first quarter actions related to reports and reviews. As described below in Task Priorities, the COTR in Experimental Methods requested that the contractors develop a report on the priorities for evaluation tasks in Phase 1. In order to facilitate the development of the report, the COTR attempted to minimize or delay the initiation of work on specific experiments. In addition, the COTR emphasized that he was primarily interested in the identification of evaluation needs in on-going experiments rather than the needs for experiments still under design at that time (COTR, Note 29).

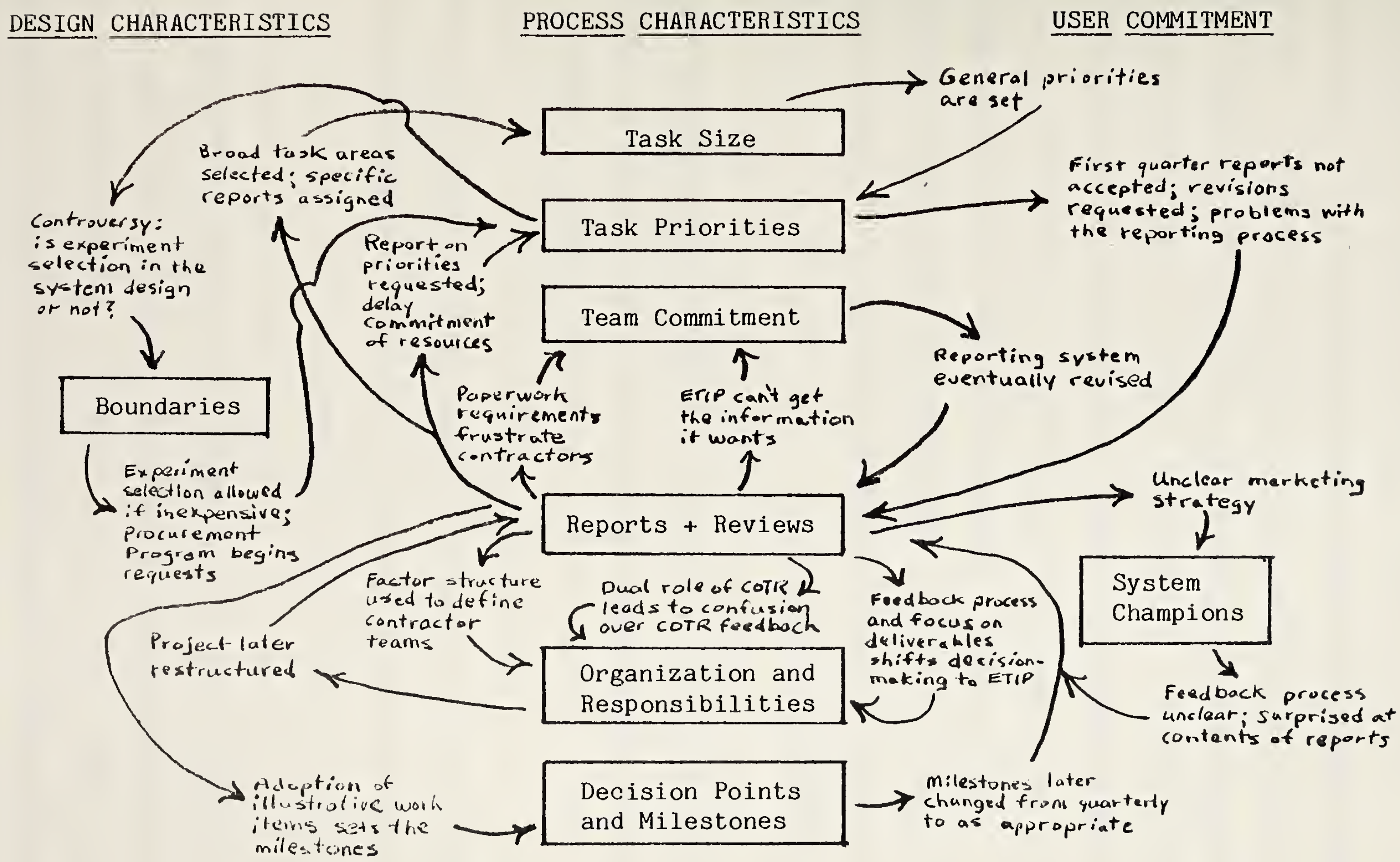

FIGURE 6.3 RELATIONSHIP OF ACTIVITIES CONCERNING REPORTS AND REVIEWS TO OTHER PROJECT AREAS

These requests were not completely supported by the Procurement Program or the PAAs. During this initial period of the evaluation project, their support needs related primarily to the selection and design of new experiments and they were very interested in having the contractors provide this support (Transcript of Meeting, Note 30; ETIP, Note 10; Contractor C, Note 31). While these needs were not entirely outside the scope of the project and it was expected that the evaluation system would eventually provide this type of support, the COTR and Experimental Methods staff felt that the involvement with new experiments would divert too much attention from overall planning and the identification of existing evaluation needs in experiments already underway.

The controversy over the COTR approach produced some uncertainty in the Procurement Program and PAA staff over whether the system would ever support experiment design (Contractor C, Note 32, Note 33; ETIP, Note 34). This uncertainty was further enhanced by the reluctance of the contractors to become involved with the design of new experiments, an activity they considered outside of the evaluation system (ETIP, Note 35; COTR, Note 36).

Task Size. While both contractors technically were free to examine the needs of ETIP and the PAAs and to determine the tasks for Phase 1 (COTR, Note 22; ETIP, Note 37), decisions concerning reports and reviews early in the project broadly defined the tasks before their examinations were completed. As discussed above in section

6.3.2.2, ETIP proposed in the first several weeks that the seven factors used in the RFP work statement (management, reports and reviews, background, objectives, data collection, data analysis, and evaluation design) be used to structure the tasks of the project for Phase 1. The items in the illustrative work statement, specifying relevant activities and reports for each factor, were also included in the discussions. As a result, both contractors quickly adopted this structure and defined their tasks in Phase 1 according to the illustrative items (Contractor A, Note 16; Contractor C, Note 25, Note 17). Since many of the illustrative items described reports to be produced at certain times, this early decision to adopt the illustrative work statement increased attention on deliverables much before analyses had been made on which experiments and evaluations would be supported by the project. The emphasis in both ETIP and the contractors was more on meeting the schedule of deliverables than on the underlying activities they required.

Task Priorities. The adoption of the illustrative work statement items described above essentially set the general task priorities for Phase 1 and led to a schedule of reports to be produced by the contractors. One of these reports in the first quarter was to outline the specific priorities for evaluation in Phase 1 (i.e., which experiments were to be evaluated) and provide the supporting justifications for selecting these priorities. The Experimental Methods staff were especially interested in this report because it was to provide essential information on the experiments not available within ETIP at the time (ETIP, Note 38; COTR, Note 21, Note 22). The COTR thus attempted to minimize or delay the initiation of work on specific experiments until this report was completed.

However, as reported in Boundaries above, this approach caused some concern in the Procurement Program area and the PAAs because it prevented attention to their immediate needs for support. During this period, these two groups were attempting to design several new experiments or obtain key information on activities of existing experiments (e.g., a survey of industry reaction to a proposed experiment). They felt that the emphasis on the priority report, especially one aimed at identifying evaluation needs of existing experiments, was overlooking their primary interests. Eventually, to help reduce this controversy, the COTR decided to allow some work on experiment design if it was simple and inexpensive (ETIP, Note 10).

Despite this early concern over the report on priorities, the reports submitted by each contractor several months later were very unsatisfactory to the Experimental Methods staff. Contractor C's report described six specific projects for priority attention but did not include the detailed supporting justifications expected by ETIP. These choices were also a surprise to the PAA involved in the projects (ETIP, Note 38). Contractor A's report did not provide a specific list of priorities or the justifications. This unsatisfactory outcome led the COTR to request extensive revisions in the reports before they would be accepted.

Dissatisfaction with the reports also raised some problems for the system of reports and reviews. ETIP had expected to be closely involved with the technical work of the project. In this particular case, close involvement meant being able to observe the project review process implemented by each contractor in the determination of priorities. The lack of details on the process in the reports or during their preparation frustrated the COTR (COTR, Note 39). In addition to this problem, the request for extensive revisions in the reports before acceptance countered the expectation that final reports would primarily serve to document already established progress, thus avoiding the problems of revisions after the fact. The lack of acceptance added further frustrations to both the contractors and ETIP as some attention to first quarter issues had to be continued during the second quarter.

Team Personnel Commitment. Problems concerning the system of reports and reviews began to have an effect on the morale of the contractor teams in the second quarter. Contractor A reported in December that the extensive documentation requested by ETIP was frustrating the professionals on project teams (ETIP, Note 24). These professionals felt that the dummy approach to reporting was a waste of time since it required submitting documents that would soon be improved anyway (ETIP, Note 42). Later in December, the project leader for Contractor A reported his own frustrations over the continuing delays of their teams in producing reports for ETIP (ETIP, Note 26). These delays were partly attributed to unsatisfactory communications with

ETIP, especially in obtaining decisions from the COTR. The project leader added, however, that their internal frustrations were not a sign of decreasing interest in the project; on the contrary, the leader emphasized their growing enthusiasm for the project.

Similar concerns were also evident with Contractor C. At a meeting with ETIP in November over ways to improve communication with ETIP, the senior level supervisor from Contractor C commented on how the project used to be fun, but was becoming a chore because of all the paperwork (Tape of Meeting, Note 27).

Organization and Responsibilities. The organization of contractor teams was directly affected by events concerning reports and reviews. As discussed above, both contractors adopted the factor structure of the work statement in organizing their tasks, and this also led to a similar structuring of their teams. Within the first several weeks of the project, team leaders were assigned to each factor area and reports relevant to the area (as proposed in the illustrative work statement) were identified. Only Contractor A reported that it felt that staff responsibilities did not fit neatly within the factor structure and that some other approach was needed (ETIP, Note 1).

The division of responsibilities between ETIP and the contractors was also affected by events in reports and reviews. The contractors perceived a dual role for the COTR: one as the ETIP decisionmaker specifying requirements they had to meet and another as an evaluation stakeholder trying to help solve the technical problems of the project. The contractors had difficulty deciding which role they were seeing in the feedback from the COTR and felt that they had to respond to every comment (COTR, Note 28; Contractor C, Note 40). They also felt that the extensive and repeated feedback from the COTR conflicted with the often stated COTR approach of wanting the contractors to run their own projects (i.e., conduct they work they were expected to perform). The problem eventually was solved by having the COTR identify which role he was taking in all future feedback on contractor progress and reports (COTR, Note 41).

This confusion over feedback from the COTR reflected a much broader problem: that of a subtle shifting of decisionmaking responsibility from the contractors to ETIP. This was enhanced by several other ETIP actions concerning reports and reviews:

- Focusing attention early and regularly in the first quarter on deliverables.
- Emphasizing the deliverables proposed in the illustrative work statement.
- Emphasizing the RFP factor structure for reporting while at the same time emphasizing that the contractors should design a reporting system that made them comfortable (ETIP, Note 13).
- Proposing detailed financial reporting requirements which later led the contractors to feel that ETIP was trying to second guess them (COTR, Note 42).

Identification of these actions and their effects on the division of responsibilities eventually led to a restructuring of the project by ETIP and the contractors in the second quarter.

Decision Points and Milestones. As mentioned several times above, both contractors adopted the factor structure and the respective proposals on reporting that were included in the illustrative work statement. This structure also included a quarterly schedule for reporting in Phase 1 in which major reports for each factor were expected in three month intervals. These quarterly dates for reports and related activities thus became the milestones for the project. ETIP also planned major reviews of progress at the end of the first two quarters.

This schedule of activities and reports was later questioned in the second quarter when elements of the first quarter report were found to be unsatisfactory by ETIP. Subsequent discussions of project structure eventually reduced the emphasis on the quarterly milestones in favor of more appropriate individual milestones for each specific technical activity.

System Champions. Liaison with the partner agencies involved with experiments was an important objective for the evaluation project (Thompson, 1976, p. 47). Besides their importance to the design and implementation of specific evaluations, some or all of the partner agencies were expected to become eventual owners of the evaluation system being developed by ETIP and the contractors. ETIP thus wanted partner agencies closely involved in the system for reports and reviews as a means of ensuring that evaluations were useful to the respective agency and that they cooperated in the project.

However, the idea of using reports and reviews to help market the project (and eventually the system) to important agency staff was not developed in the first six months. Contractor C recognized the importance of PAAs to the project (ETIP, Note 43) and proposed that reports be used in marketing (COTR, Note 44), but later decided that they key reports of the first quarter would be aimed at ETIP, which would then decide how they should be distributed (Contractor C, Note 45, p. 8). Contractor A appeared reluctant to have the PAAs involved in reviewing deliverables even though the COTR emphasized to them that PAA cooperation was essential to the project (COTR, Note 9).

As a result, the feedback process on the first quarter reports was disorganized. For example, one major PAA (the Federal Supply Service) found Contractor A's first quarter report useful but long, and was uncertain how to provide feedback to the contractors (ETIP, Note 46). For Contractor C's report, the same PAA was surprised by the six projects selected for priority attention and had to suggest alternatives after the fact (ETIP, Note 38). These problems did not demonstrate a well targeted process for reports and reviews that was promoting PAA cooperation. They also led to frustrations on all sides over the inability of the reporting system to provide an orderly communication process among the numerous participants in the project (Tape of meeting, Note 27).

6.3.2.5 Resolving the Problems with Reports and Reviews

During the last two months of the second quarter, ETIP and the contractors revised the system of reports and reviews to improve communications and eliminate the problems arising from the initial approach of the first quarter. These changes also affected the structure of the project (tasks and teams) for the contractors for the remainder of Phase 1.

Perhaps the most significant change involved the elimination of the items and structure of the illustrative work statement adopted by the contractors during the first several weeks of the project. ETIP had not intended these proposals to be requirements the contractors had to meet, although the numerous references to them at meetings and in official communications led the contractors to assume the opposite. ETIP reaffirmed that they were not requirements during the last two months of the second quarter, and the matter was immediately referred to the contracting officers of each organization to confirm that this was the case.

Another major change at this time was that the COTR finally accepted the first quarter reports from the contractors as submitted. The revisions desired by ETIP were now to be incorporated into future reports as appropriate. This allowed both ETIP and the contractors to focus full attention on the activities of the second quarter as they were evolving.

Several other ideas were accepted by both sides to improve communications and reduce paper work. These included:

- Elimination of the quarterly schedule of reports in favor of individual schedules for each specific technical activity.
- Elimination of the continuous "dummy" approach to progressive review in favor of a more finite set of working papers and drafts and increased interaction.
- Use of monthly contractor reports as the primary means of documenting progress.
- Encouragement of increased communication both formal and informal. Staff in ETIP and the contractors who could make commitments were now designated.
- Refinement of COTR feedback. The COTR was now to define feedback in terms of requirements or suggestions.
- Use of the management plan as the primary device for controlling the project.

Following these agreements, Contractor C issued a revised management plan to firmly document the changes and establish a different structure for their operations (Contractor C, Note 47). Contractor C teams were now organized around specific technical areas or management, eliminating the factor structure of teams used in the first quarter. As a result, task structure was also simplified: the broad areas of the factor structure were now replaced by a simple list of work areas and respective accounts. Monthly reports were also redesigned to follow this structure.

Similar changes were made for Contractor A and were reflected in their management plan submitted later in the third quarter.

6.3.2.6 How the Monitoring Framework Could Have Helped

The system of reports and reviews was a significant source of attention and problems during the first six months of the project. In the earliest weeks, ETIP placed great emphasis on the establishment of a reporting system and the identification of deliverables which were expected from the contractors. Given the physical distances between ETIP, the contractors, and the partner agencies, the numerous activities and people involved, and the ambitious objectives and technical uncertainties concerning evaluation and system design, a workable system of reports and reviews was clearly a priority need which justified significant attention in the early months of the project.

However, the concentration on developing the reports and reviews system did not produce an effective process. By the end of the first three months, the resulting system was proving to be unsatisfactory to both ETIP and the contractors. ETIP was not able to obtain the information it wanted on contractor activities nor was it able to effectively communicate its concerns to the contractors. On the other hand, the contractors were becoming increasingly frustrated with the excessive paper work requirements of the system and the extensive and disorganized feedback from ETIP and PAAs which caused uncertainties on what was required in the project. Review sessions which attempted to resolve these problems were becoming more confrontative and increasing the distance between ETIP, the contractors, and the PAAs.

In addition, activities and problems concerning reports and reviews in the first two quarters were affecting other areas of the project and broadening the impact on the project in general. Problems were raised over the division of responsibilities between ETIP and the contractors, cooperation with agency partners became endangered, and uncertainties were raised over the general design of the evaluation system being developed. Eventually, these problems had to be discussed extensively by project leaders in the second quarter in order to reduce their effects on the conduct of work in general in the project. A revised system of reporting was established along with changes in the approaches to managing the project.

Given this history, the primary benefit of using the monitoring framework in project management might have been to help establish a more workable system of reports and reviews earlier in the project, thus avoiding the cumbersome problems of the initial approach. A project monitor located in ETIP might have been able to identify the existence and growing impact of problems with reports and reviews that project leaders may have been too busy to appreciate. Alternative strategies for the system, possibly similar to those eventually developed, might then have been suggested much sooner.

For example, a project monitor might have:

- Monitored Team Personnel Commitment, thus identifying that the excessive paper work requirements were promoting frustrations on both sides.
- Monitored Decision Points and Milestones, thus determining that control and information transfer were not being accomplished with the quarterly reporting format.
- Monitored Reports and Reviews, thus identifying that ETIP itself was not following its desires for the system of reports and reviews, and leading to contractor uncertainties over the needs.
- Monitored Organization and Responsibilities, thus identifying the subtle shifting of control to ETIP enhanced by events with reports and reviews.
- Monitored Task Priorities, thus determining that the contractors were not establishing the information base or involving the people required for making decisions on priorities.
- Monitored System Champions, thus improving the ability of the system of reports and reviews to enlist cooperation of key agency staff and market the evaluation system.

Earlier monitoring of one or more of these areas might have helped project leaders identify the growing ineffectiveness of the reports and reviews system. In addition, disassembly, via the framework, of the system's effects into these other areas might have helped develop more effective approaches to the increasingly intertwined problems of the system and the rest of the project. In any case, the time and energy expended in creating and revising the initial approaches to reports and reviews might have alternatively been focused more on the central technical problems of the project and approaches to meeting them.

6.4 CONCLUSION

This chapter has presented a preliminary exploration of the usefulness of the framework in a specific ETIP development. The ETIP project, an evaluation system development, was first reviewed to help familiarize readers with events of the case. One selected period of the project, the first six months, was then discussed using the framework.

The application demonstrated two qualities of the proposed framework. First, by mapping the framework onto events of the selected period, it was shown that the factors were relevant to the case. Second, using this mapping, it was then shown that use of the framework as a whole might have helped project managers identify earlier a critical problem of the period and thus possibly have promoted more efficient actions relevant to the problem. The application did not show, however, the usefulness of the other functions of the framework, including strategy development, research, documentation, and dissemination.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

7.1 AN OVERVIEW OF RESULTS

This dissertation has been concerned with the problems of managing complex system developments where there are substantial uncertainties in system requirements, development processes, and ultimate ownership. The specific environment for the research has been the Experimental Technology Incentives Program (ETIP) in which complex system developments have been conducted as part of its research program with other government agencies.

It was shown within the ETIP environment that managers needed a mechanism to monitor the numerous and evolving activities that a complex development contained. The monitoring process specifically had to help managers:

- Sense or anticipate problems earlier among the numerous, interrelated events of a development.
- Help tie together short and long range perspectives when solving specific problems.
- Establish an information base for the formulation of more effective management control interventions.

It was further shown that the extensive literature reviewed on systems development did not contain an explicit model of monitoring that could be readily adapted into the ETIP environment. Moreover, few specific approaches to the monitoring problem in general were uncovered. Instead it was found that the literature was separated into several distinct areas relating to system development -- that of case studies of developments, development strategy models, important factors in developments, and system designs arising from specific situations. Each area emphasized a different perspective on developing a system and concentrated on selected sets of factors which were important considerations for developers. For example:

- Few sources recognized the broad range of factors potentially important in a development (and thus important for monitoring).
- The changing and evolving circumstances of a complex development were rarely integrated with discussions of the important factors developers should consider (thus defining when factors should be monitored).
- Little attention was given to the process by which users come to accept and support a system and how this process is intertwined with development activities (and thus important for monitoring also).

While some sources in these four different areas recognized the need for a monitoring process, these discussions were not yet integrated with the specific knowledge already available. Several sources in the literature confirmed aspects of this problem by calling for more research on managing complex developments and the development of models managers might use to control the complex circumstances of their own situations.

A monitoring framework for ETIP has thus been proposed both as a mechanism for ETIP managers and as an initial attempt to respond to the management research needs of the literature. The framework contains a broad range of factors to be monitored and is accompanied by a set of procedures for these factors. The procedures are divided into five related functions which reflect the administrative and research purposes monitoring can serve. These functions include:

- Problem identification -- The tracking and assessment of key areas where development problems typically occur, both in the short and long range.

- Strategy development -- The identification and development of explicit management actions to solve problems and revise strategy.

- Research -- The design and implementation of real-time studies of the development process.

- Documentation -- The establishment of an organized and stable recording process which can identify special or recurring problems, and support decisionmaking and research.

- Dissemination -- The distribution of key development information to those inside and outside a development as a means of facilitating coordinated actions and distributing knowledge gained.

Thirty factors important for monitoring a development are identified for the framework based on studies of ETIP projects and the systems literature (see Figure 7.1). The factors are divided into three main categories:

- Design characteristics -- Factors related to the design and functioning of the system.

- Process characteristics -- Factors related to the methods, organization, personnel, resources, and procedures used in the development process.

DESIGN CHARACTERISTICS

- OPERATION AND PERFORMANCE FACTORS
  1. Response Time
  2. Quality
  3. Cost of Operation
  4. Input/Output Operations
  5. Interconnection of Subsystems
- BOUNDARY FACTORS
  6. Capabilities/Limitations/ Expectations
  7. User Groups and Their Interrelationships
  8. Interfaces with Other Systems and Organizations
- ADAPTATION FACTORS
  9. Flexible Specifications
  10. Matching the System to the User
  11. Novelty of the Design
  12. Evaluation and Updating

PROCESS CHARACTERISTICS

- TASK STRUCTURE FACTORS
  13. Task Size
  14. Task Priorities
- TEAM PERSONNEL FACTORS
  15. Skills
  16. Turnover
  17. Commitment
- PROJECT CONTROL FACTORS
  18. Organization and Responsibilities
  19. Decision Points and Milestones
  20. Reports and Reviews
- INTERACTION WITH THE USER ENVIRONMENT FACTORS
  21. User Involvement
  22. Problem Identification
  23. Testing
  24. Transfer

USER COMMITMENT CHARACTERISTICS

- SYSTEM USE FACTORS
  25. Applications
  26. Consequent Actions
  27. Extent of Use
- SYSTEM SUPPORT FACTORS
  28. System Champions
  29. Resource Commitments
  30. Changes in the User Organization

FIGURE 7.1 THE MONITORING FRAMEWORK

- User commitment characteristics -- Factors related to user acceptance and support of the system.

While this structure is specifically aimed at the development circumstances of the ETIP environment, it also reflects to some extent the types of problem areas discussed in the literature from other experiences.

Finally, the monitoring framework has been illustrated with several system development cases from ETIP. First, three ETIP projects have been briefly described and then used to provide examples of the framework factors in actual developments. Second, an additional case, that of the evaluation system project, has been described and used to demonstrate how the framework as a whole might be applied. This application further showed that the factors were relevant to an actual development and that the framework could have assisted project managers in the earlier identification of one specific problem which arose in the case. The application did not, however, provide supportive illustrations of the strategy formulation, research, documentation, or dissemination functions for which the framework has also been designed.

7.2 CONTRIBUTIONS OF THE RESEARCH

7.2.1 Increase in Confidence

The main claim made as a result of the research is that use of the monitoring framework can help project managers more effectively develop a complex system. Two requirements had to be met in order to reach this conclusion. First, a management problem occurring with the development of complex systems needed to be defined. Second, a credible approach to the problem had to be developed. These requirements have been met to a varying degree by the research discussed in this dissertation.

The following sections discuss the research results in relation to these two requirements and the increases in confidence these results represent.

7.2.1.1 Definition of the Problem

The problems associated with developing complex systems are quite extensively examined in the broad systems literature currently available. As shown in Chapter 3, numerous perspectives and sources exist on these problems. Even though a broad study was made of the literature, the results presented in Chapter 3 by no means completely cover the breadth and depth of the knowledge available.

The problems associated with managing complex developments are thus, in one form or another, available in the literature. Even the problem of monitoring a complex development to which the dissertation is devoted is not a new concept. As shown in Chapter 4, several sources in the literature have identified the need for monitoring approaches which enable developers to control the numerous, intertwined factors important in a complex project. Some writers have also suggested the need for frameworks to structure the important factors in systems development, although these proposals have not necessarily been aimed at the monitoring problem in actual projects. It also seems likely, since complex systems have been successfully produced in both public and private sectors, that the monitoring problem has been recognized before. This may be especially the case for the large scale systems produced in the private sector and in military weapon system applications. These areas admittedly need a more extensive examination than is provided in Chapter 3.

However, within the confines of ETIP experiences and the broad range of literature which has been examined, an explicit, detailed discussion of the monitoring problem (or approaches) has not been found. In particular, existing presentations in the literature have only generally raised the problem and have neglected to discuss its dimensions or components. It appears overall that the various management problems of developing complex systems are not yet fully integrated with the numerous and more narrow facets of system development that are extensively represented in the literature. This has especially been the case with the monitoring problem. The dissertation has thus presented a more detailed examination of the problem than previously available and has tied together many of the existing ideas that are related to it.

Describing the Problem in the Dissertation

Definition of the problem was an exploratory process conducted over a lengthy period of time. It involved detailed studies of ETIP projects and the systems literature and repeated comparisons of these sources to the needs of ETIP managers. During this process, the monitoring problem definition changed considerably.

To some extent, this exploratory process has been represented by succeeding chapters of the dissertation. For example, the case studies of Chapter 2 were written early when the monitoring problem was still unclear. At that time, discovering factors important in a development was the primary thrust of the research. These factors were of course later adapted into the revised monitoring framework. In a similar manner, Chapter 3 represented the continuing search for factors after the case studies were completed. However, Chapter 3 also documented several key pieces of the evolving monitoring problem which were uncovered by that time.

Because definition of the problem was a key contribution of the research, it was decided that the process should be summarized in one place (a case study of its own). A portion of Chapter 4 was therefore used to trace development of the problem and show how the preceding background chapters had been a part of the process. Besides summarizing the problem and the methods used to define it, Chapter 4 also enables readers to trace the process for themselves and to evaluate the change in knowledge which has been achieved.

7.2.1.2 Development of the Monitoring Framework

Many of the ideas which have been presented for the monitoring framework are neither novel to ETIP nor the literature. As shown in the preceding chapters, most of the factors in the framework are recognized in the systems literature or are a result of ETIP based experiences. Organization of the factors into design, process, and user commitment categories is not unique to the research either. These terms and their corresponding elements are recognized in one form or another in the literature, although the emphasis on user commitment in this research is more a result of ETIP thinking than a well defined position in the literature. Finally, to some extent, even the problem of monitoring has been discussed elsewhere.

However, it is the combination of these various ideas into a specific approach that represents the contribution of this research (besides a more explicit recognition of the problem, as discussed above). The proposed framework offers a substantially more detailed structure for monitoring than available and provides a mechanism of value both to administrators of developments and to researchers of system development processes.

An initial attempt has also been made to demonstrate the usefulness of the framework in an actual case. The application to the ETIP evaluation system project showed that the framework factors were relevant to the case and that use of the framework as a whole might have contributed to problem identification during a selected period.

The application has only been partially successful in demonstrating usefulness. Several problems in the test were noted:

- Some interaction between framework development and the specific case.
- Only one specific situation was explored with the framework.
- Not all functions of the framework were supported by examples from the application.
- The application has not included comments or perspectives from the personnel involved with the case.

Thus the usefulness of the framework, and ultimately its contribution to the management and research of complex system developments, still remains to be fully shown. Several ideas on further research in this direction are presented in the concluding section of this chapter.

7.2.2 Utility of the Results

The results of the dissertation are useful to several audiences. For ETIP, the identification of the monitoring problem and the studies of specific projects represent the first detailed examination of system development processes within the program. In addition, the resulting monitoring framework is specifically aimed at ETIP projects and offers managers an approach which should improve the conduct of developments and the chances of success. The dissertation thus documents important lessons of the ETIP research program and using these ideas provides a technique for future projects.[1]

For others outside of the ETIP environment, the results may have both administrative and research value. Other system developers may find that the framework offers an approach to improving the management of complex system developments in their own situations. For instance, the framework factors can highlight the various factors which may be important in their development projects. Alternatively, the functions monitoring can serve may suggest ways that a structured, routine information gathering process can increase the manager's chances of success. It is not being suggested, however, that the framework as a whole can replace the seasoned judgement of experienced developers. Rather, it is the overall thrust of the monitoring approach, which can easily be adapted to different situations, that other developers may find to be the most significant contribution.[2]

For researchers interested in system development processes, the results of the dissertation present several useful contributions.

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[1] Some comments on use of the monitoring framework within ETIP have been obtained. See APPENDIX C.

[2] The approach may be most useful when tied to a front-end system planning process which identifies in advance the key areas of concern in a project (Parsons, Note 1). See APPENDIX C.

First, the identification of the monitoring problem represents a more detailed examination of the problem than has been previously undertaken in most parts of the literature. The general problem of monitoring which several sources present has been related to other ideas on important development problems, thus providing some dimensions and elements to the problem.

Second, the supporting background reviews of the dissertation offer researchers several items which may be useful in the structure of future research. The first of these is the broad structuring of the current literature into four distinct areas (case studies, models of development, important factors in development, and system designs arising from specific projects). It has been shown that the distinct perspectives of these areas have yet to be commonly combined into research endeavors, thus narrowing the contribution researchers can make by relying on one perspective or another. The use of each perspective in this dissertation (i.e., combining case studies, models, factor, and design approaches) may offer researchers an alternative on how to improve their presentations and make them more usable by others. A second item useful to researchers may be the example case studies which have been used to describe specific ETIP experiences. Detailed reviews of projects similar to these are not commonly found in the systems research literature. Thus, the cases presented may offer a model that in the future can be replicated in many other situations, thereby increasing the exposure of readers of the literature to what actually happens.

Finally, the framework offers researchers a mechanism which may assist in the design and implementation of future studies. The monitoring process provides researchers with a means of conducting research on projects in real-time. By combining research objectives with administrative use of the framework, researchers may be able to design and implement studies in actual projects rather than relying solely on retrospective approaches or more informal case studies. This may, in turn, help generate the empirical evidence that several systems researchers identify as needed.

More generally, the results of the dissertation may be of use to developer and researcher audiences involved with a wide variety of complex systems. While the framework has been specifically designed for the information system projects of the ETIP environment, it has relied on concepts endogenous to both hardware and software systems, and public and private experiences. System development problems are similar in these areas, but they have not often been compared. In addition, useful approaches to development from these areas have often not been combined. The dissertation may thus help promote the transfer of knowledge between these sectors and offer guidance to developers regardless of the type of system being developed.

7.3 EXTENSIONS OF THE RESEARCH

There are several problems which remain unresolved in the dissertation and these suggest several areas where further research may be conducted. These problems center upon two areas: framework design and testing. The following sections discuss each area.

7.3.1 Improving Framework Design

The current framework design represents the initial attempt by the writer to define a monitoring structure for the management of system developments. Since the framework is preliminary, it is likely that there are gaps in the factors and that alternative organizations or structures might improve its usefulness and comprehensiveness.

Concerning the framework factors, several possible changes have already been identified. For example:

- The subcategory of Operation and Performance factors might be separated into two areas, thus increasing the attention on each (Libman, Note 2). In addition, a factor for maintenance of the system might be added to the operation factors.
- Concerning Team Personnel Factors, two other factors, motivation and recruitment of personnel, might be added as separate items (Thompson, Note 3).
- The term Task Size might be better phrased. In addition, a factor concerning project goals might be added in order to highlight the more overall task structure.
- A factor for planning might be added to Process Characteristics, although it is unclear where it should be placed since elements of it are present in several of the existing factors (Thompson, Note 3).
- Requirements analysis may need more emphasis in the framework, possibly under the Problem Identification factor (Berlin, Note 4).
- There may be alternative names to the factors in System Use Factors that are better designed.

Finally, for all of the factors, the brief descriptions and the supporting discussions might be improved.[3]

Concerning the organization of the framework, the categories used above the factor level, such as Task Structure Factors, may also need revision. These categories were originally included to highlight closely related factors and to facilitate understanding the numerous factors. However, it may be that framework users won't pay much attention to them (Thompson, Note 6) and that their function is limited. A simplified structure may be more useful, although it is currently unclear what this might contain.

Ideas for either better factors or organization may be available from other experiences which haven't been reviewed for this research. For example, monitoring approaches may be available from experiences in the private sector or in military systems applications. It would also seem likely that techniques used in sales and marketing desciplines would be applicable (Berlin, Note 4). These areas need more examination.

In addition, actual use of the proposed framework might uncover better ideas. Some thoughts on testing the framework are discussed below.

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[3] A related problem is that the text is too long to promote applications among readers (Schofer, Note 5). A manual summarizing the monitoring process proposed in the dissertation has thus been developed and is presented in APPENDIX B.

7.3.2 Testing the Framework

Perhaps the most significant problem of the research is that the framework remains untested in an actual system development. The retrospective application of the framework to the ETIP evaluation system project has not been a very effective substitute for a real application. It has at best suggested that the framework might be useful to project managers in the solution of complex problems arising in a development. It has not shown that the framework might also be useful to managers for strategy development, dissemination, or documentation, and useful to researchers for the conduct of structured investigations of development processes.

In developing an actual test, several questions about the framework should be considered. The first of these is to determine whether the monitoring functions are useful to project managers. This would include, the example, whether the framework is a useful mechanism in identifying problems that are of interest and importance to project managers. Generally, a future test of the framework should examine questions similar to this for each function. Other suggestions are as follows:

- Problem Identification.

  Is the framework useful in identifying problems, both in the short and long term?

- Strategy Development.

  Is the framework useful in helping to revise strategy? Does it provide an information base that can help devise strategy? Does it provide a means of evaluating strategy?

- Research.

  Does the monitoring framework enable research to be conducted on an evolving development? Are there areas where researchers can support project managers? How should monitoring be conducted to help improve research designs? Does the process provide a useful means of information transfer between developments and the research literature?

- Documentation.

  Does documentation provide a means to identify special, evolving, or recurring problems not evident on a short term basis? Does documentation help evaluate strategies and provide decisionmaking information? Does documentation provide a means of informing new staff and help alleviate the problem of turnover?

- Dissemination.

  Does the framework monitoring make it easier to generate key information for those inside and outside a project? Does this dissemination help promote coordination? Does monitoring information itself help facilitate further implementation of the monitoring process as a project unfolds?

A second line of questions for future framework testing should be aimed at whether the framework factors are appropriate for the functions. For example, it must be examined whether problems that arise in a development can be adequately characterized and analyzed by the existing factors. Analysis would have to include how the factors are used, whether there are any missing or inappropriate factors, or whether they might be better organized. Examination at this level should help determine what revisions are needed in the current structure.

In a broader perspective, future testing of the framework should also examine whether the framework is of value to administrators and researchers of different types of complex system developments.

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APPENDIX A

Background Materials on the Experimental Technology Incentives Program

EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

(Background For A Briefing For Secretary of Commerce, Elliot L. Richardson) (1976)

HISTORY AND DEVELOPMENT

Background

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards was created by Presidential direction in early 1972.

The President's decision was based on the studies of potential means for stimulating the nation's technology which were undertaken by a special team headed by Dr. Ezra Solomon of the President's Council of Economic Advisers. This was a part of the Domestic Council's New Technology Study conducted in the last half of 1971. Dr. Solomon's study group recommended experiments be conducted to determine effective means for stimulating industrial productivity.

The President's State of the Union Message of January 20, 1972, stated, "Over the last several months, this administration has undertaken a major review of both the problems and the opportunities for American technology. Leading scientists and researchers from our universities and from industry have contributed to this study. One important conclusion we have reached is that much more needs to be known about the process of stimulating and applying research and development. In some cases, for example, the barriers to progress are financial.

In others they are technical. In still other instances, customs, habits, laws, and regulations are the chief obstacles. We need to learn more about all these considerations--and we intend to do so.... But while our knowledge in this field is still modest, there are nevertheless a number of important new steps which we can take at this time. I will soon present specific recommendations for such steps in a special message to the Congress."

The President's Economic Report of January 1972 indicated the importance which technology is perceived to have in the American economy by stating "Investments in scientific knowledge and in its application to productive uses have become an important characteristic of the American economy. Benefits from the development and utilization of knowledge are many and varied. They are evident in improved health for millions of Americans as well as in our greater understanding of outer space. They include entirely new products that enhance the quality of life and new techniques that expand the productivity of the Nation's human and physical resources. While an accurate evaluation of those benefits that directly improve economic performance is difficult--to say nothing of the less tangible benefits--it is widely agreed that the group of activities called research and development (R&D) plays a central role in our economy. It has led to new products and industries; and it can contribute in important ways to solving today's complex economic and social problems."

3.

<u>The President's Science and Technology Message</u> of early 1972 provided specifics about the NBS Program. The Science and Technology Message states the new Program was "to <u>determine effective ways</u> of stimulating non-Federal investment in research and development and of improving the application of research and development results. The experiments to be set up under this Program are designed to test a variety of partnership arrangements among the various levels of government, private firms and universities."

<u>Purpose</u>

In his presentation to the Congress as a part of the FY73 budget process NBS Director Lewis Branscomb identified the new NBS Program as being a response to the "need to learn." Branscomb further indicated that the new Program's final measure of success would be whether or not its results survived in the marketplace.

Commerce Secretary Peterson indicated in testimony before the Congress that he perceived the new Program as part of the Government's encouragement of greater private sector R&D by improving the <u>climate</u> for it.

Thus the purpose of ETIP, as envisioned by those responsible for the conduct of the Program, can be summarized as the carrying out of experiments to learn more about the process of stimulating and applying technology.

4.

On April 6, 1973, Commerce Secretary Fred Dent approved and transmitted a Program Plan for ETIP to the Director of the Office of Management and Budget. That plan stated "The objective of the Program is to learn how the Federal Government can provide policies and incentives which will encourage greater technological innovation in the private sector."

ETIP's refined Program Plan was approved by Commerce Secretary Dent at the conclusion of a briefing on February 1, 1974, and it reaffirmed that ETIP's purpose was "to initiate a series of experiments to find better ways to encourage private investment in R&D."

Approach

The approach to that knowledge-gaining objective has evolved over time.

Initial thinking was that ETIP would, in cooperation with industry, launch technology-stimulating projects. Secretary Peterson provided guidance that he did not believe that the Department of Commerce should pursue industry-specific projects unless given a Congressional mandate.

A second approach considered was that ETIP would focus on the effectiveness of various mechanisms such as (a) aggregation of industrial R&D capability to address industry-wide

5.

technical problems, (b) new methods for transferring government-held technology, and (c) market aggregation to stimulate technology. This approach was determined not to be feasible because of the absence of government entities which could react to these various mechanisms.

A third approach considered was the development of a model of the processes by which technological invention and innovation take place within the industrial community to identify ways of improving the processes. This approach was abandoned because of the widely held perception that the complexities of the innovation process precluded useful modeling within the state of the art.

Still another approach considered was the examination of national problem areas in which new technology could be effective and the investigation of ways to facilitate the introduction of such technologies. This approach was discarded because national problem areas tend to draw the attention of many Federal agencies and the activities of those agencies precluded the establishment of meaningful experiments.

The approach finally selected for the Program was based on consideration of specific Government policy questions related to how and if the Government can influence the rate and direction at which research is performed and utilized.

6.

In the pursuit of this selected approach, it was determined that it would not be practical to conduct experiments on a single firm basis because of the very large number of such experiments that would have to be conducted before one had sufficient data for determining public policy. It seemed to make good sense that the governmental agency responsible for implementing policy changes in a specific area should be involved in ETIP's experimental activities. Governmental agency participation in ETIP's activities would not only assure intense interest in the conduct of the experiments, but also largely overcome the problems of aggregation. A selection was made of an initial set of Government policies based on pragmatic considerations which limited the number of experimental opportunities which could be simultaneously pursued. These considerations include:

- The policy questions selected should be those for which there is a reasonable expectation for obtaining answers based on experience.
- The policy questions selected should draw on the capabilities of the Department of Commerce and should be related to the broad mission of the Department.
- The policy questions chosen should be those where the private sector would be expected to respond.

Areas chosen for concentration are procurement policy, regulatory policy, civilian research and development policy, and economic assistance policy.

7.

(Areas considered for experimentation but not selected for early attention include patent policy, trade policy, tax policy and antitrust policy.)

General Hypotheses

The background statements give rise to two implicit general hypotheses:

- There exist forms of government policies capable of modifying the rate and direction of technological change.
- An appropriately designed set of experiments can both test the hypothesis above and uncover "better ways" for formulating and implementing those policies.

Goal

ETIP's goal is the development of a set of policy guidelines on technological change and the body of knowledge necessary for their effective use. ETIP will, in the course of its efforts, stimulate changes in technology. (Such changes are a by-product of its primary task. The significant output of ETIP must be pragmatic and effective methodologies that the Federal Government can use in ? stimulating the entire process of technological change within the economy in general.)

8.

Operational Strategy

ETIP's Program Plan states that "ETIP must provide both for the development of new policy guidelines and for their adoption by those agencies that are to use them..."

ETIP experiments and studies are directed towards testing and analyzing specific sub-hypotheses of the hypothesis associated with each policy area. When possible sub-hypotheses are drawn from the existing literature and prior research. When prior research and literature are not adequate to permit the formulation of sub-hypotheses, then ETIP conducts background studies before initiation of experiments. ETIP has commissioned a number of such background studies and analyses to provide appropriate understanding.

ETIP has adopted an operating strategy of working in partnership with responsible mission agencies in the conduct of its experiments. Because of the partner's greater experience in the specific subject area of the experiment, that agency normally takes the lead in the conduct of the experiment and ETIP operates in a supportive posture. ETIP's contributions to these experiments are the provision of a rigorous design and the conduct of a careful evaluation with the expectation that the experiment will yield unambiguous data which will significantly contribute to the resolution of a policy issue.

9.

It is recognized that the agency's interest is primarily in the specifics of the individual experiment as it contributes to the agency's mission, while ETIP's interest is primarily focused on the process being used in the experiment. Continuing interaction is needed in order to meet the interests of both of the partners. The partner agency is asked to commit significant resources to the experiment. This increases the leverage of ETIP's efforts. It also insures the continuing interest of the partner agency.

This operating strategy means that the partner agency which must implement the procedural change learns with ETIP during the course of the experiment. The agency is then ready to undertake change when warranted on its own initiative. This strategy precludes the need to implement change by high level directive. It rests rather on an incentive of instituting change for the improvement of agency performance.

Measures of Success

The most appropriate measure of the Program's success is that asserted in its approved Program Plan. That measure is "the number and quality of the ETIP policy guidelines adopted and used." Although specific technical improvements will occur in the conduct of many ETIP experiments, those results are not measures of ETIP's progress toward its objective. Specific technical changes do, however, indicate that ETIP's policy guidelines can be used to influence the rate and direction of technological change.

10.

SPECIFIC EXPERIMENTAL POLICY AREAS

Procurement

The hypothesis underlying ETIP's procurement activity is that the rate and direction of private sector innovation can be influenced by using government purchasing power to reduce market entry risks for innovative products.

In this area ETIP has initiated 25 projects with a total ETIP funding commitment of $3,201,000.

In the procurement area, experiments are being conducted in cooperation with the General Services Administration, the Veterans Administration, and other agencies including State and local governments to learn how changes in procurement policies and practices can stimulate innovation by private firms selling to government. The procedures used by the Federal government can also be used by State and local units of government. The efforts in the procurement subprogram are intended to identify, investigate, test, and recommend changes in procurement policy that will stimulate a market for technologically improved goods. Activity in this area

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concentrates on experimenting with changed procurement practice through the use of such techniques as:

- Life cycle costing
- Value incentive clauses
- Performance specifications
- Warranty considerations
- Multiple award contracts
- New product introductory schedules
- Multiple year contracts
- Cost plus contracting

In order to gain the confidence of the agencies who have responsibility for procurement policy, ETIP adopted a technique of experimenting first with those procurement techniques where there was high likelihood of provoking response on the part of the private sector. Thus ETIP concentrated on life cycle costing, value incentive clauses, and the use of performance specifications. Progress in the conduct of experiments with those three techniques has been encouraging.

- GSA has estimated savings on the following bulk orders of household appliances as a result of the use of life cycle costing:

	Air Conditioners	Water Heaters	Electric Ranges	Gas Ranges	Refrigerators Freezers
Energy reduction	21%	13%	7%	7%	15%
Net savings (life cycle)	$428,000	$326,000	$121,000	$1,545,000	$377,000

12.

- The Federal Supply Service now incorporates a value incentive clause in all contracts for more than $100,000 that involve specifications of some type. The value incentive clause permits product change suggestions by suppliers. Any savings to the government are shared with the vendor. When the Government's cost of ownership is reduced, the contractor is awarded 20% of an average year's savings as his share. Reductions in contract price during the term of the contract make the vendor eligible for an incentive share of 50% of the instant savings.

Vendors have exercised value incentive clauses in eight contracts. One contract was for the provision of household moving containers. The contractor's product improvement will increase the number of times the containers may be used by a factor of five. It is estimated that this change will result in the Government saving of about $7,500,000 in the next ten years, on the first years purchase of 10,000 containers. Among the other contracts were two that recommended modification to the design of computer air conditioning systems and each is expected to save the Government about $400,000 in energy costs during the next ten years. These two contracts each involve an

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estimated purchase by the Government of 20 units for each of two specific sites. The total Government buy of such air conditioners is estimated as 1,000 units annually.

- Experience in writing performance specifications has shown that this type of specification is feasible in such products as ranges, frost-free refrigerators, and lawn mowers.

- ETIP's procurement activity has expanded from the federal focus to include State and local procurements as well. Seven items have been initially selected for attention at the State level. These are: air conditioners, reflective materials, storage batteries, cut sized office paper, two-way radios, copy machine toner, and synthetic oil. States which are participating in these procurements include: Kentucky, North Carolina, Michigan, Illinois, Pennsylvania, Washington, Texas, Kansas, Colorado, Florida, and Virginia.

Prior to the initiation of the ETIP procurement experiments, the Government bought on a lowest initial cost basis. This resulted in many cases in the Government buying an item which was well below the level of available commercial products. The ETIP experiments to date have provided convincing evidence that the experimental techniques can improve the quality of the products that the Government buys. This improvement in Government procurement has been cost effective but it is not the end toward which the ETIP effort is directed. ETIP is convinced that as industry becomes convinced that the experimental techniques will continue to be used, industry will respond to the reduced market entry risk incentive for new products. We believe that prior to 1980, it will be possible to support the procurement area hypothesis that government purchasing can stimulate product innovation.

Regulatory

The hypothesis underlying ETIP's regulatory activity is that the rate and direction of private sector innovation can be influenced by using government regulatory power to reduce uncertainty and other regulatory constraints. It is further hypothesized that such use of government regulatory power can be made without interferring with the main purpose of the regulations.

In this area ETIP has initiated 10 projects with a total ETIP funding commitment of $2,597,000.

The ETIP plan for experimental regulatory projects requires data gathering in a number of problem areas. All of those areas have been identified by regulatory reformers as being significant. They include:

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- excessive regulation
- unfavorable cost/benefit ratios
- inflexible, unrealistic standards, rates or enforcement schemes
- lag and delay in issuing standards, approving rates, or certifying products
- inadequate, unfair and unscientific decisionmaking processes
- uneven, unsure or unfair enforcement systems.

Examples of ETIP activity in the regulatory area are:

- The joint ETIP/Nuclear Regulatory Commission project seeking to reduce lag time for the development of nuclear power plant standards has been completed. The three draft standards were developed. They concern: (1) certification of nuclear materials managers, (2) discharge of thermal effluent into surface waters, and (3) guidelines for evaluating combinations of natural and man-made hazards at power reactor sites. It has become clear that the time to develop draft consensus standards can be reduced from the normal time of about two years to a few months. However the major lesson that ETIP has learned from this experiment is that addressing the problem that is widely held to be a regulatory barrier may in fact not be strictly a regulatory barrier. In this case acceleration of the development of the draft consensus standards has been achieved. But its not clear yet that the stages following the drafting stage will work faster than the old process. Thus in addressing a problem in standards, ETIP has learned to focus on the entire process in order to accelerate the entire standards development rather than focusing on a portion of the process.

- The joint Federal Rail Administration/ETIP project seeking to determine the feasibility of experimenting with shipping of perishables in a way that would stimulate innovation. It is widely believed that the rate regulation structure has been responsible for the railroads not investing in new technology. As a result a rapidly declining portion of perishable freight has been shipped by rail. This project is examining alternatives which might reverse this trend. It is intended that the results of this project will be used by a party-at-interest to petition the Interstate Commerce Commission for rate revisions or other appropriate remedies. Such parties-at-interest include the railroads, shipper cooperatives, wholesale and retail distributors and growers.

17.

- A joint project with EPA seeking to examine alternatives with respect to rigorous product testing at manufacturer's expense which may be pursued without increasing health risks. Specifically this project is looking at alternative certification procedures for pest control systems. Included in such alternative procedures are: (1) a variety of ways in which financing could be provided (including direct payments, loans, loan guarantees, or the establishment of revolving fund), (2) greater use of Federal laboratories in performing effectiveness testing, (3) government provided insurance, and (4) experimental use permits.

- A joint project is being carried out with the Federal Power Commission that seeks to reduce regulatory lag which is hypothesized as being an important determinant in the decisions of utilities to innovate. The project is testing and evaluating a series of new procedural tools in cooperation with the public utility commissions in the States of North Carolina, Ohio, Montana, California, and New York. The procedural tools include: (1) case load management, (2) new method for computing test years, (3) revised rate structure, (4) the development of comparative measures of operating efficiency and service quality, (5) new methods for utility proposal evaluations, (6) development of performance benchmarks for regulated industry, and (7) analyses of long range planning.

- A joint project with the Food and Drug Administration has been initiated to experiment with post-marketing surveillance of adverse drug effects. This project will provide a new alternative--a policy decision based on experimental evidence. This contrasts with the two existing policy options of maintaining the status quo or embarking on a major regulatory change with no real confidence as to its effects.

It is ETIP's belief that these experiments will yield unambiguous information which will contribute to an improved regulatory decision process. Understanding of those circumstances where regulations can influence the rate and direction of private sector technological change must await additional experimental results.

ETIP has discovered that more important than its dollars is its contribution of ideas about what can be determined in experiments that are important in the regulatory area. The complexities of the regulatory process require heavy commitment of ETIP's staff time for the successful initiation and conduct of regulatory experiments.

19.

<u>Research and Development</u>

The hypothesis governing ETIP's activity in research and development is that the nearly $9,000,000,000 of annual Federal funding for civilian research and development can be more effectively directed towards use in new and improved products. Civilian research and development is defined as Federally-funded research other than defense and space. The Federal Government is not the main purchaser of the technological products developed by civilian research and development.

In this area ETIP has initiated eight projects with a total ETIP funding commitment of $1,976,000. $475,000 has been devoted to conducting research on fiber, textile, and apparel flammability in response to a Congressional mandate contained in the FY 1973 Senate Appropriations Committee Report.

Civilian research and development programs have been viewed by many people as the Government trying to find practical uses for the technology it had developed. This was viewed as creating a technology push program. ETIP's view is that the applied research portion of this program can be with proper organization and management pursued in a problem solving mode. The research would then tend to become more of a technology pull process because the problem definition activity would have to involve more deeply the ultimate user of the problem solving products being developed.

The research and development area is investigating incentives and practices that might be employed by Federal agencies that fund civilian research and development to facilitate the end use of the research and development results. Experiments are being conducted with Health, Education, and Welfare, National Science Foundation, and private sector organizations. It is a widely recognized consensus that expenditure of Federal civilian research and development funds (where the Federal government is not the user of the product--development of better police radios, for example), has generally failed to result in a flow of products into the marketplace. Government funded civilian research and development must be more closely coupled to the production and marketing decisions of firms if it is to influence the rate at which the private sector innovates. This program is investigating previous Federal activity to establish the factors that characterize projects which have resulted in commercialization and use of the R&D results. ETIP is also pursuing experiments in this area.

ETIP projects in this area are as follows:

- A study on the effect of federal funding of civilian research and development as an incentive for technological change concluded that federally-funded civilian research and development is not sufficient to bring about technological change in the private sector to any significant extent. The

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study found that commercialization of federally-funded R&D is nearly always accompanied by <u>company</u> policy measures that cause or stimulate market demand. Technical innovation is most often "pulled" into the marketplace through appropriate incentives rather than "pushed" by federally-funded R&D. Therefore, policies for federally-funded applied civilian R&D should be formulated in the larger context of the complex process of innovation.

- A study on analysis of federally-funded demonstration projects concluded that: diffusion depends on market pull rather than technology push; demonstration projects appear to be weak tools for tackling institutional and organizational barriers to diffusion; large demonstration projects with heavy federal funding are particularly prone to difficulty; on site project management seems to be generally effective; dissemination of information from demonstration projects has not been a serious problem; and demonstration projects should have a narrow scope for effective use.

The report suggests a number of guidelines for federal agencies to follow in planning and conducting demonstration projects.

Both the Energy Research and Development Administration and the Environmental Protection Agency have arranged to be briefed on the detailed guidelines and have indicated their intent to adopt the guidelines in their decisions.

- The ETIP project seeking improved flammability of cotton/polyester blends through the use of a consortium has led to the preliminary finding that a consortium composed of individuals and institutions representing the wide spectrum of interests present in research and commercialization can be an effective mechanism for directing government research towards practical marketplace use.

- Early results from the joint ETIP/NSF project seeking to accelerate the flow of technology from universities provides evidence that the number of invention disclosures having commercial potential can be significantly increased when the university offers incentives to the individual who has made the invention.

- The HEW/ETIP effort seeking to cause the implementation of the integrated utility system at universities provides evidence that shows that the federal government can induce the use of technology, where it is cost effective, through the provision of engineering and economic information. The implication of these findings is that under certain circumstances the government need not mount expensive demonstration projects but can leverage with rather modest amounts of funds the expenditures of capital funds by the users of the technology.

23.

Economic Assistance

The economic assistance policy area embraces ETIP's investigation of subsidy policies and also includes ETIP's activity with small business assistance policies. (This expansion of interest is based on ETIP's conclusion that the mechanisms for providing financial assistance to small business are included in the microeconomic policy tools applicable to the general economy.) The main hypothesis underlying investigations in this area is that Federal economic assistance programs can be used as an effective tool for stimulating the use by the private sector of desirable new technology. In addition, a number of these programs, while not having technological change as an explicit objective, nevertheless impact this important element of economic growth. Unfortunately, these impacts often take the form of barriers to the development and adoption of new technologies. Thus, policymakers must be sensitive to the technological impacts in a wide variety of assistance programs.

In this area ETIP has initiated ten projects with a total ETIP funding commitment of $2,165,000.

ETIP has selected as subjects for experiments:

- subsidize users rather than providers of a good or service
- couple rate and direction of subsidies with rate and direction of relevant technological change so that the level and nature of the technology

embodied in the capital is appropriate for efficiently providing the output required to meet the existing social demand

- couple operating, capital, and price subsidies
- do not constrain technological alternatives by subsidizing only certain approaches to a problem
- improve demand forecasting as input to subsidy planning and allocation

In this policy research area the results of two important studies may be summarized as follows:

- The first study involved analysis of internal venture capital market imperfections. The research on this question found no evidence of substantial market imperfections that restrict the flow of funds to small technology-based firms and no indication that small technology-based firms paid higher rates of interest or returned their unaffiliated stockholders more than other small firms. The study further found that there was no evidence that suppliers of funds of small technology-based firms earned higher profits than could be earned by investing in listed securities and no elements of the structure of behavior in the venture capital industry which would enable firms in the business to charge higher rates or earn greater profits than necessary to compensate for the risks assumed. However, a number of new securities regulations have been enacted in recent years for which impact data are not available. Thus, this area should be researched further.

25.

The conclusion that there are no substantial capital market imperfections does not necessarily imply that the supply of funds to new technology-based firms in some sense is ideal. This is because many external factors which influence the investor's expected risk/reward ratio act on this market. Thus, the study concluded that, with a given risk/reward ratio, attempts to increase the flow of funds by direct government investment in small technology-based firms may tend to displace private funds rather than increase the total flow of funds.

- A study to develop an understanding of what federal policies are needed under what circumstances to deal with major economic disruptions in markets for critical raw materials reached two general findings. These findings are:
  - Due to its flexibility, stockpiling is generally an effective policy tool. Other policy tools have lesser net potential benefits because of the flexibility of stockpiling. While this conclusion applies generally, it is not applicable in every market studied (for example, energy).
  - Technical knowledge about substitute materials that might be used and other technical information that would be of value to users of raw materials is widely scattered. Information

diffusion channels are inefficient, fragmentary, and sometimes inaccurate. This situation means that consumers of raw materials cannot effectively plan for potential sudden shortages. They also cannot participate intelligently in the development of technical alternatives. ETIP may have a substantial experimental role in diffusion of technical information.

In addition to these general findings and many specific ones in the individual commodity studies, the contractor developed a reasonably general computerized method for evaluating policy options including supply and demand side technological options, stockpiles, tariffs, and subsidies.

Three projects with small business focus have matured sufficiently to provide meaningful results.

- A study seeking to evaluate alternative policies that the government might pursue in assisting small firms to comply with impacting government regulations found fragmentation of regulation affecting small firms ... problems raising capital for "non-productive" investments in compliance techniques ... a tendency to seek "end of pipe" rather than "process" solutions ... economies of scale in complying with environmental standards ... lack of small business voice in Washington.

27.

The report recommended that SBA intervene in the legislative and regulatory process as an "active but objective" advocate of small business interests. The report further recommended increased financial assistance via loans and lease guarantees, more technical assistance and encouragement of various types of cooperation among small firms.

- The ETIP project with the Connecticut Product Development Corporation has indicated the many administrative difficulties which must be overcome in the transplantation of an organization mechanism from one political environment to another. It is reasonable to conclude that the ability to evaluate the technical merits of individual products is one of the least critical items in determining the viability of a quasi-state activity such as CPDC. Rather, it is the economic or market potential of the new product and the management capability of the firm which are the deciding factors.

- The ETIP sponsored evaluation of the Small Business Administration innovation loan program found that the federal taxes generated by those projects that were successful exceeded the amount of write-off of loans associated with those projects that were not successful. The study supports the hypothesis that financial criteria can be relaxed when making loans to firms that want to innovate without suffering major loss of funds due to default.

ETIP's experience in the Economic Assistance Policy Area has shown that experimentation with economic assistance policy is feasible. Such experiments are expected to provide a better information base upon which to make policy decisions.

Evaluation

In this area ETIP has initiated eleven projects with a total ETIP funding commitment of $2,068,000.

A major activity of the ETIP Program is the conduct of full and careful evaluations with respect to experiments. These evaluations involve the selection, collection and analysis of information to permit the assessment of the actual effects of the experiment and its secondary impacts in the presence of rival activities. Based on this assessment, the evaluation activity will then seek to draw conclusions as to whether or not the benefits of the experimental intervention have been a gain to society. The initiation of ETIP's evaluation projects is following the same development as did ETIP's experiments. In FY 1976 ETIP initiated the evaluation of its procurement activity to be followed in FY 1977 by evaluation of regulation and 1978 by evaluation in economic assistance. Each of these three policy area evaluations will be comprised of two separate efforts, one that evaluates the impact that the experiment has had upon the agency partner of ETIP and the other the impact that the experiment has had in the marketplace.

29.

In order to provide evaluations of experiments ahead of the schedule outlined above, special evaluation activity for selected projects has been undertaken in all policy areas to provide preliminary results to guide subsequent management and direction of ongoing experiments. In procurement, field surveys have gathered information from appliance manufacturers in an effort to learn their reaction to the ETIP/FSS appliance experiments. Funds have been transferred to the Nuclear Regulatory Commission to evaluate the cost effectiveness of the procedures that resulted in the acceleration of the development of consensus nuclear standards. ETIP's right to carefully observe the activities of the Connecticut Product Development Corporation are being carried out by a contractor who is collecting, summarizing, and interpreting data on the Connecticut experience. Separate contract activities are providing real-time observations of the experiments in the flammable fabrics and integrated utility system for the purpose of providing definitive case histories of these two activities. The evaluation of this kind will be absorbed into the main evaluation systems being developed as they come on line.

One important purpose of the evalution effort of ETIP is to provide definitive information such that a decision can be made in FY 1980 as to what the future of ETIP should be. It must be remembered that although every effort will be made to have the necessary information developed for the 1980 decision, the phenomena being researched are contained in a complex field situation.

ETIP's experience with the conduct of evaluations to date has shown that its experiments can be evaluated. Businessmen have been very open in discussing with evaluators their plans for technological change and the impact that ETIP's work is having upon those plans.

GENERAL CONCLUSIONS

ETIP has tested the hypotheses listed in each of the specific experimental areas. The level of current knowledge with respect to those hypotheses are shown at the end of each of the area discussions. With respect to the general hypotheses, ETIP is convinced that each of the four policy areas under investigation do modify the rate and direction of technological change. ETIP is also convinced that the cooperative experimental approach is a viable means for testing hypotheses and uncovering "better ways" for formulating and implementing those policies. However, at this early time we do not have sufficient evidence to demonstrate specific rates and directions of technological change as a result of the limited number of policy guidelines investigated.

31.

In the course of the design and conduct of its projects, ETIP has found that the complexities of policy analysis require more work in the design of experiments than had been anticipated. Specific documentation of the project design in considerable detail is needed before the initiation of the experiments. Close and continual interaction with the other agency partner is a necessity to assure the maximum policy output from ETIP's activities.

The ETIP Program may be characterized as having survived a difficult birth and grown through the learning process of adolescence and is now just beginning to have the maturity and understanding needed to develop the policy recommendations which are its reason for being.

September 15, 1976

Comment due Sec to GAO 60 days from 7/25/77

Victor 2

UNITED STATES
GENERAL ACCOUNTING OFFICE

Potential Problems That Should Be Considered In Evaluating The Experimental Technology Incentives Program

Department of Commerce National Bureau of Standards

Under the Experimental Technology Incentives Program studies and experiments are conducted to develop policy recommendations on how the Government can affect the rate at which the private sector innovates.

GAO has identified problems in Program performance which could hinder the Program's ability to meet its objectives.

The Department's current evaluation of the Program should determine the extent to which these problems have an impact on its performance. If it is found that the Program's objectives are not being achieved, then action should be taken to overcome them and/or modify the objectives.

PSAD-77-132

JULY 25, 1977

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

COMMUNITY AND ECONOMIC
DEVELOPMENT DIVISION

B-114821

The Honorable
The Secretary of Commerce

Dear Madam Secretary:

We have been conducting a survey of the Experimental Technology Incentives Program of the National Bureau of Standards. In view of the evaluation of the Program recently started by your Department, we are discontinuing our survey. However, the information gained and observations made during our survey show potential problem areas that could hinder the ability of the Program to meet its objectives of (1) conducting coordinated studies and experiments with Government agencies to test and evaluate how Government policies affect the rate at which the private sector innovates, and (2) publishing definitive reports that evaluate the results of the experiments and recommend appropriate policy.

We discussed these potential problems with the Assistant Secretary for Science and Technology and other agency officials concerned with the Program. We are bringing them to your attention for consideration in your Department's evaluation and forthcoming budget decisions for the Program.

Science and technology experts believe that the Program is directed toward an important need and participating agency officials said that their association with the Program had been beneficial. However, Program personnel have encountered management difficulties that have hampered Program activities and could continue to do so in the future.

The size of the present staff and its reliance on other agencies to assist in conducting cooperative experiments have made it difficult for Program management to plan and conduct the number of experiments considered necessary to obtain information to make policy recommendations. The effectiveness of the method being used for evaluating experiments has yet to be determined. There also seems to be a need for more effective interaction between Program personnel and Federal policy-making and policy research organizations having similar or related objectives. Also, the Program should remain in the National Bureau of Standards unless the advantages provided by its location can be matched or surpassed elsewhere. These matters are discussed more fully in the appendix.

We recommend that your Department's current evaluation of the Program determine the extent to which these problems impact on its potential for developing policy recommendations on what the Government can do to accelerate private sector innovation. If it is found that the objectives of the Program are not being achieved because of these problems, then action should be taken to overcome them and/or modify the objectives.

We shall be pleased to discuss the contents of this report in further detail should you so desire. Please contact Mr. Jack S. Heinbaugh, Assistant Director, Procurement and Systems Acquisition Division on 275-3195.

As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report, and the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the Chairmen of the four committees identified above; the Director, Office of Management and Budget; and the Chairmen of the Senate Commerce, Science and Transportation Committee, the House Interstate and Foreign Commerce Committee, and the House Science and Technology Committee.

Sincerely yours,

Henry Eschwege

Henry Eschwege
Director

ISSUES FOR CONSIDERATION IN EVALUATING THE EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

ORIGIN OF PROGRAM

In the summer of 1971, the Nixon Administration attempted to bolster the lagging economy. Adverse conditions included a high inflation rate, a worsening foreign trade balance, and a high level of unemployment, including a large number of scientists and engineers. With the growing realization by economists that research and development has a positive impact on economic growth and productivity, Administration officials began to look for ways to apply scientific and technological resources to civilian sector problems.

In July 1971, the President launched the New Technological Opportunities Program to generate proposals for new Federal initiatives in science and technology. This effort initially consisted of three elements: Office of Science and Technology personnel reviewed proposals for new technology projects from Federal agencies; a member of the Council of Economic Advisers headed a study of potential economic incentives to spur the funding and utilization of R&D in industry; and a group headed by the Treasury Department dealt with the transfer of technology among nations. Opinions were solicited from industry executives and specially convened advisory panels. This entire effort was coordinated through staff of the Domestic Council and ultimately reviewed by White House staff.

The New Technological Opportunities Program generated many proposals, but by December 1971, the White House staff recommended that no major funding be provided. It was felt that there was no sound basis for funding major new projects because not enough was known about how the Government could bring about change in technological innovation in the marketplace. As a consequence, officials at the National Bureau of Standards and the National Science Foundation were told to design experimental programs to test various means of providing this information. The new programs were included in the Fiscal Year 1973 budget request.

On March 16, 1972, the President sent a science and technology message to Congress which included goals for three new programs. The Experimental Research and Development Incentives Program at the National Science Foundation and the Experimental Technology Incentives Program (ETIP) at the National Bureau of Standards were conceived to "...determine effective ways of stimulating non-Federal investment in research and development and (improve) the application of research and development results." The experiments of the programs were to be "...designed to test a variety of partnership arrangements among the various levels of government, private firms and universities."

Also, a study program known as the Research and Development Assessment Program was established at the National Science Foundation to "...support assessments and studies focused specifically on barriers to technological innovation and on the consequences of adopting alternative Federal policies which would reduce or eliminate these barriers."

Our work focused on the Experimental Technology Incentives Program's management and activities. Our survey was performed at the Department of Commerce headquarters, the National Bureau of Standards, the National Science Foundation, the Office of Management and Budget, and several other Government agencies and groups involved with the Program. We also obtained views on the Program from acknowledged experts in science and technology policy. Our observations follow.

THE ETIP PROCESS

The strategy of the Program is first to identify Government functions that may influence whether and in what ways private industry makes use of new technology and then to develop experiments in cooperation with other Government agencies and private sector organizations, testing whether new policies or procedures can lead to more effective use of technology in private industry.

Experiments and studies in three areas of Government policy are being conducted:

--procurement, including the testing of potential incentives to technology innovation such as life cycle costing, value incentive clauses, and performance specifications;

--regulation, including changes such as alternatives to mandatory standards and reducing the time to establish new standards; and

--economic assistance, including problems relating to venture capital, small business policies, and commodities supplies and shortages.

Early projects proposed for the Program included policy subjects such as patents, taxes, and anti-trust administration. Cooperation with industry to develop specific technologies was also considered. However, these proposals were not accepted.

In February 1974, the Secretary of Commerce approved the present ETIP Plan and released funds previously appropriated. As of March 1, 1977, there were 17 full-time staff positions and 78 projects had begun, consisting of 26 experiments, 22 studies, 12 evaluation projects and 18 other projects. As of September 30, 1976, $14.7 million had been obligated and for Fiscal Year 1977 $3.1 million has been apportioned.

The methodology of the Program for gaining information that might lead to policy recommendations is:

--researching broad technology-economic related issues to identify areas for potential study and experimentation;

--working with an agency to define specific subjects likely to result in some policy changes;

--designing an experiment or a background study which can lead directly to experimentation, or designing a general study if experimentation is inappropriate;

--conducting the experiment or study in cooperation with the agency based upon a project plan;

--evaluating the project to assess its impact on the agency and the economy; and

--following up on the information gained from individual projects and recommending appropriate policy.

We have identified potential weaknesses in the activities of the Program as discussed in the following sections.

PLANNING, CONDUCTING AND EVALUATING THE PROGRAM'S STUDIES AND EXPERIMENTS

Planning Experiments

The ETIP staff has found that background literature does not exist in many areas of Program interest and background studies must be performed before experiments can be designed to test how the Government can increase technological innovation in private industry. A satisfactory method of studying and analyzing program areas and designing experiments has not yet been developed.

The Program management has concluded that the ETIP staff must perform problem area identification rather than relying on contractors. In dealing with contractors, difficulties encountered included delays caused by the contracting process, the costs of the contracts, and the length of time required for the contractors to learn about agency operations. In addition, having contractors perform studies does not allow the ETIP staff to gain the direct knowledge through research that would be valuable in managing the experiments identified as a result of the studies.

The Program staff has found that the potential cooperating agency must help in defining the reasons for and scope of experiments. The staff needs to make sure that the objectives of both ETIP and the other agencies are met through the cooperative arrangement and must overcome administrative barriers encountered due to the limited experience most agencies have had in working in a cooperative arrangement. A methodology for combining the resources of ETIP, potential cooperating agencies, and contractors is still being developed.

Designing experiments has been unexpectedly difficult because of the inherent complexities of making policy analyses and working with other agencies. Also conducting and monitoring on-going projects has limited the staff time available for planning new projects. The Program's management does not believe the existing staff level is sufficient to perform background research needed to identify problems and design experiments.

The experience gained in developing on-going Program areas should be considered in order to formulate time and staff requirements for identifying problem areas and designing experiments. This information should improve future planning by permitting a better balance between program objectives and program resources.

<u>Conducting ETIP Experiments</u>

The Program plan approved in 1974 stated that many experiments would be necessary to develop general conclusions upon which policy recommendations would be based. In the procurement area, the strategy is to test known incentives in as many environments as possible. Several subjects have been identified for experiments in the regulatory area. However, the Program staff has encountered difficulties that have slowed the rate at which experiments can be initiated.

The strategy of the Program requires that the staff be heavily engaged in all phases of the experimentation process. The staff initially underestimated the time required to effectively plan, conduct, and monitor experiments. The activities of the Program are far more complex than originally envisioned, partly because the agencies cooperating with ETIP have different mission objectives.

We believe that the Department's current evaluation of the Program should determine:

--whether the present rate of experimentation is adequate to develop information useful for making policy recommendations within an acceptable period of time; and

--the extent to which increases in ETIP staffing could increase the rate of experimentation.

Evaluating Experiments

The importance of evaluating experiments to provide a sound basis for policy recommendations was noted in ETIP plans. However, the designs for some experiments started in Fiscal Years 1974 and 1975 did not adequately consider evaluation needs and there were uncertainties in initial experimental results. In January 1976, ETIP personnel stressed the need to incorporate evaluation designs in project planning. Thus, recent ETIP experiments may permit more useful evaluations than earlier ones. However, most ETIP experiments begun since that time have not been completed. Therefore, it is not yet possible to determine the extent to which improved project designs will result in useful evaluations.

Evaluation difficulties are major problems in obtaining useful information from experiments on how Government action can increase technological innovation in private industry. Experience to date indicates that the following factors may limit the information that can be obtained through evaluation or increase the time and cost of evaluation activities:

--the difficulties in convincing cooperating agencies of the importance of rigorous evaluation plans;

--the complex problem areas addressed by ETIP experiments. For instance, it is difficult to relate the effect of specific regulation changes on technology innovation;

--the need to complete many experiments before drawing general conclusions about a problem area;

--the cost of collecting information necessary to reach conclusions from experiments and studies. For example, about $3 million has been obligated for ETIP procurement experiments and studies and $1.8 million for evaluation of their results. The ETIP staff estimates that evaluation requires at least one half the staff required for conducting and monitoring projects;

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--the length of time needed for policies to have an effect on technological innovation by industry. The National Bureau of Standards estimates that it could take years for new procurement experiments to produce technological innovation in industry.

ETIP plans call for contractors to assess the impacts of experiments and studies in procurement, regulatory, and economic assistance policy areas. In 1976, ETIP management contracted with Stanford Research Institute and Research Triangle Institute to evaluate the procurement experiments and studies. The contractors are to submit their evaluation plans to ETIP in September 1977 and evaluation reports in 1978. A contractor evaluation of the regulatory area is scheduled to begin in Fiscal Year 1977. The economic assistance evaluation is scheduled to begin in 1978.

It will not be possible to judge the effectiveness of the present strategy of using contractors to assess the impact of experiments and studies until reports are prepared on the procurement area in 1978. Thus, ETIP management does not now have a proven method of gaining useful information from its experiments for making recommendations on technology policy.

INTERACTION WITH OTHER POLICY-MAKING AND POLICY RESEARCH GROUPS

Agencies

The strategy of the Program is to conduct experiments with other Government agencies. The staff believes that, by cooperating in ETIP experiments, Federal agencies can become familiar with the use of new procedures and prepare for expanded use of procedures being tested.

Officials of cooperating agencies whom we contacted told us that the experiments have benefited their agencies. For example, a Federal Supply Service official told us that the Program has improved the Service's ability to develop new procurement procedures. The role of the Program in Federal Supply Service efforts to apply life-cycle costing was discussed in a previous General Accounting Office Report.1/ Officials of other agencies told us that association with ETIP helped them become more aware of their activities' effect on industry and that the expertise obtained from the Program staff helped them develop better projects.

1/Letter Report to the Administrator of General Services, General Services Administration, PSAD-76-160, July 23, 1976.

However, we are concerned about reliance of the Program on agencies to conduct cooperative experiments on those issues that have been identified as necessary to provide a knowledge base in a policy area. For example, Program officials believe that multi-year contracting may encourage technology innovation in private industry and information on this aspect of the procurement process is necessary. However, they have not been able to reach an agreement with another Federal agency to test multi-year contracting. Consideration should be given to the extent to which the inability to reach agreements with other Federal agencies has hindered the effectiveness of the Program.

Policy Groups

Since ETIP began, policy-mechanisms have been legislatively established that might assist Program officials in reaching agreements with agencies to conduct experiments:

--The Office of Science and Technology Policy, established in 1975, is responsible for recommending Federal policies designed to advance the application of scientific and technological capabilities to national needs;

--The National Center for Productivity and Quality of Working Life, established in 1975, is responsible for developing a national policy for productivity growth in consultation with the appropriate organizations in Government; and

--The Office of Federal Procurement Policy, established in 1974, is responsible for providing overall direction of procurement policy.

The participation of these groups in identifying issues appropriate for experiments should be considered as a way to increase the ability of ETIP personnel to conduct experiments on technology policy questions. Their involvement in the planning of ETIP experiments could also enhance the usefulness of ETIP results in policy-making by these groups.

ETIP staff members have coordinated informally with these policy-making groups. For example, the Program staff has kept the Office of Federal Procurement Policy aware of its procurement experiments. As a result of a request by the ETIP Director, the Office of Federal Procurement Policy issued a letter in January 1977 encouraging greater use of the Life-Cycle Costing technique in procurement. However, as noted in a previous GAO report 1/, greater

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1/Manufacturing Technology--A Changing Challenge to Improved Productivity, LCD-75-436, June 3, 1976.

coordination among groups concerned with productivity and technology could yield more effective results. Therefore, the Department of Commerce's evaluation of ETIP should consider the benefits of better interaction with appropriate policy-making groups.

Improved coordination with Federal organizations conducting research in areas related to ETIP experiments may also be beneficial. Personnel in the Division of Policy Research and Analysis in the National Science Foundation identify issues relating research and development and technology innovation to national purposes, and analyze policy options and their potential effect. The Division staff has studied the effect of Government regulations on technological innovation and sponsored research on factors affecting industrial productivity.

In the past, informal interaction has taken place between personnel at ETIP and the Division of Policy Research and Analysis on the planning and management of specific projects. However, as previously noted, the ETIP staff has concluded that it is necessary in many cases for them to perform background research before initiating experiments to find out how the Government can increase technological innovation in the private sector. Better interaction may enable ETIP personnel to make more use of research performed by others in planning its experiments.

ORGANIZATIONAL LOCATION OF ETIP

The Congress has questioned whether ETIP should continue to be a part of the National Bureau of Standards.

In considering the institutional setting of the Program, we noted that the Department of Commerce's mission includes stimulating and supporting industrial research and development. The National Bureau of Standards has a tradition of cooperative interaction with mission-oriented Government agencies and private industry. Also, the Bureau's management understands the long time frames required for experimentation and is sensitive to the uncertainty of the research process.

The location of ETIP at the Bureau appears suitable because of the following characteristics of the Program:

--Program experiments must continue for 3 to 6 years before results can be observed,

--Access to other agencies is necessary for experimenting, and,

--All experiments contain the risk of failure.

APPENDIX I

Unless these advantages can be matched or surpassed elsewhere, we believe that the location of ETIP is less important to success than the commitment of management reflected through adequate staffing and funding support.

CONCLUSIONS

In managing projects, the ETIP staff has encountered difficulties that have hampered Program activities and could continue to do so in the future. The size of the present staff and its reliance on agencies to assist in conducting cooperative experiments have made it difficult to plan and conduct the desired number of experiments. Also, the effectiveness of the method being used for evaluating experiments has yet to be determined.

We believe that more effective interaction is needed between personnel at ETIP and Federal policy-making and policy research organizations that have similar or related objectives. Greater coordination and cooperation could help ETIP staff achieve the objectives of the Program by improving the performance of necessary background research, abetting the ability of the staff to conduct experiments on technology policy issues, and enhancing the usefulness of experiment results to policy-makers.

RECOMMENDATION

We recommend that the Department of Commerce's current evaluation of ETIP determine the extent to which these problems impact on the potential of the Program to develop policy recommendations on what the Government can do to accelerate private sector innovation. If it is found that the objectives of the Program are not being achieved because of these problems, then the Secretary of Commerce should act to overcome them and/or modify the objectives as necessary.

APPENDIX B

A Manual for Designing and Implementing
A Process to Monitor
Complex System Developments

A Manual for Designing and Implementing

A Process to Monitor Complex System Developments

Preliminary Draft

Stephen D. Garrity

Washington, D.C.

May 1981

Contents

I. Introduction

This document is the preliminary version of a manual to help system developers design a process to monitor the development of complex systems. It is specifically aimed at projects where developers are faced with substantial uncertainties over design requirements, development processes, and the ultimate home for a system.

The manual is also expected to be of use to researchers of system development processes. By combining research objectives with administrative use of the monitoring process, researchers can conduct structured investigations of system developments in real-time.

The manual is divided into several sections. First, the monitoring problem is identified so that readers can recognize how the proposed process fits into a development. Second, a framework of factors which should be monitored is described. Third, the functions monitoring can serve in a development are discussed. Finally, a general model is provided on how the process can be implemented in a project.

Readers interested in examining the background behind development of the monitoring process should consult the following document:

> Garrity, S. D. Monitoring system development: A framework and application (Doctoral dissertation, Northwestern University, 1981).

I.1 How to Use This Manual

Developers or researchers interested in using the proposed monitoring process may find it useful to scan the manual before beginning to read the details. It is suggested that all readers review the Introduction section first in order to understand the general problem under discussion and the basic components of the proposed approach. After this, several different readings might be useful.

System developers may want to scan the section on monitoring functions first to determine whether monitoring can enhance their current management practices. They then might turn to the section on monitoring factors to examine what factors they need for monitoring.

System development researchers may want to scan the monitoring factors first to determine whether use of the factors matches their current research interests. They then might turn to the sections on functions and implementation in order to develop ideas on how to conduct their research within an actual project.

I.2 Who Should Use This Manual

The manual has been developed from a government program where information systems were needed. Thus, to some extent, the monitoring process is oriented toward information systems rather than systems in general.

However, researchers and developers involved with a variety of complex system developments should find the manual useful for their situations.

II. The Monitoring Problem

II. 1 Complex System Developments

Projects aimed at developing new systems where there are substantial uncertainties as to system requirements, development processes, and ultimate ownership can present managers with a range of complex, unstructured problems. General models or paradigms to guide system development are of limited use in these cases since circumstances are unpredictable and changing. A process to control development activities as a project evolves is thus a key component for successful management of a complex development.

II. 2 Monitoring a Development

A critical need in controlling a complex development is information. Developers must be able to sense when things are going well or poorly and then be able to revise strategy accordingly. For example, if system requirements are initially uncertain, then it would be important to ensure that requirements are established and subsequently reflected in a changing development process. Project managers need to determine whether this is occurring in a satisfactory manner and leading to an acceptable design.

The range of important factors involved and the need for timely action suggests that information be gathered in a structured, routine process over the duration of a project. Managers could use such a process to monitor key areas where problems may arise and affect development strategy. The process would provide a early warning of situations requiring management intervention as well as establish a base of information on which to analyze and implement change.

II. 3 A Research Role for Monitoring

A monitoring process can also be an important device for researchers of system development processes. Much of the current research in the literature is based on reports of experiences or retrospective analyses in which the researcher is either isolated from the project or unable to implement rigorous designs. Systems researchers have a critical need for more access to actual projects, especially in early stages where the research can be implemented concurrently with the project.

A monitoring process may provide the means by which researchers can gain access to projects. An on-going monitoring system aimed at administrative needs might easily be structured to also satisfy research needs.

II. 4 The Proposed Approach

A monitoring process has thus been developed and is proposed as a device which can meet management and researcher needs in a system development process. The process consists of three components:

- A framework of thirty factors which should be monitored.
- A set of five functions which monitoring information can be used for.
- A general model of how the monitoring process should be implemented within a project.

A section is provided on each of these in the manual.

III. The Monitoring Factors

III.1 Introduction

This section describes a framework of factors to be used for monitoring a system development. Thirty factors are identified and they are divided into three categories: design characteristics, process characteristics, and user commitment characteristics.

Design characteristics are factors which describe what a system looks like and how it works. Monitoring these characteristics is important for several reasons. First, the design must be sound, meaning that it actually provides the functions needed by users as well as meet the specific performance requirements. Second, the design must be attractive to users in order to gain their support and use. This means that the design must help users solve important problems in a manner which is matched to their style and other organizational processes.

Process characteristics are factors which describe the methods, structures, procedures, resources, and personnel used to conduct and control the development. Monitoring these characteristics provides developers with an indication of whether process they are using is producing the appropriate design and leading to full implementation of the system at the end of the project.

The third framework category, user commitment, consists of factors which characterize behaviors related to use and support for the system in the prospective owner organization. Commitment is viewed here as developing over time, making it essential to monitor it during the project and determine whether it is increasing or decreasing. The final user decision to fully implement a system will be a reflection of the commitment already established during development.

Two figures are provided to summarize the factors of the framework. First, Figure III.1 lists the framework categories and all of the 30 factors. Second, Figure III.2 provides a brief description of each factor. These descriptions are also used in the more detailed discussions of the factors.

DESIGN CHARACTERISTICS	PROCESS CHARACTERISTICS	USER COMMITMENT CHARACTERISTICS
• OPERATION AND PERFORMANCE FACTORS 1. Response Time 2. Quality 3. Cost of Operation 4. Input/Output Operations 5. Interconnection of Subsystems • BOUNDARY FACTORS 6. Capabilities/Limitations/ Expectations 7. User Groups and Their Interrelationships 8. Interfaces with Other Systems and Organizations • ADAPTATION FACTORS 9. Flexible Specifications 10. Matching the System to the User 11. Novelty of the Design 12. Evaluation and Updating	• TASK STRUCTURE FACTORS 13. Task Size 14. Task Priorities • TEAM PERSONNEL FACTORS 15. Skills 16. Turnover 17. Commitment • PROJECT CONTROL FACTORS 18. Organization and Responsibilities 19. Decision Points and Milestones 20. Reports and Reviews • INTERACTION WITH THE USER ENVIRONMENT FACTORS 21. User Involvement 22. Problem Identification 23. Testing 24. Transfer	• SYSTEM USE FACTORS 25. Applications 26. Consequent Actions 27. Extent of Use • SYSTEM SUPPORT FACTORS 28. System Champions 29. Resource Commitments 30. Changes in the User Organization

FIGURE III.1 THE MONITORING FRAMEWORK

DESIGN CHARACTERISTICS

Operation and Performance Factors

General Description: The functioning of the system design in the user organization.

Factors:

1. Response Time -- The amount of time it takes a system to respond to a user inquiry.
2. Quality -- The accuracy, credibility, and utility of input and output information in the system.
3. Cost of Operation -- The amount of resources needed to operate the system.
4. Input/Output Operations -- The mechanics of user interaction with the system.
5. Interconnection of Subsystems -- The interrelationships of system elements.

Boundary Factors

General Description: The borders of system and subsystem designs.

Factors:

6. Capabilities/Limitations/Expectations -- The conceptual boundaries of a system prescribed by the various groups of people involved in the development.
7. User Groups and Their Interrelationships -- The roles and costs and benefits of involvement with the system pertaining to the different groups of the user organization created by the system design.
8. Interfaces with Other Systems and Organizations -- The relationships between the system and other systems and organizations.

Adaptation Factors

General Description: The match between the system design and the user organization.

Factors:

9. Flexible Specifications -- The match between design specifications and the existing uncertainties over system objectives, processes ownership, products, etc.

FIGURE III.2 BRIEF DESCRIPTIONS OF THE MONITORING FACTORS

10. Matching the System to the User -- The match between the system design and the user organization structure (structural), the abilities, methods, and personal styles of individual users (technical), and the personal relationships of individuals in the user organization (personnel).
11. Novelty of the Design -- The change a new system represents over the existing system.
12. Evaluation and Updating -- The provision of evaluation and updating functions in the system design.

FIGURE III.2 (continued)

PROCESS CHARACTERISTICS

Task Structure Factors

General Description: The design of project tasks to develop the system.

Factors:

13. Task Size -- The amount of resources (money, manpower, and time) assigned and consumed in the performance of individual system development tasks.
14. Task Priorities -- The relative emphasis across tasks at a given point in time and the ordering of tasks over time.

Team Personnel Factors

General Description: The availability and functioning of project personnel.

Factors:

15. Skills -- The availability of technical and interpersonal skills in project teams as required by system development tasks.
16. Turnover -- The change of personnel involved with project teams.
17. Commitment -- The team member support for and implementation of the goals, strategies, and tactics of the system development.

Project Control Factors

General Description: The structures and processes used to control project activities.

Factors:

18. Organization and Responsibilities -- The structure of project teams and responsibilities in the system development.
19. Decision Points and Milestones -- The structure of specific events created by project managers to recognize or review progress and decide future courses of action.
20. Reports and Reviews -- The structure of written and oral communication mechanisms used to document and review development progress.

Interaction with the User Environment Factors

General Description: The involvement and contact between the project and members of the user organization.

FIGURE III.2 (continued)

Factors:

21. User Involvement -- The participation of members of the user organization in the managerial and technical teams of the project.
22. Problem Identification -- The overall amount of attention to and the amount of contact with the user organization in the definition of user problems.
23. Testing -- The amount of concept and design testing conducted in the user environment.
24. Transfer -- The amount of attention devoted to the transfer of the system to the user environment.

FIGURE III.2 (continued)

USER COMMITMENT CHARACTERISTICS

System Use Factors

General Description: User actions related to application of the system in organizational processes.

Factors:

25. Applications -- The use of specific elements of the system in specific units of work of the user organization.
26. Consequent Actions -- The actions resulting from areas of direct system use.
27. Extent of Use -- The amount of use relative to the number of potential applications.

System Support Factors

General Description: User actions related to supporting application of the system to organizational processes.

Factors:

28. System Champions -- The emergence of advocates for the system in the user organization.
29. Resource Commitments -- The type and extent of resources allocated by the user organization to support the system.
30. Changes in the User Organization -- The alteration of policies and procedures in the user organization in order to support system operation.

FIGURE III.2 (continued)

III.2 Design Characteristics (Factors 1 - 12)

The 12 design factors are separated into three major categories: (1) operation and performance factors, (2) boundary factors, and (3) adaptation factors.

III.2.1 Operation and Performance Factors

This category of design characteristics measures how the system operates and performs tasks related to meeting user requests. These characteristics have an impact on people using the system and thus are ultimately linked to the success or failure of the system. Monitoring them during development may decrease the likelihood that inappropriate designs or poor performance stay uncorrected and act as barriers to obtaining full support of the system.

Factor 1 -- Response Time

Description. The amount of time it takes a system to respond to a user inquiry.

Discussion. The time it takes a system to respond to a user, usually in relation to a request, is an obvious design characteristic which will affect use. Long delayed responses might be expected to gradually discourage a user from interacting with the system. Quick turnaround might accelerate introduction of the system and build user confidence. Developers need to monitor the derivation of the response time requirement and its development within the system.

Factor 2 -- Quality

Description. The accuracy, credibility, and utility of input and output information in the system.

Discussion. Quality is used as a measure of input and output information characteristics, especially as to their accuracy, credibility, and utility. This factor is important from two perspectives. First, the system must provide correct information. Second, the system must produce what is needed by users and lead to their support and commitment to institutionalization. While these attributes can be related, developers must ensure that the system has both since one does not necessarily follow the other.

Factor 3 -- Cost of Operation

Description. The amount of resources needed to operate the system.

Discussion. The cost of running a system is another factor which developers should monitor. If a system is going to cost to much to operate relative to its benefits or user resource constraints, users will be less likely to support it. Obviously, there is a tradeoff between the quality represented in the system design and the economy in operating costs.

It is difficult to know operating costs in advance however, especially if there are great technical uncertainties or little historical data on other systems which might be used as a benchmark. Developers must thus closely monitor costs as a project proceeds and ascertain whether the expected costs of operation are remaining feasible with users.

Factor 4 -- Input/Output Operations

Description. The mechanics of user interaction with the system.

Discussion. The operation of input and output functions of the system is important to monitor for several reasons. First, it must be mechanically easy for users to interact with the system. If it appears too difficult for them to get a request in or out of the system, most likely they will not use it or will find ways to go around it. Second, the same conditions apply to personnel responsible for providing data to a system. It may be difficult to collect the data or there may be uncertainty as to how to put it into the system. These problems could have significant impacts on staff support. Generally, the design of input and output functions may conflict with or enhance the way an organization works or solves problems. Developers should spend time monitoring this characteristic.

Factor 5 -- Interconnection of Subsystems

Description. The interrelationships of system elements.

Discussion. An important characteristicc to monitor is whether and how elements are connected to each other. Developers should consider organizing subsystems such that interactions between them are minimized. Besides allowing for easier removal and update of components, minimizing interactions may also help minimize the impact of changes to the user organization or personnel relevant to these subsystems.

III.2.2 Boundary Factors

A system can be described by what is included and what is excluded. Similar descriptions can be used at the subsystem level. The boundary of a system is an important concept to developers and its placement can be very influential on development activities.

The main concern in this section is the conceptual boundaries which define the system and the implications they have for the user organization. Conceptual boundaries are the words, thoughts, plans, objectives, expectations, models or roles represented in or guiding design characteristics.

Factor 6 -- Capabilities/Limitations/Expectations

Description. The conceptual boundaries of a system prescribed by the various groups of people involved in the development.

Discussion. Developers need to monitor how well design capabilities, limitations, and expectations match across user groups (and between users and developers). The system's anticipated capabilities should not be oversold; unmet expectations may cause support to whither away or be unattainable. Conversely, user expectations which are lower than the capabilities claimed by developers may cause the system to appear too grandiose and consequently gain little attention among users.

Factor 7 -- User Groups and Their Interrelationships

Description. The roles and costs and benefits of involvement with the system pertaining to the different groups of the user organization created by the system design.

Discussion. A system usually creates a number of different groups in the user organization. For example, there can be system owners, input sources, output users, system managers, performance evaluators, or system operators. These groups may cut across already established organizational lines.

Another way to identify system boundaries then is to study these groups and their interrelationships. Each group has a specific role in the system and certain costs and benefits associated with it. Some groups may even have multiple roles, such as when owners and users are the same people. Developers need to address both the imbalances a design creates within a group (e.g., between the cost and payoff of participating) and any resulting implications for group interactions (e.g., cost/payoff differences between groups).

Factor 8 -- Interfaces with Other Systems and Organizations

Description. The relationships between the system and other systems and organizations.

Discussion. Various other systems or organizations can interact with a given system. For example, they may be:

- Sources of data,
- Controllers of system resources,
- Users of system outputs, or
- Competitors.

Developers need to monitor the relationships to these outside operations such that the proper ties are made in the design.

III.2.3 Adaptation Factors

Developers need to monitor how well the system and the user organization are fitting together. A poor match should be identified early so that the design and/or organization can be adjusted. In addition, developers also need to integrate the procedures to examine the match into the final design so that they can be used to continually improve the system during its operational phase.

Factor 9 -- Flexible Specifications

Description. The match between design specifications and the existing uncertainties over system objectives, processes, ownership, products, etc.

Discussion. A system design should be kept flexible during a development in order to accommodate (as appropriate) the uncertainties which are likely to arise. Uncertainties may exist from a lack of knowledge about an area (such as a novel technical problem) or might evolve from changes in personnel, organization, or budgets.

In order to keep design specifications flexible, developers should identify and monitor areas that have major implications for the design if they in some way change.

Factor 10 -- Matching the System to the User

Description. The match between the system design and the user organization.

Discussion. As designs are created and detailed, developers need to test the match between the design and the user. This will help determine whether the design and the development strategy are satisfactory.

Three categories of matching seem to capture the major overall concerns:

1. Structural matching.
   This is the match between the structure of the system and the structure of the user organization. Structural characteristics include goals, priorities, patterns of communication, operations, relationships and

responsibilities.

2. Technical matching.
   This is the match between the system design and the abilities, methods, and personal styles of individual users.

3. Personnel matching.
   This is the match between the people in the user organization according to their relationship within the system. Basically, the question is whether people will be able to work together as required in the design.

Factor 11 -- Novelty of the Design

Description. The change a new system represents over the existing system.

Discussion. Developers need to monitor the degree of change a new system represents relative to the existing system. It should be expected that novel changes will be difficult to make or will generate user resistence; incremental change may facilitate conversion to the new system.

Developers need to monitor changes in the following areas and determine implications for development strategy:

- System functions.
  Functions previously unavailable may represent a significant change to users. These functions may have been impossible to develop before, or maybe they were not considered. There may have been no preexisting need.

- Performance.
  Dramatic changes in performance over an older system may represent a source of significant change to users. While the actual performance improvement could represent a small design alteration, the implications of it may be much broader for all associated activities.

- Operation.
  New ways of doing things may be a significant change for users familiar with the older system.

- Other systems.
  The relationship to other systems may change with the implementation of a new system.

- Support.
  The organizational support for a new system might be very different than that given to the old one. A new system may create previously nonexistant barriers to its operation.

Factor 12 -- Evaluation and Updating

Description. The provision of evaluation and updating functions in the system design.

Discussion. In order to maintain the adaptability of a system, developers need to ensure that updating functions are built into a system design. Several different areas need to be examined concerning evaluation and revision processes, including:

- Evaluation criteria.
  Assuming that some kind of evaluation is needed, developers should identify the decisionmakers involved and their criteria. These decisionmakers might include groups well outside of the immediate user units. These criteria may be uncertain in early project stages and may need development. Developers should think through how these criteria can be applied and built into a design.

- Decision points.
  If explicit decision points are used to control a project at each stage (see also Decision Points and Milestones below), developers should examine early what information might be needed about the system. Implications from analyses like these may possibly provide the basic strategy for later system testing (see also Testing, Factor 23).

- Other organizational review processes.
  If the system is to become an integral part of an organization, its evaluation and updating functions may need to be tied to already existing organizational review procedures. These might include reviews of the organization conducted from the outside as well. Developers may have to adjust designs to accommodate changes from these sources.

- Freezing a design.
  At some point it may be advantageous to freeze a design in order to bring the full system into operation without continuing distractions for revisions. Developers need to examine where updates should be made and which ones can be delayed without risking problems. In cases where updates are put off, provisions should be made for users to initiate them when they assume complete responsibility for maintenance of the system.

- Mechanisms.
  Finally, developers need to examine how evaluation and updating function overall. They should study whether problems are identified, whether redesigning occurs in a timely manner, and whether changes actually are, or can be, made. This mechanism must be operational like any other system component when the system is finally institutionalized.

III.3 Process Characteristics (Factors 13 - 24)

III.3.1 Introduction

A system development can be described by the methods, procedures, personnel, resources, and structure developers use to operate the project. These factors contain a process perspective in that they are a means towards an end: the eventual design and institutionalization of the system. Factors which denote project activities like these are defined as process characteristics in the monitoring framework.

The following sections identify and describe 12 factors. These have been separated into four categories: task structure, team personnel, project control, and interaction with the user environment.

A special note should be made here concerning the different groups which may be involved in the development. A development may be the responsibility of several different institutions which are normally independent of each other. For example, contract support may be needed or a third party may provide financial support.

The development process under multiple group arrangements like these can be complicated. Responsibilities are shared, the different groups must be coordinated, and different perspectives on strategy may arise.

For this reason, some of the following sections for each factor include discussion on how multiple group situations can affect a project, particularly in contracting cases. These discussions illustrate the additional characteristics developers should monitor when more than one group is involved.

III.3.2 Task Structure Factors

A system development can be divided into a series of specific tasks or group of tasks. Tasks are usually grouped into categories or phases, such as problem identification, design, or evaluation. These demarcations are fairly arbitrary, however, and disguise the true cyclic process and sequencing of development tasks.

Of more interest are the actual tasks which occur within and across phases like these. Identification and coordination of these tasks represent a significant problem to developers. For example, tasks related to different subsystems may be similar and need coordination. In other parts of the design, some subsystems may need to be fully developed before others.

Developers need to monitor both the size and priority of tasks as the development proceeds.

<u>Factor 13 -- Task Size</u>

<u>Description</u>. The amount of resources (money, manpower, and time) assigned and consumed in the performance of individual system development tasks.

<u>Discussion</u>. The size of project tasks, or group of tasks, is one characteristic developers should monitor throughout a project. The size of a task includes the amount of money, manpower, and time consumed in performance of the task.

One of the main reasons to monitor size characteristics is to control costs. Costs can easily expand beyond initial expectations if there are major technical uncertainties in the design or numerous changes of course in the project. Early and progressive monitoring of resource expenditures may help avoid becoming overcommitted to a narrow portion of the project or running out of resources at key points.

While there is no one right size for project tasks, many sources recommend dividing projects up into small, manageable steps which are easier to control. There are several reasons behind this strategy:

- Overall, system developments are complex undertakings which involve numerous, intertwined problems. Breaking off and working on small pieces of the problem can make the project easier to handle. As more is learned about the user environment, more complex and expansive tasks can be undertaken.

- In early stages of a development, smaller investments of resources by users and developers can reduce the risks involved in choosing one direction over another. The chances of a large scale failure may then be reduced.

- Developments are likely to contain a number of changes which can upset the flow of the project. Using smaller, discrete tasks and gradually moving towards more complex undertakings can help protect against major disruptions.

- Overall success may be more easily attained when smaller lines of work are used. A strong track record of modest success may increase the likelihood of overall success.

On the other hand, smaller, more numerous tasks imply more project control and monitoring than might otherwise occur. This could become most inefficient if carried to an extreme. Developers have to balance the risks in commiting themselves to certain task sizes with the benefits they can achieve in work flow, control, and likelihood of eventual success.

Factor 14 -- Task Priorities

Description. The relative emphasis across tasks at a given point in time and the ordering of tasks over time.

Discussion. The priority of tasks is another characteristic developers should monitor throughout a project. Priorities include both the emphasis across tasks at a point in time and the ordering of tasks over time.

There are a number of factors which can affect priorities and these should be considered when priorities are monitored. These include:

- Resource availability (When will money and manpower be available for a task?).

- Time needed to accomplish a task (Is a task uncertain or well understood?).

- Priority of user needs (What should be accomplished first from the perspective of the user?).

- Interrelationships of subsystems (In what order must subsystems be developed?).

- Need for accomplishments (What tasks will help build momentum for the project and build credibility with the user?).

III.3.3 Team Personnel Factors

A second process characteristic developers need to monitor is the operation of the system development team.

Developers must first ensure that the skills needed in the project team are obtained. These will range from managerial to technical areas.

Second, developers must monitor the turnover in personnel that is likely to occur. Turnover of key personnel can slow progress in a development by consuming time to transfer knowledge between incoming and outgoing personnel, or by bringing in new perspectives which must be accommodated with already existing strategies.

A final area developers should monitor is the commitment of personnel to the project. Commitment of the staff to a project is a predecessor to the more comprehensive commitments by users. Changes in these commitments, or differences between team members, may be an early indication of uncertainties in project goals or stategy.

Factor 15 -- Skills

Description. The availability of technical and interpersonnel skills in project teams as required by system development tasks.

Discussion. System developments require a range of skills which developers must ensure are available. At one level, there are the technical aspects of design which require people trained in specialized areas. At a second level, there are interpersonnel aspects of design which require people trained in understanding and working with people. A development team should have a mix of these skills. It is also important to have people with a mix of both technical and interpersonnel skills who can effectively handle the complex, intertwined problems that developments involve.

Contracting for these skills may be necessary, and this may present an additional number of problems developers should consider. For example, contracting requires developers to design a procurement procedure that specifies the kinds of skills needed. In addition, contracting for support results in a new, outside team that requires integration into the user organization.

Factor 16 -- Turnover

Description. The change of personnel involved with project teams.

Discussion. A major problem for a development team is turnover in its personnel. Important knowledge can be lost in key project areas that ensures continuity. Even in cases where no knowledge is lost, newcomers will need time to familiarize themselves with a project. This can cause delays.

Developers might prevent some turnover by initially obtaining long term commitments from key team members who would represent a significant loss to the project. If contractors are involved with the project, this is often done through the use of key personnel clauses in the contract.

Changes are inevitable, however, and developers need also to examine ways to minimize their impacts during a project. Several actions may be taken:

- Developers can establish an executive management team, and other teams for that matter, such that key tasks and responsibilities are shared among several people.

- Another method is for developers to continuously encourage people to remain throughout a development.

- Developers may want to minimze broad assignments for project personnel.

Factor 17 -- Commitment

Description. The team member support for and implementation of the goals, strategies, and tactics of the system development.

Discussion. Commitment of project team members to the goals, strategies, and tactics of the development is an important predecessor to the eventual full user commitment to the system. A lack of personal commitment may result in key staff turnovers (see preceding section), or be evidence of a much broader problem in the home organization. Gaps in commitment between team members may be a source of confusion and uncertainty which slows progress. Gaps between team members and their home organizations may have the same effect. Developers (team members) need to be sensitive to the commitments of personnel in the project. Shifts or gaps need to be detected early and their broader implications handled in line with project goals.

Several indicators of project team commitment are the following:

- The involvement of key, experienced personnel on project teams from the various groups participating (e.g., from the user organization, contractors, etc.).
- Top level management support from the home organizations.
- Time spent on the project versus time spent on competing projects in the home organization.
- Differences in commitment between personnel of separate home organizations.

III.3.4 Project Control Factors

Several factors having a significant effect on a system development are the processes used by developers to control the project. Large scale system developments are complex undertakings which involve numerous activities, problems, technical issues, opportunities, etc. They can be further complicated in situations where more than one organization is involved in the project. Developers need to monitor the control processes used so that revisions can be made if they prove ineffective for accomplishing project objectives.

Three categories of process control methods are discussed in this section. The first is the organization of teams and responsibilities. Developers need to establish a management structure which matches the complexity of the development and the appropriate level of distributed responsibility. The second category is the use of decision points and milestones. Developers can use specific points in time or the accomplishment of selected tasks as control points where progress can be reviewed, problems can be identified, or approvals for further work can be obtained. The final category is the use of reports and reviews to monitor work, document and discuss problems, or to disseminate information about the project to relevant outside stakeholders who may have influence over the development.

Factor 18 -- Organization and Responsibilities

Description. The structure of project teams and responsibilities in the system development.

Discussion. A key part of project control is the team structure used by developers to manage and conduct the project. Part of the structure should include a central authority which can coordinate and manage the numerous organizations and people involved. Another part of the structure will involve the distribution of responsibilities to the personnel actually performing the work. Day-to-day control of project activities will be located at lower management levels. Developers will need to examine early in a project the kind of structure they use to conduct and control the work and then progressively monitor its effectiveness in accomplishing project tasks.

Many sources advocate the use of a small central team for managing a systems project. This team controls development overall and reports to higher level decisionmakers in the organizations supporting the project. In projects where only one organization is involved, such as with an in-house development, the team should probably consist of both users and designers with users retaining ultimate control.

However, the situation may be more complex when mulitple organizations are involved, such as when contractors are used. While central authority should still reside with the user organization, much of the project work may occur outside of the user organization. Thus, to some extent, control must be more distributed. A structure must be established that provides a locus of control while ensuring adequate responsibility to outside groups.

Another issue is whether developers utilize new teams or existing ones to form the working level structure. Developers may choose to form new teams to conduct the work by drawing on personnel from existing organizational units. An alternative is to rely on already existing groups or structures. In this case, project tasks would be assigned to the units who would then decide how to perform the task and staff up for the work.

Whichever approach is taken, developers will have to examine how responsibilities are delegated to the working level teams. Centralized control of all project activities will likely be impossible, and for that matter, inefficient and unnecessary. Numerous problems and decisions can be delegated to lower level working groups where they can be effective handled as they arise. It will be advantageous overall if working level groups can gain the sability to recognize problems and opportunities on their own and then have the flexibiity to handle them as appropriate for project objectives.

It should be recognized, however, that some problems (or opportunities) may arise which fall outside the organizational lines chosen by developers. Developers should consider the need for ombudsmen who can be assigned to these unique problems. These individuals might report directly to the central management team.

Factor 19 -- Decision Points and Milestones

Description. The structure of specific events created by project managers to recognize or review progress and decide future courses of action.

Discussion. Large scale developments involve numerous activities, problems and opportunities which need some level of ongoing recognition and approval from the central management team. Developers first need to examine in advance where major and minor decision points should be placed and then actively monitor their occurrence.

Major decision points should be located at the end of each phase to mark the conclusion of the activity and to select the strategy for the next phase. They can also protect against making commitments too early (or the fly before buy strategy).

The exact placement of major decision points is fairly arbitrary, however. Activities implied by the name given to a particular phase probably recur throughout the development of a system, particularly if the progress on different subsystems varies or if cycles are made to refine earlier designs in light of new information about the user. Developers may have to select points at which the development is, in general, making a transition.

Major decision points at the end of phases are not the only control points needed in a project. Developers will also need to emphasize sequential approval and acceptance of progress during each phase. Problems and opportunities can be identified more quickly and acted on at a point when action is needed. Reworking, redesign, and argument after the fact can be avoided.

Within each phase, developers should thus select events or milestones as formal, recognized points for monitoring. Milestones can be either points in time or events. They might represent a series of events which conclude with some identifiable accomplishment. The key is for developers to select milestones which provide insight to project activities and prediction power for future sucess or failure. Milestones should be:

- Objective, in that they are not subject to widely different interpretations,
- Material, meaning they can be seen directly, and
- Significant, in that their accomplishment has some significance in the project.

A series of milestones can have the additional benefit of leaving a better documentation trail and improving the decisionmaking conducted periodically at the end of phases.

Factor 20 -- Reports and Reviews

Description. The structure of written and oral communication mechanisms used to document and review development progress.

Discussion. Decisionmaking and control of a complex system development will involve some level of information transfer between the various groups involved. Transfer and liason with other groups outside of the project may also be needed. Two common mechanisms for processing and transferring information are reports on project activities and periodic reviews of major technical and organizational issues. Developers need to structure in advance where these reports and reviews occur and who will be involved. Developers then need to monitor whether these mechanisms prove to be sufficient for transferring key information of the level and at the timing needed to control the project.

Developers need to consider several factors when designing or scheduling written reports. First, reports require a significant amount of time to prepare. They can distract key members of the development team from the priorities of the project. Developers should keep the number and extent of reports small and monitor whether too much effort is being diverted to their production.

Second, reports may serve several purposes beyond project control which need to be considered when reports are designed. For example, developers may want to document portions of the project for later review. This might be important in areas where uncertainties remain and developers choose to forego further work; later exploration could be more fruitful. Reports might also act as marketing documents for the project and the system.

Third, developers need to consider the appropriate level of reporting. In some cases, more informal liason between groups may serve the purpose of transferring the needed information, while in other cases more formal communication through channels is needed.

Finally, since reports take time to prepare and revise, their utility in real time project control may be limited. Developers may need to rely on other means to help control the project (see design reviews below) and let reports act more as a record of already recognized and approved activity.

More direct real time control may be exerted through the use of face-to-face meetings and discussions which can quickly pinpoint problems and options. It is common practice in system developments to use design reviews for the purpose of reviewing general problems, strategies, and the like, and making changes.

The basic strategy of these reviews is to compare progress, either in specifying a design or actual construction, with previous design plans. Inspections, for example, mean comparing hardware with the paper design. Demonstrations can mean the review and acceptance of assembled subsystem components in comparison to expected overall system performance specifications. Reviews like these could also be extended to more narrow, specific problems or subsystems and occur more frequently than once during a phase. Developers need to identify what reviews are useful and who should participate and contribute to them.

III.3.5 Interaction with the User Environment Factors

A key part of system development is the interaction developers have with the user environment. Interaction is needed in order to transfer information about the user problems to the design teams and to progressively develop and transfer the system to users. Interaction is also beneficial for establishing relationships with users. Their openness and support will be critical for design and eventual institutionalization.

There are two related perspectives developers should monitor about interaction. First, there is direct user involvement in the project. User involvement is usually one of the main factors found to be important to project success. Second, there is contact with the user organization in general. Extensive contact should be made in order to extract the key user problems around which the system needs to be designed, verify concepts and system performance, and to transfer the finished design. Sections on each of these processes are presented below.

Factor 21 -- User Involvement

Description. The participation of members of the user organization in the managerial and technical teams of the project.

Discussion. One of the major factors found to be important in system development is the involvement of users. Projects conducted in isolation from users have often resulted in designs which do not meet user needs and gain little support for institutionalization. Developers need to identify areas where user participation is required or beneficial and monitor tasks to ensure that participation is solicited and utilized.

One approach to user involvement is to include users on project teams, both at the managerial and working levels. This provides a mechanism for user control of the project and a basis for eventual ownership of the system. It also helps ensure access to the organization for the collection of information needed by design teams.

Developers should also consider involving users from different levels of the organization. Managers and line groups may have different perspectives on the information problems and the appropriate designs.

Obtaining user involvement may be a difficult problem in itself, however. Users may not have the time to be actively involved or it may be unclear who should be involved, particularly if the system is a new entity for the organization and the final home is unknown. If there is little concensus on the need for a system, users may also resist involvement and continue to support other systems.

Close involvement may also have some risks which developers should consider in soliciting participation. Early project stages are likely to be characterized by exploration, uncertainty, and shifting concepts. Utilizing the limited time of users at this stage may be inefficient until clearer tasks emerge. In addition, high levels of involvement may raise expectations about the system. Difficulties or delays may lead to higher disappointments later if these initial expectations are not met.

Factor 22 -- Problem Identification

Description. The overall amount of attention to and the amount of contact with the user organization in the definition of user problems.

Discussion. One of the important parts of the development process is problem identification. Information problems are likely to be unstructured and complex. They will probably be closely intertwined with other problems in the user organization. Early definitions of the problem may be too general or simplistic and, in any case, will probably change as more is learned about the user environment and design options. Attention to problem definition should be given early and routinely throughout a project.

A systematic approach to problem identification will benefit the development. Emphasis should be placed on learning about the user environment from a number of different perspectives: how it works, goals, decisionmaking styles, decision processes, information flows, other information systems, etc. The goals and expectations for a new system would also be an important item to include here. Developers should conduct analysis at the highest decisionmaking levels and work into the organization, while concurrently examining the lower working levels and moving up decisionmaking chains.

Problem identification should also be extended to the external environment of the user. The user organization will probably have relationships with outside groups that can have significant effects on the organization itself. Developers should examine and monitor these linkages and determine how they might affect system design (see also Boundary Factors above). It would also be beneficial to determine what information about the system these groups might need during the development (see also Reports and Reviews, Factor 20).

As information is gathered from these areas, it may become useful to organize it by constructing some models. At first these might be descriptive models about what is happening: the players, the decisions, and the information needs. Later, a second set of normative models can be developed to describe the decision processes users would like to have. Descriptive and normative models can then be compared to help identify key information problem areas.

Developers should also consider how the information they collect during problem identification can be used to help the organization directly. A system development may present one of the first times the organization has been closely examined, particularly by outsiders. Developers may uncover factors about the organization that were not previously known. Detailed feedback to users about current processes may identify improvements which can be made immediately without proceeding with a new design. Close study may also reveal widely varying knowledge or perspectives on organizational problems, including the information problem of concern. It may be important to project success to reduce these differences. User recognition of the need for change has been found to be a key factor in successful developments. Developers should spend time communicating and selling the problem to the user.

Spending time on problem definition with users may also have additional benefits besides locating the need for a system. It will begin to set a precedence for close user contact and involvement with the development. Some users may not understand what a systems project is or will have significant anxieties over how it will change their jobs. They may resist providing information or access to their programs. Similarly, developers may be uncertain of what will happen or be inexperienced in what to do. Close contact between these two groups can help reduce these problems by promoting a mutual understanding.

Other benefits might include the following:

- Establishing a language about problems and designs which users and developers understand.
- Identifying key underlying assumptions in problem definitions which need examination.
- Discovering areas where resistance to change may be great and organizational politics important.
- Starting to build user commitment to the system.

Factor 23 -- Testing

Description. The amount of concept and design testing conducted in the user environment.

Discussion. As more is learned about the user information problems and the user environment, concepts and designs for the system will emerge. Eventually, it may become necessary to directly test designs in the user environment as a means of substantiating design claims. Testing in the user environment may also be important and beneficial for:

- Competitive demonstration.
  Several competing proposals for a system design may emerge in the project and testing in the user environment may be critical for selecting among them.

- User involvement.
  Testing in the user environment can give users something to react to, especially those users not directly involved in project teams. Their knowledge and opinions may be critical factors for system designs. Participation in a low risk test may be an effective means of obtaining their ideas and support.

- Commitment.
  Favorable results from tests may be one important factor which eventually results in full user commitment to the system. In addition, opportunities may arise for early use of the system while it is still under development. These may provide an early payoff which should be taken advantage of.

Developers should establish an active program of testing with users and continue it as long as necessary in order to resolve uncertainties in design.

There are several levels of testing in the user environment which might be considered by developers. One is to use models on paper or dummy mock-ups of the system and/or its products. The earliest of these might be descriptive and normative models of user decision processes which evolve in problem identification activities (see above section). Rapid feedback to users of information like this can further educate users as to what is needed as well as provide a test to determine whether developers are understanding their needs.

At another level, working models of subsystems might be constructed and pilot tested under various conditions with users. Different parts of the overall design can be tested by themselves and at the appropriate stage of development. For example, developers might choose to focus on a particular decision problem and then produce a working model to test their design concepts for this one problem.

Finally, as many of the system components become developed, a prototype system can be formulated and tested with users. A prototype design would be expected to include most or all of the functions developers had found to be needed by users. It would also include the various interconnections between subsystems or between the system and outside groups. The prototype design would provide for a full scale system test and check the emerging design against the original performance objectives.

An important part of testing at any of these levels will be the development of user criteria to evaluate the performance of designs. Developers will need to identify in advance and progressively refine the criteria users prefer to apply. Some of them may be appropriate for institutionalization within the system for routine use after development is completed (see also Evaluation and Updating, Factor 12).

Factor 24 -- Transfer

Description. The amount of attention devoted to the transfer of the system to the user environment.

Discussion. A key transition point in a systems project is the transfer of control and support from the developer to the user. Transfer of the system to the user is often referred to by several names: implementation, institutionalization, cut-over, or conversion. Developers need to think through the implications of changing to a new system and routinely monitor whether their strategy is leading to a smooth transition of ownership and full user commitment.

Transfer of the system to the user is an activity which can and should begin early in a project. As concepts and pieces of the design evolve during problem identification activities, developers should consider how the designs would become fully operational and institutionalized within the organization. Examining the differences between the new design and existing practice will help identify possible transition strategies and key problems (see also Novelty of the Design, Factor 11). Close user involvement in this analysis is also important, both to identify issues and to initiate the transfer of concepts.

Later as designs are detailed, testing provides another stage in which transfer considerations should be studied by developers. Tests in the user environment may be designed to include user participation in using and working the system. This will provide a temporary means of exploring how to transfer system components to users from the developer perspective. It will also provide a low risk means for users to explore the transition to a new system. Feedback from their perspective will be useful. Developers should be able to learn lessons about transfer from testing which can be used later in future tests and final institutionalization.

When it is appropriate or required, the system or individual components will be transferred permanently to users (the turnkey system). Developers may have the choice of transferring the system gradually or quickly making the transition from the old to the new system. Several factors can be considered in deciding which approach to take:

- Abrupt transition.
  Complete rapid transition to a new system may be too risky or unnecessary. If there are user problems needing quick attention, it may be beneficial to institutionalize key components as they are available. Radical changeover may create a number of side impacts with users that only complicate the transition and start-up periods.

- Backup systems.
  It may be beneficial to gradually phase in the new system while gradually phasing out the old. This will provide some backup or protection should unexpected problems occur. Users should not be left without any system if delays occur.

- Training.
  Users need to be trained to work with a new system. Users should be involved in developing training programs and training needs should be a part of design activities. The availabil-

ity of these programs may influence the transfer point.

- Documentation.
  Documentation of the design and related matters should be complete, especially before transfers are made. Areas where design problems remain should be thoroughly documented so that users can continue development later.

- Management support.
  As the point for transferring a system to users approaches, it is possible that managers (both of the project and the user organization) may start assuming that the system is complete and its implementation routine. This may cause a lack of attention towards transfer which jeopardizes final stages. For example, lower level and less experienced staff may be assigned to transfer tasks and cause implementation failure.

When the system has been mostly or completely transferred to the user, a final stage of withdrawal and termination should begin for the project teams. In termination, developers need to ensure that:

- Ownership and control of the system rests with those who must use and maintain it.

- Necessary new patterns of behavior have become a stable part of the user's routine.

The basic goal is to refreeze the organization by removing the disturbances of change and leaving the organization in a stable position. Developers should ensure that evaluation and updating functions become operational so that users learn to revise the design themselves (see also Evaluation and Updating, Factor 12).

III.4 User Commitment Characteristics (Factors 25 - 30)

III.4.1 Introduction

The final category of factors in the monitoring framework is for measuring the extent of user commitment to the system. Commitment to the system is viewed as a series of user decisions or actions over time which indicate increasing user interest, support, and acceptance of the system. Full commitment to the system will emerge when users elect to assume total responsibility for the operational system and the development project is terminated.

This section identifies and describes six factors for developers to use in monitoring commitment. These have been divided into two areas: factors relating to use of the system and factors relating to support of the system.

III.4.2 System Use Factors

Major indicators of user commitment to a system are the actions taken toward use of the system. In early project stages, these user actions may be decisions about the design and application of the system to organizational processes. Later, as the system is developed, these actions will change to use of the prototype system or subsystems. Developers need to closely monitor these actions so that changes can be made in the design or the development process if needed.

Three factors are described in this section. First, developers need to identify the types of applications of the system (or ones it is expected to have). This requires identifying system actions with specific user tasks. The second indicator of use is the activity resulting (or expected to result) from system applications. These actions need to be documented as they will likely play a key role in obtaining user commitment to the system. Finally, developers should monitor the extent of use in order to gauge how frequent and widespread it is (or will be). This may be an especially important factor to the top level managers who will decide whether to provide the resources needed to fully support and institutionalize the system.

Factor 25 -- Applications

Description. The use of specific elements of the system in specific units of work of the user organization.

Discussion. Developers need to identify the applications of a system to user problems as one part of monitoring user commitment to the system. In early project stages when designs are being formulated, developers will have to rely on the expectations and plans about applications rather than actual cases (see also Boundary Factors above). These plans can provide important insight, however, to the extent and type of commitment users expect to make. Later, as system components become operational in testing and implementation stages, developers can then monitor whether the applications are in fact occurring and are leading to full institutionalization of the system. Problems or changes in applications may indicate a need to revise the design or project strategy.

It is important that developers take a broad view of what constitutes an application. This primarily means that definitions of use should not be restricted to simply identifying whether a major decision is the result of system use. Numerous applications of the system may have occurred to support a decision process even though a major decision is not evident.

Developers should also include unexpected applications and areas of non-use. Users may perceive that the system will not (or actually doesn't) solve their problems. They may turn to other systems and withdraw their support from the project. Developers may also find that staff who operate the system are having difficulty doing so. They might prevent or seriously impair further operation in an area unless the design is changed or they receive more training. User resistance at these levels may have serious implications for eventual user commitment to the system.

The key problem in determining where applications occur (or will occur) is to match some unit of work in the organization, such as a decision, with some unit of system action. This matching can be greatly facilitated by the use of models which detail the information and decision flows of the user organization. Developers can take these models and identify places where the system interacts with the user. The range of applications can then be determined as can the specific user behaviors which define work tasks.

It is advantageous to start modeling early, such as during initial problem definition stages when extensive contact with users occurs (see also Problem Identification, Factor 22). Developers can then:

- Obtain an early indication of commitment by matching expected system products and applications. This can be compared to project goals (see also Boundary Factors).

- Plan the occurrence of applications as the project proceeds, possibly starting with simpler ones and then moving into more complex undertakings (see also Task Structure Factors).

- Obtain a basis for establishing measures of actual use which can be applied later during testing and implementation (see also Project Control Factors).

- Uncover any different perspectives as to what constitutes use. Differences among users may prevent agreement that an application has occurred (or will occur) and have an effect on eventual institutionalization (see also Boundary Factors).

Factor 26 -- Consequent Actions

Description. The actions resulting from areas of direct system use.

Discussion. Further indicators of use are the user actions which come about as a consequence of system applications. These actions should be observable user behaviors which can be documented and shown to others. Changes in thinking may be a valuable result of system use, but these are hard to measure and probably would be considered weak evidence to justify support for the system. Credible evidence is of critical importance to both users and developers. User managers need proof that a system improves the operation of their organization before they provide full support. Developers need to evaluate performance and commitment and then determine whether changes are needed in design or strategy.

There are several categories of actions developers might consider monitoring in order to measure the effects of system use. These include:

- Follow-on actions in organizational processes.
  Developers can identify the linkages of various organizational actions and trace the impact of system use down the line.

- Organizational changes.
  Use of the system may eventually bring about changes in the organization, such as in structure or official procedures. Changes may occur in other systems or processes which support system use (see Changes in the User Organization below).

- Performance changes.
  Factors which are used by the organization to measure performance might record changes which coincide with the introduction of the system. Performance improvements may consequently lead to high level commitment to the system.

- Avoidance or non-use of the system.
  Negative experiences in a particular application may lead some users to avoid further contact with the system, discontinue their support, or work against the system (see also System Champions below).

As with identifying system applications, determining where actions like these occur and then measuring them can benefit from initial detailed modeling of user processes. Models can help identify the flow of information or decisions and provide developers with a means of tracing user actions which emerge from specific system applications. Identifying these actions in advance also provides a means of determining what decisionmakers consider valid evidence of use. In addition, expected actions identified early through modeling can be compared with actual behavior during use and provide a means of measuring changes in user commitment.

Factor 27 -- Extent of Use

Description. The amount of use relative to the number of potential applications.

Discussion. The third indicator for monitoring use is the extent of system applications to user processes. Measuring extent includes determining the frequency of use and the amount of use relative to the number of potential applications. These factors should be monitored over the life of the project and used to indicate changes in user commitment. Stable or decreasing levels of use might indicate dissatisfaction with the system design or loss of momentum in project strategy. Revisions in both areas may be needed.

One major question that developers and users alike have to consider is how much use constitutes acceptance of the system. User top management will likely have some threshold for the extent of use above which they will give serious consideration to full support and institutionalization. This threshold may be based on how often the system is used over the range of different applications as well as how this use affects the performance of the organization. Developers can begin to uncover thresholds like this early by spending time detailing the types and extent of applications decisionmakers expect to achieve. This may be best done by, again, modeling user processes where the system is to operate and determining what use specifically means. Developers should then continue to examine the extent of use as designs are implemented and determine whether the expected levels are achieved and prove to be significant enough to justify full institutionalization.

III.4.3 System Support Factors

Besides monitoring the direct use of the system to determine user commitment, developers should also monitor other user actions which indicate support for the system. These actions may include early signs of user acceptance such as the emergence of user advocates as well as longer range institutional changes which are needed to support the operation of a system. The lack of supporting actions like these may indicate that the system is isolated from the user organization and that it will not become fully implemented when the development ends.

Three factors for monitoring system support are described in this section. These include the emergence of system champions, the resources allocated by the user during development, and the changes in the user organization which are needed to support system use.

Factor 28 -- System Champions

Description. The emergence of advocates for the system in the user organization.

Description. An important source of support for a system development can be a critically placed key man, advocate, or system champion. A system champion is a person, perhaps best located in the user organization, who believes very strongly in the system: its concepts, design, performance, etc. The system most likely matches the champion's objectives and the organization's objectives. A champion has credibility inside the organization, hopefully across different levels. His credibility may even extend outside the organization as well. He can push the system into existence and also find the pull for it from users. He should also be able to isolate the system from attack by others.

Developers should seek out system champions and cultivate their participation. Their help can be a critical element for success throughout a project, especially in early stages when both the project and the system are being defined. System champions may offer the earliest sign of user commitment and act as a catalyst for acquiring user support.

Champions may emerge from different levels of the user organization and developers should actively seek this broad-based support. Champions from top levels of management are clearly important to a development since they may have great influence over resources, access to the organization, or project strategy. However, developers should seek champions at other levels as well. This can help gain credibility for the system with key groups and also expose project teams to different perspectives or expectations about system design or project strategy. In addition, multiple champions, either within or across organizational levels, may reduce the potential disruptions caused by the loss of any one of them.

Developers must be skeptical, however, of champions who may be overly supportive or controlling. They may be attempting to capture the project, and thus the system, in order to use it for their own personal rather than organizational objectives.

Developers must also be aware of those who actively oppose the system. Just as the new system may have a key advocate, it may also have someone who is uninterested or critical. Opponents may fight development at each stage or build up opposition. They may also elect to hamper an operational system as much as possible or sabotage system processes. Developers should be open to the possibility that opponents exist, or will develop, and be prepared to actively counter the effects of their actions.

System opponents may not be limited to those who oppose development outright from the inital planning stages. Technical problems, in-fighting already existing in the organization, differences of opinion over designs, or opposition to particular project decisions may create new opponents during a development. In these situations, it is critical that developers direct specific attention to the resolution of conflicts and consensus building. System developments can involve change and disruption to users, and the creation of an active opposition only makes strategy that much more complex and success that much more difficult to achieve.

Factor 29 -- Resource Commitments

Description. The type and extent or resources allocated by the user organization to support the system.

Description. A key indicator of user support for a system is the type and extent of user resoucres committed during the development. The two primary resources users can provide are manpower and money. In early development stages, these might be supplied to the project to support design and testing. Later, as subsystems become available for implementation, user resources may be supplied to operate them. Each of these allocations is a sign of user commitment to implement a system after the development is completed.

There are several characteristics concerning allocation of money to a project which developers may want to monitor. These are:

- Temporary versus permanent allocations.
  In some cases, part or all of the development may be funded out of special user project funds and be combined with resources originating from outside third parties. A change in budgeting, where the system becomes a line item in a user budget, may be an important indicator of emerging support.

- Origin of money.
  Developers may want to compare the origins of financial resources with the location of primary users. Arrangements not following organizational lines could mean broad support or potential ownership problems. In addition, if multiple sources are involved, developers may want to consider the relative proportions of allocations versus expected use. Continuing support from all parties may be essential for full scale system implementation.

- Planned allocations/expenditures.
  Developers may want to examine how user allocations are planned over time and in what system areas they apply. Targeted resources may signal important areas where user commitment will be based. User expenditures should also be monitored. Success in the development will most likely be followed by increasing resource allocations.

These factors may not apply in projects which are entirely based on third party funding and where user resources are expected only after successful development.

Similar characteristics can also be monitored for user allocations of manpower. They may apply independently of any funding allocations and be essential for strategies involving close user involvment. Developers should consider:

- Temporary versus permanent assignments.
  User staff may only be temporarily assigned to project teams or to the operation of initially available subsystems. While these conditions would indicate an initial commitment, a transition to permanent assignments to operate the system components would indicate a more significant level of support.

- Type of personnel assigned.
  The development may require the skills and involvment of users, and developers should monitor whether they are made available. The assignment of key people in an organization may signal

a high degree of user commitment to the system (see also Team Personnel Commitment, Factor 17).

- Level of involvment.
  A key sign is also the extent of involvement. User personnel assigned to work on the system a small part of the time may be too distracted by other business to contribute effectively to project objectives. Allocation of significant portions of staff time may indicate a solid commitment to the system. Commitment would also be indicated by increases in the proportion of their time.

Factor 30 -- Changes in the User Organization

Description. The alteration of policies and procedures in the user organization in order to support system operation.

Discussion. Other indicators of user support and commitment to a system are the changes which take place around the system. Systems are placed into complex organizations involving intertwined line of communication, support, responsibility, and activities. Changing over to a new system likely causes and/or requires changes in other places and sytems. New relationships and functions may be established. Developers should look beyond the immediate areas of system impact to other areas where change may indicate a positive or negative force for user commitment.

There are numerous potential changes inside the organization which developers can monitor. Some may occur in the areas which are to support the operation of the system. For example, the system may require new types of personnel or new positions which must be arranged for by personnel divisions. Some users, may need training in order to operate the system and new programs may be created for this. Another similar change is the creation of an incentive system either to attract users to the new system or to acknowledge improved performance because of its use. Other changes may occur in processes, such as decisionmaking style or how an organization works. Changes may also be observed at higher management levels. For example, the system may support a new policy which high level decisionmakers must acknowledge and support. Finally, developers should examine changes in competing systems. The continuation of competing systems may indicate a lack of support for a new system, while conversely, the gradual withdrawal of support from them may indicate the opposite.

Developers should also monitor actions or conditions outside of the user organization which may affect user commitment to the system. For example, outside institutions may mandate the use of the system. Outside organizations may also have a role as system users or suppliers of information. Changes in their roles or activities may be a direct or indirect sign of system acceptance and support in the user organization.

IV. The Monitoring Functions

The following sections describe the five functions monitoring can serve in a system development. As described earlier, the monitoring process has been designed to serve both administrative and research purposes.

The five functions have been designed to overlap and support each other for these uses. These functions are:

- Problem identification -- The tracking and assessment of key areas where development problems typically occur, both in the short and long range.
- Strategy development -- The identification and development of explicit management actions to solve problems and revise strategy.
- Research -- The design and implementation of real-time studies of the development process.
- Documentation -- The establishment of an organized and stable recording process which can identify special or recurring problems, and support decisionmaking and research.
- Dissemination -- The distribution of key development information to these inside and outside a development as a means of facilitating coordinated actions and distributing knowledge gained.

IV.1 Function #1 -- Problem Identification

Problem identification is the major function for the framework, reflecting the ETIP management need for a procedure to anticipate and pinpoint key problem areas. The framework is structured to contain key elements of a systems project, areas where problems usually occur and which are important to eventual project success. By routinely monitoring these areas, managers can identify problems more quickly and possibly earlier than would be the case without a framework. Use of the factors may also promote easier recognition of problems. In addition, problems which are new, complex, or multi-faceted, may be more easily decomposed into recognizable, manageable components by analyzing them with the framework factors.

IV.2 Function #2 -- Strategy Development

The second major function for the framework is strategy development. The performance of a strategy can be monitored through the elements of the framework. Problems and progress identified in these areas may highlight the need to change some or all of a strategy in order to continue progress towards objectives. If strategy problems occur, the factor structure and the information base available from regular monitoring may then also assist in formulating the changes needed. In addition, the framework can promote better strategy by offering a means to consider longer term pespectives. First, retrospective analysis of the factors may uncover problems that are unidentified by constant attention to immediate circumstances. Similarly, by focusing on specific framework factors during strategy revision, managers may be encouraged to predict the effects of strategy changes in the future. Besides bringing a longer term perspective to problem solving, this can provide an opportunity to identify the conditions or points in time when a strategy should again be reviewed. The longer term cause and effect linkages which are identified through these analysis may also help managers avoid repeating mistakes.

IV.3 Function #3 -- Research

The third function of the framework is to provide a means for researchers to study and contribute to on-going system developments. This reflects the finding that systems researchers see a need for closer contact with actual projects -- partly to gather empirical evidence not easily available through other means and partly to transfer the guidance available in the literature to practitioners who some claim have difficulty using the literature. While these two problems are to some extent exacerbated by the few incentives practitioners have to study their own experiences, it does appear that an approach which unites researchers and practitioners may be a good way to gain the access needed by the research community.

The monitoring framework provides a research opportunity by establishing a data collection process that researchers can use to define and implement studies. By adapting their studies to the framework structure and procedures, researchers can acquire a series of data points at the same time as project managers. They can then use this data to study changes and linkages between factors of interest and to produce valuable insights of use to others.

Researchers may find it beneficial to design their studies with the project managers. Besides helping to ensure continuing access to the project, this approach may provide researchers an opportunity to help managers with problem solving. Research studies could be designed to support problem solving. In addition, researchers might be able to bring in relevant guidance from the literature to help managers. This would help counter the claim that research in the systems literature cannot be used.

IV.4 Function #4 -- Documentation

The fourth function of the framework is to document project activities for the administrative and research purposes discussed above. Documentation here means establishing an organized and stable written record of project activities as they occur in the key selected areas of the framework. In the short term, this function can help project managers identify current problems and progress and assist in finding ways to improve the project. For researchers, documentation of project events as they occur is one essential feature of the monitoring approach that makes it attractive over retrospective studies.

Documentation is seen as particularly useful, however, for tracing and analyzing selected factors over long periods of time. For managers, documentation of project activities can be inefficient for short term problem solving. In addition, documentation over the long term can provide several benefits that may be difficult to obtain from short term analyses of immediate actions:

- Routine documentation over the long term can help managers identify special, evolving, or recurring problems.
- Longer term analyses of management actions may help identify successful and unsuccessful approaches, promoting improved strategies or new ideas for current actions.
- Long term documentation can support decisionmaking in the project, particularly for major decisions at the end of phases. These decisions may rely on credible evidence of performance -- unattainable from quick retrospective analyses at the time of the decision.
- Documentation can be used to inform new staff or project history and thus ease the problem of turnover.

For researchers, the long term stream of data available from documentation provides the data base on which to conduct research. In particular, long range documentation provides;

- The evidence upon which to identify and test relationships between important factors in development.
- A basis of developing models of the dynamic, evolving process of a large scale system development presently missing in the literature.
- Empirical evidence about all project stages that is also needed in the literature according to some researchers. This may be especially important for other researchers who need better access to actual projects.

IV.5 Function #5 -- Dissemination

The fifth and final function of the monitoring framework is to promote dissemination of information about the system development to groups not directly involved in oversight roles. The framework structure and resulting data base can facilitate the transfer of information to these groups by making it easier and quicker for managers to generate the information needed. This of course must be tempered with the need to avoid release of interim or uncertain information which might harm the project.

Managers may find the dissemination function useful both inside and outside a project. For insiders, dissemination of monitoring information can facilitate a common awareness of problems and progress and help promote united actions. In a large project, this may be especially important in coordinating groups working on different parts of a system. Dissemination of pertinent information about progress may also have the secondary effect of promoting or facilitating the monitoring activity. Project staff may come to rely on periodic reports of activities for guiding their own work.

For outsiders, dissemination of monitoring information can be essential to keeping groups informed about progress and building awareness and support for the system. This may be especially critical to user groups not directly involved in the development, but having some indirect role in future system operations. Other important groups can be top level managers or outside institutions who supply resources to the project, periodically review progress, and approve continuations of the work. These people may need current and retrospective reports on development activities, both easily supplied if monitoring has been routinized.

Dissemination is also important to researchers. By providing the opportunity to closely study on-going development activities, the framework can facilitate the transfer of information to the systems literature. For example, the framework can help provide a more dynamic, evolving view of development and other empirical evidence that some researchers believe are needed in this area. Besides helping other researchers, real time analysis of project activities may offer insights to other system developers who are looking for guidance of use in their own situations.

V. A Model for Implementing the Monitoring Process

V.1 Introduction

The framework has been designed with a set of procedures that managers can use to apply it to specific developments. This process is modeled in Figure IV. 1 by a flow diagram of events which are generally expected to be a part of monitoring. The model is illustrative; modifications would likely be needed in order to match the process to the project.

V.2 Implementation Procedures

As shown in Figure IV. 1, the monitoring process begins when project managers identify the need for monitoring and proceed to specify the indicators, procedures, and staff needed to operate the monitoring system. To specify the monitoring indicators, managers need to examine the individual elements of the framework and decide what indicators are needed. For example, under the category of user commitment, managers need to identify events that will indicate use and support for the system. For the system champion factor listed under support, this will involve identifying where champions would arise and what actions will be considered supportive. This identification process will of course be influenced by what managers and others, inside or outside the project, need to know during a development. In addition, managers may find gaps in the elements or alternative factors which

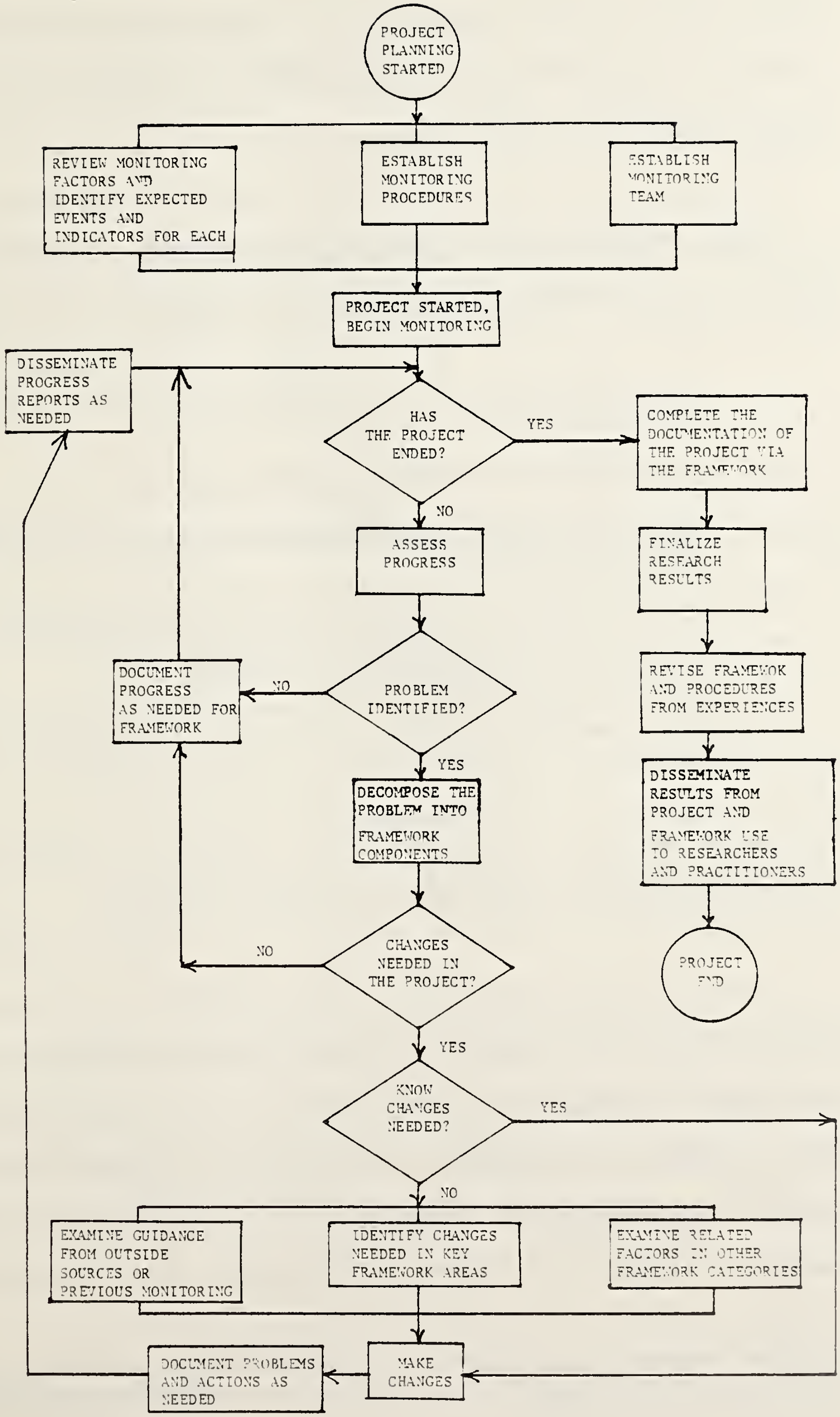

FIGURE IV.1 A GENERAL MODEL FOR APPLYING THE MONITORING FRAMEWORK better match their specific situation.[2] Analysis of each framework element in this manner will specify where monitoring should occur and what needs to be monitored.

Next, managers need to specify the procedures for monitoring. Some of the considerations include the following:

- How monitoring will be coordinated with major decision points in the project.
- How monitoring data will be collected.
- Who will receive monitoring information and what information will be supplied.
- The storage and location of monitoring information.
- What kind of documentation is desired.
- How research activities will be tied to management activities.

Operational details in these areas will establish how monitoring is to be performed and integrated into project management.

Finally, at the same time as these procedures are being explored, managers should also identify the team which will perform the monitoring. While top level project managers are the main users of monitoring information, their role in collecting the information should be minimal. This work should be delegated to the staff supporting project leaders. Managers will have to decide who will be on the team and

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[2] The framework is intended to be comprehensive. However, this is still the first attempt at defining such a framework. Revisions and additions are expected.

how the different groups in a development should be represented. It will be beneficial if the team consists of members from all participating groups: the user organization, the development team, and the group of researchers (if present) studying the development. This should help ensure collection and use of monitoring information, while improving the credibility of the monitoring by bringing different perspectives to the process.

After these initial preparations are completed, the monitoring process is started. Problems and progress in the specific areas of framework are identified as they occur or at selected periodic reviews.[3] If the situation is new or not well understood, the monitoring team may need to decompose project events into smaller elements by identifying the relevant factors in each framework category. The relationships between different factors should also be considered. As appropriate, the monitoring team then produces a problem statement for project managers. This procedure is illustrated in Figure IV. 2.

With the problem identified, managers then decide what, if anything, should be done. This is when the strategy development function of the framework can be useful. If managers know what should be changed, then no further analysis is needed and the changes should be made. In this case, the only remaining tasks for the monitoring team are

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[3] It is assumed here that situations occur which require intervention by project managers.

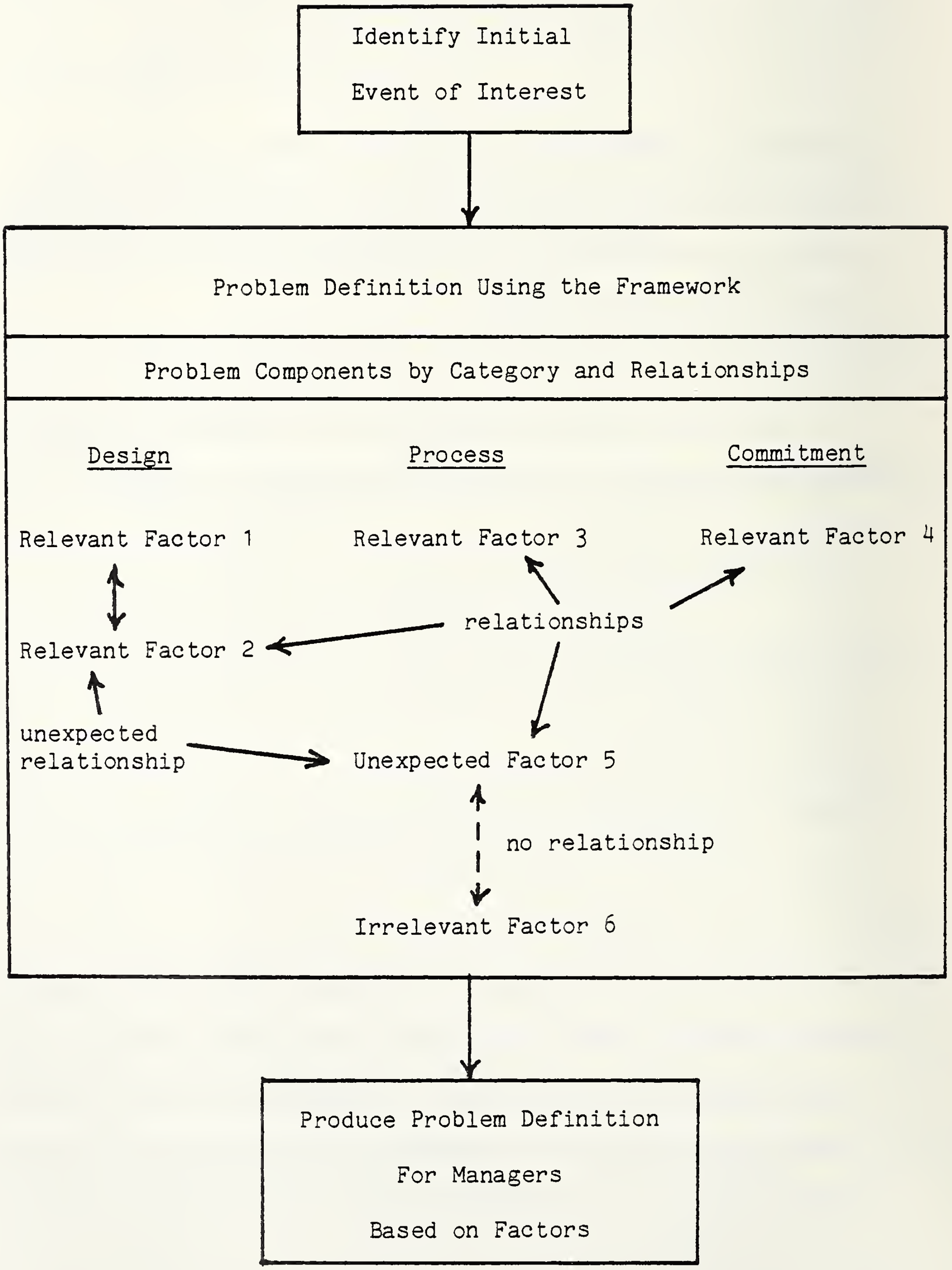

FIGURE IV.2 PROBLEM SOLVING USING THE FRAMEWORK to: document the problems and actions taken for future reference, identify future conditions when these actions should again be reviewed, and disseminate information as needed about the management activity.

However, if the appropriate action is uncertain, further analysis of the problem using the framework may be beneficial for identifying options. In this case, the framework factors may provide a focus both for the problem and the management intervention. Managers can:

- Identify the key components of the problem using the elements of the framework and what actions might be targeted at these areas.
- Identify and examine the relationship between problem elements, using the different framework categories to decompose a complex situation.
- Examine guidance on the problem elements from previous monitoring information, project research underway, or other outside sources.

Once the interventions are specifically identified, the monitoring team then determines how to trace the effects in the future and whether special attention is needed to identify when a review of the changes may be needed (see illustration in Figure IV. 3). Over the long run, tying the state of the project to management interventions should help the monitoring team identify successful approaches and promote better management control.

After the changes are made and plans for future monitoring are established, the monitoring team documents the activities and dissemi-

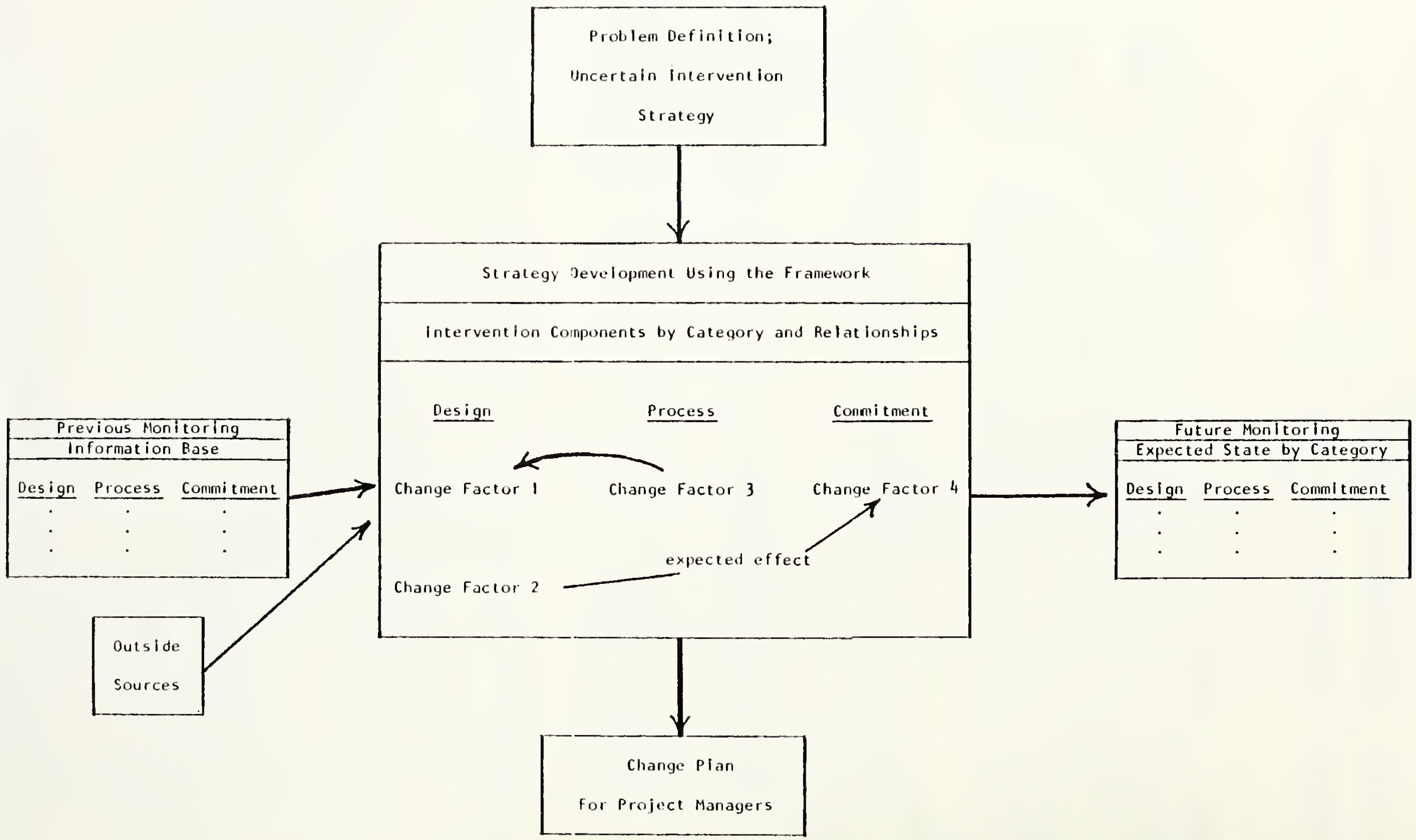

FIGURE IV.3 STRATEGY FORMULATION USING THE FRAMEWORK nates information about them as needed to others inside and outside the project.

This pattern of monitoring continues during the project until monitoring is no longer needed by managers. At this time, the monitoring team completes documentation of the project, emphasizing the final state of the project in terms of the framework elements. Researchers, if present, then conduct analyses of the data collected by the monitoring team according to their earlier plans. The monitoring team should also review the framework to determine how well it worked and whether changes are needed for future applications.

Finally, the results of the project are disseminated as appropriate to other interested researchers and practitioners.

V. Conclusion

This manual has presented a process managers and researchers can use to monitor important areas of complex system developments. The manual has described a framework of thirty monitoring factors, five functions monitoring can serve, and a general model for implementing the process.

APPENDIX C

Letters From Reviewers

(retyped for the dissertation)

April 8, 1981

Dr. Charles W. N. Thompson
Northwestern University
Evanston, Illinois 60201

Dear Dr. Thompson:

Steve Garrity has asked me to review his dissertation and provide some comments on his results. Since these comments might be useful in his defense of the research, I thought I might briefly describe my reactions to you in time for the meeting on April 13.

I have reviewed most of the dissertation -- reading some parts, scanning others, and passing over others (per his instructions). I have reviewed most closely Chapters 1 and 7, the introduction and conclusions, respectively. I have scanned Chapters 2, 5, and 6, in order to review the proposed monitoring framework and the specific ETIP cases which Steve has used in its development and testing. I did not review either Chapter 3 or 4.

I have some overall observations about Steve's work at this time. I think his work, and especially the proposed framework, are valuable contributions to ETIP. I am very interested at this point in having the approach implemented within the Regulatory Program over the next several months. I have already requested that Steve begin planning a series of briefings to ETIP, contractor, and agency staff as a means of initiating this monitoring function.

I hope you find these comments useful in your deliberations on Steve's accomplishments in his dissertation.

Sincerely,

Daniel W. Fulmer
Group Leader
Experimental Technology Incentives Program

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Productivity, Technology and Innovation
Washington, D.C. 20230
(202) 377-3111

April 10, 1981

Dr. Charles W. N. Thompson
IE/MS Department
Technological Institute
Northwestern University
Evanston, Illinois 60201

Dear Dr. Thompson:

Steve Garrity had asked me to review key portions of his dissertation dated April 13 and provide comments to him as partial preparation for his defense next week. I have responded to Steve orally but he thought my comments relative to the utility of its results might be useful to you as well.

Most of my career, industry and government, has involved system development projects, primarily of major hardware systems. For example I was a key player on the FAA team that directed the SST development during the 1964 through 1971 period. In industry at Martin-Baltimore I was an associate program director of the Mobile Mid Range Ballastic Missile (MMRBM) program and played supporting roles in other major space developments as well. In my last assignment before assuming my present assignment I was Associate Administrator for R&D at the FRA and inherited many projects that were in trouble due to improper system integration and project monitoring. As you can ascertain from the above, I'm familiar with large scale, complex system developments that are primarily hardware oriented.

Since taking command there at Commerce of the ETIP program, I have noted striking similarities between my past hardware related experiences and ETIP issues and problems. In short I find the same system engineering/management approach applicable to both. More to the point, I find at ETIP ample evidence of a lack of front end system planning and a management process that assists ETIP staffers to effectively monitor and stay ahead of program problems.

In this respect Steve's framework contains the key elements I have found to work successfully in staying on top of complex systems.

1. Task structure breakdown - or WBS-permits tracking of resource commitments and schedules for areas that have measurable outputs (tasks must be selected to meet these criteria)

2. Early user input to define outputs and determine champions.

3. General periodic monitoring to relate output performance, resource application, and schedules at task levels.

4. Detailed monitoring of those areas where either costs, schedule or outputs start to show significant deviations - this is the first sign of problems and is key to a living planning process.

5. Broad, experienced project monitoring people to do above.

I haven't gone over his entire list but they either fit directly into the pattern I have used or indirectly link with the system.

In summary, I believe the factors presented in the framework cover the key areas of consideration one must tie into a planning and monitoring process. If managers would use this list in that manner, I believe issues would be identified early enough in the program development cycle so that corrective actions strategies could be implemented in a timely manner.

Sincerely,

Robert E. Parsons

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Stephen D. Garrity

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See also related manual: Garrity, S.D. A manual for designing and implementing a process to monitor complex system developments. Washington, D.C.: Experimental Technology Incentives Program, National Bureau of Standards, September 1981. (NBSIR 81-2328)

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

Projects aimed at developing new systems where there are substantial uncertainties as to system requirements, development processes, and ultimate ownership can present project managers with a range of complex, unstructured problems. A process to help identify and solve these problems in a timely, controlled manner is of central importance to the successful conduct of a development with these circumstances.

This document describes a research project devoted to the examination of problems in complex system developments and to the development of a process managers can use to deal with them. Conducted within the Experimental Technology Incentives Program (ETIP), the research includes analysis of several ETIP projects, a review of the systems literature, presentation of a monitoring framework to help manage complex developments, and a brief application of the framework to one ETIP project.

The proposed monitoring process consists of a framework of thirty factors and a set of five functions which monitoring can serve. The factors are divided into three main categories -- design, process, and user commitment characteristics -- which reflect the general types of problems found to be important in the ETIP environment and the system literature. The functions of the framework, designed to serve both administrative and research purposes, include problem identification, strategy development, research, documentation, and dissemination. A model of how the framework might be implemented within a project is also described.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Administrative experiment; evaluation systems; Experimental Technology Incentives Program; information systems; project management; system acquisition; system development.

13. AVAILABILITY

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