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A STUDY OF CRITICAL FACTORS IN THE DEVELOPMENT OF AIR FORCE COM--ETC(U)
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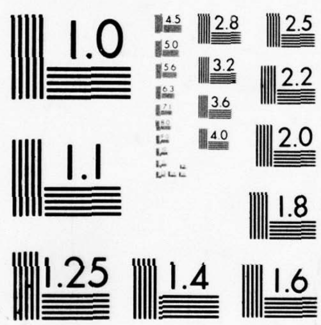

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IN THE DEVELOPMENT OF AIR FORCE COMPUTERIZED
MANAGEMENT INFORMATION SYSTEMS.

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A STUDY OF
CRITICAL FACTORS IN THE DEVELOPMENT OF
AIR FORCE COMPUTERIZED MANAGEMENT INFORMATION SYSTEMS

THESIS

Presented to the Faculty of the School of Engineering

of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

by

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Graduate Systems Management

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Contents

List of Figures

List of Tables

Abstract

The problems of developing computerized systems, particularly management information systems (MIS), are discussed frequently in the literature. However, there is little agreement on the reasons for failure or the important factors for success. One study using survey data, performed by D. M. Carter, et al, in 1975 found four factors critical to MIS: Planning and Control, Expertise, Attitudes and Involvement. For several reasons, a new study appeared desirable. A new survey was developed and administered to 456 computer specialists at three Air Force bases. Analysis of the data found the survey samples of this and the Carter study similar, although not the same statistically. A number of the factors important to MIS were found to vary with System Size, Difficulty and Contractor Involvement. Factor analyses of the sample and two subsets each revealed three factors: User Involvement; Capabilities of the Project Organization; and Planning and Control. Several predictive models were developed for system success, the best of which explained 43% of the variance in success for the total sample, and 52% of the variance in more strongly contracted efforts. It was concluded that six factors are critical to MIS, the three factor analysis factors plus: Size and Difficulty; Criteria for Continuing the Project; and Test Time. A process model, consistent with the data, of the initial stages of a MIS was proposed.

A STUDY OF

CRITICAL FACTORS IN THE DEVELOPMENT OF

AIR FORCE COMPUTERIZED MANAGEMENT INFORMATION SYSTEMS

I. Background

Introduction

> Delays, from various causes, arose in the progress of the work, and great expenses were incurred. The machine was altogether new in design and construction. . . "It involved," to quote again from the Report of the Committee of the Royal Society, "the necessity of constructing, and in many instances inventing, tools and machinery of great expense and complexity." . . . Similar circumstances will, I apprehend, always attend and prolong the period of bringing to perfection inventions which have no parallel in the previous history. . . . The necessary science and skill specially acquired in executing such works must also, as experience is gained, suggest deviations from, and improvements in, the original plan of those works. . . . From whatever cause, however, the delays and expenses arose, the result was that the government was discouraged and declined to proceed further with the work (Ref 1:2305-6).

The above quote is an excerpt from a letter from Charles Babbage to Lord Derby, written June 8, 1852, explaining the problems encountered in constructing a "Difference Engine," the first mechanical calculator. Such were the troubled beginnings of what is now a major industry worldwide, the processing of data and information by machine. The industry has undergone tremendous changes since Babbage. Inexpensive handheld calculators now perform calculations far more sophisticated than Babbage would have dreamed possible. Manufacturing organizations now spend more money on information than on direct labor, according to one expert (Ref 2:257). The problems which frequently accompany large projects, however, have apparently undergone little change. Frederick Brooks, for example, compares large scale software projects to the tar pits which ensnared dinosaurs millions of years ago (Ref 3:4):

> Large-system programming has over the past decade been such a tar pit, and many a great and powerful beast have thrashed violently in it. Most have emerged with running systems--few have met goals, schedules, or budgets. Large and small, massive or wiry, team after team has become entangled in the tar. No one thing seems to cause the difficulty--any particular paw can be pulled away. But the accumulation of simultaneous and interacting factors brings slower and slower motion.

This paper seeks to investigate the problems involved in developing one particular class of computer systems, computerized management information systems. Specifically, the objectives of this study are:

1. To determine what factors are most important to the successful development of Air Force computerized management information systems,
2. To determine if and how the important factors vary with a number of system and project attributes,
3. To attempt to develop a predictive model which may be of some use in evaluating and managing future development efforts.

In pursuit of those objectives, this chapter discusses the nature of management information systems (MIS), research into critical factors for developing MIS, and summarizes the literature on important factors for MIS. The second chapter describes the methodology that was followed in surveying computer systems personnel at three Air Force installations, and in analyzing the results of the survey. The third chapter presents the results of the analysis, and the final chapter, conclusions and recommendations for further research.

The Nature of MIS

Experts have sought to segregate the problems involved in developing management information systems from those involved in other kinds of systems for a number of years. One of the central problems involved in such an approach is that there is no single, common definition for MIS. Most writers avoid defining MIS at all. The definitions available range from purely on-line interactive computer systems that provide information only on request (Ref 4:54) to the notes that the owner of a small business might carry in his hat (Ref 5:2). Clearly the two extremes involve completely different problems. Based upon research used in developing this paper, this writer contends that the broader definitions are closest to what practitioners think of when they hear the term MIS.

For purposes of this study, a management information system is defined as: the total collection of resources and procedures used to collect, process and disseminate the information used by managers to make the decisions required to further the objectives of the organization. Given this definition it is apparent that any organization has such a system. It is also apparent that any such system also has two basic parts: a formally sanctioned or "official" part and an informal part. Many organizations have in some form or another, taken a further subset of the formal information system and automated it. This is the computerized management information system. For purposes of this study, a computerized management information system is defined as: a computer system which is used as part of the total collection of resources and procedures used to collect, process and disseminate the information used by managers to make the decisions required to further organizational objectives.

What is it then, that makes developing a computerized MIS different from developing any other computerized system? I contend that the main differences arise from the fundamental nature of MIS in general and to a lesser extent to the inherent difficulties involved in any computer system which is used by non-computer specialists.

In any MIS where personnel other than the using managers are made responsible for collecting or reporting information, it is necessary to identify some form of an information requirement. This is a fairly trivial step for the small businessman mentioned earlier, but more difficult in more complex organizations. It requires that the responsibilities of related departments be somehow delineated. It requires that the decisions required by each be identified. The information which is needed to support those decisions must then be identified in terms of level of aggregation, timing, and currency. This is not possible if the managers cannot identify what information is needed to make the decisions, if the problem is not easily solved by analytical techniques.

The difficulties of MIS become compounded in any organization which operates in a changing environment, is characterized by frequent internal organizational changes, or in which some departments make decisions requiring information which is the "property" of other departments.
A changing environment demands different decisions which requires that the cycle of identifying the information and defining the requirement must be repeated. Internal organizational changes create confusion over roles and responsibilities making it difficult to determine "who" makes "what" decisions. When information is shared or passed between departments, it is necessary to establish the authority and the priority of the using department to have the information.

MIS are also often beset by any number of human behavioral problems, especially when the system is used for performance evaluation and control. It is frequently the case in such systems that the personnel whose activities are to be controlled with the system are the same personnel required to prepare inputs to the system. In these cases it is very difficult to establish the motivation necessary to insure accuracy, and the system may even be "sabotaged" with inaccurate inputs. In the case of using a system for performance evaluation, it is very difficult to develop performance measures which cannot be "gamed" nor result in dysfunctional behavior. That is, to the extent that the performance measure is a substitute for organizational objectives, the individual's or the department's goal becomes the substitute measure rather than the real organizational goal.

Given the problems inherent to MIS in general computerized MIS are subject to additional problems due to their use by non-computer specialists. Among these are communication between user and computer personnel and resistance to automation and change. As indicated earlier, any time the information needed to make a decision is to be collected by other than the using manager, it is necessary to develop some form of an information requirement. This problem is compounded in computerized systems for at least two reasons. First, the using manager probably does not understand what the computer can and cannot do for him and therefore does not know what to ask for. Second, the computer specialist probably does not understand what the user needs and therefore what to give him.

The problems of resistance to change and automation have received a great deal of attention in the literature. However, these problems are probably greatest for MIS because of the closer interaction with non-computer personnel than in most other computer systems, and because of the use of the system as a medium for control and performance measurement, as discussed earlier.

The differences between computerized management information systems and other computerized systems can be summarized as follows:

1. Management information systems have as an objective providing information to managers for decision-making, but the decisions and the information required to support the decisions are often difficult to identify.

2. The decisions made by managers may easily be changed by changes in either the external or internal organizational environment. Thus the MIS is in turn easily affected by organizational changes. These two effects interact with each other.

3. MIS frequently require inputs from departments other than the departments using the information. This creates organizational conflict and lack of support by the "input" organizations.

4. MIS are often used for performance measurement and control. This may result in inaccurate inputs.

5. Computerized MIS depend upon the ability of user managers and computer specialists to communicate very effectively to overcome the lack of a common background.

6. Computerized MIS are probably more affected by resistance to change and automation than are other systems.

Of the differences listed, the MIS objective of assisting and supporting the decision making activities of managers has probably received the most attention in the literature. Perhaps this is due in part to the inherent difficulties involved in defining and quantifying the inputs and parameters to many management decisions. Were all such decisions capable of complete definition, automation would probably be possible and managers unnecessary. In any case, it is those undefinable decisions which may be most important to the continued prosperity of the organization. One example can be found in the conduct of war, which few would argue could ever be completely automated. On that subject, former Deputy Secretary of Defense William P. Clements, Jr. stated, "Throughout history, the outcome of conflict has been determined as much by the collection and proper use of good information as it has been by the quality and quantity of weaponry" (Ref 6:10).

Background of Critical Factors Research

The inadequacies in computer system development projects have been stated time and time again in the literature:

> Many organizations have experienced serious difficulties in developing complex computer-based systems, especially their software components. The problems include large cost overruns, schedule slippages, inadequate performance, and inability to use the system as envisaged (Ref 7:1).
>
> Both surveys and practical experience have indicated overwhelmingly that most computer systems installed during the fifties and sixties have failed in at least some important respect (Ref 8:3).
>
> . . . software is often excessively costly, late in completion, poor in performance, and "unreliable" (Ref 9:296).

As indicated earlier, the lack of any uniform definition of the term MIS, makes it difficult to determine specifically what the problems of developing MIS are. One result of this situation is that when viewing quotes such as those listed above, it is impossible to determine to what extent the problems in the past resulted from MIS, and to what extent the problems resulted from other systems. The problems of MIS have received specific mention on a number of occasions, however:

> Abandoning multimillion dollar MIS efforts is a relatively common place occurrence today (Ref 10:29).

> Management information system projects generally have two distinguishing characteristics: 1) they are late, and 2) there is usually a significant cost overrun (Ref 11:73).

> . . . most information systems have failed . . . (Ref 12:6).

Not all of the authors agree on the magnitude of the problem. Long contends that while the problems have been widely publicized, some firms have successfully been developing MIS quietly under wraps (Ref 13:25). The Air Force however had a very visible example of failure with the cancellation of the $800 million Advanced Logistics System in 1975 by Congress (Ref 14:68). The problems of that system, as reported in the ALS Assessment, are in my opinion remarkably similar to the problems encountered by Babbage and his "Difference Engine" cited at the beginning of this study, and of course both systems met the same fate at the hands of the legislature. Although the degree of schedule slippage cannot be determined from the ALS Assessment, the initial contract cost at award was to be $80 million over the life of the system (Ref 15:22). This cost cannot be compared with the cost at cancellation, because that higher cost included substantial amounts for in-house programming efforts. However, it does give at least a sense of the probable magnitude of the overrun.

Despite general agreement that MIS projects have been less than completely successful, there is very little agreement concerning the reasons for failure and the most important factors for success. A few authors have cited a single most important reason. Axelson states that success depends on all levels of the organization recognizing the importance of the system and that most failures were due to lack of management involvement in the project (Ref 15:26). Lucas says the most important reason for failure is that ". . . we have ignored organizational behavior problems in the design and operation of computer-based information systems" (Ref 12:6). Turn says "One major reason for such lack of success has been the inability of management of the organization or the development effort to understand the need for a total-system management approach" (Ref 7:1). Donelson says "With better project management tools, virtually all DP [Data Processing] system implementations can be successful and cost effective" (Ref 11:73). Brooks says "More software projects have gone awry for lack of calendar time than for all other causes combined" (Ref 3:14). The important factors and relative lack of agreement are more fully discussed in the next section. However, at this point the following conclusions can be drawn:

1. Successful management of MIS projects is a complex and little understood subject.

2. There is a need for empirical research into what factors are most important to the successful development of MIS, so that future projects can be enhanced by concentrating on the most important issues.

One such research effort was undertaken by a team of researchers at Colorado State University (CSU), led by D. M. Carter. The effort was performed under contract with the Air Force Office of Scientific Research during the period September, 1972, to March, 1975 (Ref 17:1-5). The purpose of the CSU study can be summarized (Ref 17:1):

> The effectiveness of computer-based information systems undoubtedly is dependent upon many factors. Factors usually

> discussed are: hardware, systems personnel, operating management . . . and so forth, to an almost inexhaustible list. A major question, however, has not been answered: what are the most critical factors that contribute to the successful development of an information system? In addition, can the factors be measured? If an organization could measure the value of each factor and obtain a statistical composite value of all factors, predictions could be made as to the probable success or failure of a proposed system effort.

The methodology followed by the CSU researchers was to first determine what factors were potentially most important, and then to reduce these factors to the critical factors. This was followed by efforts to develop survey and other measuring instruments to determine the level of attainment of each factor in a given systems effort. The researchers then developed an interactive goal programming model to assist project personnel in determining what variables and factors needed increased attention in order to achieve project success (Ref 17).

In order to determine which factors were important, the CSU researchers first interviewed a total of 40 systems and general management personnel in business and government agencies in Colorado. Based upon the interviews, a 20 factor checklist was developed and tested on the same personnel. Based upon these results, a refined 14 factor checklist was sent to 200 systems analyst and management personnel throughout the U. S. The researchers received 120 usable returns and the results are shown in Table I.

The researchers performed an analysis of the ten factors common to the two checklists using the Spearman rho statistic to verify that the rankings were from the same population. Additionally, analysis of variance was used to verify that the means of the factor ratings did not vary significantly by industry type. The researchers then used factor analysis to group the 14 factors into four "critical" factors. These

Table I
Results of the CSU Critical Factors Checklist

Rank	Mean	Std. Dev.	Factor
1	.89	.15	Definition of the objective of a specific information system
2	.88	.13	Identification of the information needs of management
3	.81	.17	Attitude of management toward a given system effort
4	.80	.16	Communication abilities of design team
5	.72	.20	Expertise and creative ability of design team
6	.72	.30	Determination of company objectives
7	.68	.27	Justification of system cost
8	.66	.29	Participation of management on design team
9	.65	.23	Adequacy of time frame for system effort
10	.64	.22	Attitudes of design team toward user department
11	.61	.26	Attitudes of user department toward design team
12	.60	.25	Resistance to change by management
13	.50	.23	Resistance to change by employees
14	.47	.26	Sophistication and ambitiousness of project

(From Ref 17:10)

factors were named planning and control, attitude, expertise and involvement. The researchers then use "selected systems educators and practitioners" to weight each of the factors in terms of importance to project success (Ref 17:7-16).

The procedures used by the CSU researchers in determining the important factors were critical to all of the subsequent work performed by the team. The use of factor analysis to determine the "critical" factors was an abstraction from the original data. The efforts to determine appropriate weights for the critical factors and ways to measure the level of attainment of those factors were both further abstractions. Thus the accuracy of the original data was critical if the subsequent work was to be usable. However, the writer found a number of potential problems with the original data, such that a further survey effort appeared desirable. These problems are:

1. Although the research was to determine factors critical to the development of Air Force systems, only non-Air Force agencies were surveyed.
2. The survey asked each respondent to rate each of the factors for systems in general.
3. The survey gave no indication of the appropriate level of attention that should be given each factor.
4. The survey did not appear sufficiently inclusive.

With respect to the first point, the CSU researchers surveyed non-Air Force institutions because of the accessibility of those institutions. The researchers "believed a high degree of correlation to exist between critical factors in Air Force systems and factors in non-Air Force systems" (Ref 17:7). This hypothesis was at least partly supported both by findings that the two survey groups rated the factors the same in a statistical sense, and that the means of the factor ratings did not vary significantly with industry type (Ref 17:11-12).

However, this researcher feels that there are a number of reasons why critical factors in the Air Force may be significantly different. Most authors, for example, place considerable emphasis on determining the objectives of the organization. This process is complicated in the

Air Force by at least three issues: the fact that the Air Force is a government organization and must satisfy a multitude of goals beyond the basic mission; the absence of an easily definable and measurable product (combat capability); and the absence of a profit motive. Other potential reasons why the Air Force may be different include the size, nature and intended use of Air Force systems, as well as the complex organizational relationships that frequently occur in the Air Force. The last point will be discussed in the next chapter. With respect to the other issues, the Air Force has been involved in a number of extremely large projects, such as the ALS and the Worldwide Military Command and Control System. Air Force projects since the Semi-Automatic Ground Environment system have frequently been on the forefront of the state-of-the-art. Also in command and control systems, for example, speed, reliability and flexibility become far more critical than in most business-oriented systems. Therefore, I contend that it may be very useful to know not only if the factors vary for Air Force versus non-Air Force systems, but also whether the important factors vary significantly across a number of other parameters. These include the intended use, size, sophistication, project organization, maintenance arrangements and contractual arrangements.

The problem with asking survey respondents to rate the factors in terms of importance to systems efforts in general is that there may be a tendency to rate according to some theory or teaching, rather than by experience. The opposite problem may be encountered by those respondents who attempt to rely on experience. The factor checklist asked the respondents to rate each factor in terms of importance ". . . to the systems effort" (Ref 17:82). The problem is that importance to success does not necessarily equate with level of effort or attention. For example, a factor may be critically important if completely ignored, yet only slightly important if given minimal attention. The opposite situation could also occur, if a factor was accorded too much attention. Thus, it may be important and useful to both tie the ratings to specific development efforts, and to achieve some sense of the appropriate level of effort for each factor.

The final point, that the critical factor checklist was not sufficiently inclusive, will become more evident in the next section. In summary the writer believes that, while the CSU study was enlightening and a valuable effort, that a new survey is needed to overcome some of the potential difficulties of the CSU critical factor checklist. The survey instrument developed by this researcher (discussed in the next chapter) attempts to overcome these difficulties.

<u>Literature Search</u>

As a first step in this effort, a literature search was performed in order to obtain an improved list of factors important to the successful development of MIS. The search was broadly based, both because of the lack of a uniform definition of MIS and the fact that MIS development inherently involves problems of both software development and project management. Relevant articles and reports were found under such classifications as: automation, computers, electronic data processing, management, management systems, planning and control, project management and software development. A total of over 150 significantly different and potentially important "factors" or "problems" were listed by the more than 50 references surveyed. Despite the numbers involved, the writer was only reasonably confident that the full breadth of opinion had been determined. As an indication of the diversity of opinion, at least eight distinct and well-developed models of the steps involved in developing MIS or software were located (Refs 7,8,19,20,21,22,23).

As shown earlier, a few authors did list a single most important factor. In addition, several listed a relatively manageable number of important factors. A few of these are shown in Table II. This table also gives a little better feel for the possible existence of some truly common factors. These might include management involvement and user needs. By looking at the important factors listed by the 50 plus authors, the writer was able to pick out some candidate critical factors, simply by finding the factors listed most often. These were (followed by the number of authors specifically listing the factor):

Management involvement (13)

User involvement (13)

Some form of disciplined project management approach, characterized by phased reviews (9)

Some form of formalized change control or configuration management (8)

Information needs of users (7)
("Total" needs also listed by 2)

Human factors (5)

System objectives (5)

Adequacy of planning (4)

System requirements determination (4)
("Complete, unambiguous, testable" requirements also listed by 3).

A variety of project management approaches were proposed. Of these, however, nine authors specifically stressed the need for periodic management reviews (generally including user representatives) during the project.

Table II
Factors Listed by Selected Experts

Joseph Orlicky (Ref 4:4):

1. Understanding of the business function to be automated...
2. Motivation to innovate.
3. Competence in design and ability to relate the system's functions to operating needs.
4. Authority and prestige (of project personnel).
5. Insight into how human factors affect the success of a computer-based system.

John V. Soden (reasons for failure) (Ref 10:29):

1. User needs not fully understood before systems design.
2. Alternative system designs not evaluated for costs and benefits.
3. Performance due to technical design.
4. Capability to perform within budget.
5. Scheduling of potential MIS not based upon organizational objectives.

Joel E. Ross (reasons for failure) (Ref 24:36):

1. Lack of management involvement.
2. Too much useless data.
3. The communications gap (between users and systems).
4. Lack of planning.
5. Failure to identify information needs.
6. Reliance on manufacturer or consultant.

Martin J. Shio (reasons for failure) (Ref 25:38-9):

1. Lack of proper objectives and goals for many MIS projects.
2. Lack of management participation and development.
3. Control measures and evaluative criteria are inadequate or absent.
4. False assumptions are used in designing MIS.
5. Inability of many system designers to identify information needs for managers.
6. Lack of flexibility in many MIS.
7. Poor implementation plan.
8. Too much emphasis is placed on technical aspects while placing relatively little emphasis on human factors.

Information needs of users was listed by seven authors, and an additional two felt it important to stress the "total" needs of users. System requirements determination (or phase) was listed by four, and three others indicated the attributes of requirements shown.

The critical nature of user involvement is further demonstrated by Table III, which consists of a partial list of other factors listed by the authors relating directly to user involvement. As can be seen from the list, user involvement is far more important than the 13 "votes" would indicate; furthermore, the authors disagree substantially on the best way to achieve user involvement. The critical nature of user involvement was particularly well-demonstrated by the results of a study of 56 systems performed by Alter (Ref 27:103):

> Intended users neither initiated nor played an active role in implementing 11 of the 15 systems that suffered significant implementation problems. Conversely, there were relatively few such problems in 27 of the 31 systems in which users had a hand in initiating and/or played an active role in implementing.

Although management involvement also received 13 "votes," far fewer factors were specifically related to management involvement than were to user involvement. Perhaps this is due in part to some conceptual difficulty on the part of some authors in differentiating users from managers. Generally speaking, the writer found the issue clearest when "managers" was used to refer only to "top management." The factors relating to management involvement were (not direct quotes):

Management knowledge and experience with computers (Refs 4,7)

Task force of top management used in problem definition (Ref 32)

Top management control of system development efforts (Refs 8,13,34)

Removal of the human and organizational barriers to system development (Ref 5)

Table III
Factors Relating to User Involvement*

1. Quality of user team members (Refs 4,8).
2. User experience and knowledge of computers (Refs 4,21,26).
3. Promoting the system to users (Refs 8,27,28).
4. Users perform testing (Refs 7,8).
5. Continuing MIS education of users (Ref 13).

6. Project managed by users (Refs 29,30).
7. System goals same as user goals (Ref 29).
8. Final decision belongs to the user (Refs 8,26,29).
9. User responsibility of project success (Ref 27).
10. Communications between users and systems personnel (Refs 7,24).

11. Systems personnel knowledge of user goals and operations (Refs 26,31).
12. User control of requirements, but with the use of an independent validation agency (Ref 7).
13. Continuous evaluation (during operation) of user satisfaction with the system (Ref 28).
14. User training begun early, performed intensively (Refs 4,8,32).
15. User should participate, but design and develop independently to control changes (Ref 7).

16. Full-time systems representatives in user departments (Ref 29).
17. Training of employees performed by users (Refs 4,8).
18. Total needs of users (Refs 10,28).
19. Information needs of users (Refs 4,8,24,25,29,33,34).
20. User commitment to achieving the benefits of the system (Refs 4,8).

21. User acceptance and commitment to implementing the operational changes required by the system (Refs 8,21,34).
22. Evaluation of the impact of the system on users (Refs 8,21).
23. Identification of organizational responsibilities and support tasks that will be required (Refs 29,34).
24. Systems personnel respect for the users as "owners" of the system (Ref 8).
25. User participation in project reviews (Refs 7,35,36).

*Factors are not direct quotes.

Treating information as a major business function (Ref 16)

Ability of top management to evaluate the system (Ref 33)

Direction from top management on development policy and procedural changes (Ref 32).

Given the complex, contradictory and apparently unlimited advice in the literature, the question posed by the CSU researchers remains: ". . . what are the most critical factors that contribute to the successful development of an information system" (Ref 17:1)? If the CSU researchers were correct, there should be a relatively manageable number of truly common and critical factors. Shaw tends to agree when he says (Ref 8:26):

> Experience, then, has proved that there are certain common denominators involved in planning, developing, and implementing a computerized data processing system. These common denominators, as far as can be determined, apply to virtually all system development situations.

Although Shaw does not distinguish MIS from other systems, in my opinion the development process propounded by Shaw appears specifically geared toward MIS. Regardless of whether the factors are common to MIS or all systems, the sheer number of factors alleged to be applicable to MIS presents a real problem in terms of developing a methodology for determining the truly critical factors. Obviously it would be impractical to design an effective survey for measuring 150 factors.

As an initial step in reducing the number of factors to a manageable number, the writer developed the list shown below. This list is a synthesis of the more prevalent views in the literature. Further refinements were made in developing the survey and are discussed in the next chapter. The categories under which each of the factors is listed are not intended as steps in a development process, but rather as a class of activities. Even this distinction is somewhat arbitrary, since many of the factors apply to several activities.

Environmental Factors

1. Information treated as a major function.
2. Formalized organizational goals.
3. Use of long-range organizational planning.
4. Use of long-range systems planning to support organizational plans.
5. Management and user knowledge/experience with computers.
6. Attitude of users toward systems personnel/projects.
7. Attitude of systems personnel toward users.
8. Involvement and support by top management in system development.

Project Management Factors

1. Quality of project managers.
2. Use of a disciplined development approach with periodic reviews involving users and top management.
3. Emphasis on the planning aspects of projects.
4. Use of formalized change control procedures.
5. Commitment by users to the success of the project.
6. Management control system (e.g., PERT).

Project Initiation Factors

1. Identification of system requirements.
2. Identification of system performance and acceptance criteria.
3. Identification of project success criteria.
4. Identification of milestones.
5. Definition of the size and scope of the project.
6. Identification of system objectives.
7. Justification of system cost.
8. Relationship between system goals and long-range plans.
9. Prioritized development of systems.
10. Integration of systems.
11. Identification and documentation of the assumptions of the project.
12. Adequacy of calendar time for the project.
13. Assignment of adequate resources to the project.
14. Identification and adequacy of the authority and responsibility of the project manager.
15. Use of a project organization.

Analysis Factors

1. Objectives of the user organization.
2. Analyst knowledge of user operations.
3. Evaluation of the impact of the system on users.
4. Information needs of users.
5. Experience and creative ability of analyst personnel.

Design Factors

1. Use of a disciplined design approach.
2. Thoroughness of design.
3. Ability to view the system as a complete entity.
4. Use of automated software development tools.
5. Specification of run, module and interface requirements.
6. Abilities of design personnel.
7. Continuity of work force.
8. Evaluation of alternative designs.
9. Quality, timing and usability of output.
10. Simplicity and logic of the system design.
11. Responsiveness of the system to special requests.
12. Adequacy of hardware.
13. Staffing of the design team.
14. Management and user involvement in design.
15. Communication abilities of the design team.
16. Use of a prototype.

Programming Factors

1. Use of a standard high-order language.
2. Modularity of programs.
3. Maintainability, reliability and adaptability of programs.
4. Documentation.
5. Identification and control of work assignments.
6. Use of methods and work standards.

Test Factors

1. Adequacy of calendar time for test.
2. Use of a formal test plan and methodology.
3. Availability of hardware and software for debugging programs.
4. Adequacy of test data.
5. User involvement in test.

Implementation Factors

1. Commitment by users to achieve the benefits of the system.
2. Commitment to implement the procedural and organizational changes required by the system.
3. Education and training of users.
4. Use of a formalized problem reporting system.
5. Promotion of the system to users.
6. Formalized turnover or transition.
7. Performance of a post-implementation review.

This chapter has discussed the nature of management information systems and a literature review of the research addressing the factors critical for development of MIS. The second chapter describes the methodology that was followed in surveying computer systems personnel at three Air Force installations, and in analyzing the results of the survey. The third chapter presents the results of the analysis, and the final chapter, conclusions and recommendations for further research.

II. Methodology

The Survey Instrument

As discussed earlier, the survey used in this study attempts to overcome four potential problems with the CSU 14 factor checklist. These were:

1. Administering the survey to only non-Air Force agencies.
2. Not tieing the factor ratings to specific systems.
3. Not obtaining a measure of the appropriate level of attention that should be given each factor.
4. Not including enough factors in the checklist.

A copy of the survey developed and administered for this study is shown in Appendix A. The survey consists of three parts. Part A measures 7 demographic variables, Part B 12 system attributes and Part C the importance of 40 different factors. The first problem was overcome simply by giving the survey within Air Force organizations. The second and third were more difficult. The fourth was solved by reducing the number of factors shown at the end of the first chapter using criteria discussed later in this section.

One problem with asking respondents to rate a specific system is that a number of respondents may have no experience with a specific MIS. To overcome this, the survey allows respondents with no experience to rate the factors for systems in general, and those with experience to rate a specific system. This design permits testing the hypothesis that it makes no difference which way the factors are measured. This may be useful for evaluating the CSU study and in guiding future efforts.

The third problem, obtaining a measure of the appropriate level for each factor, is more difficult to address. The main problem is that there are too many potentially useful dimensions (factors) relating to project success. One factor used in this study, and essentially the same as one used in the CSU study, was "identification of the information needs of users." There are several useful things to know about this factor. First, how "well" should it be accomplished? How much does the factor contribute to project success compared to other factors? Is the factor critical in the sense that, if it is not attained at a minimum level, the project will fail? How "important" is the factor to project success?

Consideration was given to measuring each of the dimensions listed. One of the early test versions of the survey attempted to have the respondent first indicate if the factor was present in the project at about the level indicated (by the wording of the factor). The respondent was then to indicate how important the presence or absence of the factor was to the success of the project. A pretest of that design yielded that it was extremely time consuming for respondents to complete, and that the use of adjectives to describe the level of fulfillment both offended the respondents and yielded vague results.

The design settled upon through six different test versions of the survey is shown in Figure 1. The dimension to be measured by this design is "how important each factor should be treated in order for a project to be successful." Respondents who have no experience with specific MIS development efforts rate only the right column, based upon what they

Importance Given on This Project	Ideal Importance		
_____	_____	56.	Control and coordination of changes.
_____	_____	57.	Identification of the information needs of users.
_____	_____	58.	Commitment and support by users.

RATING SCALE:

A	B	C	D	E
Critically Important	Very Important	Important	Somewhat Important	Not Important or Not Applicable

Fig. 1. Design of Survey Part C

think is most important for the successful development of MIS in general. Respondents with experience rate both how importantly each factor was treated during the project in the left column, and how important the factor should have been considered to make that project more successful in the right column. I considered this dimension to be probably the most beneficial to project managers, since it attempts to answer "how much attention should I give to factor X" and "how much more important is factor X than factor Y?" This measurement form, if successful, should have the end result of allowing project managers to concentrate their efforts on the factors most requiring their attention.

The problem of including enough factors was addressed in Chapter I. The list presented at the end of that chapter was viewed with two objectives when constructing the survey: (1) choose only the apparently most important factors (since the average time to complete the survey should not exceed 30 minutes or response rate will be low), and (2) avoid choosing factors that appear to be some expert's technique or a controversial issue. The final version of the survey measured a total of 40 factors. It was found in pretests that 40 were as many as respondents could rate (in addition to the preliminary questions in the first two parts) in the allotted average 30 minutes. With respect to techniques and controversial issues, the use of top-down structured programming, standardized high-order languages and a number of other potential factors were not surveyed. Since there is currently some controversy over the use of these techniques, it was felt that a survey would reveal primarily that opinion is polarized. Modularization and integration were included since these approaches have been espoused for some time in the literature.

Certain of the factors are common (with some rewording) to both the CSU study and this survey. These are shown in Table IV. Part of the rewording consists of changing "management" in the CSU factors rated second and eighth to "user" on this survey. It was felt that the CSU study implicitly equated the two terms in those two factors. That is, in many civilian institutions, the most relevant managers are users. This may not be the case with all Air Force development agencies. The use of common factors should allow evaluating the hypothesis that the survey populations are the same (discussed in the section on methods of analysis).

One of the study objectives stated in the first chapter was "to determine if and how the important factors vary with a number of system and project attributes." The attributes measured in Part B of the survey were:

System success

Table IV
Factors Common to the CSU Study

Ranking on CSU Study	Wording on CSU Study*
1	Definition of objectives of a specific info. sys.
2	Identification of info. needs of mgt.
3	Attitude of mgt. toward a given sys. effort.
4	Communication abilities of the design team.
5	Expertise and creative abilities of the design team.
6	Determination of company objectives.
7	Justification of system cost.
8	Participation of mgt. on the design team.
9	Adequacy of time frame for system effort.
10	Attitude of design team toward user dept.
11	Attitude of user dept toward design team.

Equivalent to CSU Factor	Wording Used on Survey**
1	Definition of the objectives of the system (38).
2	Identification of the information needs of users (57).
3	Involvement and support of top management (33).
4	Personal communication ability of the designers (48).
5	Expertise and creative ability of the designers (21).
6	Determination of the objectives of the user organization (25).
7	Justification of system cost (55).
8	Involvement in system design by users (47).
9	Scheduled time for the project, excluding test (40, test time measured by 42).
10	A positive attitude by the designers toward the users (28).
11	A positive attitude by users toward designers (49).

* (Ref 17:10)
** Number in parentheses after each factor is the question number as used on the survey.

Project size
Single versus multiple installation
Software-only projects, versus software and hardware
Number of user organizations, and similarity of their requirements
Application type (accounting, command and control, project management, research)
Technical difficulty
Contractor participation
Use of long-term warranties (on contracts)
Maintenance arrangements
Time since project completed
Whether the system is still in use.

The "system success" variable was included to provide a criterion variable for use in regression analysis in developing a predictive model. Size was included since many experts have argued that there are problems involved in large projects that are not important in smaller ones. The number of installations and user organizations, as well as the similarity of user requirements was measured because these factors would appear to impact both on the ease with which users may be involved in the project, and the need for involvement. Other hypotheses to be tested include that the factor ratings vary significantly for software-only projects, with application type, with the degree of contractor participation, and with the degree of technical difficulty.

Maintenance arrangements, use of long-term warranties and project organization were included primarily as candidate regression (independent) variables. A number of experts have cited both project organization and maintenance arrangements as important factors. However, since it is not well agreed what form of organization or maintenance arrangement is best, these factors are best measured as nominal variables rather than continuous ordinal factors. This is why the two were included in Part B of the survey. The use of long-term maintenance warranties was included since that procedure was strongly recommended by a study performed for the Department of Defense in 1974 (Ref 9:17).

Description of the Population

Software development and the development of MIS in the Air Force are performed by a wide variety of organizations for many different purposes. Figure 2 is intended to illustrate this variability by showing some of the Air Force agencies involved in MIS development. Individual bases, on the one extreme, develop systems for local users. At the other extreme, the Air Force Data Systems Design Center (AFDSDC), under the Air Force Data Automation Agency (AFDAA) is responsible for developing and maintaining standard automated data systems for use throughout the Air Force. This currently involves 196 systems operating on 350 computers worldwide (Ref 38:1). The Air Force Military Personnel Center (AFPMC) is responsible for all common use personnel systems. The Electronic Systems Division (ESD) of Air Force Systems Command (AFSC) becomes involved in many larger projects. Each major command (MAJCOM) develops systems for its own unique requirements.

These systems also vary considerably both in size and use. For example, in a survey of 25 System Development Corporation and Department of Defense project managers, "Project size varied from 2 persons and 5000 object instructions to 200 persons and 1.2 million instructions . . . Projects ranged from 8 months to 6 years in length" (Ref 35:2). Additionally, systems in the Air Force vary from relatively familiar accounting and inventory applications to extremely sophisticated command and control applications.

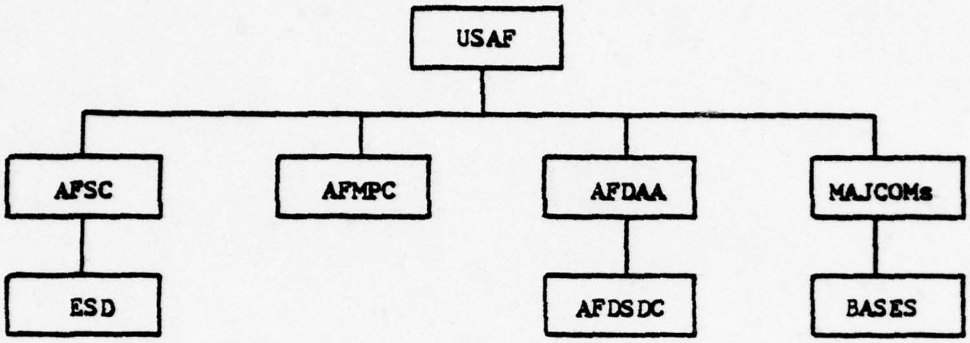


Fig. 2. Some Air Force Organizations Involved in MIS Development (Not an official listing or organizational chart)

Thus one problem in determining the survey sample was to obtain data from the full range of development types and system uses. Additionally, it would have been ideal to obtain responses from users as well as developers of MIS. Unfortunately it is probably impossible to identify an adequate sample of "experienced users." Therefore the approach taken was to select development agencies to be surveyed. The agencies selected were the AFDSDC at Gunter AFS, Alabama, Air Force Logistics Command (AFLC) activities at Wright-Patterson AFB, Ohio and Air Force Systems Command activities (Aeronautical Systems Division, Foreign Technology Division and others including the Air Force Avionics Laboratory, Air Force Materials Laboratory and Aero-Propulsion Laboratory) at Wright-Patterson AFB, Ohio. Also surveyed was Data Automation at Headquarters, Strategic Air Command (SAC), Offutt AFB, Nebraska.

Although this sample is biased toward agencies with a large investment in software development, responses indicated a fair percentage of smaller efforts, and several of the units surveyed at Wright-Patterson are involved in base-level type activities. These units also reflect a complete cross section in terms of systems application. SAC is heavily involved in command and control, AFLC in accounting-type applications, and AFSC in project management and research. AFDSDC was included to find the, possibly unique, problems of a developer of standardized systems.

The next problem was to identify the personnel to be surveyed. It was decided at this point to survey only personnel of a rank high enough so that they would probably be aware of managerial problems as well as technical issues. For that reason the sample was limited to Air Force officer personnel and civil servants in grades GS-9 and above. It may have been, in retrospect, desirable to include senior noncommissioned officers (grades E-8 and E-9). The AFDSDC, in particular, has a number of highly qualified personnel in that category, some in policy making positions.

Because there is no single pool of personnel working in systems development at Wright-Patterson AFB, personnel selected to participate at that base were limited to "computer specialists." These were Air Force specialty codes 51XX and civil service codes 33X and C1520 (C1520 is mathematician, but most at Wright-Patterson work primarily with computers). The sample was not limited by specialty code at AFDSDC and SAC, since personnel working with systems development at those locations are primarily all in one organization, and therefore easily identified. Also, since both of those organizations have chosen to facilitate user involvement by including functional specialists, this gave the opportunity to gain more of a "user's perspective" in the data. The AFDSDC, in particular, makes a practice of obtaining highly qualified functional (for example accounting, logistics, operations, medical) personnel. These personnel often serve a tour of duty at AFDSDC working in system development, and subsequently spend much of their careers alternating between their functional specialties in the field and AFDSDC. SAC also has a number of personnel who are highly qualified in both a functional specialty and systems development.

Approximately 40% or 750 of the nearly 1900 personnel working in computer-related duties (in the appropriate grades) at the three locations were chosen to participate in the survey. Selection was made randomly. The sample size was large because of the need to maintain an adequate cell count throughout the analysis. If, for example, the opinions of inexperienced personnel (in terms of either MIS projects or years working with computers) are significantly different when other variables are controlled, it may be necessary to segregate those responses from the rest of the data. The seven demographic questions of Part A of the survey provide a capability to segregate the data based upon command, years experience, specialty, job orientation, grade, user contact, and MIS project experience, or any combination of these variables.

One problem in designing Part B of the survey originated from the inclusion of relatively lower-grade, technically-oriented personnel in the sample. It would have been ideal, for example, to obtain relatively precise measures of system size and cost. It was found during the pretest however that the technically-oriented respondent had little idea of system cost, and often a not much better idea of system size in terms of precise measures like lines of code, or man-years. A related problem was found when using relatively precise measures of size with respondents whose experience involved only small projects. Size is not logically measured on a linear scale. Recalling the project manager survey cited earlier, the largest project included in that survey involved 200 people, for example (Ref 35:2). A linear scale with five possible responses and a maximum value of "200 or more" would have responses at 40, 80, 120 and 160. Well over 90% of Air Force projects would fall into the first category, but a few extremely important projects would be included in the last. Thus a nonlinear scale with intervals at 5, 10, 20, 50, 100 and 200 (for contractor personnel) was attempted on the first pretest. The use of such a scale made the survey seem very imposing to those involved in only very small projects and they were then unmotivated to complete the survey. That experience also taught that technically-oriented personnel often have very little idea how many personnel a contractor had working on a project. The final version of the survey utilized subjective judgment of size, based upon the number of people and the duration of the project. These were some of the considerations which led to the final design of survey Part B.

The surveys were administered during September, 1977. The surveys were hand carried to most of the organizations at Wright-Patterson AFB, and I gained the support and cooperation of the appropriate supervisor at each organization visited. Although participation was voluntary, past survey efforts have found that response rates are higher when supervisors indicate that they support the project. The surveys administered at Hq. SAC were mailed to a project officer who made distribution. Respondents returned the surveys directly through the mail upon completion. The researcher was able to personally visit the AFDSDC. That organization had appointed a central project officer to assist in making necessary arrangements, and each Directorate had in turn appointed a project officer to distribute and explain the survey to the respondents. This left the researcher relatively free and the opportunity was taken to visit each of the Directorates and conduct personal interviews.

Nearly all of the AFDSDC Directorate chiefs or their deputies (in some cases both) were interviewed during a three-day period. A list of personnel interviewed is contained in Appendix B. The interviews were performed with the understanding that the interviewees would not be quoted directly, specific systems would not be mentioned by name and that only summary information would be presented in this study. The questions asked are shown in Figure 3.

There were three objectives in performing the interviews: to obtain the views of top-level managers concerning what factors are most important for developing Air Force MIS, to obtain information about what factors emerge as most important outside the confines of a highly structured survey, and to obtain a better idea if and in what ways MIS development in the AFDSDC and the Air Force may vary from MIS development in the civilian community. The results of the interviews are contained in the next chapter along with the results of the survey.

Methods of Analysis

The analysis plan followed can be divided into four parts: initial investigation of the data, analysis of the factor ratings, factor analysis (in the statistical sense) and regression analysis. During the initial investigation of the data a simple cross-tabulation technique was

1. How would you compare computerized management information systems in the Air Force to those in civilian organizations?
   a. In terms of the nature of the systems?
   b. In terms of the development process?

2. Do you think that the development of Air Force systems requires the use of procedures, management emphasis or skills which are different from those required to develop civilian systems? If so, in what ways?

3. Has your Directorate ever been involved in the development of management information systems? If so, were there any problems which you think were peculiar to your particular mission or organizational structure?

4. What "factors" are most important to the successful development of Air Force management information systems? Are these factors different for AFDSDC?

5. Recall the most successful management information system development effort with which you are familiar. Briefly describe the project in terms of size, intended use, technical difficulty, organizational structure and contractual arrangements.
   a. What "factors" were most important to the success of that system? Please rank-order the factors (1st, 2nd, ...) in terms of importance.

6. Recall the least successful management information system development effort with which you are familiar. Briefly describe the project in terms of size, intended use, technical difficulty, organizational structure and contractual arrangements.
   a. What "factors" were most important to the failure, or lack of success of that system? Please rank-order the factors (1st, 2nd, ...) in terms of importance.

Fig. 3. Format Used in Interviewing AFDSDC Personnel

used to determine the cell counts for various combinations of demographic variables and system attributes (Parts A and B of the survey). A typical output of this analysis would be that there were n "very large," "technically difficult," "successful" systems included in the survey responses (n respondents indicated that particular combination in Part B).

This also gave some initial feel for any trends (correlation or biasing) in the data.

Cross-tabulation was followed by the use of the Automatic Interaction Detection (AID) algorithm with System Success as the criterion variable. The AID algorithm operates by dividing the total sample into the most statistically homogeneous groupings possible relative to the criterion variable. The measure of homogeneity is the sum of the squared differences between the response for each individual in the group and the group mean (called the sum of squares). For example, if Size were used as the independent variable for a split, the algorithm might split the total sample into two groups: Group 2 consisting of responses A through D ("very small" to "fairly large"); and Group 3 consisting of responses E and F ("large" and "very large"). The mean value of Success is calculated for each group, and then the sum of squares for each group is calculated (Ref 40:24-26).

The algorithm operates in a two-stage process to determine the "best" split of a group. First it determines the best split for each independent variable by calculating the sum of squares for all possible splits, where a "possible" split is one which results in two mutually exclusive groups that are exhaustive of all available responses. The sum of squares is then calculated and the split resulting in the smallest sum of squares is selected as best. The algorithm then repeats the procedure for the remainder of the independent variables and the variable with the best split of the entire set is selected to split the group. The procedure is repeated until preset limits, such as group size, are reached. For example, if the first split were made on Size as described above, Group 2 might subsequently split on Preliminary Design into Groups 4 and 5, and Group 3 might split on Education and Experience of the Project Manager into Groups 6 and 7. The results of the process may be displayed, if desired, as a tree diagram (Ref 40:24-26).

One advantage of AID in this particular application is that it allows the use of nominal variables (such as a number of the questions on Part A and B of the survey) without requiring the analyst to identify and compute dummy variables. One potential drawback is that AID may result in idiosyncratic results in smaller samples such as the one used in this survey, as found by Gooch (Ref 41:71). The intent of using AID in this particular application is both to provide an initial indication of any unproductive paths planned a priori in the remainder of the modeling effort and to discover trends which may not be apparent from a cursory examination of the data.

Three different techniques were used in the investigation of the factor ratings. These were t-tests, analysis of variance (ANOVA) and the Spearman Rank-Order Correlation coefficient. Given the aggregate factor ratings (Part C of the survey) for the entire sample, the mean and variance for each factor was computed. The sample was then broken down into groups to test the hypothesis that the mean ratings for each group for each factor were equal. For those independent variables used to divide the sample into groups which could logically be divided into only two groups, the t-test was used. This was used, for example, to determine if those respondents who rated the factors for a specific system differed significantly from those who rated the factors only in general.

It was necessary to use ANOVA for those independent variables that logically had to be divided into more than two groups, such as command of assignment of the respondent. The ANOVA procedure is based upon decomposing the variance in the dependent variable (the factor ratings in Part C of the survey) into the portions due to the presence of the independent variable, say command, and that due to random effects or error. The F-statistic is then used to test the hypothesis that the means are equal. This procedure was used carefully, however since the F-statistic will permit the hypothesis that there is no difference to be rejected even if only one category is significantly different. For example, if information needs were the dependent variable, and each of the commands placed about the same mean importance on information needs with the exception of AFLC, the F-statistic causes the hypothesis to be rejected. If this hypothetical situation were found for a number of the factors when evaluated by command, it would be an indication that further analysis was needed to determine why AFLC was different.

It was necessary to use the Spearman rank-order correlation coefficient, a nonparametric statistic, to test the hypothesis that the Air Force population included in this survey is the same as the non-Air Force population surveyed by the CSU researchers. This procedure is used by treating the two sets of results (CSU and this study) as variables and the ranks of the 11 common factors (Table IV) as cases. For example, of the common factors, information needs might be ranked 1, and objectives 2. The data is paired rank against rank for both studies (for example (1,3),(2,4),(3,1) for all 11 factors), and the correlation coefficient is a measure of how well the rank on the one study predicts the rank on the other study. This procedure also produces a statistic which is tested for significance against the T-distribution with n-2 (9) degrees of freedom. In the event that little correlation exists between the two studies, the analysis can also be attempted without factors 3, 8, and 9 since the difference in wording between the two surveys is greatest for those factors. It should be added that this procedure cannot prove conclusively that the two populations are truly different, only that the populations are the same (as far as how the factors were ranked) or that the factor ranks are not the same. This is due both to the nature of the hypothesis and because the survey designs are completely different.

The third and fourth steps in the analysis were the use of factor analysis and multiple regression. Factor analysis was used both as a data reduction technique and to search for underlying relationships in the data. For example, the CSU researchers used factor analysis to reduce the 14 variables on their factor checklist to four "critical" factors which they call planning and control, attitude, expertise and involvement (Ref 17:14). The procedure operates by finding associations between the variables. Each set of associations is developed such that it is statistically independent from every other set of associations built by the procedure. These associations are used to define the resultant factors. Recalling Table III in Chapter I, "Factors Relating to User Involvement," it is relatively apparent that a number of potentially important factors relate to this potential "critical" factor. This researcher felt a priori that factors 31, 33, 37, 47, and 58 related to user involvement. Other potential critical factors hypothesized a priori related to the "front end" of the project (requirements definition, initial analysis, determination of user objectives, system definition), control, attitude, planning and expertise. The underlying rationale for using factor analysis is that, given the underlying relationships between the variables which define the factor, the really critical thing for the project manager to concentrate is the level of the factor. The results of the factor analysis were used in multiple regression, along with a number of other potential independent variables, in the effort to develop specific models for predicting system success. Further discussion of the modeling effort is reserved for the next chapter, along with the results of the analysis.

III. Results

Interview Results

As discussed in the last chapter, a series of personal interviews were performed while administering surveys at the AFDSDC, Gunter AFS, Alabama, using the format shown in Fig. 3 (Page 35). The objectives in performing the interviews were: to obtain the views of top level managers concerning what factors are most important for developing Air Force MIS; to obtain information about what factors emerge as most important outside the confines of a structured survey; and to obtain a better understanding of how MIS development in the AFDSDC and the Air Force differs from MIS development in the civilian community.

The views of the interviewees with respect to the most important factors are summarized in Table V. The classification of these factors into the areas of user involvement, requirements definition, development approach, resources, organization or technical issues is based upon the perceived intent of the interviewees. The factors listed are those mentioned by two or more interviewees. The numbers listed in the first column to the right of each factor indicate how many interviewees cited the factor as being important to the successful development of systems in general. The second and third columns indicate respectively, the number of persons listing the factors as of primary importance for the success of specific successful systems and the lack of success of unsuccessful systems. The results of the interviews were surprising to this researcher in terms of the amount of emphasis placed upon requirements definition activities and upon the use of a structured development

Table V
Summary of Interview Results

Factor	In General	To Successful Systems	To Unsuccessful Systems
	Number of Interviewees Citing as important:		
<u>User Involvement</u>			
throughout the project	4	4	
during requirements definition	3		
by including functional users in development team	4	2	
in planning	2		
determining the information needs of user management	1	2	
<u>Requirements Definition</u>			
clear, formal	5		5
understanding of requirements	1	1	2
<u>Development Approach</u>			
formalized, with reviews	5		2
reviews at all levels, involve user	1		2
formalized change control	3		3
incremental development	2	2	
control, visibility		1	2
<u>Resources</u>		1	3
ability, attitude of the developers	6	3	
ability of the project manager	4		
top management support	2	3	1
<u>Organization</u>			
centralized development		2	1
single managership		2	2
<u>Technical Issues</u>			
size			2
difficulty			4

approach. The emphasis placed upon requirements definition at AFDSDC may be somewhat greater, in my opinion, than that given to that activity elsewhere because of the mission of the AFDSDC of supporting many diverse, geographically separated users. The use of a structured development approach has been receiving increased attention in the literature in recent years. The AFDSDC has developed and applied one such approach through the medium of AFDSDC Manual 300-8. Although some of the personnel contacted considered the manual as somewhat controversial, a number of the directorate chiefs and their deputies indicated that the concepts and procedures involved were critical to systems success. The manual was a point of pride among some of the interviewees who considered it revolutionary in terms of disciplining the development process.

Another point of interest concerning the interview results was the relative distribution of the factors between those important to success and those causal of failure. Although the classification scheme is somewhat arbitrary, it is interesting to note that user involvement and resources were associated primarily with successful efforts and the (lack of) requirements definition and a disciplined development approach with unsuccessful efforts. Additionally, the "technical issues" arose only in conjunction with less successful systems. This finding provides some indication that it may be useful in future efforts to take a two model (success and failure) approach to modeling MIS efforts. This is discussed more fully in the section on the "Predictive Modeling Efforts."

The interviewees in general felt that there were few significant differences between system development in the Air Force or at the AFDSDC and in the civilian community. The most frequently cited sources of difference between the Air Force and the civilian community were (followed by the number of personnel citing the reason):

1. Civilian project managers are less constrained, given greater flexibility. (4)

2. The Air Force must make resource decisions further in advance, making long range planning more important. (3)

3. The Air Force project manager has less control over personnel resources, in terms of both availability and quality. (2)

4. The Air Force is less concerned with cost than with mission effectiveness, as opposed to business organizations that attempt to quantify benefits in terms of more measurable profits. (2)

Similarly, the interviewees felt that the AFDSDC was not significantly different from the rest of the Air Force. No single reason was cited by more than one person.

Summary Data from the Survey

A total of 456 of the original 750 surveys were returned in a form suitable for inclusion in the data. This represents a 60.8% return rate with little followup and no second mailing. Of the total, 176, 146, 87, and 44 respectively were received from AFDSDC, AFLC, SAC and AFSC. Command could not be determined on three forms. The average respondent had at least 10 years experience in the computer systems career field, and 123 respondents indicated that they had more than 15 years experience. The average civilian grade was GS-12 and the average military respondent was somewhat above O-3. A total of 280 respondents were civilian and 166 military. A total of 79 respondents formally belonged to a specialty not designated as a full-time computer specialty. This gives some idea of the degree of "user" participation in the survey. The respondents were about evenly split between managers and technicians, although only 126 classified their jobs as involving primarily new (as opposed to existing) systems. The average respondent felt that their jobs brought them into contact with users at least "often" and had been involved in at least two MIS development efforts in the last ten years. A total of 126 indicated no experience with MIS development and therefore did not complete Part B, and completed Part C only for systems in general. The distribution of the responses to Part A and Part B questions is shown in Appendix C.

As discussed in the last chapter, the design of Part C of the survey is such that respondents who have not been involved in one or more MIS development efforts rate each of the factors in terms of how important that factor should ideally be treated for the successful development of MIS in general. Respondents who have been involved in specific efforts rate each factor in terms of how important the factor ideally should have been treated for a specific effort, and how important they feel it actually was treated. The means and ranks of the top 30 variables on the ideal plane are shown in Table VI. The possible range for each variable is from 5.0 or "Critically Important" to 1.0, "Not Important or Not Applicable" (zero was reserved for missing data not included in the calculations). The left column shows the means and ranks for the total sample, the middle the ratings by experienced respondents, and the right the ratings by inexperienced respondents.

As is apparent, the ratings are fairly close between the two groups. Using the t-test of significance for differences between means, only 10 of the entire 40 variables and 7 of the 30 shown in Table VI vary significantly at the .05 level. These are (question number shown in parentheses):

User Experience with Computers (26)
Use of Automated Development Tools (27)

Table VI
Mean and Rank of Top 30 Part C Variables, Ideal Ratings, for Total Sample, MIS Experienced and Inexperienced Respondents

Variable Name (Nr)*	Total Sample Mean	Total Sample Rank	Experienced Mean	Experienced Rank	Inexperienced Mean	Inexperienced Rank
**Determination of User Objectives (25)	4.39	1	4.37	1	4.44	1
**Definition of System Objectives (38)	4.29	2	4.26	3	4.37	2
**Information Needs of Users (57)	4.29	3	4.26	2	4.34	3
Control of Changes (56)	4.10	4	4.07	7	4.17	4
Detail of Development Plan (20)	4.09	5	4.07	8	4.14	5
**Expertise, Creative Abilities of Designers (21)	4.07	6	4.11	4	3.99	10
Impact of System on Users (36)	4.07	7	4.09	6	4.02	8
Thorough Preliminary Design (41)	4.05	8	4.11	5	3.90	16
Comprehensive, Current Documentation (32)	4.03	9	4.01	12	4.10	6
Comprehensive Test Plan with Data (24)	4.03	10	4.04	10	3.98	11
Commitment, Support by Users (58)	4.01	11	4.05	9	3.90	*** 17
User Involvement in Reviews (31)	4.01	12	3.98	14	4.07	7
Staffing of Design Team (34)	4.00	13	4.00	13	4.00	9
Simplicity, Logic of Overall Design (54)	3.96	14	3.97	15	3.91	17
**Designer Attitude Toward Users (28)	3.95	15	4.02	11	3.78	23
System Performance Criteria (59)	3.95	16	3.95	16	3.94	12
**Top Management Support, Involvement (33)	3.94	*** 17	3.96	17	4.87	20
Authority of Project Manager (43)	3.94	*** 18	3.94	***18	3.94	13
Experience, Education of Project Manager (46)	3.92	19	3.94	***19	3.90	*** 18
Stability of System Requirements (51)	3.89	20	3.91	21	3.85	21
Use of a Disciplined Development Approach (29)	3.85	21	3.92	20	3.70	24
Periodic Reviews of the Project (22)	3.84	22	3.82	23	3.90	*** 19
Controllable Work Assignments (45)	3.83	23	3.84	22	3.79	22
**User Attitude Toward Designers (49)	3.72	24	3.79	24	3.54	27
Communication Ability of Designers (48)	3.71	25	3.75	25	3.59	26

Table VI (continued)
Mean and Rank of Top 30 Part C Variables, Ideal Ratings, for Total Sample, MIS Experienced and Inexperienced Respondents

Variable Name (Nr)*	Total Sample Mean	Total Sample Rank	Experienced Mean	Experienced Rank	Inexperienced Mean	Inexperienced Rank
Criteria for Continuing the Project (50)	3.70	26	3.61	30	3.91	15
**User Involvement in Design (47)	3.67	27	3.75	26	3.48	29
Education, Retraining of Users (37)	3.63	28	3.64	28	3.63	25
**Scheduled Time for Project (40)	3.62	29	3.69	27	3.46	30
Strength of Project Organization (35)	3.59	30	3.62	29	3.51	28

*Number in parentheses beside each factor name indicates question number.
**Variable common to the CSU study.
***Tied Ranks.

Designer Attitude Toward Users (28)
Use of a Disciplined Development Approach (29)
Scheduled Time for the Project (40)
Thorough Preliminary Design (41)
User Involvement in Design (47)
User Attitude Toward Designers (49)
Criteria for Continuing the Project (50)
Contractor Responsiveness (52)

The inexperienced respondents rated 26, 27, 28, 50 and 52 higher and the remainder lower. Variable 52, Contractor Responsiveness, cannot be appropriately compared since only about half of the experienced respondents rated systems in which contractors were involved. Using the Spearman Rank Order Correlation as a summary comparison of the inexperienced and experienced groups (across all 40 variables), a correlation of .8584 was found, which is significant at the .001 level. Thus the hypothesis that it makes no difference which way the entire set of variables (as a group) is measured on the ideal plane is acceptable. This is somewhat more significant given the relative compression of most of the variables on the rating scale. The minimum rating of the 30 variables shown (for the total sample) is 3.59, or more than half way between "important" and "very important." Only three (30, 26 and 27) of the variables were rated less than 3.0 for the total sample, and four (same three with 52) for the experienced group.

Those variables common to both this effort and the CSU study are indicated by asterisks next to the factor name in Table VI. As can be seen, the CSU researchers independently identified the three most important variables which emerged from the results of this survey; and the top four which emerged from the experienced respondents. The remainder of the CSU variables are scattered throughout the remaining ranked variables used in this study.

The Spearman Rank Order Correlation was used to compare the results of the two studies over the 11 common variables, as discussed in Chapter II. The results of this procedure are shown in Table VII for the total sample, experienced and inexperienced respondents. As can be seen, none of the correlations are significant at the .05 level, and the correlation worsens when only the eight "most common" are examined. Other groups were examined for closer correlations. One of these, the ideal ratings for systems that were single (as opposed to multiple) installations, correlated significantly at the .048 level, which makes sense intuitively in that most of the CSU respondents were probably involved in single installation projects. However, given that the correlation is close to statistical significance and that only 11 variables are involved, the search for closer correlations is a dubious procedure. For example, while examining the hypothesis that accounting systems would correlate more closely, this researcher instead found that the opposite was true and that command and control systems correlated at the .028 level. In summary, it cannot be concluded that the two populations are the same or that the method of measurement does not matter.

However the correlations are relatively close to significance, so that it probably can be concluded that there are strong similarities. Examining Table VII, the primary areas of difference concern (question numbers in parentheses) User Objectives (25), Attitudes (28,49) and Justification of Cost (55). The Objectives of the User Organization were rated first of the Part C variables by nearly all groups analyzed by this researcher. This corresponds nicely with my hypothesis stated in Chapter I that the process of setting objectives is more difficult in the Air Force than in civilian organizations. One counter explanation might be

Table VII
Comparison with the CSU Study

Variable Name(Nr)	CSU Rank	Rank by Total	Rank by Exper	Rank by Inexper
System Objs (38)	1	2	3	2
Info Needs (57)	2	3	2	3
*Top Mgt Supp (33)	3	6	6	5
Comm Ability (48)	4	8	8	1
Design Expert (21)	**5	4	4	4
User Objs (25)	**6	1	1	1
Justif of Cost (55)	7	11	11	9
*Users Design (47)	8	9	9	10
*Project Time (40)	9	10	10	11
Designer Att (28)	10	5	5	6
User Attitude (49)	11	7	7	8
Spearman correlation for 11 vars:		.506	.515	.465
Significance:		.057	.053	.075
Spearman corr for 8 most common:		.491	.467	.431
Significance:		.109	.122	.144

*Three factors excluded in the analysis of the 8 most common variables.
**Tied ranks.

that the respondents associated or confused System Objectives (38) with User Objectives (25). Were this the case, it would be expected that the two variables would load on the same factor during factor analysis. However that was the case in only one of three primary factor analyses, as is discussed in that section. The fact that Justification of Cost (55) was rated as less important in these results than in the CSU results corresponds with the views of some interviewees discussed earlier. It may well be that the emphasis on mission effectiveness and the relatively unquantifiable nature of the benefits of that goal override the Justification of Cost in the Air Force. One explanation for the greater emphasis placed upon Designer and User Attitudes by the Air Force respondents might be that the greater physical separation between developer and user organizations in the Air Force requires greater use of informal rather than formal authority. That is, since it would usually be necessary to appeal to a very high organizational level in most Air Force developments to find an individual with authority over both users and developers, the emphasis is placed upon avoiding being forced to make such an appeal. The developers prefer to rely on informal authority and good relationships.

Analysis of System Attributes

One of the objectives of this study was to determine if and how the important factors vary across a number of system attributes. These attributes were measured by the questions in Part B of the survey. Three of the most important attributes in that part concerned the Success (8), Size (9) and Technical Difficulty (13) of the project. The responses to each of these questions were approximately normally distributed, although there were relatively too many "very large" and "unsuccessful" systems for a normal distribution. The mean rating for Success (9) was "successful" (3.96), for Size "fairly large" (3.91) and for Technical Difficulty "difficult" (2.77). As might be expected, there was a negative correlation between both Size and Technical Difficulty and System Success. This is discussed in the section on the "Predictive Modeling Efforts."

One advantage to the design of Part C of the survey is that it permits analysis of each of the variables from three perspectives: how important the variable was treated (Actual), how important it should have been treated (Ideal), and the difference between the two (Delta).

Each of these perspectives was taken while analyzing the variables across the range of System Success. As would be expected, few of the Ideal ratings vary significantly with Success. It was interesting to note however that three variables, Use of a Prototype, Integration of Systems and Contractor Responsiveness (questions 30, 44 and 52) were significantly more important for unsuccessful systems than for those systems on the remainder of the range of Success. This is a possible indication that these variables might be causes of failure when not applied where needed.

A total of 29 of the variables for the Actual ratings and 19 of the Delta ratings vary significantly with System Success. These were used as variables in the regression models discussed in the last section of this chapter. Of the variables that vary significantly, all of the Deltas and all but one of the Actuals correlate positively. That is, as System Success increases, the Actual ratings increase and the Delta ratings become more positive (Deltas are Actual ratings less Ideal ratings). The question with the negative correlation was 52, Contractor Responsiveness. This was due, in my opinion, to the confounding effects Size, Difficulty and Contractual Involvement (question 14) and not from a fundamentally negative relationship. This is discussed more fully later in this section.

The Ideal variables which vary significantly with Size and Technical Difficulty are shown in Table VIII. That table includes only those variables which also display some organized pattern across the range of the two variables, be that pattern linear, curvilinear or two-tiered as indicated in the notes at the bottom of the table. Of the variables

Table VIII
Ideal Variables Varying Significantly with System Size or Technical Difficulty

Variable Name (Nr)	System Size High Mean	System Size Low Mean		System Size Sig*	Technical Difficulty High Mean	Technical Difficulty Low Mean		Technical Difficulty Sig*
Design Expert (21)	4.25	3.78		.024	4.28	3.90		.024
Reviews (22)	4.10	3.40		.000	4.19	3.47		.015
Modularization (23)	3.70	3.33		.005	3.61	2.86	***	.031
Automated Tools (27)	2.69	2.24		.000	2.78	2.20	***	.003
Prototype (30)	3.52	2.90		.000	3.50	2.62		.007
Top Mgt Supp (33)	4.25	3.96	**	.000	4.37	3.50		.000
Design Staff (34)	4.12	4.00	**	.002				N.S.
Str Proj Org (35)	3.78	3.15	***	.018	4.00	3.21		.024
Ed, Tng Users (37)	3.83	3.48		.010	3.97	3.20		.008
Career Mgt Des (39)	3.76	2.64		.000	3.66	2.80		.000
Project Time (40)	3.87	3.09		.003				N.S.
Proj Mgr Auth (43)	4.28	2.41		.000				N.S.
Integration (44)	3.96	3.13		.000	4.09	2.55		.000
Proj Mgr Ed, Exp (46)	4.31	3.04		.000	4.31	3.63		.003
Proj Criteria (50)	3.93	3.52	**	.047	4.22	3.03		.005
Stab Reqmts (51)	4.04	3.65	***	.002				N.S.
Abil to Track (53)	3.72	3.23		.000				N.S.
Justif of Cost (55)	3.85	3.30		.001	4.06	3.41		.018
Change Control (56)	4.16	3.72		.009				N.S.

*N.S. indicates not significant.
**Non-linear, middle values rated lowest.
***Varies only at the low or high end of the scale.

shown, only four (21, 39, 43, and 46) display a strongly linear trend when viewed across system Size and only two (30 and 33) across the range of Technical Difficulty. The high and low means are the mean of the dependent variables for the high and low values of the independent variable (Size or Difficulty). Interestingly, a combined Size Plus Difficulty variable (recoded from the maximum possible 11 categories to only 6 categories) did a better job of discriminating for 10 of the variables (23, 27, 30, 33, 35, 37, 44, 50, 52, and 55) and a Size Times Difficulty variable (similarly recoded) a better job of discriminating groups for Designer Expertise (21).

A number of the ideal variables vary significantly across the range of Contractor Involvement (question 14) with the clearest difference occurring between answers B and C ("Contractor provided hardware only" and "Air Force and contractor each developed portions of the operating system(s) . . ."). The ideal ratings were reexamined using question 14 to split the sample into two groups called "Weakly Contracted" (consisting of responses A and B) and "Strongly Contracted" (responses C through F). The t-test of significance for differences between means was applied and the 16 variables varying significantly are shown in Table IX.

Table IX
Ideal Variables Varying Significantly Between
Weakly and Strongly Contracted Efforts

Variable Name (Nr)	Mean for Strongly Contracted	Mean for Weakly Contracted	Sig
Development Plan (20)	4.21	3.96	.011
Reviews (22)	3.99	3.69	.004
Modularization (23)	3.63	3.37	.047
Automated Tools (27)	2.39	2.12	.035
Designer Att (28)	3.88	4.12	.013
Prototype (30)	3.20	2.65	.001
Top Mgt Supp (33)	4.12	3.84	.011
Ed, Tng Users (37)	3.82	3.50	.008
Career Mgt Des (39)	3.61	3.17	.001
Project Time (40)	3.82	3.57	.009
Integration (44)	3.63	3.23	.008
Contractor Resp (52)	3.61	2.17	.000
Abil to Track (53)	3.65	3.23	.000
Justif of Cost (55)	3.63	3.38	.040
Syst Perf Critr (59)	4.06	3.86	.037
Development Approach (29)	4.06	3.79	.015

One difficulty with distinguishing between strongly and weakly contracted efforts is the degree of association between contracts and Size, Technical Difficulty and Success. The strongly contracted efforts were somewhat less than "successful" (4.27) while the weakly contracted were halfway between "successful" and "mostly successful" (3.45). Additionally, the strongly contracted systems were close to "large" (4.67) while the weakly contracted were closer to "medium" (3.33). Finally, the strongly contracted were more than "difficult" (3.25) while the weakly contracted were more than "somewhat difficult" (2.39). Given these associations it is difficult to say to what extent the variables in Table IX vary due solely to Contractor Involvement. However, the table does present the relative importance of Contractor Responsiveness (52), given that the project strongly involved a contractor. Given that Contractor Responsiveness is much more important for strongly contracted efforts, and that contracted efforts are generally less successful (due at least in part to size and technical difficulty), the slight negative correlation between Contractor Responsiveness and Success for the total sample is not surprising. Given that the system is contracted to some degree, Contractor Responsiveness has a slight positive correlation (zero order is .02).

The explanatory power of the remainder of the Part B variables is somewhat less than those discussed thus far. Concerning the Nature of the Development as measured in question 10, it was found that single installations of software and hardware were most successful (3.34) and multiple installations of hardware and software least successful (4.67). Size, Difficulty and Degree of Contractor Involvement all increased almost linearly across the four responses with Size varying from 2.6 to 4.8, Difficulty from 2.15 to 3.27 and Contractor Involvement from 1.56 to 2.78. Only two of the Ideal ratings varied significantly in light of this covariance. Test Time (42) varied from a low of 3.3 for single installations of software to 3.78 for single installations of software and hardware. Information Needs (57) were by far most important for single installations of software (4.52).

Analysis of question 11, Nature of the User Organization(s) found that projects involving only a single user organization were most successful (3.0), smallest (1.73) and easiest (2.37). Given this relationship, a number of variables were significantly less important to the single user type project, however all were easily explained by the covariance of Success, Size and Difficulty. None of the factors varied significantly across the other responses.

Little analysis was performed of question 12, System Use, since the vast majority (194) of the responses indicated accounting type applications. It was found however that command and control systems were more Difficult and required greater User Experience with Computers.

It was necessary to group some responses to question 15, Maintenance, since there were so few responses indicating answers C through F (a total of 36). These could be logically grouped as those cases in which a different organization than the developers or a contractor performed system maintenance. Given this still small cell count, System Success was least for that group, or 4.75 versus 3.96 and 3.58 for the other responses. Contractor Involvement was also highest (3.33) for that group. None of the factor ratings varied significantly, other than to the extent that would be expected from the variance in Contractor Involvement and Success.

It was found that Success, Size, Difficulty and Contractor Involvement all varied quite significantly with the Use of Long-Term Maintenance Warranties (question 16), with the 67 systems that used such warranties the largest, most difficult, most contracted and least successful. Given the variance with Size, Difficulty and Contractor Involvement, it cannot be concluded that long-term warranties make projects less successful. On the other hand, this study found no evidence to indicate that such warranties make systems more successful.

Analysis of question 17, Project Organization, discovered a number of interesting relationships. Generally it was found that projects with no formal organization were smallest (2.9) and those organized into two or more independent teams under no single manager (response E, with only 23 responses) were largest (5.18), followed by two or more teams under a single manager (4.61). Technical Difficulty followed a similar pattern. Success was greatest for those efforts in which there was a project manager and loaned resources (3.58), followed by those with a formal project organization (3.90), two or more teams under a single manager (4.01) and those with no formal project organization (4.10), and finally those with two or more independent teams under no single manager (5.13). Since the efforts using a project organization were significantly larger (4.25) than those using a project manager with loaned resources (3.25) or those with no formal organization (2.90), it can be concluded that the use of a formal project organization contributes materially to project success (given the negative relationship between Size and Success).

Similarly, the projects with no formal organization were less successful than the small size would tend to predict, and in general a case can be made for single project leadership.

Another point of interest concerning this question is that both Project Time and Test Time (questions 40, 42) were observed to follow a curvilinear pattern across the various organizations, being rated most important for those projects with a formal project organization (3.87 and 3.78) and least important for the projects at either end of the scale. One explanation for this might be that the tighter control associated with a formal project organization allows greater emphasis to be placed upon schedule. The variance of the other Part C variables was well explained by the variance in Size and Technical Difficulty.

Questions 18 and 19, Years Since the System was Completed and whether the System is Still in Use, provided little explanatory power other than the somewhat obvious observation that systems not still in use were less successful (since this group included the total failures).

Factor Analysis

A number of different directions were taken in the course of performing the factor analyses, the most important of which were the analysis of the Actual ratings of the Part C variables for all systems, and subsequently for strongly contracted and for weakly contracted systems (where partitioning was based on the same criteria as was used in the preceding section). The Actual ratings were used rather than the Ideal ratings because of the intent to use the factors as independent variables in the models for predicting System Success. Principal component factoring with iterations and orthogonal rotation using the varimax criterion was used for all analyses. The factors were orthogonally rotated in order to derive maximally independent, interpretable factors. The varimax criterion was used to derive the simplest factors by causing the factors to load on as few variables as possible (Ref 41: 468-485).

Factor analysis was first run with all 40 variables. The general procedure was then to delete any variable not loading .30 or greater on one or more of the significant (eigenvalue greater than 1.0) rotated factors and rerun the analysis. This iterative procedure was followed until only variables loading .30 or better on the significant factors were included. The variables then not included in any of the factors were run separately (from the variables already used) to determine if any further interpretable factors could be derived. The final results are shown in Table X.

The initial analysis for all systems yielded a total of four significant factors. The fourth loaded on the four lowest ranked variables, and those variables were therefore discarded from the analysis. The first factor consisted primarily os User Involvement in reviews (31), Identification of Information Needs (57), Determination of the Objectives of the User Organization (25) and User Involvement in Design (47). This factor was highly significant (eigenvalue 9.61 and explained 51.4% of variance in the sample) and makes sense from the literature. The other two factors were tentatively called "Control" and "Capabilities of the Project Organization." The final factor loadings, eigenvalues and per cent of variance explained are shown in Table X. The previously excluded variables were then included in a separate analysis. This ultimately

Table X
Summary of Results of Factor Analysis on Actual Ratings

Variable Name (Nr)	Factor Loadings (Greater than .30								
	User Involv			Capabilities			Plan, Control		
	All	Strong Contr	Weak Contr	All	Strong Contr	Weak Contr	All	Strong Contr	Weak Contr
User Objs (25)	.69	.59	.75						
Users Review (31)	.58		.59						
System Impact (36)	.51	.59	.51						
Users Design (47)	.64	.61	.55						
Info Needs (57)	.72	.65	.79						
User Support (58)		.66	.43				.54		
Designer Att (28)	.53	.59		.39	.47				
Comm Ability (48)	.38	.43		.50	.45	.46			
User Attitude (49)	.53	.55		.31					
Designer Expert(21)				.54	.60	.48			
Design Staff (34)				.39	.85	.72			
Str Proj Org (35)				.59	.46	.62			
Proj Mgr Exper (46)				.59	.57	.71			
Career Mgt Des (39)				.49		.50			
Proj Mgr Auth (43)						.51			
System Objs (38)		.57			.42		.57		
Prelim Design (41)		.33			.43		.64	.41	
Simp,Log Des (54)					.37		.57	.43	
Syst Perf Crit(59)			.48				.61		.58
Dev'pt Plan (20)		.39					.61	.47	.64
Documentation (32)							.53		
Reviews (22)									.54
Test Plan (24)									.53
Proj Criteria (50)							.43		
Abil to Track (53)								.59	.45
Stab Reqmts (51)							.50	.59	
Change Control (56)							.62	.54	.67
Justif of Cost (55)								.62	
Initial:									
Eigenvalue	9.6	11.0	8.9	1.2	1.1	1.8	2.0	1.7	1.1
Per Cent Var	.51	.51	.43	.07	.05	.09	.11	.08	.05
*Final:									
Eigenvalue	4.4	6.8	4.3	1.1	1.3	1.4	3.2	1.2	2.0
Per Cent Var	.80	.69	.70	.20	.13	.23	1.0	.12	1.0
(Relevant Vars Only)									
*See Text									

resulted in a single factor, "Planning and Control." The use of a second analysis explains why the final per cent of variance explained by Planning and Control is 100%. It was the only factor in that analysis.

The analysis for strongly contracted systems yielded similar results. The first run on this analysis disclosed a total of seven significant factors. The first was again highly significant with an eigenvalue of 11 and explained 51% of the variance in this sub-sample. There was again a User Involvement factor consisting primarily of Information Needs (57), User Support and Commitment (58), Impact of the System on Users (36) and System Objectives (38). This was the only factor in which User and System Objectives both appeared, which tends to discount the argument mentioned earlier that the two may have been erroneously associated by the respondents. Two of the other initial factors re-emerged: "Planning and Control" and "Capabilities of the Project Organization." The remaining factors were generally uninterpretable. The procedure of eliminating variables was followed until the final three factors shown emerged. No second analysis was required in this case, and further analysis yielded uninterpretable results.

The analysis of weakly contracted systems was similar. The initial User Involvement factor (eigenvalue 8.90 and explained 43.4% of the variance) consisted primarily of User Objectives (25), User Involvement in Reviews (31) and Information Needs (57). For reasons unexplainable by this researcher, the Attitude (28, 49) and Communication (48) variables did not enter or load on this User Involvement factor. It may be that attitude is a separate dimension for weakly contracted efforts, but such a factor failed to emerge. The final factors were User Involvement and Capabilities of the Project Organization. An analysis of the remaining variables disclosed the Planning and Control factor shown. This particular analysis demonstrated the sensitivity of factor analysis (given a relatively small number of cases, 147) to the variables included in the analysis. It was found that when the System Performance Criteria variable was inadvertantly dropped from the variable set that the User Involvement factor dropped to second after Capabilities. Whichever variable set was used, the first factor tended to be quite significant. Given that User Involvement had been by far the most significant factor until that point, I elected to retain the System Performance Criteria even though it had been subsequently included in the Planning and Control factor.

Thus the factors which evolved were consistent across the three analyses. It is interesting to note the comparison between these three factors and the four found by the CSU researchers. The four factors found in that study were Planning and Control, Attitude, Expertise and Involvement (Ref 17:14). No indication was found of an Attitude factor in this study. This may be due in part to the fact that fewer attitude variables were included in the survey. Two variables used in the CSU study, Management and Employee Resistance to Change, were rated 12 and 13 (out of 14) on that study and therefore not included in this survey (Ref 17:10). The naming of the Expertise factor in the CSU study was probably again, in my opinion, the result of the variables included in the survey. The Capabilities factor in this study involves the same variables, plus a number of others relating to the total human resources of the project organization. This is particularly the case if attitudes such as good will are considered an asset. The fourth factor, User Involvement, was the same although it apparently emerged much more strongly in the data from this survey. As stated by the CSU researchers, "In the early phases of this study, interviews with the Colorado business community had established 'user involvement' as a very critical factor" (Ref 17:15). This study has found that, at least from the factor analytic standpoint, User Involvement is by far the most critical factor.

Other factor analyses performed included an analysis of the Ideal ratings by both (separately) experienced and inexperienced respondents, the Delta variables and the Actual ratings for more successful projects. Of these attempts, only the analysis of the Ideal ratings by the experienced respondents yielded interpretable results. That analysis found two factors in separate increments of the variables interpreted as User Involvement and Planning and Control. The User Involvement factor emerged first and consisted primarily of User Support (58), User Attitude (49), Information Needs (57), User Involvement in Reviews (31), User Objectives (25) and Designer Attitude (28). The Planning and Control factor consisted primarily of Periodic Reviews (22), Documentation (32), Development Plan (20), Preliminary Design (41) and Work Assignment (45).

Predictive Modeling Efforts

As discussed in the last chapter, the Automatic Interaction Detection (AID) algorithm was used both to indicate trends in the data and to point out any unproductive paths planned a priori in the regression modeling efforts. At one point, the AID models appeared to be indicating that less experienced personnel, both in terms of years and number of MIS efforts, held different opinions than more experienced personnel. This split occurred at the third or later levels, however, and given the small sample size (for AID) was probably indicative only of idiosyncracies in some fairly small subset of the data. Modeling efforts without the less experienced personnel failed to yield more consistent models. Similarly the exclusion of responses relating to the ALS (discussed further later) made little change in the model. The use of the AID algorithm was generally unproductive for other purposes. The sample size was too small to allow this analyst to draw any conclusions after the third level, and the relationship between the independent variables and the criterion (success) were consistent with theory to that point.

Multiple regression, both with and without dummy variables, was used for the remainder of the modeling effort. Stepwise regression with the algorithm selecting on each iteration the variable with the greatest contribution toward total explained variance in the criterion (Success), was used for all models. Listwise deletion of cases with missing data was used for all models. If a respondent failed to answer any of the questions used as variables in the model, that entire set of responses was ignored for that model. Because it seemed desirable to determine if different variables became important for predicting success for different levels of success, each model was run for at least three ranges of success. The numerical assignment for responses to success used in regression is reversed from that used in the analyses presented earlier. Highly successful systems were assigned a value of 7.0 and unsuccessful systems a value of 1.0. All models were run for the full range of Success. The models for the total sample (called all systems) and strongly contracted efforts were then run for Success better than "unsuccessful" (Response G) and for Success better than "somewhat unsuccessful" (F). Since only three weakly contracted efforts were rated "unsuccessful," those models were run for Success better than "somewhat unsuccessful" (F) and for Success better than "mostly successful" (E).

Most of the models for all systems and for strongly contracted systems were also checked with and without responses identified as probable ALS responses, on the theory that the ALS may have been such a unique and strong experience that it would bias the models. The criteria used for identifying the ALS responses was any questionnaire indicating AFLC as command, an unsuccessful system, a very large system, and Technical Difficulty as either very difficult or extremely difficult. Nineteen responses fell into this category for the total sample, and after listwise deletion, 12 ALS responses were identified in the models for all systems, and 11 in the contracted systems models.

Models were created using the Actual ratings, Delta ratings, and selected Part B variables as well as factors. In cases where both the Actual and Delta ratings for a variable appeared as potential variables in a regression, only the stronger predictor was retained in the final models. Where factor analysis factors were used as variables, neither their component Actual variables nor the associated Deltas were used. Further, other variables which seemed related to the factors were not used in those cases where there was a strong correlation. Factors were calculated for each case from the formula

$$\text{Factor 1} = FS1(X1-\bar{X}1)/SD1 + FS2(X2-\bar{X}2)/SD2 + \ldots FSn(Xn-\bar{X}n)/SDn \quad (1)$$

where FS1 to FSn are the factor score coefficients for each component variable of the factor, X1 to Xn the values of the variables for the case, and $\bar{X}1$ to $\bar{X}n$ and SD1 to SDn the mean and standard deviation for the variables. For ease of presentation, the factors in this section are shown simply as Factors 1,2, and 3, where Factor 1 refers always to User Involvement, 2 to Capabilities, and 3 to Planning and Control. In all cases the factors were calculated based upon the factor analysis performed for the same sample being used in the model. That is, the Factor 1 used in the regression for strongly contracted efforts is the Factor 1 which emerged in the factor analysis of that sub-sample.

Selected Part B questions were included in the regression models as either continuous or dummy variables. Size and Technical Difficulty (questions 9 and 13) were used as continuous variables, as were two combined measures, Size Plus Difficulty and Size Times Difficulty. Part B questions 10, 14, 15, and 17, Nature of the Development, Contractor Involvement, Maintenance and Project Organization were used as dummy variables. The notation used in this section is:

	Question Nr	Response(s)
Development 2	10	B
Development 3	10	C
Development 4	10	D
Contractor 2	14	B
Contractor 3	14	C
Contractor 4	14	D,E,F
Maintenance 2	15	B
Maintenance 3	15	C,D,E,F,G
Organization 1	17	A
Organization 2	17	B
Organization 4	17	D
Organization 5	17	E

In each case, as is required for the computation of the regression model, one response is omitted such that all correlations are relative to the response(s) not included in the model. These reference responses were the development of software only for a single installation for the Development variables, maintenance by the same Air Force personnel who developed the system for the Maintenance variables, no contractor involved for the Contractor variables, and a formal project organization for the Organization variables. Two of the variables use combined responses. Contractor 4 represents the cases where a contractor provided at least part of the operating system and Maintenance 3 the cases where maintenance was performed by a contractor or an Air Force organization other than the developers.

The results of the modeling efforts are summarized in Table XI. The general criteria followed in determining the models presented was that each independent variable must contribute at least 1.3% to total explained variance (R^2) and that each variable must be significant at the .05 level or better. These criteria were extended in the cases where dummy variables were included in the regression to allow a lesser contribution to explained variance and significance somewhat less than .05 (the lowest significance actually used was .082). In all cases, the adjusted R^2 was checked for an increase with the addition of each independent variable. All significances shown in the tables are for the contribution of the variable, given that all of the other variables are in the equation. As can be seen from the table, the best models were found for strongly contracted efforts, and the models for weakly contracted efforts were the least successful. Additionally, the use of factors in lieu of raw variables improved the model in only one case (Factor 1 and variables, over variables only in the regression for all systems).

Table XI
Summary of Regression Analyses

	Per Cent Variance Explained (R^2)			
All Systems:	For All Success	Without ALS	Better than Unsuccess	Better than Somewhat Unsuccess
Variables only	.33	.25	.25	.18
Vars, Dummy Vars	.43	.37	.30	.25
3 Factors only	.19(4)		.20(4)	.14(2)
3 Fac, Vars, Dummy Vars	.39(2)	.33(2)	.24(2)	.19(2)
3 Fac, Vars	.31(1)	.23(2)	.17(2)	.12(2)
Factor 1, Vars, Dummy Vars	.43	.35	.26	.21
Factor 1, Vars	.35	.24	.21	.14
Approx Samp Size	264	252	230	210

Contracted:	For All Success	Without ALS	Better than Unsuccess	Better than Somewhat Unsuccess
Variables only	.42	.37	.25	.14
Vars, Dummy Vars	.52	.43	.37	.37
3 Factors only	.13(4)		.17(2)	.11(2)
3 Fac, Vars, Dummy Vars	.41(4)		.25(2)	.29(2)
3 Fac, Vars	.34(4)		.15(2)	.11(2)
Facs 1,3, Vars, Dummy Vars	.44(1)	.32	.24(1)	.26(1)
Facs 1,3, Vars	.35	.22	.17(1)	.11(1)
Approx Samp Size	118	107	91	78

Noncontracted:	For All Success	Better than Somewhat Unsuccess	Better than Mostly Success
Variables only	.24	.22	.20
Vars, Dummy Vars	.28	(3)	(3)
3 Factors only	.15(2)	.15(2)	.13(1)
3 Facs, Vars	.19	.20	.30(2)
3 Facs, Vars, Dummy Vars	.25(2)	.20	(3)
Fac 1, Vars	.19	.23	.30
Fac 1, Vars, Dummy Vars	.25	.26	(3)
Approx Sample Size	143	129	116

Notes: (1) Factor 3 did not enter; (2) Factors 2,3, did not enter; (3) No dummy vars entered; (4) Factor 2 did not enter.

Selected regression models for all systems are presented in Table XII. From this table, it is apparent that Size and Difficulty are very important in predicting unsuccessful efforts, but not nearly as important once the unsuccessful efforts are excluded. The reasons for the small magnitude correlation coefficient for Size Times Difficulty is that the maximum value was 30. Conversely, the coefficients for the dummy variables are large in magnitude because the maximum value is 1.0. The more appropriate measure of contribution is the Beta Weight. Test Time (42) and the Delta for Stability of Requirements (51) are also important predictors of unsuccessful efforts. As only more successful efforts are included, Designer Attitude (28) becomes relatively more important than User Objectives (25). The other variable which seems to increase in relative importance with success is Preliminary Design (41). When Factor 1 is used in lieu of raw variables, it enters second in place of User Objectives and Designer Attitude, two of the main components of the factor. The main effect of removing the ALS from consideration seems to be to decrease the importance of Size and Difficulty in predicting failure. The particular model shown also demonstrates the effect of excluding the combined Size and Difficulty variables. As is shown, Size continues to enter with a negative coefficient, although it would enter sooner with greater significance if the ALS were not excluded. In those models in which the ALS was excluded and the combined Size and Difficulty were variables included, the Size Plus Difficulty variable normally entered second and added about .05 to explained variance (R^2). When all three factors are regressed without any other variables, the result is:

	Regr Coef	Sig	R^2
Factor 1	.51	.000	.17
Factor 3	.28	.064	.19
Factor 2	.17	.186	.20

Table XII
Selected Regression Models for All Systems

Variable Name (Nr)	Regr Coef	Beta Wt	Sig	R^2	Change R^2
All Success, Vars, Dummy Vars:					
Size X Difficulty	-.04	-.21	.000	.16	.155
User Objs (25)	.31	.20	.000	.25	.096
Development 2	1.01	.28	.000	.30	.054
Designer Att (28)	.24	.16	.005	.34	.038
Delta Proj Criteria (50)	.20	.16	.002	.37	.028
Maintenance 3	-.75	-.13	.008	.39	.020
Test Time (42)	.20	.12	.013	.41	.015
Maintenance 2	.40	.10	.043	.42	.011
Development 3	.52	.10	.047	.43	.009
Constant	1.79				
Better than Unsuccess, Vars, Dummy Vars:					
User Objs (25)	.29	.24	.000	.15	.149
Designer Att (28)	.22	.18	.005	.20	.053
Development 2	.59	.21	.000	.25	.043
Delta Proj Criteria (50)	.17	.16	.005	.27	.026
Maintenance 3	-.67	-.14	.015	.29	.021
System Impact (36)	.16	.12	.047	.30	.012
Constant	2.10				
All Success, Variables Only:					
Size X Difficulty	-.06	-.27	.000	.15	.153
Designer Att (28)	.27	.18	.003	.25	.094
Delta Stability Reqmts (51)	.18	.12	.026	.28	.036
User Objs (25)	.25	.16	.009	.30	.020
Test Time (42)	.19	.12	.030	.32	.016
Delta Proj Criteria (50)	.16	.12	.030	.33	.013
Constant	2.70				
All Success, Factor 1, Vars, Dummy Vars:					
Size X Difficulty	-.05	-.26	.000	.16	.161
Factor 1	.66	.35	.000	.28	.120
Development 2	.99	.28	.000	.34	.055
Delta Proj Criteria (50)	.24	.19	.002	.36	.022
Maintenance 3	-.83	-.15	.003	.38	.022
Test Time (42)	.23	.14	.006	.39	.014
Development 3	.61	.12	.020	.41	.013
Average Delta	-.62	-.20	.008	.42	.008
Delta Stability Reqmts (51)	.20	.14	.016	.43	.013
Constant	3.66				

Table XII (continued)
Selected Regression Models for All Systems

*All Success, Factor 1, Variables: Variable Name (Nr)	Regr Coef	Beta Wt	Sig	R^2	Change R^2
Size X Difficulty	-.07	-.33	.000	.16	.161
Factor 1	.62	.33	.000	.28	.121
Delta Proj Criteria (50)	.23	.18	.004	.30	.018
Test Time (42)	.21	.13	.018	.31	.015
Proj Mgr Ed, Exper (46)	.19	.12	.027	.32	.010
Average Delta	-.71	-.23	.005	.33	.010
Delta Stability Reqmts (51)	.23	.16	.007	.35	.019
Constant	3.59				
All Success, Variables, Dummy Variables, Without ALS:					
Designer Att (28)	.27	.18	.002	.12	.120
Development 2	.81	.24	.000	.20	.076
Delta Stability Reqmts (51)	.17	.12	.024	.24	.049
Contractor 4	-.48	-.10	.069	.28	.032
Maintenance 2	.45	.12	.026	.30	.024
Delta Proj Criteria (50)	.15	.12	.029	.32	.021
User Objs (25)	.22	.15	.014	.34	.015
Maintenance 3	-.65	-.12	.028	.35	.013
Test Time (42)	.21	.13	.012	.36	.014
Size (9)	-.13	-.12	.026	.37	.013
Constant	2.39				

*It was decided to extend this model beyond Test Time, in spite of the low contributions by Proj Mgr Ed, Exper and Average Delta because of the larger contribution by Delta Stability Reqmts.

As can be seen, of the three factors, only Factor 1, User Involvement, is an important predictor of System Success, although Factor 3 was significant at better than .05 prior to the entry of Factor 2. The effect of the dummy variables is discussed at the end of this section.

Selected regression models for strongly contracted efforts are shown in Table XIII. The same general observations made for the models of all systems apply equally well here. One of the main differences is that User Objectives (25) are considerably less important for predicting Success in strongly contracted efforts and the attitude "side" of User Involvement, as well as the Impact of the System on Users (36) are relatively more important. Test Time seems to be considerably more important in strongly contracted efforts. Two additional predictors of failure emerge in this set of models, the Experience and Education of the Project Manager (46) and Career Management of the Designers (39). The Delta for Project Criteria (50), although an important predictor for all systems, is considerably stronger for strongly contracted efforts. The "Average Delta" variable is a simple unweighted average of all of the Delta variables in a case. When it enters, it always has a negative coefficient, simply indicating that, on the average, the respondents tend to overestimate the magnitude of the Delta variables. The mean Average Delta was -.67. The results of regressing only the three factors were:

	Regr Coef	Sig	R^2
Factor 1	.31	.112	.10
Factor 2	.36	.057	.13
Factor 3	.08	.682	.13

Factors 1 and 2 were significant at .000 and .042 until Factor 3 entered the model. In general however User Involvement is least important as a predictor in strongly contracted efforts than for either the total sample or for weakly contracted efforts.

Selected models for weakly contracted efforts are shown in Table XIV. As indicated earlier, the modeling effort for weakly contracted systems

Table XIII
Selected Regression Models for Strongly Contracted Efforts

All Success, Vars, Dummy Vars: Variable Name (Nr)	Regr Coef	Beta Wt	Sig	R^2	Change R^2
Size X Difficulty	-.07	-.31	.000	.21	.208
Test Time (42)	.46	.27	.000	.31	.104
Delta Proj Criteria (50)	.27	.23	.002	.37	.058
Development 2	1.42	.32	.000	.44	.069
Delta System Impact (36)	.29	.17	.016	.47	.029
Contractor 4	-.51	-.13	.062	.49	.017
Proj Mgr Ed, Exper (46)	.22	.13	.060	.50	.016
Development 3	.54	.12	.082	.52	.013
Constant	2.62				
Better than Unsuccess, Vars, Dummy Vars:					
Delta Proj Criteria (50)	.23	.24	.015	.16	.158
Designer Att (28)	.31	.26	.007	.22	.060
Development 2	.75	.24	.008	.27	.057
Delta System Impact (36)	.23	.17	.067	.32	.044
Maintenance 3	-.67	-.18	.050	.34	.022
Delta Stability Reqmts (51)	.22	.18	.056	.37	.027
Constant	3.61				
All Success, Vars Only:					
Size X Difficulty	-.08	-.40	.000	.22	.220
Test Time (42)	.38	.22	.005	.32	.103
Delta Proj Criteria (50)	.22	.19	.019	.37	.051
Career Mgt Design (39)	.22	.16	.042	.40	.025
Delta System Impact (36)	.24	.15	.048	.42	.021
Constant	3.39				
All Success, Vars only, Without ALS:					
Test Time (42)	.57	.35	.000	.14	.140
Size + Difficulty	-.24	-.29	.001	.23	.085
Delta System Impact (36)	.40	.26	.007	.28	.059
Delta Stability Reqmts (51)	.25	.19	.037	.32	.034
Delta Proj Criteria (50)	.29	.25	.016	.33	.015
Average Delta	-.77	-.25	.042	.35	.016
Proj Mgr Ed, Exper (46)	.27	.16	.050	.37	.025
Constant	3.12				

Table XIII (continued)
Selected Regression Models for Strongly Contracted Efforts

*All Success, Factors 1,3, Vars, Dummy Vars: Variable Name (Nr)	Regr Coef	Beta Wt	Sig	R^2	Change R^2
Size X Difficulty	-.07	-.35	.000	.22	.225
Factor 1	.48	.28	.000	.31	.087
Development 4	-.55	-.16	.072	.37	.054
Career Mgt Design (39)	.25	.17	.020	.39	.027
Maintenance 3	-.74	-.16	.027	.42	.026
Development 2	.68	.15	.064	.44	.026
Constant	4.17				
Better than Unsuccess, Factor 1, Vars, Dummy Vars:					
Delta Project Criteria (50)	.29	.31	.004	.15	.146
Factor 1	.29	.22	.038	.20	.052
Development 2	.71	.23	.016	.25	.049
Organization 1	-.86	-.19	.041	.28	.032
Maintenance 3	-.68	-.17	.057	.31	.030
Constant	4.34				

*Factor 3 did not enter. The reason this model is presented rather than Factor 1 plus vars and dummy vars is that Factor 1 does not enter into the contracted all success levels model when the component variables of Factor 3 are included.

was least successful. One general observation is that the attitudinal variables seem to be of considerably greater importance for predicting Success in weakly contracted efforts than for either of the other groups. As mentioned in the section on the factor analysis, the attitude variables did not enter the User Involvement factor in the factor analysis for weakly contracted efforts. The zero order correlation between the User Involvement factor and Designer Attitude is .43 and .28 for the Delta for User Attitude (the stronger predictor when Factor 1 is used in the model). Although the first is a relatively high correlation, it is

Table XIV
Selected Regression Models for Weakly Contracted Efforts

All Success, Factor 1, Vars, Dummy Vars: Variable Name (Nr)	Regr Coef	Beta Wt	Sig	R^2	Change R^2
Factor 1	.43	.28	.001	.15	.155
Development 2	.61	.21	.005	.19	.037
Designer Attitude (28)	.29	.21	.011	.23	.034
Maintenance 2	.50	.15	.047	.25	.022
Constant	3.10				
All Success, Vars, Dummy Vars:					
User Objs (25)	.34	.26	.001	.15	.151
User Attitude (49)	.27	.19	.011	.20	.045
Development 2	.62	.21	.003	.24	.041
System Impact (36)	.23	.17	.033	.27	.028
Maintenance 2	.46	.14	.060	.28	.018
Constant	1.30				
Better than Mostly Success, Factor 1, Vars, Dummy Vars:					
Prelim Design (41)	.25	.28	.002	.09	.091
Designer Attitude (28)	.16	.18	.049	.15	.063
System Integration (44)	.17	.25	.005	.19	.038
Average Delta	-.58	-.30	.002	.22	.032
Size (9)	-.17	-.26	.007	.25	.026
Factor 1	.23	.21	.039	.28	.027
Difficulty (13)	.18	.19	.044	.30	.027
Constant	3.01				

not high enough to say that the two measure the same dimension. One reasonable hypothesis may be that there is yet another dimension to human behavior not found by this study that is important to success in weakly contracted efforts.

It is also interesting to note that, for weakly contracted efforts, the highest R^2 was found for Success better than "mostly successful." This particular model strengthens the observation made earlier that

Preliminary Design (41) is a predictor of Success for more successful efforts. System Integration (44) emerges as a predictor in this model, although not near as strongly as Preliminary Design or Designer Attitude (28). This variable also emerged at higher success levels for some of the models of strongly contracted systems not shown. System Size (9) emerges in this model with a negative coefficient, and in general, Size only entered the models of the weakly contracted efforts at higher levels of Success, and always with a negative coefficient. Although Size did not enter the models of more successful efforts for the other two groups at a significant level, it would eventually be included with a negative coefficient if the algorithm was allowed to continue. Thus Size apparently continues to have a negative impact, even after the very large, difficult systems have been excluded from the data. This was not the case with Technical Difficulty which emerged as a predictor of Success (with a positive coefficient) in this and some of the weakly contracted system models for higher levels of Success. For the other two groups, Difficulty, when it entered, always had a negative coefficient. One explanation might be that for weakly contracted efforts, given that the effort is mostly successful or better, increased difficulty becomes a measure of the sophistication or challenge associated with the system.

In general dummy variables were found to add considerably to the predictive quality of the models for both the total sample and for strongly contracted systems, but not the weakly contracted systems. This is probably because there is in general less variability in the ways in which weakly contracted systems are developed and maintained. The strongest predictor among the dummy variables was Development 2, the development of software and hardware for a single installation, which always entered with a positive coefficient. This was followed by Maintenance 3, maintenance performed by a contractor or organization other than the developers, which was negatively correlated with Success in all cases. As was mentioned earlier, this variable was comprised of only 36 cases. The third most powerful was Development 3, which entered positively. Contractor 4, those cases in which a contractor provided at least the operating system, entered negatively when observed, as did Organization 1, no formal organization. The zero order correlations for each group of systems at all levels of Success are shown in Table XV. Although not conclusive, this table does provide some implications for policies concerning project organization and maintenance.

Table XV
Zero Order Correlations for Dummy Variables

		All Systems	Strongly Contracted	Weakly Contracted
Development	2	.31	.26	.18
	3	.00	.13	.00
	4	-.34	-.35	-.09
Maintenance	2	.16	.16	.19
	3	-.22	-.21	-.16
*Contractor	2	.04		
	3	-.23		
	4	-.19	-.05	
Organization	1	-.04	-.15	-.05
	2	.13	.14	.02
	4	-.02	-.10	.01
	5	-.14	-.08	.04

*Only Contractor 4 is available in strongly contracted efforts (since strongly contracted efforts are defined as those contracted to a degree at least equivalent to 3), and no contractor dummy variables are available in weakly contracted efforts.

Concerning the distorting effects, if any, of the ALS, the choice of a "best" model depends on two issues which cannot be resolved by this study. The first is whether or not the 19 cases identified as referring to the ALS included all or at least enough of the ALS responses to test the models adequately both with and without the ALS. If the ALS was properly identified, then the main effect of removing that system from consideration is to make the Size and Difficulty variables somewhat less powerful predictors. The second issue becomes, given that the ALS was adequately segregated, to what extent do the distributions of the Success, Size and Difficulty variables with the ALS included reflect reality? Recalling the discussion of these variables earlier in this chapter, each was approximately normally distributed, however there was an excessive number of "very large" systems, as well as an excessive number of "extremely difficult" systems and similarly too many "unsuccessful" systems. In terms of the number of systems in the population, these distributions are very likely inaccurate. In terms of both the "kinds of systems people have mostly worked with" (given that the larger the project, the more people involved) and in terms of "total dollar investment," these distributions may more closely reflect reality. Thus if the ALS was adequately segregated, then the choice of model depends upon the purpose to which it is to be applied. If the purpose is to attain the greatest number of successful systems, then it is best to select a "without ALS" model, or a model for Success greater than unsuccessful. If the purpose is to attain the greatest success per dollar invested, then the most appropriate model includes the ALS and all levels of Success.

Concerning the development of two separate models for predicting success and failure discussed at the beginning of this chapter, it was interesting to note that some of the interview results were confirmed by the survey analysis. The "technical issues," Size (9) and Technical Difficulty (13) did prove to be strong predictors of failure. Similarly, requirements definition, as it was phrased in the discussion of the interview results, and Stability of Requirements (51), the logical corollary of the Part C variables, both proved to be predictors of failure. Unlike the interview results, the survey analysis found the User Involvement factors to be of importance throughout the range of success. This may be due in part to the dependence of good requirements definition upon user involvement. The requirements must reflect what users need, as is reflected by the strong loading by the User Involvement factor on both User Objectives (25) and Information Needs (57). In summary however this study did find some evidence of two separate models at work. The strongest predictors are classified as predicting "regardless of success level," "of failures," or "of success given more successful efforts" in Table XVI.

This study was generally unable to develop separate success and failure models, however. That is, the factor analysis of more successful efforts did not yield interpretable results, and despite the classification scheme of Table XVI, the predictor variables (with the exception of some of the failure predictors), tended to act as if on a continuum. For example, as Success increased, Preliminary Design became gradually more important. This does not exclude however the possibility that there are really two potential criterion variables, a success criterion and a

Table XVI
Classification of Strongest Predictor Variables

Strongest Predictor Variables:

Regardless of Success Level	Of Failures	Of Success, Given More Successful Efforts
Factor 1	Size (9)*	Preliminary Design(41)
Designer Att (28)	Difficulty (13)*	User Attitude (49)
User Objs (25)	Test Time (42)	
Proj Criteria (50)**	Stab Reqmts (51)**	To a Lesser Degree:
System Impact (36)**	Proj Mgr Ed, Exp (46)	
	Career Mgt Des (49)	Integration (44)
		Design Expert (21)
		Test Plan (24)
		Design Staff (34)

*Most powerfully, a combination of Size X Difficulty or Size + Difficulty, depending if the ALS was included.
**Used in the regression models as either an Actual variable or as a Delta variable, depending on the model.

failure criterion. These might be normally distributed adjacent to each other along some grand continuum with an overlap between the two curves such that most systems were operating somewhere on both curves at the same time. This might explain the excessive number of systems in the survey data at the lower end of the success scale. It would require two criterion variables and a complete set of "success" variables as well as a set of "failure" variables to test this idea, and these were not available on this survey.

Critical Factors

Although it is beyond the scope of this study to develop a conceptual model of the MIS process, the Ideal variables rated as "Very Important" or higher by the experienced respondents (Table VI, page 46) suggested the partial process model shown in Fig. 4. "Steps" or

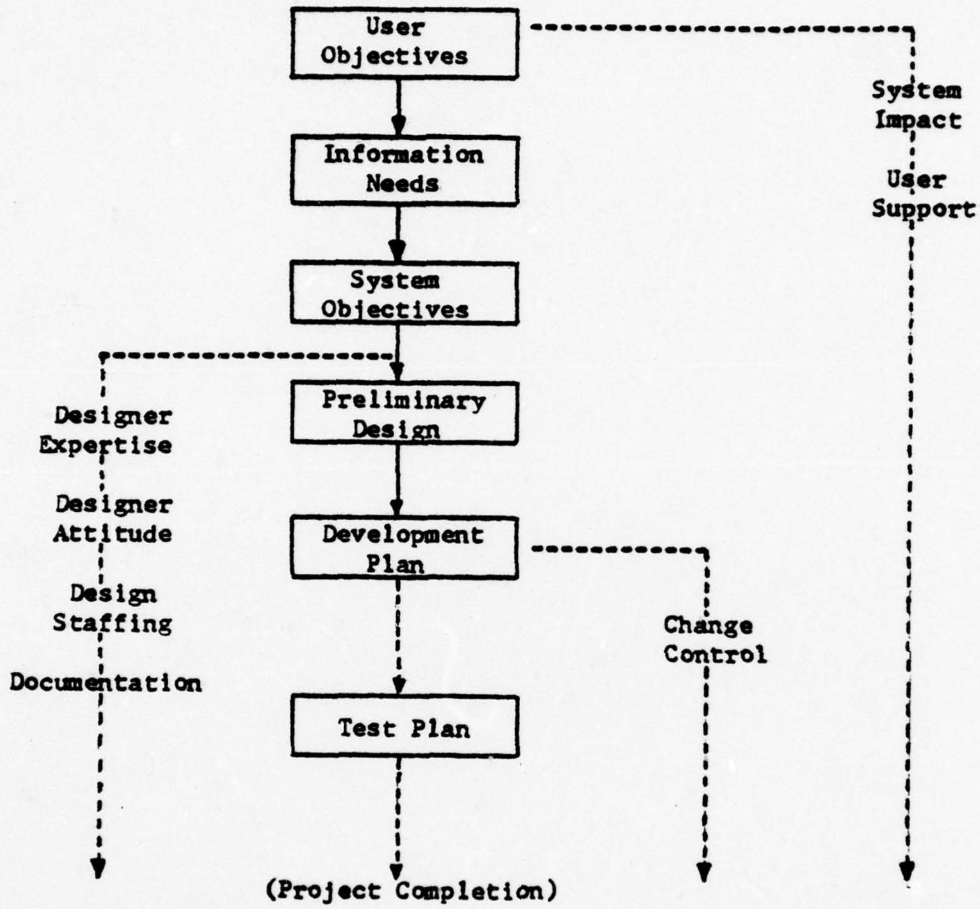


Fig. 4. Ideal Variables Rated as Very Important by Experienced Respondents Shown as a Process Model.

"activities" are shown in boxes in the model, while attributes and items to be emphasized in order to be successful are shown without boxes. The dashed lines are used, in the case of items to be emphasized, to indicate the portion of the project during which the item must be considered to achieve success. The Impact of the System on Users for example should be considered right from the outset and then throughout the project.

The dashed lines in the case of activities indicates that other activities not shown would be performed between the two activities shown. The first three activities were in fact worded as activities on the survey, as in "Determination of . . ." or "Identification of . . . ."

Perhaps the greatest difference between this (partial) model and the models in the literature is that it does not begin with a "Requirement." That activity was not included in the survey other than in the form of Stability of Requirements. However the first three steps in Fig. 4 constitute one way to go about defining the requirement. In my opinion, two of the main problems of development efforts listed in the literature (constantly changing requirements and not delivering what the user really needed) may be due to not following a basically similar procedure. It may or may not be coincidental to this model that those three steps were rated first, second and third in the order shown. However much of the literature is in agreement that the earlier that a factor becomes important to success in a project, the more critical it is in the sense that it is fundamental to all that follows.

Another point of interest concerning this model is that it consists almost entirely of what some call the "front end" or initial project definition stages of a project. In the interviews performed at AFDSDC, a number of personnel mentioned the critical nature of the front end. The front end was not discussed in that section however because it is a combination of many other variables. But with the exception of Change Control and possibly Test Plan, all of the top 13 variables are related to the front end. Test Plan may or may not be, as there is disagreement in the literature about when test planning should be performed, however nearly all of the authors agree that at least some test planning should be done in the initial stages of the project.

Fig. 5 adds the strongest predictor variables to the Ideal variables in Fig. 4. The predictive modeling effort disclosed that Size and Difficulty, (especially Size Times Difficulty), Stability of Requirements, Test Time, Impact of the System on Users, Designer Attitude, Career Management of the Designers, Criteria for Deciding to Continue the Project, Education and Experience of the Project Manager, User Attitude and Staffing of the Design Team were all critical to system success. It is reasonable to add highly ranked Ideal variables to predictor variables in this conceptual model since an Ideal variable which is being given about the right level of attention in the sample will not emerge as a predictor variable, even if it is critical. The Ideal variables in a sense represent critical factors that have been recognized and accounted for, while the predictor variables have not been adequately treated in at least some subset of less successful efforts. User Support, Documentation and Change Control are three variables that fall into the category of being ranked highly on the ideal plane but not emerging as predictor variables. The model continues to be a model of only the front end of a project, with the exception of Test Time.

The three primary factor analyses performed in this study (for the total sample, strongly and weakly contracted efforts) each revealed the same three factors. The first factor, User Involvement, was highly significant in all cases. The second and third factors, Capabilities of the Project Organization and Planning and Control were less (although still) significant. When the User Involvement factor was used in lieu

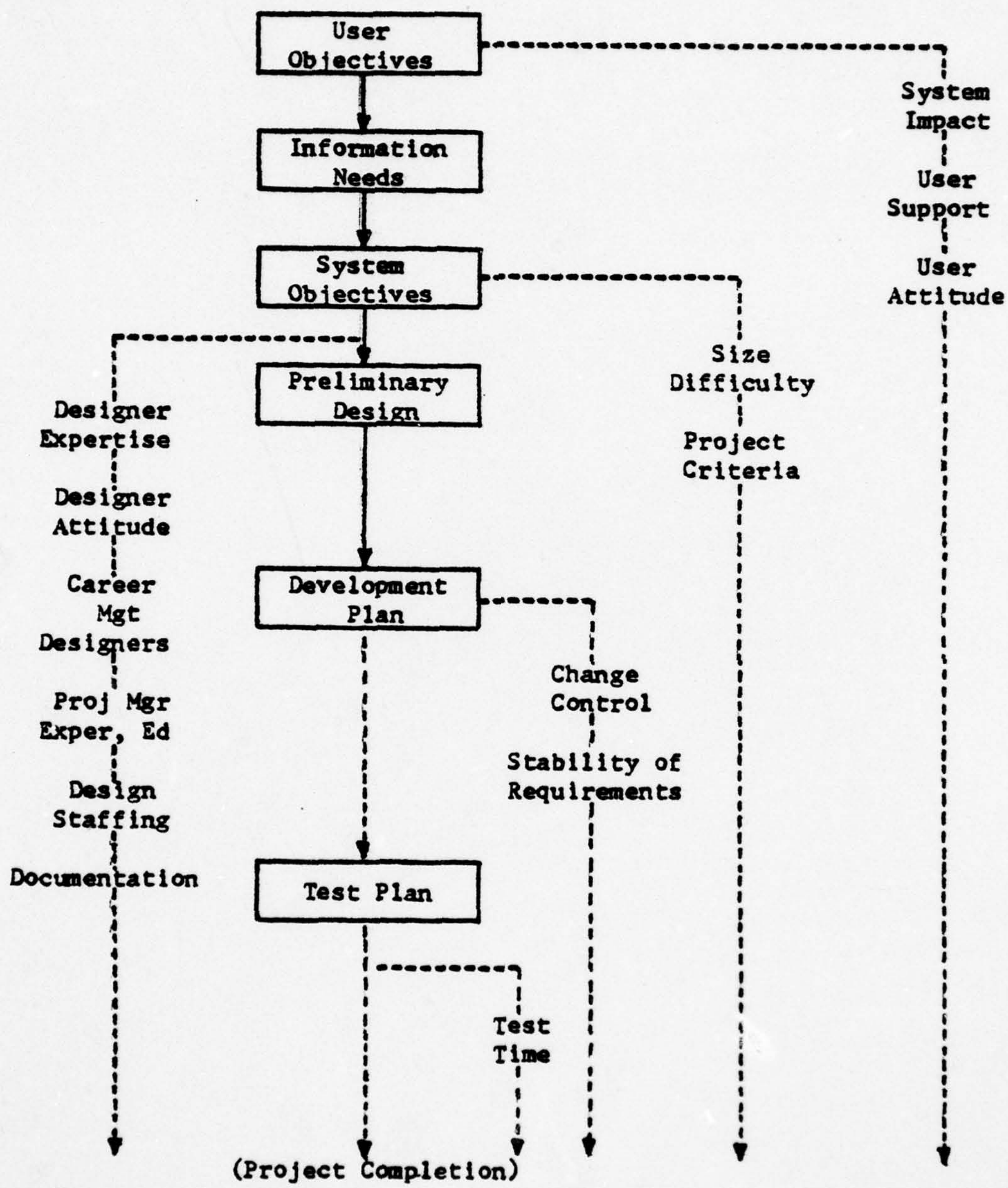


Fig. 5. Ideal Variables and Strongest Predictor Variables from Regression Models Shown as a Process Model.

of component variables in regression modeling it generally emerged as a very strong predictor of success. The three factors are shown in Fig. 6 in place of component attributes, but not in place of component steps or activities. This considerably simplifies the model.

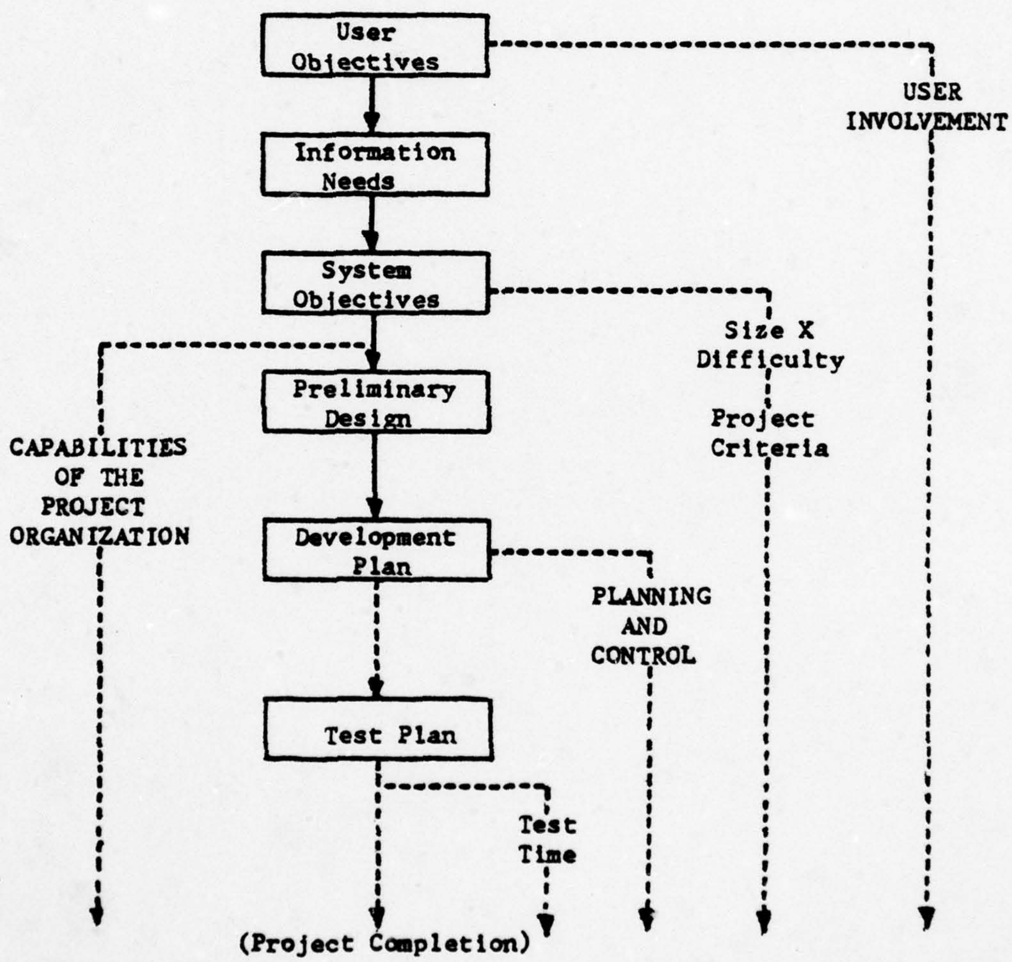


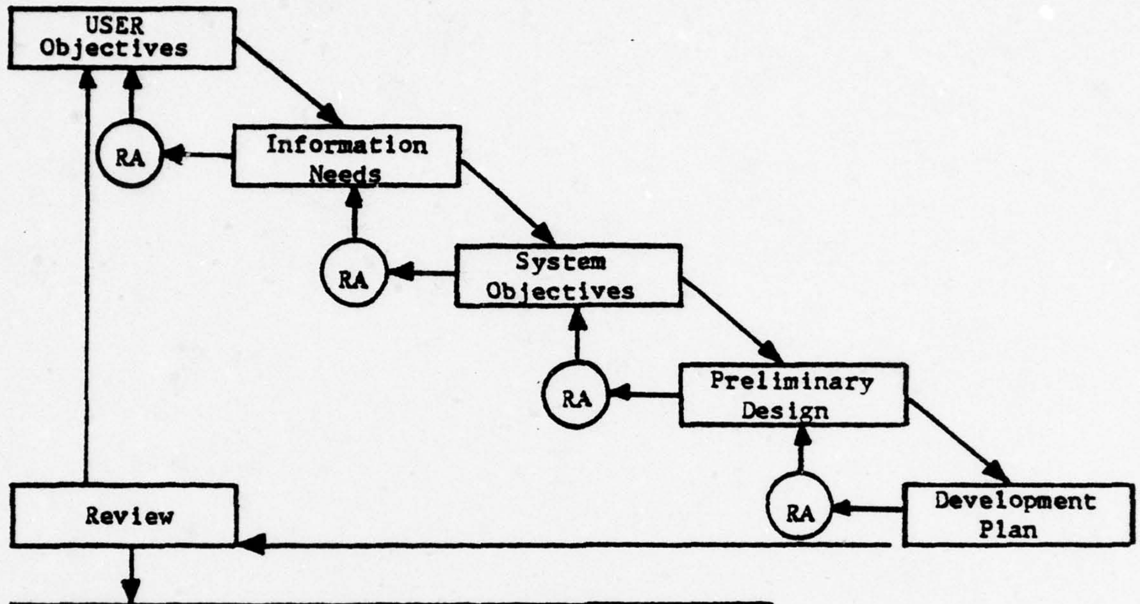
Fig. 6. Process Model of a Project Using Factors in Place of Component Variables.

Using only the independent (versus component) variables from this model, the "Critical Factors in the Development of Air Force Computerized Management Information Systems" evolving from this study are:

1. User Involvement.
2. Size and Difficulty.
3. Criteria to be Used in Deciding to Continue the Project.
4. Capabilities of the Project Organization.
5. Planning and Control.
6. Test Time.

The component variables shown in Fig. 5 can of course be substituted for the factors in the list, and in general the component variables when used in Regression resulted in a more powerful model in terms of per cent of explained variance. However the underlying dimensions, that is the factors, are of sufficient clarity that little information is lost and much conceptual clarity is gained by using the factors in lieu of variables in a list of Critical Factors. The front end of a project may also be considered a critical factor in that all of the other critical factors (with the exception of Test Time) relate closely to the front end.

Recalling that the development of a conceptual model of the MIS development process is beyond the scope of this study, I would however like to propose a model of the front end which is consistent with my data. This is shown in Fig. 7. The model consists of the same five first steps shown in the models presented earlier. Each step is followed by a informal review and approval of the outputs of the step. For example, the question to be asked in review of Information Needs is "Do the Information Needs specified meet the stated User Objectives, and if



Products of the Review:

1. Commitment by Users to the Project as Outlined.
2. Evaluation of Feasibility (Size, Difficulty, Time).
3. Evaluation of the Impact of the System on Users.
4. Criteria to be Used in Deciding to Continue/ Terminate the Project.
5. Evaluation, Commitment of Resources.
6. System Performance Criteria.
7. Essential Elements of the Test Plan.
8. Configuration Management Plan (Change Control).
9. Documentation Standards.

*RA Stands for Review and Approval.

Fig. 7. Proposed Process Model of the Front End of a MIS Development.

not which (needs or objectives) should be changed?" The Development Plan is followed by a formal Review involving top and working level managers from both the user and developer organizations. The products to be approved in the Review are shown. These products address all of the critical factors not otherwise shown in the model, plus the System Performance Criteria.

This model formalizes User Involvement in three essential ways. First, requirements definition is considered as three separate user-oriented activities. Second, reviews involve the user. Third, the products of the formal Review represent a formal commitment by the user to: what the system is to do; how well the system must do it; and how well the project team must perform in order to be successful. This model does not rule out long range planning as a medium for overall system development, but rather can be used to support and extend the planning process. Nor does the model rule out incremental development, which may be deemed essential if considerations of feasibility or objectives, which are particularly difficult to specify, are encountered. The model in itself does not show, however, that User Involvement cannot be completely formalized. User Involvement depends a great deal upon Designer Attitude toward Users and on User Attitude toward Designers. The model also cannot guard against changes imposed at a level higher than the user or unforeseen occurrences. But it can, in my opinion, make MIS development more successful.

IV. Conclusions and Recommendations for Further Research

Conclusions

As stated in Chapter I, the objectives of this study were:

1. To determine what factors are most important to the successful development of Air Force computerized management information systems.
2. To determine if and how the important factors vary with a number of system and project attributes.
3. To attempt to develop a predictive model which may be of some use in evaluating and managing future development efforts.

Taking the second objective first, it was found that Size, Difficulty and Degree of Contractor Involvement were major determinants of how a number of the Ideal variable ratings varied in importance. These variables were shown in Tables VIII and IX. As was expected, nearly all of the significant variance was in a positive direction. That is, the larger, more difficult, more strongly contracted efforts required that greater emphasis be placed upon the variables than did the smaller, less difficult, weakly contracted efforts. The one exception was that Designer Attitude was significantly more important for weakly contracted efforts.

In general the most linear relationships with Size were found to be in Designer Expertise, Career Management of the Designers, Authority Available to the Project Manager and the Education and Experience of the Project Manager. In addition, the Use of Automated Development Tools,

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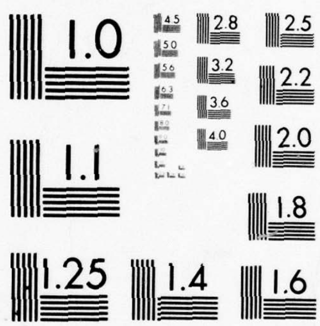

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Development of a Prototype, Top Management Support, Integration of Systems and Ability to Track Cost, Schedule and Performance varied significantly (at less than the .001 level) with Size.

Development of a Prototype and Top Management Support showed the strongest linear relationships with technical difficulty. In addition, Integration of Systems varied significantly at the .001 level, although the relationship was not strongly linear.

Concerning the Degree of Contractor Involvement, it was difficult to say with assurance to what degree the variance of the Ideal variables was due solely to Contractor Involvement. That is, the strongly contracted efforts also tended to be the largest and the most difficult. Six of the variables which varied significantly at the .05 level for Degree of Contractor Involvement did not vary significantly with either Size or Technical Difficulty. These were the Development Plan, Designer Attitude, Contractor Responsiveness, Justification of Cost, System Performance Criteria and the Development Approach. The remainder of the Part B variables demonstrated considerably less explanatory power than did Size, Technical Difficulty and Degree of Contractor Involvement.

A number of predictive models for system success were developed in pursuit of the second objective. Of these models, the models for strongly contracted efforts demonstrated the highest percentage of explained variance (52% with dummy variables and 42% without), followed by the models for all systems (43% with dummy variables and 35% without) and the models for weakly contracted efforts (28% with dummy variables and 24% without).

One of the most important findings of the modeling effort was that different variables become important predictors of success when unsuccessful efforts are included in the model than when the unsuccessful efforts are excluded. From this it was concluded that Size, Technical Difficulty, Test Time, Stability of Requirements, Education and Experience of the Project Manager, and Career Management of the Designers all tend to be predictors of failure. That is, these variables were strong predictors when unsuccessful efforts were included in the sample used to develop the model, but not when the unsuccessful efforts were excluded. The strongest predictor of failure was a combined variable, Size Times Difficulty. The logical way for a manager to handle this situation is to first insure that the "failure" variables are adequately satisfied, and then to concentrate on the "success" variables.

It was found that Preliminary Design, User Attitude, and to a lesser degree Integration of Systems, Designer Expertise, Test Plan and Staffing of the Design Team were predictors of greater success, given that only more successful efforts were included in the model. That is, given that the project does not fail, these variables are important to greater success. The User Involvement factor, Designer Attitude, Determination of the Objectives of the User Organization, Criteria for Deciding to Continue the Project and Impact of the System on Users were all strong predictors of success, regardless of what success levels were included in the model. Although, as discussed at length in Chapter III, the existence of separate failure and success predictors suggests the possibility of separate models for success and failure, this study is unable to provide such models due to the predominantly one-way (success) orientation of the data. It is also consistent with the data to consider the failure variables as "minimum" requirements for success; these variables must be satisfied in order to insure that the project does not fail, but do not of themselves lead to success greater than failure.

It was found that the use of dummy variables in general added considerably to the predictive power of the models. Two of the strongest dummy variables emerged from Question 10, Nature of the Development. From this question it was found that the most successful efforts tended to be those involving the development of both hardware and software for a single installation, and the least successful efforts were those involving multiple installations of hardware and software. The development of software only for multiple installations tended to be either uncorrelated or slightly (positively) correlated with success.

With respect to Question 15, Maintenance, it was found that the systems for which maintenance was performed by a organization other than the developers or by a contractor were least successful. However there were too few systems in this category (36) to draw very strong conclusions. Analysis of Question 14, Degree of Contractor Involvement, indicated that the more strongly contracted efforts were least successful. Question 17, Project Organization was discussed in both the "Analysis of System Attributes" and the "Predictive Modeling Efforts" sections of Chapter III. In summary it was found that those projects which were formally organized under a project manager were most successful, and those with two or more independent teams under no single project manager were least successful, followed by those with no formal project organization.

Figure 8 summarizes the results of the predictive modeling effort by assigning a number of attributes to successful and unsuccessful efforts. While, as shown, successful efforts tend to be the reverse of unsuccessful efforts (plus a few variables), it is <u>not</u> necessary for a successful system to be small and easy from a technical standpoint. Although both variables are generally negatively correlated, it seems to be sufficient for success that the effort <u>not</u> be <u>both</u> large and difficult. Also, while successful efforts are characterized by a high degree of User Involvement, including the three variables shown, a fourth, User Attitude toward Designers, is also a characteristic of successful efforts.

Three different approaches were used in pursuit of the first objective of this study: "To determine what factors are most important to the successful development of Air Force computerized management information systems." These were: analysis of the Ideal variable ratings, the predictive modeling effort and factor analysis.

The means and ranks for the 30 most highly rated Ideal variables were shown in Table VI (page 46). It was found that all of the 30 variables there shown were of considerable importance in general, the lowest mean being 3.46 (by inexperienced respondents), or about half way between "Important" and "Very Important" on the rating scale used in the survey. It was also found in the analysis of the ideal ratings that it did not make much difference whether the variables were rated by experienced (in MIS) or inexperienced respondents. I was unable to conclude however that the respondents to this survey and the CSU survey rated the 11 common variables the same, but the correlation was close to significance.

Unsuccessful Efforts Tend To:

1. Be very large and very difficult technically.
2. Be characterized by a low degree of User Involvement:
   - Inadequate Determination of User Objectives.
   - Poor Attitude by Designers toward Users.
   - Inadequate evaluation of the Impact of the System on Users.
3. Be those in which inadequate consideration was given to the Criteria to be used in Continuing the Project.
4. Have inadequate Test Time.
5. Have unstable Requirements.
6. Have less qualified Project Managers.
7. Have Maintenance performed by an organization other than the developers or by a contractor.
8. Have poor continuity in Designers (Career Management of the Designers).
9. Be more heavily Contracted.
10. Have no formal organization or have two or more independent teams with no single project manager.

Successful Efforts Tend To:

*THE REVERSE, PLUS:
1. Emphasize Preliminary Design.
2. Have highly Expert, Creative Designers.
3. Involve the development of software and hardware for a single installation or software only for multiple installations.
4. Have a good Test Plan.
5. Have good Staffing of the Design Team.

*See Text.

Fig. 8. Attributes of Unsuccessful and Successful Development Efforts as Found Through Multiple Regression.

The most important Ideal variables were shown as a partial process model of the "front end" of a project in Fig. 4 (page 81). The most important predictor variables from the predictive modeling efforts were added to the model in Fig. 5 (page 84). This model continued to be a model of only the front end of a project.

The three main factor analyses performed each revealed the same three factors underlying the 40 actual variables in the survey. These were: User Involvement, Capabilities of the Project Organization, and Planning and Control. These three factors were shown in the model in place of component variables in Fig. 6 (page 85). This considerably simplified the model shown in the previous figure. The factors were generally less powerful predictors of success than their component variables. However, the clarity of understanding provided by viewing only the factors was such that it was elected to list only the factors as "Critical Factors," with the understanding that the component variables could be substituted. The "Critical Factors in the Development of Air Force Computerized Management Information Systems" were therefore listed as:

1. User Involvement
2. Size and Difficulty.
3. Criteria to be Used in Deciding to Continue the Project.
4. Capabilities of the Project Organization.
5. Planning and Control.
6. Test Time.

Although it was beyond the scope of this study to develop a conceptual model of the MIS development process, the previously discussed findings suggested a process model of the front end of a project. Based upon both the findings of this study and the literature search, such a model was proposed in Fig. 7 (page 87). The greatest difference between that model and the models shown predominately in the literature is that it separates "Requirements Definition" into three steps: User Objectives, Information Needs and System Objectives. The model concluded the front end with a formal review which addressed all of the Critical Factors found by this study.

Recommendations for Further Research

As is the case with many research efforts, this effort has raised many unanswered questions and discovered several potentially profitable avenues for further research. This study was in itself a follow-on effort to the study performed by Deane Carter at Colorado State University. Four potential areas for research concern: further analysis of the data gathered by this study; the replication of this study with new variables and a different sample group; investigation of the possible existence of separate success and failure models; and application of the survey design to other kinds of projects.

Given the limited time frame available to this effort, the statistical analysis techniques used were of necessity only a start. Potentially profitable areas for analysis of the existing data include more sophisticated regression modeling methods, methods for controlling for the effects of size and difficulty, and investigation of why weakly contracted efforts appear to be in some ways fundamentally different. In regression modeling, a number of variables appeared to be exhibiting a nonlinear relationship with success. This in itself partly explains why different factors tended to be predictors of success and failure. The confounding effects of Size and Difficulty were an obstacle in many of the analysis efforts. It was for example hard to say how the important variables varied for weakly versus strongly contracted efforts, given that strongly contracted efforts were much larger and more difficult.

Potential techniques for controlling for the effects of Size and Difficulty may include canonical correlation and discriminant analysis. As discussed in the section on the "Predictive Modeling Effort," weakly contracted efforts seemed to exhibit fundamentally different behavior. Investigation is needed into why this may be the case.

Concerning possible replication of this study, the most profitable areas seem to be in the use of new variables and in the possibility of performing an "objective" study. This researcher identified over 150 potentially critical factors in the literature search. Of these, 40 were used as factors in Part C of the survey and 12 were used as attributes in Part B. There are without doubt important, if not critical factors which need to be discovered. Three variables which should be used in modified form include Top Management Support and Involvement (33), Experience and Education of the Project Manager (46) and Strength of the Project Organization (35). A number of respondents indicated that each of the first two should be divided into two separate variables. Some felt, for example, that top management support was critical but that top management involvement was undesirable. Given that the abilities of the project manager were found to be critical, added project manager variables should be considered to determine what specific abilities are most important. Strength of the Project Organization was intended to measure the degree of organizational unity (as opposed to two independent teams) and organic control over needed resources (as opposed to loaned). A number of respondents commented that the question was ambiguous and the number of missing cases seemed to bear this out.

The other area for replication concerns the possibility of an "objective" study. It might be possible to identify some specific projects, rate the projects on several objective scales for both success and attributes, and have several personnel that were involved complete Part C only of the survey. This approach could also include the users, at least in a subjective evaluation of success.

The possibility of separate success and failure models was discussed at some length in Chapter III. In summary, this study found some evidence to support the idea, and further investigation is needed as discussed in that Chapter.

The fundamental design of the survey, especially Part C, proved to be of considerable value in retrospect. The pairing of Ideal and Actual ratings made the survey relatively fast to fill out (considering a total of 99 questions and the nature of the judgments involved) but provided considerable flexibility in analysis through the availability of Ideal, Actual and Delta ratings. I believe that the same design, and even a number of the same variables, can be profitably applied to virtually any product-oriented project organization in which the developers are specialists apart from the users. The fundamental communication problems that motivate User Involvement are probably also present in those activities, although to a lesser degree than in management information systems.

Bibliography

1. Bursk, Edward C., et al. The World of Business, Vol IV. NY: Simon and Schuster, 1962.

2. Evans, Marshall K. and Lou R. Hague. "Master Plan for Information Systems," in Decision Theory and Information Systems: An Introduction to Management Decision Making, edited by William T. Greenwood. Cincinnati: Southwestern, 1969.

3. Brooks, Frederick P. The Mythical Man-Month, Essays on Software Engineering. Reading, MA: Addison-Wesley, 1975.

4. Orlicky, Joseph. The Successful Computer System, Its Planning, Development and Management in a Business Enterprise. NY: McGraw-Hill, 1969.

5. Kelly, Joseph F. Computerized Management Information Systems. NY: MacMillan, 1970.

6. Clements, William P, Jr. "Command and Control of Our Forces." Supplement to the Air Force Policy Letter for Commanders, 6:10-17 (June 1975).

7. Turn, R., et al. "A Management Approach to the Development of Computer-Based Systems." Unpublished paper. Santa Monica, CA: Rand Corp. AD A037895. July, 1976.

8. Shaw, John C. and William Atkins. Managing Computer Systems Projects. New York: McGraw-Hill, 1970.

9. Gates, Howard P., Jr., et al. "Electronics-X - A Study of Military Electronics with Particular Reference to Cost and Reliability." Unpublished paper. Washington, D. C.: ASD/TIDC. AD A00165. January, 1974.

10. Soden, John V. "Understanding MIS Failures." Data Management, 13:29-33,46 (July 1975).

11. Donelson, William S. "Project Planning and Control." Datamation, 22:73-80 (June 1976).

12. Lucas, Henry C. Why Information Systems Fail. New York: Columbia University Press, 1975.

13. Long, Maurice I. and Roy J. Brown. "MIS Implications for Top Management." Infosystems, 21:24-9 (October 1974).

14. "AF Computer Memo Disputed." Dayton Daily News. May 11, 1977, p. 68.

15. Air Force Logistics Command. "Air Force Logistics Command Advanced Logistics System Assessment." Unpublished Staff Study. Dayton: Wright-Patterson AFB. January 1975.

16. Axelson, Charles F. "How to Avoid the Pitfalls of Information Systems Development." Financial Executive, 44:25-31 (April 1976).

17. Carter, D. M., et al. "A Study of Critical Factors in Management Information Systems for U. S. Air Force." Unpublished paper. Washington, D. C.: Air Force Office of Scientific Research. AD A009647, March 1975.

18. LOGICON. "Management Guide to Avionics Software Acquisition, Vol I - An Overview of Software Development and Management." Unpublished paper. Dayton, Ohio: Aeronautical Systems Division, Air Force Systems Command. AD A030591. June 1976.

19. Kneitel, Arnold. "DuPont is Doing Things with MIS." Infosystems, 24:48-52 (February 1977).

20. Boehm, B. W. "Software Engineering." Paper prepared for IEEE transactions on Computers, December 1976. Redondo Beach, CA: TRW. October 1976.

21. Hartman, E., et al. Management Information Systems Handbook. NY: McGraw-Hill, 1968.

22. Morgon, James H. and Michael S. Lightman. "Systems for Developing Systems." Datamation, 22:62-65 (April 1976).

23. Willworth, N. E., et al. "Software Data Collection Study, Summary and Conclusions." Unpublished report. Rome, NY: USAF Rome Air Development Center. AD A036115. December 1976.

24. Ross, Joel E. "The Impact of Information Systems." Management Accounting, 56:33-36 (April 1974).

25. Shio, Martin J. "New Look at MIS." Journal of Systems Management, 28:38-40 (May 1977).

26. Vaughan, Anderson H. "Plan for Project Success." Journal of Systems Management, 25:12-15 (December 1974).

27. Alter, Steve L. "How Effective Managers Use Information Systems." Harvard Business Review, 54:97-104 (November-December 1976).

28. Schene, Charles D. and James L. Wiek. "Guide to MIS User Satisfaction." Journal of Systems Management, 28:6-10(June 1977).

29. Ainsworth, William. "The Primacy of the User." Infosystems Two-Part Article, 24:46-48 (April 1977) and 24:50-54 (May 1977).

30. Gianotti, Gene C. "Management Information Systems: How Management Can Make It Happen." Infosystems, 24:66-68 (May 1977).

31. Cohen, Burton J. Cost-Effective Information Systems. American Management Association, 1971.

32. Martino, R. L. Management Information Systems. Wayne, PA: MDI Publications, 1969.

33. Ackoff, Russell. "Management Misinformation Systems," in Information for Decision Making, edited by Alfred Rappaport. Englewood Cliffs, NJ: Prentice-Hall, 1970.

34. Heany, Donald F. Development of Information Systems: What Management Needs to Know. NY: Ronald Press, 1968.

35. Willworth, N. E., et al. "Software Data Collection Study, Survey of Project Managers." Unpublished paper. Rome, NY: USAF Rome Air Development Center. AD A036066. December 1976.

36. Braverman, Philip H. "Managing Change." Datamation, 22:111-113 (October 1976).

37. Cougar, Daniel J. and Lawrence M. Wergin. "Systems Management: Small Company MIS." Infosystems, 21:30-33 (October 1974).

38. Office of Information, Air Force Data Systems Design Center. "AFDSDC Fact Book." Unpublished report. Montgomery, AL: AFDSDC. December 1976.

39. Staelin, Richard. "Another Look at A.I.D." Journal of Advertising Research, 11:23-28 (October 1971).

40. Gooch, L. L. "Policy Capturing with Local Models: The Application of the AID Technique in Modeling Judgment." Unpublished dissertation. Austin, TX: University of Texas, 1972.

41. Nie, Norman H., et al. Statistical Package for the Social Sciences. Second Edition. NY: McGraw-Hill, 1975.

Appendix A

Survey Instrument

FOREWORD

The purpose of the attached survey is to determine what factors are most important to the successful development of Air Force computerized management information systems. This survey is being given to selected officer and civilian personnel performing duties related to system design, analysis, programming or operations at the AFDSDC, Gunter AFS, AL, Hq AFLC and AFSC/ASD at Wright-Patterson AFB, OH, and Hq SAC/AD at Offutt AFB, NE. Since the survey is concerned with management information systems, data base management systems and operating systems, for example, should be considered only to the extent that such systems are developed to support management information systems. The survey is concerned with command and control systems. Although only a portion of our business, the successful development of management information systems has often proved to be very difficult in the past, both within and outside the Air Force. In completing this survey, you may feel that some of the questions are not really applicable to your organization or background. This is because the survey is designed to obtain information about many different kinds of systems, ranging from extremely large systems involving many bases and new computers, to very small individualized systems involving only a few programs on existing computers. One of the purposes of the survey is to identify how the important factors vary across this wide range of systems. Thus, your experience regardless of the size or uniqueness of the project, is important. Also, do not be concerned if your experience is limited to either technical or managerial concerns. The survey takes your job into account. Please be candid. Your complete anonymity is assured. No attempt will be made to identify specific projects or individuals. The survey should take about 30 minutes to complete. Mark your answers directly on the survey. Please return the completed survey in the attached, stamped envelope no later than 30 September 1977. Your assistance is greatly appreciated.

Privacy Statement

In accordance with paragraph 30, AFR 12-35, the following information is provided as required by the Privacy Act of 1974.

A. Authority.

(1) 5 U.S.C. 301, Departmental Regulations: and/or
(2) 10 U.S.C. 80-12, Secretary of the Air Force, Powers and Duties, Delegation by.

B. Principal purposes. The survey is being conducted to collect information to be used in research aimed at illuminating and providing inputs to the solution of problems of interest to the Air Force and/or DOD.

C. Routine uses. The survey data will be converted to information for use in research of management related problems. Results of the research based on the data provided will be included in written Master's thesis and may also be included in published articles, reports or texts. Distribution of the results of the research, based on the survey data, whether in written form or orally presented, will be unlimited.

D. Participation in this survey is entirely voluntary.

E. No adverse action of any kind may be taken against any individual who elects not to participate in any or all parts of this survey.

SURVEY PART A

CIRCLE THE LETTER IN FRONT OF YOUR RESPONSE

1. Indicate your current assignment

A. AFDSDC
B. AFLC
C. AFSC/ASD
D. SAC
E. Other, specify __________.

2. How much experience do you have in the computer systems career field?

A. Less than 1 year.
B. From 1 to 2 years.
C. From 2 to 3 years.
D. From 3 to 4 years.
E. From 4 to 6 years.
F. From 6 to 8 years.
G. From 8 to 10 years.
H. From 10 to 15 years.
I. More than 15 years.

3. What is your current grade?

A. GS-9
B. GS-10
C. GS-11
D. GS-12
E. GS-13
F. GS-14
G. GS-15
H. 0-1
I. 0-2
J. 0-3
K. 0-4
L. 0-5
M. 0-6

4. What is your current specialty series?

   A. Civilian 33X series.
   B. Military 51XX series.
   C. Other (for example, CXXXX), specify___________.

5. Select the statement which best describes your current job. If you have been in this job less than six months, use your last job involving computers.

   A. I work primarily in a managerial capacity on existing systems.
   B. I work primarily in a managerial capacity on new systems.
   C. I work primarily in a technical capacity on existing systems.
   D. I work primarily in a technical capacity on new systems.

6. How frequently does this job bring you into contact with user personnel?

   A. Constantly
   B. Frequently
   C. Often
   D. Sometimes
   E. Rarely
   F. Almost never

7. How many management information system development efforts have you participated in within the last ten years?

   A. None
   B. One
   C. Two
   D. Three
   E. Four
   F. Five
   G. More than five

IF YOU ANSWERED "NONE" TO THE LAST QUESTION, SKIP PART B AND COMPLETE PART C.

IF YOU ANSWERED "ONE" OR MORE TO THE LAST QUESTION, COMPLETE PARTS B AND C.

PART B

Answer the following questions with respect to a single management information system development effort in which you recently participated. This system should be sufficiently completed for you to make some judgments about the success and problems of the effort.

8. Rate the successfulness of the development effort, considering both project management and the end product. Was the project, for example, completed on time at projected cost? Was the system, for example, usable, easy to maintain, and what the users really needed?

   A. Highly Successful, greatly exceeded most requirements.
   B. Very Successful, exceeded many requirements.
   C. Moderately Successful, exceeded a few requirements, and met all important ones.
   D. Successful, satisfied all important requirements.
   E. Mostly Successful, satisfied most important requirements.
   F. Somewhat Unsuccessful, failed to satisfy several important requirements, but produced a basically usable system.
   G. Unsuccessful, failed to satisfy major requirements, was unusable, barely usable or project terminated.

9. Select the statement which best describes the size of the project.

   A. Very Small, involved only a few people for a few calendar months.
   B. Small, involved several people for up to a calendar year.
   C. Medium, involved a number of people for more than a calendar year.
   D. Fairly Large, involved quite a number of people for more than a calendar year.
   E. Large, involved many people for two or more calendar years.
   F. Very Large, involved very many people for much longer than two calendar years.

10. The project required the development and/or procurement of:

   A. Software only, for a single installation.
   B. Software only, for multiple installations.
   C. Software and hardware, for a single installation.
   D. Software and hardware, for multiple installations.

11. The system was to be used by:

A. A single user organization.
B. More than one user organization, each with different requirements.
C. More than one user organization with similar requirements.
D. Many user organizations, with standardized requirements, such as those set by regulation.

12. The system was to be used primarily for:

A. Accounting type applications, for example, finance, inventory, personnel, status or performance reporting.
B. Command and control.
C. Scientific research.
D. Project management.
E. Other, specify____.

13. Rate the technical difficulty of the project.

A. Not Difficult, example, proven software/hardware in proven applications.
B. Somewhat Difficult, example, proven software/hardware in proven applications, but required some techniques that the developers were not experienced with.
C. Difficult, example, unproven software/hardware or unproven applications.
D. Very Difficult, example, unproven software/hardware in unproven applications.
E. Extremely Difficult, example, unproven software/hardware in unproven applications and required the development of substantial new technology.

14. Select the statement which best describes the degree of contractor involvement in the project.

A. No contractor involved.
B. Contractor provided hardware only.
C. Air Force and contractor each developed portions of the operating system(s), and the Air Force developed the applications programs.
D. Contractor provided all but applications programs.
E. Contractor provided most of the system, Air Force developed some of the applications programs.
F. Contractor provided the complete system, Air Force managed the project.

15. Who was to maintain the system?

A. The same Air Force personnel that developed the system.
B. Different Air Force personnel in the same Air Force organization.
C. A different Air Force organization than the Air Force organization that developed the system.
D. The Air Force, system developed by contractor.
E. The same contractor that developed the system.
F. A contractor, Air Force developed the system.
G. Contractor other than the original contractor.

16. Was the original contractor to perform system maintenance under a long term warranty (3 or more years) included in the original contract award?

A. Yes
B. No
C. No contractor involved.

17. Select the statement which best describes how the project was organized.

A. No formal project organization.
B. A project manager with resources loaned as needed.
C. A formal project organization with a project manager.
D. Two or more independent teams under a project manager.
E. Two or more independent teams under no single project manager.

18. How long ago was the project completed?

A. Project is still going on.
B. Less than 6 months ago.
C. Between 6 months and 1 year ago.
D. Between 1 and 2 years ago.
E. Between 2 and 3 years ago.
F. Between 3 and 4 years ago.
G. Between 4 and 6 years ago.
H. Between 6 and 8 years ago.
I. More than 8 years ago.

19. Is the system being used now?

A. Yes
B. No
C. I don't know.

PART C

INSTRUCTIONS FOR THOSE WHO HAVE PARTICIPATED IN NO MANAGEMENT INFORMATION SYSTEM DEVELOPMENT EFFORTS:

Rate each of the factors beginning on the next page on the scale shown. Using your experience and training, rate the importance that you think should be given to each factor for the successful development of management information systems in general. You might, for example, think that the development plan should be treated as "Critically Important" ("A" on the rating scale), but that the abilities of the designers should be treated as only "Somewhat Important" ("D"). If you think that a factor should not be considered in such projects, rate it as "Not Important or Not Applicable" ("E"). Fill your ratings in the blanks in the right hand column under "Ideal Importance." Ignore the left hand column under "Importance Given on This Project." That column is to be used by those who have participated in one or more development efforts. Begin on the next page.

INSTRUCTIONS FOR THOSE WHO HAVE PARTICIPATED IN ONE OR MORE MANAGEMENT INFORMATION SYSTEM DEVELOPMENT EFFORTS:

Rate each of the factors beginning on the next page, with respect to the same system effort used in answering Part B. First, estimate how much importance was given to the factor in the development of the system by filling in the blank in the left hand column under "Importance Given on This Project." Then rate how important the factor should have been considered in order to make the project more successful. Rate each factor on the scale shown. You might, for example, think that the development plan was treated as "Critically Important" ("A" on the rating scale), but that it should have been treated as only "Somewhat Important" ("D"). Or, for example, you might think that the abilities of the designers was treated as "Somewhat Important," but that this should have been considered "Critically Important." Rate according to your particular system. You might think that some of the factors are generally important, but were not to your system. If so, rate those factors as "Not Important or Not Applicable." Rate factors as important only if important to your system. Begin on the next page.

RATING SCALE:

A	B	C	D	E
Critically Important	Very Important	Important	Somewhat Important	Not Important or Not Applicable

Factor Ratings

IF YOU WERE INVOLVED IN ONE OR MORE PROJECTS, FILL OUT BOTH COLUMNS FOR YOUR SPECIFIC PROJECT.

IF YOU WERE INVOLVED IN NO DEVELOPMENT EFFORTS, FILL OUT THE RIGHT COLUMN ONLY FOR PROJECTS IN GENERAL.

Importance Given on This Project	Ideal Importance	
_____	_____20.	Detail, coordination and currency of the development plan.
_____	_____21.	Expertise and creative ability of the designers.
_____	_____22.	Periodic reviews of the project at predetermined phase points.
_____	_____23.	Modularization of programs.
_____	_____24.	Comprehensiveness of the test plan, including test data.
_____	_____25.	Determination of the objectives of the user organization.
_____	_____26.	User experience with computers.
_____	_____27.	Use of automated development tools, such as test data generators, logical simulators.
_____	_____28.	A positive attitude by the designers toward the users.
_____	_____29.	Use of a disciplined, sequential development approach.
_____	_____30.	Development and test of a prototype.
_____	_____31.	Involvement by users in the review process.
_____	_____32.	Comprehensiveness and currency of documentation.
_____	_____33.	Involvement and support of top management.

A	B	C	D	E
Critically Important	Very Important	Important	Somewhat Important	Not Important or Not Applicable

Importance Given on <u>This Project</u>	Ideal Impor- <u>tance</u>	
_____	_____34.	Staffing of the design team.
_____	_____35.	Strength of the project organization.
_____	_____36.	Impact of the system on users.
_____	_____37.	Education and retraining of operators and users.
_____	_____38.	Definition of the objectives of the system.
_____	_____39.	Career management of the designers, such as avoiding PCS, insuring continuity.
_____	_____40.	Scheduled time for the project, excluding test.
_____	_____41.	Thoroughness of the preliminary design.
_____	_____42.	Scheduled time for testing.
_____	_____43.	Authority available to the project manager.
_____	_____44.	Integration of independent systems.
_____	_____45.	Work assigned in identifiable, controllable packages.
_____	_____46.	Experience and education of the project manager.
_____	_____47.	Involvement in the system design by users.
_____	_____48.	Personal communication ability of the designers.
_____	_____49.	A positive attitude by users toward designers.
_____	_____50.	Criteria for deciding whether to continue the project.

<u>A</u> . . . . . <u>B</u> . . . . . <u>C</u> . . . . . <u>D</u> . . . . . . <u>E</u>

A	B	C	D	E
Critically Important	Very Important	Important	Somewhat Important	Not Important or Not Applicable

Importance Given on <u>This Project</u>	Ideal Impor- <u>tance</u>		
____	____	51.	Stability of system requirements.
____	____	52.	Contractor responsiveness to problems and changes.
____	____	53.	Ability to track project cost, schedule and performance.
____	____	54.	Simplicity and logic of the overall system design.
____	____	55.	Justification of system cost.
____	____	56.	Control and coordination of changes.
____	____	57.	Identification of the information needs of users.
____	____	58.	Commitment and support by users.
____	____	59.	System performance criteria.
____	____	60.	Other, specify ______________________________
____	____	61.	____

A	B	C	D	E
Critically Important	Very Important	Important	Somewhat Important	Not Important or Not Applicable

Thank you for your time and effort. Please write any comments in the space provided below.

Appendix B

Personnel Interviewed at AFDSDC, Gunter AFS, AL

Personnel Interviewed at AFDSDC, Gunter AFS, AL

1. Beerman, R. O., Maj. Deputy Director for Medical Systems. AFDSDC/SG.

2. Christiani, A. B., Col. Director for Comptroller Systems. AFDSDC/AC.

3. Fowler, B. L., Col. Director for Software Development. (Formerly Director for Systems Technology, replacing Col Phythyon). AFDSDC/SY.

4. Gibbons, B. I., III, Civ. AFDSDC/XMPB.

5. Glaab, P. E., Lt Col. Deputy Director for Systems Control. AFDSDC/SC.

6. Haag, C. E., CMSGT. AFDSDC/XMPB.

7. Hughes, J. D., Maj. Deputy Director for Communications. AFDSDC/DC (Det 1, CCPC/AFCS).

8. Kelly, E. F., Civ. AFDSDC/XMY.

9. Lewkovich, J., Civ. Deputy Director for Comptroller Systems. AFDSDC/AC.

10. Lyne, T. L., Col. Director for Programs and Resources. AFDSDC/PR.

11. Mayhan, A. J., Jr., Civ. AFDSDC/DM.

12. Neibling, R., Civ. Deputy Director for Logistics Systems. AFDSDC/LG.

13. Noblitt, J. W., Lt Col. Director for Operations Systems. AFDSDC/XO.

14. Orton, S. L., Lt Col. Deputy Director, Office of A PS Management. AFDSDC/DM.

15. Phillips, R. S., Col. Chief, Office of Plans and Management. AFDSDC/XM.

16. Phythyon, B. C., Col. Director for Software Development. (Retiring, to be replaced by Col Fowler). AFDSDC/SD.

17. Ragsdale, H. E., Lt Col. Chief, Office of Data Processing. AFDSDC/AD.

18. Reid, R. W., Lt Col. Director for Systems Control. AFDSDC/SC.

Appendix C

Distribution of Survey Parts A and B Variables

<u>Distribution of Survey Parts A and B Variables</u>

QUESTION

1. Command
   - A. 176 D. 87
   - B. 146 *E. 19
   - C. 25

2. Years Experience
   - A. 18 F. 47
   - B. 20 G. 50
   - C. 19 H. 104
   - D. 26 I. 123
   - E. 40

3. Grade
   - A. 13 H. 12
   - B. 2 I. 19
   - C. 53 J. 64
   - D. 99 K. 45
   - E. 88 L. 22
   - F. 19 M. 4
   - G. 6

4. Specialty
   - A. 244
   - B. 131
   - C. 79

5. Job
   - A. 147 C. 177
   - B. 50 D. 76

6. User Contact
   - A. 134 D. 62
   - B. 125 E. 37
   - C. 75 F. 18

7. MIS Experience
   - A. 126 D. 62
   - B. 92 E. 37
   - C. 75 F. 18

8. Success
   - A. 21 E. 38
   - B. 46 F. 26
   - C. 77 G. 43
   - D. 74

9. Size
   - A. 25 D. 69
   - B. 40 E. 54
   - C. 68 F. 70

10. Development of
   - A. 58 C. 37
   - B. 107 D. 118

11. Nature of Users
   - A. 62 C. 92
   - B. 86 D. 84

12. System Use
   - A. 194 D. 28
   - B. 42 E. 61
   - C. 4

13. Technical Difficulty
   - A. 33 D. 44
   - B. 118 E. 32
   - C. 100

14. Contractor Involvement
   - A. 155 D. 19
   - B. 27 E. 18
   - C. 103 F. 2

15. Maintenance
   - A. 214 D. 8
   - B. 71 E. 9
   - C. 18 F. 1

16. Warranties
   - A. 67 C. 186
   - B. 63

17. Project Organization
   - A. 50 D. 51
   - B. 81 E. 23
   - C. 119

18. Years Since Completion
   - A. 75 F. 23
   - B. 29 G. 23
   - C. 34 H. 16
   - D. 69 I. 8
   - E. 37

19. System Used Now
   - A. 239 C. 18
   - B. 70

VITA

Jere Wayne Retzer was born on 3 August 1948 in Palo Alto, California. He graduated from high school in Palos Verdes Peninsula, California in 1966 and attended the United States Air Force Academy from which he received a Bachelor of Science majoring in Engineering Management and Economics, as well as a commission in the USAF in June 1970. He completed pilot training in August 1971, and served as a T-29/C-131 Pilot and subsequently as T-29 Flight Instructor and T-29 Training and Operations Officer in the 4600th Air Base Wing, Peterson Field, Colorado until June 1975. He then served as a Crew Senior Director at Murphy Dome AFS (NORAD Control Center), Alaska until December 1975 and as Radar Operations Officer at Tin City AFS (NORAD Surveillance Station), Alaska until his entry to the School of Engineering, Air Force Institute of Technology, in August 1976.

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The problems of developing computerized systems, particularly management information systems (MIS), are discussed frequently in the literature. However, there is little agreement on the reasons for failure or the important factors for success. One study using survey data, performed by D. M. Carter, et al, in 1975 found four factors critical to MIS: Planning and Control, Expertise, Attitudes and Involvement. For several reasons, a new study appeared desirable. A new survey was developed and administered to 456 computer specialists at three Air Force bases. Analysis of the data found the survey samples of this and the

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